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Development of Thai Speech Audiometry Materials for Measuring Speech Recognition Thresholds

Lauren Alexandra Hart
Brigham Young University - Provo

DEVELOPMENT OF THAI SPEECH AUDIOMETRY MATERIALS FOR MEASURING SPEECH RECOGNITION THRESHOLDS

by

Lauren Alexandra Hart

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of a thesis submitted by

Lauren Alexandra Hart

This thesis has been read by each member of the following graduate committee and by majority vote has been found to be satisfactory.

Date	Shawn L. Nissen, Chair
Date	Richard W. Harris, Member
Date	Ron W. Channell, Member

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Date	Shawn L. Nissen Chair, Graduate Committee

Accepted for the Department

Date	Ron W. Channell Graduate Coordinator

Accepted for the College

Date	K. Richard Young Dean, David O. McKay School of Education

ABSTRACT

DEVELOPMENT OF THAI SPEECH AUDIOMETRY MATERIALS FOR MEASURING SPEECH RECOGNITION THRESHOLDS

Lauren Alexandra Hart

Department of Communication Disorders

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Speech audiometry materials are essential for thorough audiological testing. One aspect of speech audiometry is evaluating an individual's speech recognition threshold (SRT). Recorded materials for SRT are available in many languages; however there are no widely published recorded SRT materials available in the Thai language. The goal of this study was to develop relatively psychometrically equivalent SRT materials for evaluating the hearing abilities of native speakers of the Thai language. To accomplish this, 90 commonly used bisyllabic Thai words were digitally recorded by a male and a female talker and evaluated by 20 native Thai listeners. Twenty-eight words with relatively steep and homogeneous psychometric function slopes were selected and adjusted to reduce threshold variability. These 28 selected words were digitally recorded onto compact disc to facilitate SRT testing for native Thai speakers.

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Introduction

A commonly used diagnostic element of a hearing evaluation is pure-tone audiometry, where a series of sinusoidal tones is presented at a variety of frequencies and intensities. However, in conversation people do not communicate through sinusoidal tones, but often through the production and perception of speech in the form of a highly complex acoustic signal. Therefore, a comprehensive hearing evaluation should include an assessment of hearing that uses test stimuli similar to the auditory information conveyed during speech communication. The speech recognition threshold (SRT), a type of speech audiometry testing, is a common technique used by audiologists to estimate an individual's ability to perceive speech (Ramkissoon, Proctor, Lansing, & Bilger, 2002).

High-quality digital speech audiometry materials have been available in English for many years. However, there is an increasing need of materials in other languages. When an individual is tested in a language other than his or her native language, the test score may not accurately represent their speech perception abilities. For this reason it is important to administer speech audiometry tests in the native language of the listener. Currently high-quality digitally recorded SRT materials are not widely available in the Thai language. Thus, the aim of the present study is to create linguistically appropriate SRT materials to be used to evaluate the hearing abilities of native Thai speakers.

Review of Literature

Speech Audiometry

Pure-tone testing is a commonly used method of audiometric evaluation because it is highly reliable and simple to administer. However, the diagnostic information provided by pure-tone thresholds does not provide a comprehensive assessment of an individual's ability to perceive speech in everyday settings. The most common burden of hearing impairment is the struggle to understand speech, particularly in noisy environments (Wilson & McArdle, 2005). Thus, speech audiometry is often used by audiologists to validate an individual's performance with pure-tone testing (American Speech-Language-Hearing Association [ASHA], 1988) and as a diagnostic tool to quantify an individual’s ability to perceive speech (Bell & Wilson, 2001). One type of speech audiometry attempts to determine the nature and extent of a possible hearing impairment by comparing an individual's SRT to those of typical listeners (Epstein, 1978).

Speech Recognition Threshold

ASHA has defined SRT as “the minimum hearing level for speech at which an individual can recognize 50% of the speech material” (1988, p. 86). The SRT method has been found to be useful in part because the measure often corresponds with an individual's ability to hear pure-tone frequencies common to speech (Epstein, 1978). Any discrepancy between an individual’s pure-tone and SRT results may be attributed to an acoustic neuroma or perhaps to the client attempting a false profile (Van Dijk, Duijndam, & Graamans, 2000). Although a variety of stimuli can be used in SRT testing, English test materials are typically composed of bisyllabic spondaic words, in which both syllables have relatively equal emphasis, such as *baseball* or *hotdog* (ASHA, 1988).

When Hudgins, Hawkins, Karlin, and Stevens (1947) recorded SRT materials for the English language, they proposed that the test stimuli used should be familiar, phonetically dissimilar, represent English speech sounds, and audibly homogeneous. A study by Ramkissoon (2001) supported these claims for suprathreshold tests, such as word recognition testing, but found that only familiarity and homogeneity in audibility are essential aspects of SRT test stimuli. It is important that the individual is able to understand the test stimuli in an ideal listening environment and in the absence of any hearing impairment. Creating SRT materials from words that are familiar and used commonly in a language helps ensure that a hearing evaluation is a test of hearing acuity and not a test of receptive vocabulary. It is also important that the words are homogeneous with regard to audibility. The amplitude, test difficulty, and intelligibility of the test stimuli can all influence homogeneity (Dillon, 1983). Thus, if an individual is not familiar with a test word, or if the word is not audibly homogeneous to the other words, it should be removed from the test stimuli.

There are a number of methods for presenting SRT test stimuli, such as the use of live voice monitoring, phonographic recordings, commercial tape recordings, and digital materials stored on compact disc (CD) media. Martin, Armstrong, and Champlin (1994) conducted a survey of audiologists across the United States and found that 90% of respondents used monitored live voice for SRT. ASHA (1988) guidelines for SRT do not require one form of input over the others. However, they do note that recorded materials are preferred, due to increased reliability and flexibility during testing. The use of recorded materials ensures that the intensity and speech patterns of each stimulus presentation are reliable across clients, and from one clinic to the next. Although recorded stimuli are more consistent, some types of recordings also have drawbacks. Phonographic and tape recordings may become damaged after prolonged use. Such damage may result in distortion and extra noise not previously present in the recording. These recordings may also need an occasional replacement. Digital recordings not only alleviate many of the problems encountered with tape recordings, but also allow the audiologist to more easily customize word presentation for an individual client, as well as possibly reducing the overall test time.

Non-English Speech Audiometry Materials

A variety of digitally-recorded speech audiometry materials are available for SRT testing in English. However, English SRT materials may not be linguistically appropriate for people who are not native speakers of English. Ramkissoon, Proctor, Lansing, and Bilger (2002) suggested that stimuli used to measure SRT should be linguistically familiar to the listener.

There is a need for speech audiometry materials in languages other than English to evaluate the hearing of individuals worldwide, yet there is also an increased need for such materials within the United States as well. In 1985, Martin and Sides conducted a survey in which American audiologists reported administering 37% of speech audiometry evaluations in languages other than English. It is extremely important to administer a speech audiometry test in the listener’s native tongue in order for it to be a valid assessment.

Even if non-English speakers speak English as a second language, there is evidence that SRT testing in an individual's non-native language is inaccurate, especially at low-intensity levels. Weiss and Dempsey (2008) investigated speech perception in native Spanish speakers who were bilingual with English. They found that all of their participants perceived Spanish speech better than English speech. Padilla (2003) used English SRT materials to test native Spanish speakers who spoke English as a second language. Their SRT scores were compared with those of native English-speakers tested under the same conditions. Padilla found that the non-native listeners experienced difficulties in speech perception comparable to the perception difficulties commonly experienced by cochlear implant patients.

It may be important to not only assess an individual in their native language, but also to use materials created for their specific regional dialect. Weisleder and Hodgson (1989) tested native Spanish speakers from different countries using speech audiometry materials recorded by a native Spanish speaker from Mexico. They found that the listeners from Mexico scored better than the listeners from other countries at lower presentation levels. These differences in scores decreased as the presentation level increased. They suggested that the differences in scores were attributed to the varying regional dialects of the listeners. On the other hand, differences between test stimuli for some regional dialects that have a high degree of mutual intelligibility may be clinically insignificant. Richardson (2008) compared the SRT scores of native Mandarin speakers from Taiwan and mainland China as they were tested with materials recorded in the main dialects of both regions. Although thresholds were statistically higher when listening to a non-regional dialect of Mandarin, on average the differences were only about 1-2 dB. Although it would be ideal to create speech audiometry materials for every dialect of a language, it may not be practical, nor necessary. Nevertheless, it is important to be aware of dialectical variations when creating SRT materials.

Recently, efforts have been made to create high-quality materials for SRT, and other types of speech audiometry, in a variety of languages including Spanish (Christensen, 1995), Arabic (Ashoor & Prochazka, 1985), Danish (Elberling, Ludvigsen, & Lyregaard, 1989), Italian (Greer, 1997), Brazilian Portuguese (Harris, Goffi, Pedalini, Gygi, & Merrill, 2001; Harris, Goffi, Pedalini, Merrill, & Gygi, 2001), Polish (Harris, Nielson, McPherson, & Skarzynski, 2004a, 2004b), Japanese (Mangum, 2005), Korean (Harris, Kim, & Eggett, 2003a, 2003b), French (Nelson, 2004), Russian (Aleksandrovsky, McCullough, & Wilson, 1998; Harris, Nissen, Pola, McPherson, & Tavartkiladze, 2007), Mandarin Chinese (Nissen, Harris, Jennings, Eggett, & Buck, 2005a, 2005b), Greek (Iliadou, Fourakis, Vakalos, Hawks, & Kaprinis, 2006), Cantonese (Lau & So, 1988), and Afrikaans (Theunissen, 2008). Materials in these various languages have been very helpful in meeting the needs of audiologists' clientele in the U.S. and in other countries. However, there are still many languages for which there are no materials widely available, such as the Thai language.

Nature of the Thai Language

The Thai language, formerly know as Siamese, is the official language of Thailand. In 1991, Campbell reported that it was spoken by approximately 40 million people. More recent surveys have reported the population of Thailand to be nearly 65 million, with the majority of its inhabitants speaking standard Thai, also called Central Thai (Gordon, 2005). In addition to standard Central Thai there are numerous other dialects found throughout Thailand. The most common of these dialects are Northeastern Thai, Northern Thai, and Southern Thai. These dialects generally vary in tone and phonology (Campbell, 1991). The predominant dialect of Northeastern Thailand is the Isaan dialect. Although similar to Central Thai, the Isaan dialect is more akin to standard

Lao, often varying by a single change in phonology or tone. In Isaan the /r/ sound in many Central Thai words is changed to /h/ or /l/. For example, in Central Thai the word for *we* or *us* (เรา) is pronounced /raʊ/ with a middle tone, whereas in Isaan the same word is changed to เฮา, pronounced /haʊ/, also with a middle tone. In addition, the Central Thai word คน pronounced /kon/ with a middle tone means *person*, while the same word in Isaan may be pronounced with a high tone or a falling tone depending on the region. Some Isaan words are completely dissimilar to their Thai equivalents. For example, the Thai word for *what* is อะไร pronounced /əraɪ/ with a low tone and a middle tone, while its Isaan counterpart is อีหยัง is pronounced /ɨyʌŋ/ with a middle tone and a rising tone.

Thai is the most prominent member of the Tai language family, which also includes the Lao, Shan, and Yuan languages (Campbell, 1991). Central Thai is considered to be the main language for public education and literature in Thailand. Much of spoken and written Central Thai is derived from Sanskrit and Pali. However, there are many orthographic distinctions that set Thai apart from Sanskrit. For example, some vowels are spoken in both Thai and Sanskrit, however they may be written explicitly in Thai while they are only implied between consonants in Sanskrit. The Thai script was influenced to some extent by the Khmer version of a South Indian script, in that Thai is read from left to right, and top to bottom. Written Thai consists of 44 symbols that serve to represent 21 consonantal phonemes, due in part to the fact that multiple consonants may represent the same phoneme. For example, the Thai consonants ศ, ส, ษ, and ซ all represent the phoneme /s/. There are 14 symbols, or combinations of symbols, to represent over 30 vowel sounds. In some cases these vowels are written preceding a consonant even if the consonant is pronounced before the vowel. The word ใน meaning *in* is pronounced /naɪ/ with a middle tone, with ใ representing the vowel phoneme /aɪ/ and น representing the consonant phoneme /n/. Spaces are not included between words in connected text. Although Thai can be expressed in a Romanized form, pronunciations according to Romanized Thai may differ from standard English (Wei & Zhou, 2002). For example, *ph* in Romanized Thai is pronounced /p/, and *p* is pronounced as a voiceless, unaspirated bilabial plosive (sounding like a hard /b/ or an unaspirated /p/).

