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Development of Psychometrically Equivalent Speech Recognition Threshold Materials for Native Speakers of Samoan

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ABSTRACT

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The speech recognition threshold (SRT) is an important measure, as it validates the pure-tone average (PTA), assists in the diagnosis and prognosis of hearing impairments, and aids in the identification of non-organic hearing impairments. Research has shown that in order for SRT testing to yield valid and reliable measures, testing needs to be performed in the patient's native language. There are currently no published materials for SRT testing in the Samoan language. As a result, audiologists are testing patients with English materials or other materials not of the patient's native language. Results produced from this manner of testing are confounded by the patient's vocabulary knowledge and may reflect a language deficit rather than a hearing loss. The present study is aimed at developing SRT materials for native speakers of Samoan to enable valid and reliable measures of SRT for the Samoan speaking population. This study selected 28 trisyllabic Samoan words that were found to be relatively homogeneous in regard to audibility and psychometric function slope. Data were gathered on 20 normal hearing native speakers of Samoan and the intensity of each selected word was adjusted to make the 50% performance threshold of each word equal to the mean PTA of the 20 research participants (5.33 dB HL). The final edited words were digitally recorded onto compact disc to allow for distribution and use for SRT testing in Samoan.

Keywords: speech audiometry, speech recognition threshold, SRT, homogeneity, psychometric performance-intensity function, word lists, materials, Samoan, languages

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Introduction

Speech is the primary mode of communication for the general population and allows ideas and concepts to be transferred from one individual to another. When a hearing impairment exists, it affects the individual's ability to perceive speech and therefore interact in society. Hearing impairments are often first noticed by an individual's difficulty in being able to hear conversational partners (Hagerman, 1993). A hearing evaluation performed by an audiologist is needed to determine the individual's hearing ability. A pure-tone audiogram is obtained which documents the threshold of hearing. The audiogram provides information regarding the hearing mechanism and the patient's sensitivity to calibrated pure tones. The pure-tone examination, however, does not reflect the individual's ability to understand speech (Egan, 1979). Therefore, in order to determine the individual's ability to hear and understand speech, hearing tests need to involve speech stimuli (Brandy, 2002; Gelfand, 2001). Speech audiometry is a more appropriate method to identify an individual's ability to comprehend speech and to interact within a family, community, and society (ASHA, 1977).

Speech audiometry provides an estimate of how well an individual is able to hear speech in their daily activities. In clinical practice, speech audiometry consists of a battery of test procedures and protocols which allow for quantitative measures of hearing impairment for speech. Research has demonstrated that speech audiometry adds validity to pure-tone audiometric data and also provides diagnostic and prognostic information in regards to hearing impairments (Hirsh et al., 1952). It has been found that test results from speech audiometry are influential in diagnosing peripheral and central auditory disorders. Speech audiometry can also assist in determining an individual's candidacy for hearing aids, selecting the appropriate hearing aids, and determining the benefits of hearing aid use in improving communication abilities (Hagerman, 1984; Harris & Reitz, 1985).

Historically, speech tests were spoken or whispered messages from a talker to a listener at a designated distance, allowing for a gross estimate of the person's ability to hear and understand speech. In order to quantify and standardize these measures, recordings of spoken digits developed by Western Electric 4-C were used (ASHA, 1988). Later, lists of English words were developed which are used today to establish speech thresholds. Over time, English speech materials became more reliable, valid, and standardized. Unfortunately, these English materials do not adequately or reliably test speech thresholds for non-native English speakers