Vowels in Thai can be short or long in duration (Campbell, 1991). The Thai word for *rice* (ข้าว) is pronounced /kaʊ/ with a falling tone, and is spoken with an elongated vowel. However, if this same syllable is pronounced with a shortened vowel, it then becomes the word เข้า which means *to enter*. There are 14 diphthongs and three triphthongs. The 21 consonant sounds consist of 11 stops, one affricate, three fricatives, three nasals, two laterals, and two glides. Among these types of sounds, the bilabial, lingual-alveolar, and lingual-velar stops can each be produced with three different types of voice onset. For instance, a Thai bilabial stop may be voiced, voiceless and unaspirated, or voiceless and aspirated. Only the consonants /p, t, k, r, l, m, n, ŋ/ are permitted as final consonants. Under these circumstances, however, the finals /p, t, k/ are unaspirated, and /r/ and /l/ become /n/. The Thai glottal stop อ (/ʔ/) is also considered a consonant.

Thai syllables are pronounced with one of five lexical tones: middle, low, falling, high, and rising (Campbell, 1991). The tone of each Thai word, with consideration to its particular vowel length, determines its meaning. For example, the Thai word มัน, pronounced /mən/ with the middle tone, translates to the English word for *it*. However,

มั่น, pronounced /mən/ with the falling tone, means *to be firm*. If this same word is said with a long vowel it becomes ม่าน, which refers to *a curtain, veil, or screen*.

The sentential word order used in Thai is subject, verb, and then object (Campbell, 1991). Unlike English, adjectives follow nouns and plural markers are not distinguished except for numerals or particles such as in the word for the concept of *many*. Verbs in Thai are not conjugated for tense, so in addition to context, Thai words equivalent to English words such as *will* and *did* can be added to provide clues about the tense. In addition, there are no gender distinctions for the singular or plural forms of the third person. The use of pronouns is socio-linguistically based on the formality of the relationship between the speaker and the intended listener or audience. In common conversation, men typically use the polite particle ครับ, pronounced /krab/, with the high tone at the end of each statement or question. Women typically use the polite particle ค่ะ, pronounced /ka/, with a falling tone at the end of each statement or question. When speaking about or addressing royalty and religious personages, it is culturally appropriate to speak in a special lexicon of nouns and verbs. These linguistic characteristics are intrinsic to Central Thai, and were taken into consideration when designing the materials in the present study.

The majority word type in Thai is monosyllabic in nature, especially for nouns and verbs. Bisyllabic words are often created by combining two monosyllabic words or one monosyllabic word with a prefix or suffix. For instance, the word for *refrigerator* is ตู้เย็น, literally translated as *cabinet cold*. However, some bisyllabic words have no meaning when their syllables are isolated. The word ทะเล means *sea*, but the syllables ทะ and เล mean nothing when isolated. Polysyllabic Thai words are also created by adding multiple prefixes and suffixes to monosyllabic or bisyllabic words. Some of the Thai vocabulary consists of loanwords borrowed from other languages. For example, Thai speakers use a Thai pronunciation of the English words *computer* and *technology*, which carry the same meaning in English (Gordon, 2005).

Hearing Impairment in Thailand

Prevalence and incidence of hearing disability in Thailand. With nearly 65 million people in Thailand, hearing impairment takes a toll on many lives. Several studies have been conducted to investigate the magnitude and impact of hearing impairment in Thailand. The World Health Organization (n.d.) reported that the prevalence rate for hearing impairment in Thailand is 13.3%. A summary review of demographic data and findings on hearing impairment in Thailand (Prasansuk, 2000) revealed that 13.6% of people tested in 17 provinces demonstrated hearing impairment. This review also showed that out of 32,000 individuals tested in Thailand, 4.3% demonstrated a sensorineural loss in at least one ear. If this rate of incidence is an accurate reflection of the general Thai population, nearly 3 million people in Thailand suffer from sensorineural hearing impairment alone. This estimate does not account for those who suffer from other types of hearing impairment.

Burden of disability from hearing impairment. In Thailand, education and work opportunities are limited for those with hearing impairment and other types of disabilities. Both public and private programs in Thailand provide some education for the disabled (Wahab, 1997). However, as of 1997 there were no facilities for the education of children with multiple disabilities. The biggest dilemma regarding education for the disabled in Thailand is the lack of funds.

The burden of disability caused by hearing impairment is compounded by the inability of many hearing impaired individuals to receive a public education. Some deaf individuals in Thailand receive a formal education by learning Thai sign language, however Thai sign language is still relatively new as it was first developed in the 1950s (Nimkannon, 2005). Although sign language is beneficial, those who depend on it can only use it to communicate with others who understand it. Many deaf people who are less fortunate depend on natural gestures to communicate. These often underprivileged and uneducated individuals frequently have no choice but to work as street vendors (Wahab, 1997). If they do not find employment they become a burden to their families and to their communities. In additions to these disadvantages, people in Thailand are generally poorly informed about the causes of disabilities, and therefore underestimate the capabilities of disabled individuals, thus creating social and cultural barriers which further restrict the opportunities available to the disabled.

Etiology and treatment of hearing impairment in Thailand. Otitis media is among the most prevalent causes of hearing impairment in Thailand (World Health Organization, n.d.). Perforation of the tympanic membrane, displacement of the ossicles, and excessive middle ear fluid are all complications of otitis media which may result in hearing impairment (Klein, 2001). A child who acquires otitis media and doesn't receive timely medical treatment is commonly at risk for a mild to moderate hearing impairment, which may also result in an inability to develop the speech and language skills necessary for effective communication.

Otitis media may not be easily prevented, but it can often be treated successfully with antibiotics if available (Dodet, 2001). In developed countries, vaccines are more readily available to protect against the types of viruses and bacteria that commonly cause acute otitis media. If treated early, hearing damage caused by otitis media can often be prevented. In addition, the insertion of tympanostomy tubes, often combined with antibiotics, are effective methods of preventing recurrent otitis media and its effects on hearing (Rosenfeld, 2001). People in developing countries such as Thailand have limited access to medical treatment for otitis media, however even if individuals have access to such services, they may not be able to afford them.

As industry grows in Thailand, so does the noise levels that individuals are exposed to at work. Many people from rural Thailand have been migrating to Bangkok in search of better work opportunities. With the ever-increasing population, traffic, construction, and factories in Bangkok, noise levels have become a health concern (World Health Organization, 1997). A basic strategy for preventing noise-induced hearing impairment is to avoid extended exposure to high sound levels, by avoiding a loud environment or by wearing hearing protection. However, many citizens of Bangkok are uneducated about the risks of sound exposure and consequently do not protect their hearing. It is likely that the issue of noise-induced hearing impairment in Thailand will not be resolved until the public has a greater awareness of the risks involved.

Furthermore, exposure to ototoxic drugs along with high levels of noise can have a more dangerous affect on the human cochlea than exposure to either one independently (Brown et al., 1981). Much like with noise exposure, people using ototoxic drugs may not be aware of the risks involved. Ototoxic drugs are often used to treat health problems that are considered to be more harmful than the potential side effects of the drugs on an individual's hearing.

In Thailand, hearing impairment has also been found to result from nutrient deficiencies. Iodine deficiency is especially prevalent in northern Thailand (Rajatanavin et al., 1997). A severe lack of iodine, referred to as endemic cretinism, may cause serious neurological problems to an unborn fetus, including sensorineural hearing impairment. Endemic cretinism, and its subsequent effects, is preventable with iodine supplements. However, the lack of available iodine supplements and the lack of education about its necessity seem to sustain this cause of hearing impairment.

Prevention and proper treatment of the conditions that most commonly cause hearing impairment would preserve the quality of life for many Thai people. However, treatment or rehabilitation of already-existing hearing impairment is also an important step in addressing the burden of disability caused by hearing impairment. The efficacy of rehabilitation often depends on accurate diagnostic information provided by a full audiometric evaluation; and evaluation which would most likely include speech audiometry testing.

Purposes of the Study

Although SRT materials have been developed for many languages, there are no known digitally recorded SRT materials available to be used to assess the hearing acuity of native speakers of Thai. Thai listeners should be assessed for SRT using familiar words in their native language. Thus, the purpose of this study is to address this need by developing psychometrically equivalent bisyllabic words that can be used for SRT testing in the Thai language. In order to accomplish this goal, this study will (a) develop a list of familiar bisyllabic Thai words, (b) select a male and a female native speaker of standard Central Thai to record the materials to be evaluated, (c) make high-quality digital recordings of the selected words, (d) evaluate the psychometric performance of each word by collecting normative data from twenty listeners with normal hearing, (e) utilize logistic regression to create a list of relatively familiar and psychometrically equivalent words, and (f) create a CD of the Thai SRT materials that will be available upon request.

Method

Participants

A total of 20 native speakers of Central Thai participated in evaluating the materials developed in this study, 10 male and 10 female. The participants' ages ranged from 19 to 33 years (*M* = 24.2 years). They had resided in the United States from one week to 4.5 years; and reported that they speak Thai on a daily basis. All of the participants in this study had pure-tone air-conduction thresholds ≤15 dB HL at octave and mid-octave frequencies from 125 to 6000 Hz and ≤20 dB HL at 8000 Hz. Each participant 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). In addition, each participant passed a screening exam, which included detecting the presence of an ipsilateral acoustic reflex of 95 dB HL or better in the test ear at 1000 Hz, and signed an informed consent form. The mean pure-tone average (PTA) for the 20 participants was 6.25 dB HL. Table 1 displays a statistical summary of participant thresholds.

Materials

Word lists. A preliminary word corpus of 250 frequently used bisyllabic words was drawn from an unpublished Thai frequency dictionary by Doug Cooper (R. Dockum, personal communication, July 10, 2006). These words were then rated by 3 native judges on a scale of 1 to 5 based on how familiar a word would be to a Thai speaker from Thailand (1 = extremely, 2 = very, 3 = average, 4 = seldom used, and 5 = rarely used). Of the 250 original bisyllabic words, 160 words were eliminated from final evaluation for the following reasons: (a) the word received a mean familiarity rating of ≤ 2 from the

Table 1

Pure Tone Threshold (dB HL) Descriptive Statistics for 20 Normally Hearing Thai Subjects

	M	*Minimum*	*Maximum*	*SD*
0.125 kHz	7.3	-5	15	5.5
0.25 kHz	6.0	-5	15	6.6
0.5 kHz	7.3	0	15	5.3
0.75 kHz	6.8	-5	15	5.9
1.0 kHz	6.3	-5	15	4.6
1.5 kHz	7.3	0	15	5.3
2.0 kHz	5.3	-5	15	5.7
3.0 kHz	3.0	-5	15	5.7
4.0 kHz	4.3	-5	15	6.9
6.0 kHz	3.8	-10	15	6.5
8.0 kHz	4.5	-5	20	8.1
PTA[a]	6.3	-3.3	13.3	4.3

[a]PTA = arithmetic average of thresholds at 0.5, 1.0, and 2.0 kHz

native judges, (b) the word was thought to represent inappropriate or culturally insensitive content, or (c) two words had the same pronunciation but different meanings.

Talkers. Initial test recordings were made using 8 native talkers of Thai (5 females and 3 males). All talkers originated from the country of Thailand, who self-reported speaking a standard dialect of Thai. After the initial recordings were made, a panel of 4 native speakers evaluated the speech of each of the 8 talkers. The native judges were asked to rank order the talkers from best to worst based on vocal quality, standard dialect, and pronunciation. The highest ranked male and female talkers were selected as the talkers for all subsequent recordings.

Recordings. All recordings were made in an anechoic chamber, with approximately a 65 dB signal-to-noise ratio with the sound floor measuring 0 dB SPL, located on the Brigham Young University campus in Provo, Utah, USA. A Larson-Davis model 377B41, 1.27 cm microphone, positioned approximately 15 cm from the talker at a 0° azimuth and covered by a 7.62 cm windscreen, was utilized for all recordings. The microphone signal was amplified by a Larson-Davis model PRM902 microphone preamp, which was coupled to a Larson-Davis model 2221 microphone preamplifier power supply. The signal was digitized using an Apogee AD-8000 analog-to-digital converter and subsequently 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.

During the recording sessions, each talker was instructed to use normal vocal effort and to pronounce each bisyllabic word at least four times. A native judge then rated the second and third repetition of each word for perceived quality of production, and the best production of each word was then selected for inclusion in the evaluation portion of the study. The first and last repetitions of each word were excluded to avoid possible list effects. Any words that were judged to be poorly recorded were rerecorded or eliminated from the study prior to listener evaluation. After the rating process, the intensity of each bisyllabic word to be included in the listener evaluation was edited as a single utterance using Sadie Disk Editor software (Studio Audio & Video Ltd., 2004) to yield the same level equivalent (Leq) as that of a 1 kHz calibration tone.

Procedure

Custom software was used to control the randomization, presentation, and scoring of the bisyllabic words evaluated in the study. This software was also used to record the performance data. The signal was routed from a computer hard drive to the external input of a Grason Stadler model 1761 audiometer. The stimuli were then routed via TDH-50P headphones from the audiometer to the participant, who was seated in a double-walled sound suite meeting ANSI S3.1 standards (American National Standards Institute, 1999) for maximum permissible ambient noise levels for the ears not covered condition using one-third octave-band measurements. Prior to testing each participant, the inputs to the audiometer were calibrated to 0 VU using the 1 kHz calibration tone through customized computer software. In addition, the audiometer was calibrated weekly during and at the conclusion of data collection. Calibration was performed in accordance with ANSI S3.6 standards (American National Standards Institute, 2004). No changes in calibration were necessary throughout the course of data collection.

Each participant evaluated the test stimuli in two test sessions after passing a hearing screening exam. Participants were allowed to have several rest periods during each test session. A randomized list of the recorded 90 bisyllabic words was initially presented to each listener at a sound level 6 dB below the listener's PTA. If the listener repeated any words correctly during the initial presentation, the list intensity was decreased in 2 dB increments and played again until the listener repeated none correctly, or until the list had been played at -10 dB. After the lowest intensity had been played, a randomized presentation of the list of words was presented at 2 dB above the initial intensity. Randomized lists were presented at increasing intensities of 2 dB until the listener repeated all 90 words correctly, or until the list was presented at 16 dB. Each participant listened to the male and female talker recordings of the bisyllabic words in a sequence determined randomly. Participants repeated words verbally; which were scored as being correct or incorrect by a native judge who spoke Thai. Thus, the potential influence of learning effects was reduced by (a) the relatively large number of words evaluated by listeners, (b) the stimuli were presented from low to high amplitude, and (c) the presented stimulus items were randomized at each intensity level. Prior to the evaluation of the bisyllabic words, instructions were given to the participants in Thai. An English translation of the instructions is listed below:

> You will hear bisyllabic words which may become louder or softer in intensity. At the very soft loudness levels it may be very difficult for you to hear the words. Please 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?

Results

After raw data were collected, logistic regression was used to obtain the regression slope and intercept for each of the 90 bisyllabic words. These 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:

$$\log \frac{p}{1-p} = a + b \times i \tag{1}$$

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

$$P = (1 - \frac{\exp(a + b \times i)}{1 + \exp(a + b \times i)})*100 \tag{2}$$

In Equation 2, P is percentage of correct recognition, a is the regression intercept, b is the regression slope, and i is the presentation intensity in dB HL. By inserting the regression slope, regression intercept, and intensity level into Equation 2, it is possible to predict the percentage of correct recognition at any specified intensity level. Percentage of correct recognition was calculated for each of the bisyllabic words for a range of –10 to 16 dB HL in 1 dB increments.

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

$$i = \frac{\log \frac{p}{1-p} - a}{b} \qquad (3)$$

$$i = \frac{-a}{b} \qquad (4)$$

Calculations of threshold (intensity required for 50% correct perception), slope at 50%, and slope from 20 to 80% were made for each bisyllabic word using the logistic regression slopes and intercepts.

Thresholds for 50% intelligibility for the 90 bisyllabic words ranged from 0.5 dB HL to 14.3 dB HL (*M* = 6.7 dB HL) for the male talker words, and from -2.2 dB HL to 12.3 dB HL (*M* = 3.8 dB HL) for the female talker words. Psychometric functions for each bisyllabic word were calculated with Equation 2 using the logistic regression intercept and slope values. The slopes at 50% ranged from 2.9 %/dB to 11.6 %/dB (*M* = 8.2) for the male talker and from 3.4 %/dB to 11.0 %/dB (*M* = 7.3) for the female talker. The slopes from 20-80% ranged from 2.5 %/dB to 10.1 %/dB (*M* = 7.1) for the male talker and from 2.9 %/dB to 9.5 %/dB (*M* = 6.3) for the female talker. In comparison, the slopes at 50% were consistently steeper than the slopes from 20-80%. These thresholds for the 90 bisyllabic words, and their psychometric function slopes at 50% and from 20-80% are presented in Table 2 (male talker) and Table 3 (female talker).

In order to reduce test time, as well as improve reliability, it is recommended that words used to measure SRT have relatively homogeneous and steep psychometric function slopes (Wilson & Strouse, 1999). Thus, the 36 words that had the steepest psychometric function slopes for both the male and female talker recordings (≥ 7.5 %/dB for both male and female talkers) were selected as candidates for the final list of

Table 2

Mean Performance for 90 Thai Male Bisyllabic SRT words

#	Word	Romanization	a[a]	b[b]	Slope at 50% [c]	Slope 20-80%[d]	Threshold[e]	ΔdB[f]
1	ปรับปรุง	pràpprung	0.90624	-0.31703	7.9	6.9	2.9	-3.4
2	อากาศ	a-kàt	2.51956	-0.29467	7.4	6.4	8.6	2.3
3	สนุก	sà-nùk	3.19537	-0.27221	6.8	5.9	11.7	5.5
4	ฝรั่ง	fà-ràng	1.81933	-0.38761	9.7	8.4	4.7	-1.6
5	โดยตรง	doitrong	1.45483	-0.31918	8.0	6.9	4.6	-1.7
6	วิธี	wí-thi	2.77202	-0.37885	9.5	8.2	7.3	1.1
7	จำเป็น	champen	2.36928	-0.35055	8.8	7.6	6.8	0.5
8	เข้าใจ	khâochai	1.59421	-0.32405	8.1	7.0	4.9	-1.3
9	เกิดขึ้น	kòetkhûen	2.47442	-0.37137	9.3	8.0	6.7	0.4
10	โรงงาน	rongngan	1.80923	-0.27508	6.9	6.0	6.6	0.3
11	ผู้ใหญ่	phûyài	2.40926	-0.32510	8.1	7.0	7.4	1.2
12	ชัดเจน	chátchen	1.41959	-0.29948	7.5	6.5	4.7	-1.5
13	กระดาษ	krà-dàt	2.45299	-0.37417	9.4	8.1	6.6	0.3
14	รถยนต์	rót-yon	1.03661	-0.24859	6.2	5.4	4.2	-2.1
15	ฤดู	rí-du	2.50099	-0.32290	8.1	7.0	7.7	1.5
16	กฎหมาย	kòdmăi	2.42452	-0.40882	10.2	8.8	5.9	-0.3
17	เพิ่มเติม	phôemtoem	1.46533	-0.29511	7.4	6.4	5.0	-1.3
18	กำลัง	kam-lang	2.76088	-0.36665	9.2	7.9	7.5	1.3
19	อะไร	à-rai	1.69852	-0.32272	8.1	7.0	5.3	-1.0
20	ติดต่อ	tìttò	1.16738	-0.20610	5.2	4.5	5.7	-0.6
21	หนังสือ	năng-sŭe	3.10336	-0.35109	8.8	7.6	8.8	2.6
22	กุญแจ	kun-chàe	4.97260	-0.34830	8.7	7.5	14.3	8.0
23	จังหวัด	chang-wàt	1.72419	-0.35437	8.9	7.7	4.9	-1.4
24	เหมาะสม	mòsŏm	2.36928	-0.35055	8.8	7.6	6.8	0.5
25	เช่นกัน	chênkan	2.57593	-0.39852	10.0	8.6	6.5	0.2
26	มากมาย	mâkmai	2.27898	-0.46593	11.6	10.1	4.9	-1.4
27	ทะเล	thá-le	3.74252	-0.39570	9.9	8.6	9.5	3.2
28	บัญชี	ban-chi	3.59386	-0.43963	11.0	9.5	8.2	1.9
29	คุณค่า	khunkhâ	2.75600	-0.31052	7.8	6.7	8.9	2.6
30	อาหาร	a-hăn	2.76674	-0.33797	8.4	7.3	8.2	1.9
31	หน้าที่	nâthî	2.52996	-0.29185	7.3	6.3	8.7	2.4
32	โบราณ	bo-ran	1.97293	-0.32528	8.1	7.0	6.1	-0.2
33	ได้รับ	dâiráp	2.19408	-0.31532	7.9	6.8	7.0	0.7
34	ประตู	prà-tu	2.76674	-0.33797	8.4	7.3	8.2	1.9
35	ไฟฟ้า	faifá	0.15102	-0.31896	8.0	6.9	0.5	-5.8
36	ต่อไป	tòpai	0.51725	-0.29895	7.5	6.5	1.7	-4.5
37	ขนม	khà-nŏm	3.37387	-0.33075	8.3	7.2	10.2	4.0

#	Word	Romanization	a[a]	b[b]	Slope at 50% [c]	Slope 20-80%[d]	Threshold[e]	ΔdB[f]
38	ยอมรับ	yomráp	1.58314	-0.39350	9.8	8.5	4.0	-2.2
39	รู้จัก	rúchàk	2.56604	-0.37869	9.5	8.2	6.8	0.5
40	สมุด	sà-mùt	2.85482	-0.33512	8.4	7.3	8.5	2.3
41	ธุระ	thú-rá	2.28203	-0.25439	6.4	5.5	9.0	2.7
42	ประเทศ	prà-thêt	2.82556	-0.25847	6.5	5.6	10.9	4.7
43	ค้นหา	khónhă	2.79665	-0.34636	8.7	7.5	8.1	1.8
44	ชีวิต	chi-wít	3.21483	-0.36866	9.2	8.0	8.7	2.5
45	แท้จริง	tháeching	1.85648	-0.35643	8.9	7.7	5.2	-1.0
46	ถนน	thà-nŏn	3.54805	-0.29973	7.5	6.5	11.8	5.6
47	เพราะว่า	phrówâ	1.57221	-0.33381	8.3	7.2	4.7	-1.5
48	ศึกษา	sùek-să	2.04984	-0.25624	6.4	5.5	8.0	1.7
49	ทุกคน	thúkkhon	1.37456	-0.27943	7.0	6.0	4.9	-1.3
50	ถูกต้อง	thùktông	1.63506	-0.28894	7.2	6.3	5.7	-0.6
51	ระหว่าง	rá-wàng	3.21031	-0.29491	7.4	6.4	10.9	4.6
52	เวลา	we-la	1.88315	-0.31701	7.9	6.9	5.9	-0.3
53	บังคับ	bang-kháp	1.28650	-0.34835	8.7	7.5	3.7	-2.6
54	ก้าวหน้า	kâonâ	1.45768	-0.28208	7.1	6.1	5.2	-1.1
55	สังเกต	săng-kèt	2.58015	-0.36922	9.2	8.0	7.0	0.7
56	จัดตั้ง	chàttâng	2.22205	-0.32430	8.1	7.0	6.9	0.6
57	มั่นคง	mân-khong	0.63504	-0.27934	7.0	6.0	2.3	-4.0
58	ปลอดภัย	plòtphai	0.87075	-0.33878	8.5	7.3	2.6	-3.7
59	แนะนำ	náe-nam	1.35712	-0.35462	8.9	7.7	3.8	-2.4
60	ทั้งสอง	thángsŏng	4.33114	-0.32071	8.0	6.9	13.5	7.3
61	ต้องการ	tôngkan	1.57046	-0.35603	8.9	7.7	4.4	-1.8
62	มะพร้าว	má-phráo	1.36456	-0.30926	7.7	6.7	4.4	-1.8
63	สนใจ	sŏn-chai	2.38167	-0.33123	8.3	7.2	7.2	0.9
64	รายได้	raidâi	1.56426	-0.31229	7.8	6.8	5.0	-1.2
65	ทั้งหมด	thángmòt	3.03101	-0.32981	8.2	7.1	9.2	2.9
66	อำนาจ	am-nât	3.46761	-0.35286	8.8	7.6	9.8	3.6
67	ราคา	ra-kha	2.45238	-0.42054	10.5	9.1	5.8	-0.4
68	ปกครอง	pòkkhrong	0.79997	-0.27536	6.9	6.0	2.9	-3.3
69	รักษา	rák-să	2.81557	-0.29352	7.3	6.4	9.6	3.3
70	แก้ไข	kâekhăi	1.16479	-0.30636	7.7	6.6	3.8	-2.4
71	กระเป๋า	krà-păo	1.81993	-0.35708	8.9	7.7	5.1	-1.2
72	ภาษา	pha-să	1.92460	-0.31784	7.9	6.9	6.1	-0.2
73	อย่างไร	yàngrai	2.04232	-0.34795	8.7	7.5	5.9	-0.4
74	ขั้นตอน	khânton	1.45483	-0.31918	8.0	6.9	4.6	-1.7
75	สัญญา	săn-ya	3.44834	-0.34666	8.7	7.5	9.9	3.7
76	ไม่ใช่	mâichâi	1.67496	-0.34544	8.6	7.5	4.8	-1.4
77	แน่นอน	nâe-non	2.22538	-0.32998	8.2	7.1	6.7	0.5

#	Word	Romanization	a[a]	b[b]	Slope at 50% [c]	Slope 20-80%[d]	Threshold[e]	ΔdB[f]
78	ทดสอบ	thótsòp	1.83379	-0.32667	8.2	7.1	5.6	-0.6
79	ตลาด	tà-làt	2.71354	-0.30966	7.7	6.7	8.8	2.5
80	ก่อสร้าง	kòsâng	1.12402	-0.11637	2.9	2.5	9.7	3.4
81	หลังจาก	lăngchàk	2.16761	-0.34350	8.6	7.4	6.3	0.1
82	เริ่มต้น	rôem-tôn	0.46507	-0.34958	8.7	7.6	1.3	-4.9
83	สุดท้าย	sùtthái	2.02775	-0.38624	9.7	8.4	5.2	-1.0
84	ทำให้	thamhâi	1.67685	-0.36857	9.2	8.0	4.5	-1.7
85	สามารถ	să-mât	2.04771	-0.29966	7.5	6.5	6.8	0.6
86	วางแผน	wang-phăen	2.05859	-0.34443	8.6	7.5	6.0	-0.3
87	พิเศษ	phí-sèt	3.20647	-0.37239	9.3	8.1	8.6	2.4
88	บุคคล	bùk-khon	2.24630	-0.30798	7.7	6.7	7.3	1.0
89	จมูก	chà-mùk	3.97564	-0.28942	7.2	6.3	13.7	7.5
90	โอกาส	o-kàt	1.56426	-0.31229	7.8	6.8	5.0	-1.2
	M		2.17715	-0.32877	8.2	7.1	6.7	0.4
	Min		0.15102	-0.46593	2.9	2.5	0.5	-5.8
	Max		4.97260	-0.11637	11.6	10.1	14.3	8.0
	Range		4.82158	0.34956	8.7	7.6	13.8	13.8
	SD		0.88130	0.04820	1.2	1.0	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 20-80%. [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 (6.25 dB HL)

Table 3

Mean Performance for 90 Thai Female Bisyllabic SRT words

#	Word	Romanization	a[a]	b[b]	Slope at 50% [c]	Slope 20-80%[d]	Threshold[e]	ΔdB[f]
1	ปรับปรุง	pràpprung	0.71354	-0.26742	6.7	5.8	2.7	-3.6
2	อากาศ	a-kàt	0.14835	-0.21375	5.3	4.6	0.7	-5.6
3	สนุก	sà-nùk	3.60078	-0.29235	7.3	6.3	12.3	6.1
4	ฝรั่ง	fà-ràng	0.37405	-0.28274	7.1	6.1	1.3	-4.9
5	โดยตรง	doitrong	0.63221	-0.28405	7.1	6.1	2.2	-4.0
6	วิธี	wí-thi	3.04701	-0.42847	10.7	9.3	7.1	0.9
7	จำเป็น	champen	2.05242	-0.36936	9.2	8.0	5.6	-0.7
8	เข้าใจ	khâochai	0.45828	-0.13558	3.4	2.9	3.4	-2.9
9	เกิดขึ้น	kòetkhûen	0.39609	-0.25347	6.3	5.5	1.6	-4.7
10	โรงงาน	rongngan	1.75530	-0.31717	7.9	6.9	5.5	-0.7
11	ผู้ใหญ่	phûyài	1.31914	-0.25118	6.3	5.4	5.3	-1.0
12	ชัดเจน	chátchen	-0.14967	-0.24282	6.1	5.3	-0.6	-6.9
13	กระดาษ	krà-dàt	0.69590	-0.23007	5.8	5.0	3.0	-3.2
14	รถยนต์	rót-yon	1.04377	-0.29808	7.5	6.5	3.5	-2.7
15	ฤดู	rí-du	1.51592	-0.33631	8.4	7.3	4.5	-1.7
16	กฎหมาย	kòdmăi	0.99957	-0.34672	8.7	7.5	2.9	-3.4
17	เพิ่มเติม	phôemtoem	0.89673	-0.23438	5.9	5.1	3.8	-2.4
18	กำลัง	kam-lang	2.31462	-0.37825	9.5	8.2	6.1	-0.1
19	อะไร	à-rai	0.42626	-0.25235	6.3	5.5	1.7	-4.6
20	ติดต่อ	tìttò	0.85298	-0.28607	7.2	6.2	3.0	-3.3
21	หนังสือ	năng-sŭe	1.15775	-0.29949	7.5	6.5	3.9	-2.4
22	กุญแจ	kun-chàe	2.19409	-0.25509	6.4	5.5	8.6	2.4
23	จังหวัด	chang-wàt	1.79033	-0.35142	8.8	7.6	5.1	-1.2
24	เหมาะสม	mòsŏm	0.86377	-0.23380	5.8	5.1	3.7	-2.6
25	เช่นกัน	chênkan	2.18732	-0.35115	8.8	7.6	6.2	0.0
26	มากมาย	mâkmai	1.92331	-0.32688	8.2	7.1	5.9	-0.4
27	ทะเล	thá-le	0.74078	-0.28448	7.1	6.2	2.6	-3.6
28	บัญชี	ban-chi	2.35982	-0.44015	11.0	9.5	5.4	-0.9
29	คุณค่า	khunkhâ	2.05392	-0.34225	8.6	7.4	6.0	-0.2
30	อาหาร	a-hăn	0.33484	-0.29691	7.4	6.4	1.1	-5.1
31	หน้าที่	nâthî	2.11399	-0.28966	7.2	6.3	7.3	1.0
32	โบราณ	bo-ran	0.45385	-0.28503	7.1	6.2	1.6	-4.7
33	ได้รับ	dâiráp	0.30246	-0.31733	7.9	6.9	1.0	-5.3
34	ประตู	prà-tu	2.82630	-0.37322	9.3	8.1	7.6	1.3
35	ไฟฟ้า	faifá	-0.29125	-0.31986	8.0	6.9	-0.9	-7.2
36	ต่อไป	tòpai	-0.16815	-0.23283	5.8	5.0	-0.7	-7.0
37	ขนม	khà-nŏm	1.81730	-0.25116	6.3	5.4	7.2	1.0

#	Word	Romanization	a[a]	b[b]	Slope at 50% [c]	Slope 20-80%[d]	Threshold[e]	ΔdB[f]
38	ยอมรับ	yomráp	0.59636	-0.29572	7.4	6.4	2.0	-4.2
39	รู้จัก	rúchàk	1.89226	-0.30955	7.7	6.7	6.1	-0.1
40	สมุด	sà-mùt	2.64365	-0.25765	6.4	5.6	10.3	4.0
41	ธุระ	thú-rá	1.38400	-0.21629	5.4	4.7	6.4	0.1
42	ประเทศ	prà-thêt	0.92348	-0.30457	7.6	6.6	3.0	-3.2
43	ค้นหา	khónhă	0.48066	-0.32386	8.1	7.0	1.5	-4.8
44	ชีวิต	chi-wít	1.46051	-0.34114	8.5	7.4	4.3	-2.0
45	แท้จริง	tháeching	1.82036	-0.37288	9.3	8.1	4.9	-1.4
46	ถนน	thà-nŏn	2.71994	-0.26644	6.7	5.8	10.2	4.0
47	เพราะว่า	phrówâ	0.04651	-0.17132	4.3	3.7	0.3	-6.0
48	ศึกษา	sùek-să	1.05464	-0.27631	6.9	6.0	3.8	-2.4
49	ทุกคน	thúkkhon	2.06962	-0.33847	8.5	7.3	6.1	-0.1
50	ถูกต้อง	thùktông	1.07286	-0.25207	6.3	5.5	4.3	-2.0
51	ระหว่าง	rá-wàng	0.23012	-0.30235	7.6	6.5	0.8	-5.5
52	เวลา	we-la	1.07790	-0.32493	8.1	7.0	3.3	-2.9
53	บังคับ	bang-kháp	0.50118	-0.24504	6.1	5.3	2.0	-4.2
54	ก้าวหน้า	kâonâ	0.58342	-0.30392	7.6	6.6	1.9	-4.3
55	สังเกต	săng-kèt	0.97218	-0.30759	7.7	6.7	3.2	-3.1
56	จัดตั้ง	chàttâng	0.94619	-0.28305	7.1	6.1	3.3	-2.9
57	มั่นคง	mân-khong	0.64677	-0.33994	8.5	7.4	1.9	-4.3
58	ปลอดภัย	plòtphai	-0.49770	-0.23084	5.8	5.0	-2.2	-8.4
59	แนะนำ	náe-nam	2.16052	-0.32299	8.1	7.0	6.7	0.4
60	ทั้งสอง	thángsŏng	1.40477	-0.24981	6.2	5.4	5.6	-0.6
61	ต้องการ	tôngkan	1.34072	-0.27320	6.8	5.9	4.9	-1.3
62	มะพร้าว	má-phráo	0.08521	-0.26989	6.7	5.8	0.3	-5.9
63	สนใจ	sŏn-chai	0.70784	-0.25700	6.4	5.6	2.8	-3.5
64	รายได้	raidâi	1.36297	-0.34601	8.7	7.5	3.9	-2.3
65	ทั้งหมด	thángmòt	0.77246	-0.25674	6.4	5.6	3.0	-3.2
66	อำนาจ	am-nât	2.23385	-0.26029	6.5	5.6	8.6	2.3
67	ราคา	ra-kha	0.49110	-0.27326	6.8	5.9	1.8	-4.5
68	ปกครอง	pòkkhrong	0.71522	-0.30952	7.7	6.7	2.3	-3.9
69	รักษา	rák-să	0.59636	-0.29572	7.4	6.4	2.0	-4.2
70	แก้ไข	kâekhăi	-0.09929	-0.29864	7.5	6.5	-0.3	-6.6
71	กระเป๋า	krà-păo	0.82113	-0.33007	8.3	7.1	2.5	-3.8
72	ภาษา	pha-să	0.98816	-0.23454	5.9	5.1	4.2	-2.0
73	อย่างไร	yàngrai	0.54496	-0.33296	8.3	7.2	1.6	-4.6
74	ขั้นตอน	khânton	1.44529	-0.35541	8.9	7.7	4.1	-2.2
75	สัญญา	săn-ya	1.36878	-0.27225	6.8	5.9	5.0	-1.2
76	ไม่ใช่	mâichâi	1.36297	-0.24790	6.2	5.4	5.5	-0.8
77	แน่นอน	nâe-non	1.23029	-0.31588	7.9	6.8	3.9	-2.4

#	Word	Romanization	a[a]	b[b]	Slope at 50% [c]	Slope 20-80%[d]	Threshold[e]	ΔdB[f]
78	ทดสอบ	thótsòp	0.86671	-0.32023	8.0	6.9	2.7	-3.5
79	ตลาด	tà-làt	0.59456	-0.27269	6.8	5.9	2.2	-4.1
80	ก่อสร้าง	kòsâng	0.30893	-0.17597	4.4	3.8	1.8	-4.5
81	หลังจาก	lăngchàk	1.22712	-0.33288	8.3	7.2	3.7	-2.6
82	เริ่มต้น	rôem-tôn	0.05770	-0.22751	5.7	4.9	0.3	-6.0
83	สุดท้าย	sùtthái	1.56567	-0.32333	8.1	7.0	4.8	-1.4
84	ทำให้	thamhâi	2.24850	-0.30386	7.6	6.6	7.4	1.1
85	สามารถ	să-mât	0.60762	-0.20209	5.1	4.4	3.0	-3.2
86	วางแผน	wang-phăen	0.29569	-0.28098	7.0	6.1	1.1	-5.2
87	พิเศษ	phí-sèt	1.88015	-0.35320	8.8	7.6	5.3	-0.9
88	บุคคล	bùk-khon	1.04751	-0.23437	5.9	5.1	4.5	-1.8
89	จมูก	chà-mùk	3.14774	-0.25858	6.5	5.6	12.2	5.9
90	โอกาส	o-kàt	0.93608	-0.30790	7.7	6.7	3.0	-3.2
	M		1.14107	-0.29012	7.3	6.3	3.8	-2.4
	Min		-0.49770	-0.44015	3.4	2.9	-2.2	-8.4
	Max		3.60078	-0.13558	11.0	9.5	12.3	6.1
	Range		4.09848	0.30457	7.6	6.6	14.5	14.5
	SD		0.84283	0.05221	1.3	1.1	2.8	2.8

[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 20-80%. [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 (6.25 dB HL)

bisyllabic words. In addition, based on the overall degree of digital intensity adjustment necessary to make the list of words homogeneous, eight more words were eliminated, resulting in a final list of 28 bisyllabic words. Table 4 (male talker) and Table 5 (female talker) present the threshold, the slope at 50%, and the slope from 20-80% for the 28 selected bisyllabic words. The psychometric function slopes for the 28 selected words shown in Figure 1 (C-D) demonstrate less variability than the slopes of all 90 words (A-B). Figure 2 (male talker) and Figure 3 (female talker) display the psychometric functions for each of the 28 words and the data points used to fit the data. The combined psychometric functions for the 28 selected words are shown in the middle panels (C-D) of Figure 1.

As presented in Tables 4 and 5, the thresholds for 50% intelligibility for the 28 selected words ranged from 3.8 dB HL to 8.9 dB HL (M = 6.5 dB HL) for the male talker and from 1.6 dB HL to 7.6 dB HL (M = 4.7 dB HL) for the female talker. The psychometric function slopes at 50% threshold, ranged from 7.8 %/dB to 11.6 %/dB (M = 9.0 %/dB) for the male talker and from 7.5 %/dB to 11.0 %/dB (M = 8.6 %/dB) for the female talker. In order to decrease the variability that still existed across the thresholds of the final 28 words, the intensity of each of these words was digitally adjusted so that the 50% threshold of each word was equal to the mean PTA of the subjects (6.25 dB HL). The necessary adjustments for each of the 28 selected words for the male and female talker recordings are also presented in Tables 4 and 5, respectively. The bottom panels of Figure 1 portray predicted psychometric functions for the 28 selected words following the intensity adjustment to equate 50% thresholds for the male (E) and female talker (F). The mean psychometric functions for the selected 28 words for both male and female talkers

Table 4

Mean Performance for28 Selected Thai Male Bisyllabic SRT words

#	Word	Romanization	a[a]	b[b]	Slope at 50% [c]	Slope 20-80%[d]	Threshold[e]	ΔdB[f]
1	แนะนำ	náe-nam	1.35712	-0.35462	8.9	7.7	3.8	-2.4
2	ขั้นตอน	khân ton	1.45483	-0.31918	8.0	6.9	4.6	-1.7
3	จังหวัด	chang-wàt	1.72419	-0.35437	8.9	7.7	4.9	-1.4
4	มากมาย	mâk mai	2.27898	-0.46593	11.6	10.1	4.9	-1.4
5	รายได้	rai dâi	1.56426	-0.31229	7.8	6.8	5.0	-1.2
6	โอกาส	o-kàt	1.56426	-0.31229	7.8	6.8	5.0	-1.2
7	กระเป๋า	krà-păo	1.81993	-0.35708	8.9	7.7	5.1	-1.2
8	แท้จริง	tháe ching	1.85648	-0.35643	8.9	7.7	5.2	-1.0
9	สุดท้าย	sùt thái	2.02775	-0.38624	9.7	8.4	5.2	-1.0
10	ทดสอบ	thót sòp	1.83379	-0.32667	8.2	7.1	5.6	-0.6
11	อย่างไร	yàng rai	2.04232	-0.34795	8.7	7.5	5.9	-0.4
12	กฎหมาย	kòd măi	2.42452	-0.40882	10.2	8.8	5.9	-0.3
13	เวลา	we-la	1.88315	-0.31701	7.9	6.9	5.9	-0.3
14	หลังจาก	lăng chàk	2.16761	-0.34350	8.6	7.4	6.3	0.1
15	เช่นกัน	chên kan	2.57593	-0.39852	10.0	8.6	6.5	0.2
16	แน่นอน	nâe-non	2.22538	-0.32998	8.2	7.1	6.7	0.5
17	จำเป็น	cham pen	2.36928	-0.35055	8.8	7.6	6.8	0.5
18	รู้จัก	rú chàk	2.56604	-0.37869	9.5	8.2	6.8	0.5
19	สังเกต	săng-kèt	2.58015	-0.36922	9.2	8.0	7.0	0.7
20	วิธี	wí-thi	2.77202	-0.37885	9.5	8.2	7.3	1.1
21	กำลัง	kam-lang	2.76088	-0.36665	9.2	7.9	7.5	1.3
22	ฤดู	rí-du	2.50099	-0.32290	8.1	7.0	7.7	1.5
23	บัญชี	ban-chi	3.59386	-0.43963	11.0	9.5	8.2	1.9
24	ประตู	prà-tu	2.76674	-0.33797	8.4	7.3	8.2	1.9
25	พิเศษ	phí-sèt	3.20647	-0.37239	9.3	8.1	8.6	2.4
26	ชีวิต	chi-wít	3.21483	-0.36866	9.2	8.0	8.7	2.5
27	หนังสือ	năng-sŭe	3.10336	-0.35109	8.8	7.6	8.8	2.6
28	คุณค่า	khun khâ	2.75600	-0.31052	7.8	6.7	8.9	2.6
		M	2.32111	-0.35850	9.0	7.8	6.5	0.2
		Min	1.35712	-0.46593	7.8	6.7	3.8	-2.4
		Max	3.59386	-0.31052	11.6	10.1	8.9	2.6
		Range	2.23674	0.15541	3.9	3.4	5.0	5.0
		SD	0.58095	0.03760	0.9	0.8	1.5	1.5

[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 20-80%. [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 (6.25 dB HL)

Table 5

Mean Performance for28 Selected Thai Female Bisyllabic SRT words

#	Word	Romanization	a[a]	b[b]	Slope at 50% [c]	Slope 20-80%[d]	Threshold[e]	ΔdB[f]
1	แนะนำ	náe-nam	2.16052	-0.32299	8.1	7.0	6.7	0.4
2	ขั้นตอน	khân ton	1.44529	-0.35541	8.9	7.7	4.1	-2.2
3	จังหวัด	chang-wàt	1.79033	-0.35142	8.8	7.6	5.1	-1.2
4	มากมาย	mâk mai	1.92331	-0.32688	8.2	7.1	5.9	-0.4
5	รายได้	rai dâi	1.36297	-0.34601	8.7	7.5	3.9	-2.3
6	โอกาส	o-kàt	0.93608	-0.30790	7.7	6.7	3.0	-3.2
7	กระเป๋า	krà-pǎo	0.82113	-0.33007	8.3	7.1	2.5	-3.8
8	แท้จริง	tháe ching	1.82036	-0.37288	9.3	8.1	4.9	-1.4
9	สุดท้าย	sùt thái	1.56567	-0.32333	8.1	7.0	4.8	-1.4
10	ทดสอบ	thót sòp	0.86671	-0.32023	8.0	6.9	2.7	-3.5
11	อย่างไร	yàng rai	0.54496	-0.33296	8.3	7.2	1.6	-4.6
12	กฎหมาย	kòd mǎi	0.99957	-0.34672	8.7	7.5	2.9	-3.4
13	เวลา	we-la	1.07790	-0.32493	8.1	7.0	3.3	-2.9
14	หลังจาก	lǎng chàk	1.22712	-0.33288	8.3	7.2	3.7	-2.6
15	เช่นกัน	chên kan	2.18732	-0.35115	8.8	7.6	6.2	0.0
16	แน่นอน	nâe-non	1.23029	-0.31588	7.9	6.8	3.9	-2.4
17	จำเป็น	cham pen	2.05242	-0.36936	9.2	8.0	5.6	-0.7
18	รู้จัก	rú chàk	1.89226	-0.30955	7.7	6.7	6.1	-0.1
19	สังเกต	sǎng-kèt	0.97218	-0.30759	7.7	6.7	3.2	-3.1
20	วิธี	wí-thi	3.04701	-0.42847	10.7	9.3	7.1	0.9
21	กำลัง	kam-lang	2.31462	-0.37825	9.5	8.2	6.1	-0.1
22	ฤดู	rí-du	1.51592	-0.33631	8.4	7.3	4.5	-1.7
23	บัญชี	ban-chi	2.35982	-0.44015	11.0	9.5	5.4	-0.9
24	ประตู	prà-tu	2.82630	-0.37322	9.3	8.1	7.6	1.3
25	พิเศษ	phí-sèt	1.88015	-0.35320	8.8	7.6	5.3	-0.9
26	ชีวิต	chi-wít	1.46051	-0.34114	8.5	7.4	4.3	-2.0
27	หนังสือ	nǎng-sǔe	1.15775	-0.29949	7.5	6.5	3.9	-2.4
28	คุณค่า	khun khâ	2.05392	-0.34225	8.6	7.4	6.0	-0.2
		M	1.62473	-0.34431	8.6	7.5	4.7	-1.6
		Min	0.54496	-0.44015	7.5	6.5	1.6	-4.6
		Max	3.04701	-0.29949	11.0	9.5	7.6	1.3
		Range	2.50205	0.14066	3.5	3.0	5.9	5.9
		SD	0.62052	0.03300	0.8	0.7	1.5	1.5

[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 20-80%. [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 (6.25 dB HL)

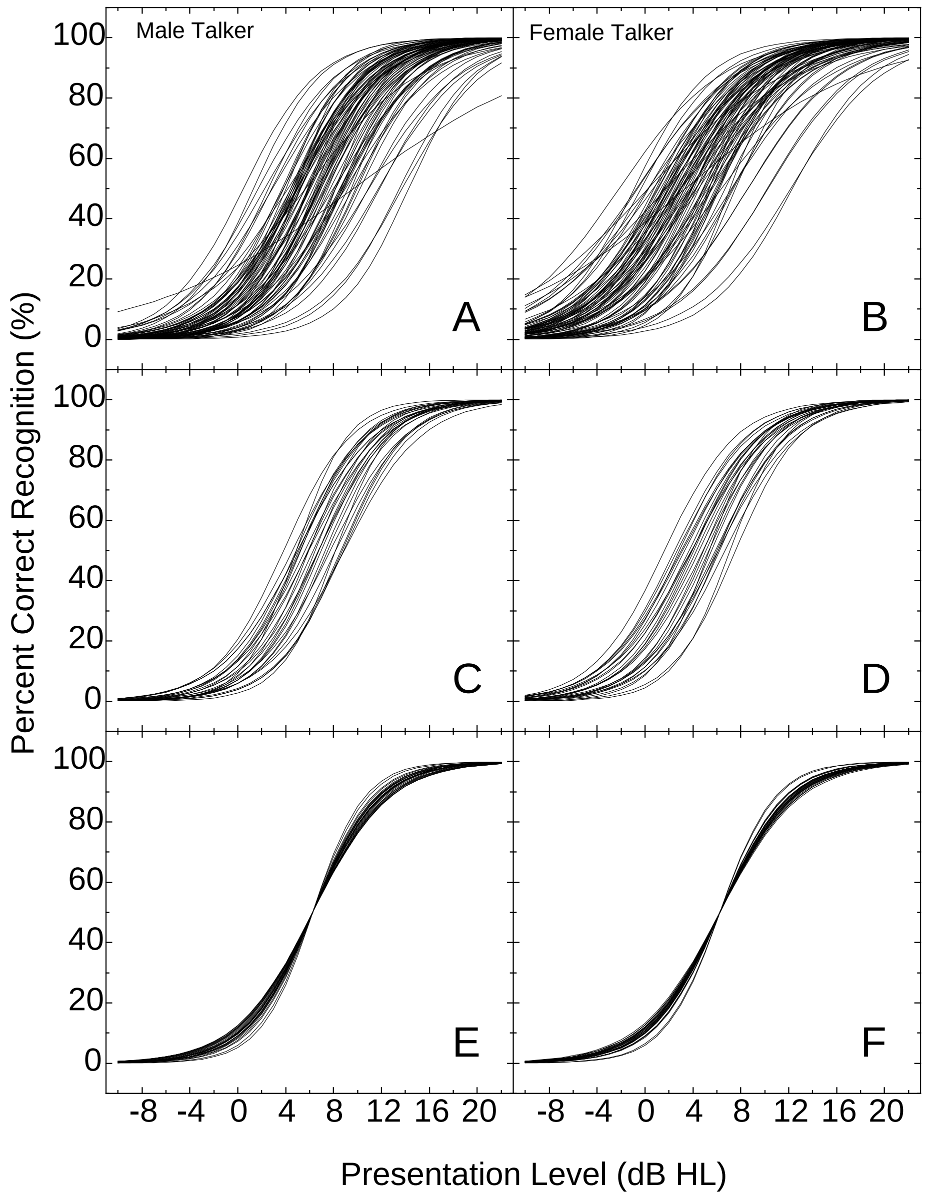

Figure 1. Psychometric functions for Thai bisyllabic words for male talker (left panels) and female talker (right panels) recordings. All 90 unadjusted words (top panels A-B), 28 selected unadjusted words (middle panels C-D), and 28 selected adjusted words (bottom panels E-F). The 28 selected adjusted words were digitally adjusted to have 50% thresholds equal to the mean PTA (6.25 dB HL) for the 20 normally hearing subjects.

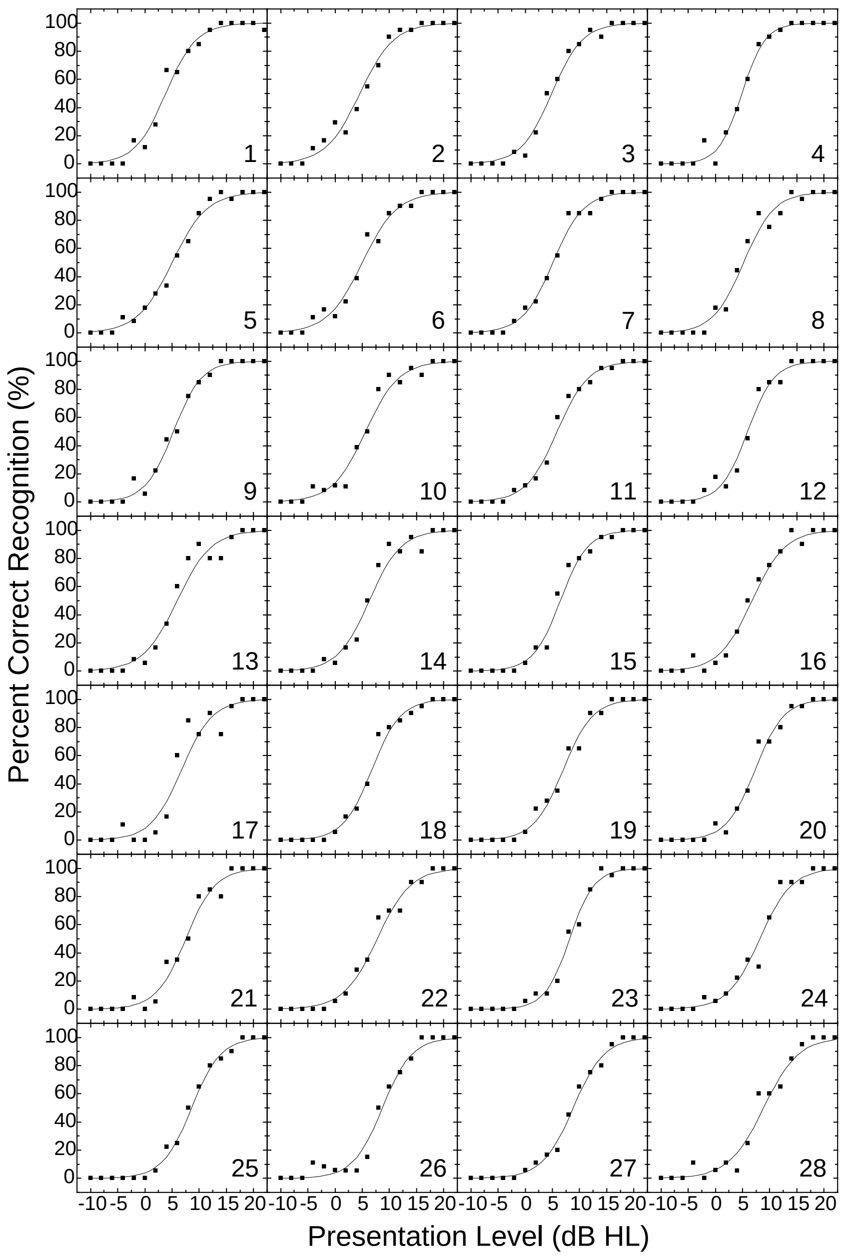

Figure 2. Psychometric functions for the 28 selected unadjusted Thai bisyllabic words spoken by a male talker. The functions were calculated using logistic regression; the symbols represent mean percentage of correct recognition calculated from the raw data for 20 normally hearing subjects.

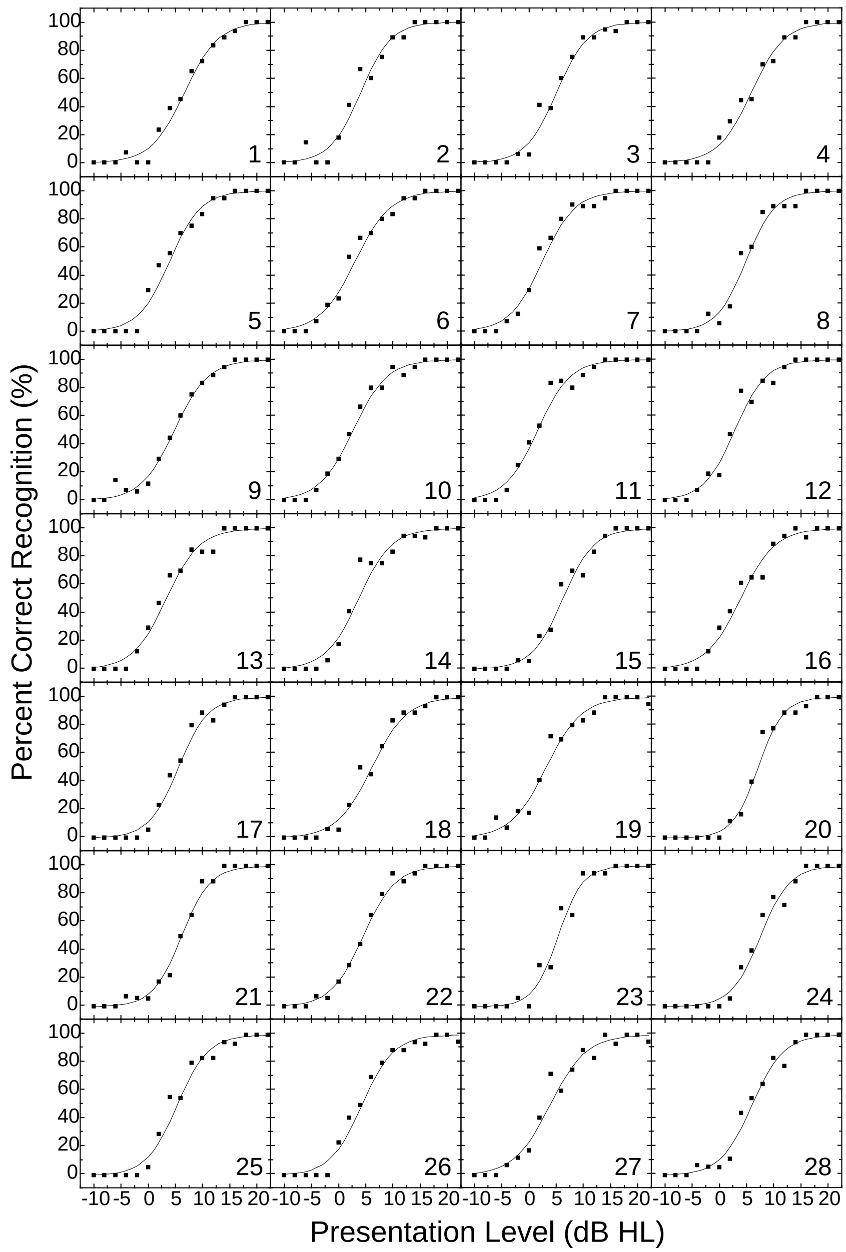

Figure 3. Psychometric functions for the 28 selected unadjusted Thai bisyllabic words spoken by a female talker. The functions were calculated using logistic regression; the symbols represent mean percentage of correct recognition calculated from the raw data for 20 normally hearing subjects.

are shown in Figure 4. This figure illustrates the slightly steeper mean slopes for the male talker recordings (9.0 %/dB) compared to the female talker recordings (8.6 %/dB).

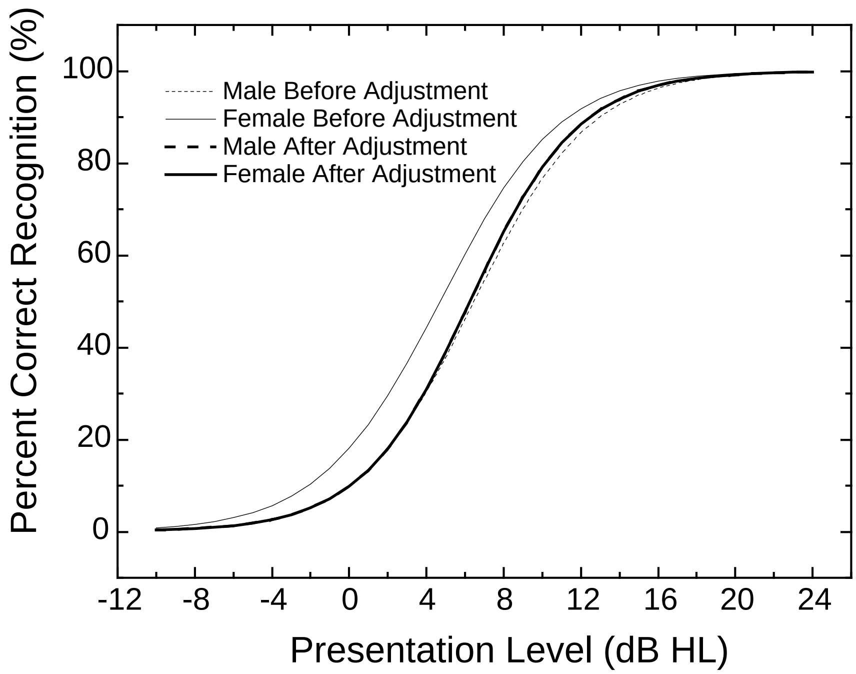

Figure 4. Mean psychometric functions for 28 selected Thai male and female talker bisyllabic words after intensity adjustment to equate 50% threshold performance to the mean PTA (6.25 dB HL) for the 20 normally hearing subjects.

Discussion

The aim of the present study was to create and digitally record a list of psychometrically equivalent bisyllabic Thai words to be used for SRT testing of native Thai speakers. Originally, 90 commonly used bisyllabic Thai words were digitally recorded by a male and female talker. After the words were evaluated by 20 native Thai listeners, 28 of the words were selected to be included in a final SRT list based on their relatively steep and homogeneous psychometric function slopes. Finally, the 28 words were digitally adjusted to reduce intensity threshold variability.

For the Thai SRT materials developed in this study, the psychometric function slopes at 50% threshold were found to have a mean of 9.0 %/dB for the male talker and a mean of 8.6 %/dB for the female talker. SRT materials for English have been reported to have mean slopes between 7.2 %/dB and 10 %/dB (Hirsh et al., 1952; Hudgins et al., 1947), and sometimes as high as 12 %/dB (Beattie, Svihovec, & Edgerton, 1975; Ramkissoon, 2001). Thus the mean slopes at 50% threshold of the 28 selected Thai words in this study were found to be within these ranges for both talker genders.

When comparing these Thai SRT materials to materials developed in other Asian languages, such as Japanese, Korean, and Mandarin, similarities were also found in the mean psychometric slope values at 50% intelligibility. Japanese SRT materials (Mangum, 2005) have been reported to have slope values of 10.3 %/dB for a male talker and 8.7 %/dB for a female talker. Korean male and female talker words were shown to have slightly higher slope values of 11.9 %/dB and 10.4 %/dB, respectively (Harris et al., 2003a). For Mandarin Chinese, the mean slopes were even higher at 11.3 %/dB for the male talker and 12.1 %/dB for the female talker (Nissen et al., 2005b). The Mandarin

Chinese and Thai were similar in that both languages use suprasegmental tone to mark a lexical contrast. However, it is important to note that the Mandarin Chinese materials described in Nissen et al. (2005b) were trisyllabic words, whereas the Thai words developed in this study were bisyllabic. This difference in word syllabic structure may explain the slightly higher values obtained for the Mandarin materials.

As previously discussed there were slight differences in slope values between the male and female recordings. There were also differences in the mean threshold required for 50% intelligibility. The mean thresholds for the male and female recordings were 6.5 dB HL and 4.7 dB HL, respectively. These values correspond to anecdotal reports from several of the listeners who reported that they could understand the female talker somewhat better than the male talker, and that the male talker's rate of speech was faster than that of the female talker. Although this study did not control for speech rate, this may be an important factor to control for in the development of future materials.

Both talkers were natives of Bangkok, however the individual manner or style of their speech could have influenced listeners' perception of the words. As previously discussed, research with native Spanish-speakers has demonstrated that listeners from a similar region as the talker scored better on SRT measures at lower intensities than those who came from other regions (Weisleder & Hodgson, 1989). On the other hand, the results from SRT research with native Mandarin-speakers from Taiwan and mainland China has shown that listeners from both regions scored better at lower intensities when listening to a speaker from mainland China than a speaker from Taiwan (Richardson, 2008). Although the results of both of these studies could be attributed to similarities or differences in regional dialect, they could also have been influenced by the talkers' individual accents or styles of speech. Thai is another such language with various dialects, accents, and styles of speech. Even though the more rural areas of Thailand are distinguished by the country's different dialects, the metropolis of Bangkok has a variety of cultural and linguistic influences. Although both talkers used in the present study were natives of Bangkok, they may have demonstrated some regional or individual speech differences that could have had a slight influence on the perception of the listeners.

Bilingualism may also have been a factor in the results of this study. Many of the listeners who participated in this study came to the United States to study at an English-speaking university or language program, thus the majority of subjects likely had a relatively high degree of English proficiency. This level of Thai-English bilingualism could have affected the perception of materials in their native language. In a recent study, Weiss and Dempsey (2008) administered both the English and Spanish versions of the Hearing in Noise Test (HINT) to bilingual Spanish-English speakers. They found that although all participants showed lower thresholds with the Spanish version, those who learned English after early childhood showed lower thresholds for both languages than those who learned English during early childhood. Weiss and Dempsey also suggested that the longer a person has been exposed to a second language, the more difficulty he or she will have in processing his or her first language. In the current study the listeners' ability to perceive words in their native language of Thai may have been negatively affected by their bilingual experience with English.

Another factor that may have influenced the development of these materials was the age of the participants. Due to the limited Thai population available for this study, the age range of the participants was somewhat limited, with listeners being 19 to 33 years of age (M = 24.2). Because the elderly tend to have a greater incidence of hearing impairment than younger individuals (Committee on Hearing, Bioacoustics, and Biomechanics [CHABA], 1988), it is likely that these materials will be used more commonly to assess the hearing acuity of elderly Thai individuals. By developing these materials with much younger listeners, factors relative to older individuals may not have been assessed. In addition, these materials have been evaluated by listeners with normal hearing, thus the performance described in this study may change when presented to listeners with hearing impairment. Because Thai is a tonal language (the suprasegmental tone is primarily carried by the fundamental frequency of the vowel) with a vast array of vowel combinations, the acoustic cues vital to word identification are likely contain relatively lower frequency spectral energy. Considering the linguistic characteristics of Thai, it is unknown how the SRT words evaluated in this study will perform when used with individuals with high-frequency hearing impairment. Further research using these materials to assess Thai speakers with different types of hearing impairment would shed more light on these speculations.

Another extension of this study may be an evaluation of the reliability of these materials under different test conditions. It is unclear if the performance of these materials will be similar across administrators with different levels of proficiency in the Thai language. The judge employed in this study was a native Thai speaker from Bangkok. However, if these SRT materials were to be used in countries other than Thailand, would non-Thai speaking audiologists be able to accurately administer and score the results? It may be the case that an audiologist would need to at least be familiar with the Thai language and the pronunciations of Romanized Thai, or be assisted by a Thai-speaking translator in order for the results to be reliable and valid.

An additional aspect of reliability to consider with these materials is test-retest reliability. Are these materials reliable across multiple test sessions and locations? Although familiarization is an essential part of an SRT assessment (ASHA, 1988), could there be a test practice-effect because the listener would be even more familiar with the test stimuli when being retested a second time? Perhaps the participants would feel more comfortable and confident in a retest situation because they would know what to expect.

To simulate more natural listening situations, it would also be valuable to evaluate these materials in the presence of background noise. Elderly listeners have been found to have relatively more difficulty understanding speech accompanied by background noise (CHABA, 1988). Wilson and MacArdle (2005) suggested that audiological evaluations should include a speech-in-noise task. They claimed that the results of such a task would be beneficial because most patients' primary complaint is that they have difficulty hearing speech in listening situations where background noise is present. Although evaluating test stimuli in the presence of background noise may compromise the development of equivalent materials (Stockley & Green, 2000), using test stimuli to evaluate each patient's ability to hear speech with background noise may better address their hearing needs and complaints.

It is also unclear if these materials are appropriate to assess the SRT of children who speak Thai. The test stimuli developed in the present study were evaluated using only adult Thai speakers. It may not be appropriate to compare a Thai child's performance to the performance of the 20 adult subjects used in this study. Children could differ from adults in their extent of language exposure and vocabulary. Also, using children's voices to record SRT materials may be more appropriate for children listeners than adults' voices. As there are no known published SRT materials for testing Thai children, this should be a consideration for future development. However, the materials developed in this study may be used to obtain normative SRT data for Thai children until child-specific stimuli are developed (Palva & Jokinen, 1975).

Despite the need for additional research in the area of Thai speech audiometry, it is hoped that this study will serve as an important first step in creating speech audiometry materials to evaluate Thai speakers. Many people in Thailand are disadvantaged in education and work opportunities due to the burden of treatable hearing impairment. Their overall quality of life is affected when they have difficulty communicating with others. The aim of this study was to develop SRT materials in the Thai language that will aid in alleviating the burden of disability caused by treatable hearing impairment by providing a way to more fully and accurately assess individuals' hearing acuity and communication abilities.

As a result of this study, psychometrically equivalent SRT materials for the Thai language were developed. A list of relatively familiar 90 bisyllabic Thai words was digitally recorded by a male and a female talker. After these words were evaluated by 20 Thai listeners with normal hearing in a quiet listening environment, 28 words with relatively steep and homogeneous psychometric function slopes were selected to be included in a final SRT word list. The words in this list were then digitally adjusted with regard to intensity to reduce threshold variability between words. These 28 selected words were then digitally recorded onto compact disc to facilitate SRT testing for native

Thai speakers. A description of the materials contained on the CD can be found in Appendix C.

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Appendix A

Informed Consent

RESEARCH PARTICIPATION FORM

Participant:_________________________________Age:_________

You are asked to participate in a research study sponsored by the Department of Audiology and Speech Language Pathology at Brigham Young University, Provo, Utah. The faculty director of this research is Richard W. Harris, Ph.D. Students in the Audiology and Speech-Language Pathology program may assist in data collection.

This research project is designed to evaluate a word list recorded using improved digital techniques. You will be presented with this list of words at varying levels of intensity. Many will be very soft, but none will be uncomfortably loud to you. You may also be presented with this list of words in the presence of a background noise. The level of this noise will be audible but never uncomfortably loud to you. This testing will require you to listen carefully and repeat what is heard through earphones or loudspeakers. Before listening to the word lists, you will be administered a routine hearing test to determine that your hearing is normal and that you are qualified for this study.

It will take approximately two hours to complete the test. Testing will be broken up into 2 or 3 one hour blocks. Each subject will be required to be present for the entire time, unless prior arrangements are made with the tester. You are free to make inquiries at any time during testing and expect those inquiries to be answered.

As the testing will be carried out in standard clinical conditions, there are no known risks involved. Standard clinical test protocol will be followed to ensure that you will not be exposed to any unduly loud signals.

Names of all subjects will be kept confidential to the investigators involved in the study. Participation in the study is a voluntary service and no payment of monetary reward of any kind is possible or implied.

You are free to withdraw from the study at any time without any penalty, including penalty to future care you may desire to receive from this clinic.

If you complete your participation in this research project you will be paid the amount of $_________ for your participation.

If you have any questions regarding this research project you may contact Dr. Richard W. Harris, 131 TLRB, Brigham Young University, Provo, UT 84602; phone (801) 422-6460 or Dr. Shawn L. Nissen, 138 TLRB, Brigham Young University, Provo, UT 84602, phone (801) 422-5056. If you have any questions regarding your rights as a participant in a research project you may contact Dr. Renea Beckstrand, Chair of the Institutional Review Board, 422 SWKT, Brigham Young University, Provo, UT 84602; phone (801) 422-3873, email: renea_beckstrand@byu.edu.

YES: I agree to participate in the Brigham Young University research study mentioned above. I confirm that I have read the preceding information and disclosure. I hereby give my informed consent for participation as described.

_________________________________ _______________
Signature of Participant Date

_________________________________ _______________
Signature of Witness Date

APPROVED EXPIRES
SEP 2 1 2007 - SEP 2 0 2008

Appendix B

Selected Bisyllabic Word Definitions

	Thai word	Romanization	Part of speech	Definition
1	แนะนำ	náe-nam	verb	to advise; to introduce
2	ขั้นตอน	khân ton	noun	procedure; method
3	จังหวัด	chang-wàt	noun	province; township
4	มากมาย	mâk mai	adjective	very much; many; several
5	รายได้	rai dâi	noun	income; earnings
6	โอกาส	o-kàt	noun	opportunity; chance
7	กระเป๋า	krà-pǎo	noun	bag; pocket
8	แท้จริง	tháe ching	adjective	inherent; real; genuine
9	สุดท้าย	sùt thái	adjective	final; last; ultimate
10	ทดสอบ	thót sòp	verb	to test; to examine; to quiz
11	อย่างไร	yàng rai	adverb	how; in what way; anyhow
12	กฎหมาย	kòd mǎi	noun	law; statute; rule
13	เวลา	we-la	noun	time
14	หลังจาก	lǎng chàk	adverb	after
15	เช่นกัน	chên kan	adverb	also; as well; likewise
16	แน่นอน	nâe-non	adverb	certainly; surely; of course
17	จำเป็น	cham pen	adjective	necessary; essential
18	รู้จัก	rú chàk	verb	to know; to be acquainted with
19	สังเกต	sǎng-kèt	verb	to observe; to notice
20	วิธี	wí-thi	noun	method; way; means
21	กำลัง	kam-lang	noun	energy; strength
22	ฤดู	rí-du	noun	season
23	บัญชี	ban-chi	noun	accounting
24	ประตู	prà-tu	noun	door; gate
25	พิเศษ	phí-sèt	adjective	special; extraordinary
26	ชีวิต	chi-wít	noun	life
27	หนังสือ	nǎng-sǔe	noun	book
28	คุณค่า	khun khâ	noun	value; worth

Appendix C

BYU Thai CD Contents

Track 1 1 kHz calibration tone.
Track 2 Bisyllabic words for use in measuring the SRT in alphabetical order for familiarization purposes.
Track 3 Bisyllabic words for use in measuring the SRT in random order, repeated in blocks.
Track 4 Word recognition List 1– 50 monosyllabic words in ranked order (difficult to easy).
Track 5 Word recognition List 2– 50 monosyllabic words in ranked order (difficult to easy).
Track 6 Word recognition List 3– 50 monosyllabic words in ranked order (difficult to easy).
Track 7 Word recognition List 4– 50 monosyllabic words in ranked order (difficult to easy).
Track 8 Word recognition List 1– 50 monosyllabic words in random order.
Track 9 Word recognition List 2– 50 monosyllabic words in random order.
Track 10 Word recognition List 3– 50 monosyllabic words in random order.
Track 11 Word recognition List 4– 50 monosyllabic words in random order.
Track 12 Word recognition List 1A– 25 monosyllabic words in ranked order (difficult to easy).
Track 13 Word recognition List 1B– 25 monosyllabic words in ranked order (difficult to easy).
Track 14 Word recognition List 2A– 25 monosyllabic words in ranked order (difficult to easy).
Track 15 Word recognition List 2B– 25 monosyllabic words in ranked order (difficult to easy).
Track 16 Word recognition List 3A– 25 monosyllabic words in ranked order (difficult to easy).
Track 17 Word recognition List 3B– 25 monosyllabic words in ranked order (difficult to easy).
Track 18 Word recognition List 4A– 25 monosyllabic words in ranked order (difficult to easy).
Track 19 Word recognition List 4B– 25 monosyllabic words in ranked order (difficult to easy).
Track 20 Word recognition List 1A– 25 monosyllabic words in random order.
Track 21 Word recognition List 1B– 25 monosyllabic words in random order.
Track 22 Word recognition List 2A– 25 monosyllabic words in random order.
Track 23 Word recognition List 2B– 25 monosyllabic words in random order.
Track 24 Word recognition List 3A– 25 monosyllabic words in random order.
Track 25 Word recognition List 3B– 25 monosyllabic words in random order.
Track 26 Word recognition List 4A– 25 monosyllabic words in random order.
Track 27 Word recognition List 4B– 25 monosyllabic words in random order.

Track 28 คุณกำลังจะได้ยินกลุ่มคำที่มีระดับความดังของเสียงต่างกัน ทันทีที่คุณได้ยินเสียงคำพูด กรุณาพูดตามคำนั้น ถ้าคุณไม่แน่ใจคำนั้น คุณสามารถคาดเดาได้
Instructions for speech recognition threshold-verbal response: “You are going to hear a series of words that may vary in volume. Please repeat each word as soon as you hear it. If you are not sure of the word that you heard, you may guess.”

Track 29 จุดประสงค์ของการทดสอบส่วนนี้ จะช่วยในการตัดสินว่าคุณมีความเข้าใจมากแค่ไหน ในคำพูดที่มีระดับความดังของเสียงเท่าเทียมกัน ทันทีที่คุณได้ยินเสียงคำพูด กรุณาพูดซ้ำคำนั้น ถ้าคุณไม่แน่ใจคำนั้น คุณสามารถคาดเดาได้ แต่ถ้าคุณไม่สามารถที่จะคาดเดาได้ กรุณาปล่อยไว้ แล้วรอคำต่อไป
Instructions for word recognition-verbal response: “The purpose of this test is to determine how well you can understand words when they are presented at a constant listening level. Each time you hear a word, just repeat it. If you are unsure of what

the word was you may have to guess. If you did not understand the word, and you are not able to guess, please remain silent and wait for the next word."

Track 30 ในการทดสอบส่วนนี้ คุณจะได้ยินเสียงรบกวนในหูข้างหนึ่ง
ส่วนหูอีกข้างหนึ่งคุณจะได้ยินคำพูด ทันทีที่คุณได้ยินเสียงคำพูด
กรุณาพูดตามคำนั้น และพยายามอย่าใส่ใจกับเสียงรบกวน
Instructions for speech audiometry-masking in nontest ear-verbal response: "During this part of the test you will hear a noise in one ear and words in the other. Ignore the noise and repeat each word when you hear it."

Track 31 คุณกำลังจะได้ยินกลุ่มคำที่มีระดับความดังของเสียงเท่าเทียมกัน
ทันทีที่คุณได้ยินเสียงคำพูด กรุณาเขียนคำนั้น ถ้าคุณไม่แน่ใจคำนั้น
คุณสามารถคาดเดาได้
Instructions for speech audiometry-written response: "You are going to hear a series of words that will be given at a constant volume. Please write each word as soon as you hear it. If you are not sure of the word you heard, you may guess."

Track 32 ในการทดสอบส่วนนี้ คุณจะได้ยินเสียงรบกวนในหูข้างหนึ่ง
ส่วนหูอีกข้างหนึ่งคุณจะได้ยินคำพูด ทันทีที่คุณได้ยินเสียงคำพูด
กรุณาเขียนคำนั้น และพยายามอย่าใส่ใจกับเสียงรบกวน
Instructions for speech audiometry-masking in nontest ear-written response: "During this part of the test you will hear noise in one ear and words in the other. Ignore the noise and write each word when you hear it."

Track 33 คุณกำลังจะได้ยินกลุ่มเสียงที่มีระดับเสียงสูงต่ำแตกต่างกัน
ทันทีที่คุณได้ยินเสียง กรุณายกมือขึ้น
ถึงแม้ว่าคุณจะไม่แน่ใจว่าคุณได้ยินเสียงนั้นก็ตาม เมื่อเสียงนั้นดับลง
กรุณาวางมือลง
Instructions for pure-tone audiometry-hand raising: "You are going to hear a series of sounds which will vary in pitch. When you hear the tone, immediately raise your hand. Put your hand down as soon as the sound goes off. Raise your hand if you think you hear the tone, even if you are not sure."

Track 34 ในการทดสอบส่วนนี้ คุณจะได้ยินเสียงรบกวนในหูข้างหนึ่ง
ส่วนหูอีกข้างหนึ่งคุณจะได้ยินเสียงปกติ ทันทีที่คุณได้ยินเสียง กรุณายกมือขึ้น
และพยายามอย่าใส่ใจกับเสียงรบกวน
Instructions for pure-tone audiometry-masking in nontest ear-hand raising: "During this part of the test you will hear noise in one ear and tones in the other. Ignore the noise and raise your hand when you hear the tone."

Track 35 คุณกำลังจะได้ยินกลุ่มเสียงที่มีระดับเสียงสูงต่ำแตกต่างกัน
ทันทีที่คุณได้ยินเสียง กรุณากดปุ่ม
ถึงแม้ว่าคุณจะไม่แน่ใจว่าคุณได้ยินเสียงนั้นก็ตาม เมื่อเสียงนั้นดับลง
กรุณายกนิ้วออกจากปุ่ม
Instructions for pure-tone audiometry-button pressing: "You are going to hear a series of tones which will vary in pitch. When you hear a sound, immediately press the button. Stop pushing the button when the tone goes off. Push the button if you think you hear the sound, even if you are not sure."

Track 36 ในการทดสอบส่วนนี้ คุณจะได้ยินเสียงรบกวนในหูข้างหนึ่ง ส่วนหูอีกข้างหนึ่งคุณจะได้ยินเสียงปกติ ทันทีที่คุณได้ยินเสียง กรุณากดปุ่ม และพยายามอย่าใส่ใจกับเสียงรบกวน

Instructions for pure-tone audiometry-masking in nontest ear-button pressing: "During this part of the test you will hear noise in one ear and tones in the other. Ignore the noise and press the button when you hear a tone."

Track 37 ในการทดสอบส่วนนี้ คุณจะได้ยินเสียงรบกวนในหูข้างหนึ่ง ส่วนหูอีกข้างหนึ่งคุณจะได้ยินเสียงคำพูด ทันทีที่คุณได้ยินเสียงคำพูด กรุณาพูดซ้ำคำนั้น พยายามอย่าใส่ใจกับเสียงรบกวน ถ้าคุณไม่แน่ใจคำนั้น คุณสามารถคาดเดาได้ แต่ถ้าคุณไม่สามารถที่จะคาดเดาได้ กรุณาปล่อยไว้ แล้วรอคำต่อไป

Instructions for speech audiometry-masking in nontest ear-verbal response: "During this part of the test you will hear a noise in one ear and words in the other. Do your best to ignore the noise and listen only to the words. Each time you hear a word, please repeat it. If you are unsure of what the word was you may have to guess. If you did not understand the word, and you are not able to guess, please remain silent and wait for the next word."

Track 38 จุดประสงค์ของการทดสอบส่วนนี้ จะช่วยในการตัดสินว่าคุณมีความเข้าใจมากแค่ไหน ในคำพูดที่มีระดับความดังของเสียงเท่าเทียมกัน ทันทีที่คุณได้ยินเสียงคำพูด กรุณาเขียนคำนั้นลงบนกระดาษที่ถูกเตรียมไว้ ถ้าคุณไม่แน่ใจคำนั้น คุณสามารถคาดเดาได้ แต่ถ้าคุณไม่สามารถที่จะคาดเดาได้ กรุณาขีดเส้นในช่องที่เตรียมไว้และรอคำต่อไป

Instructions for word recognition-written response: "The purpose of this test is to determine how well you can understand words when they are presented at a constant listening level. Each time you hear a word, please write it down on the paper provided. If you are unsure of what the word was you may have to guess. If you did not understand the word, and you are not able to guess, please draw a line in the space provided and wait for the next word."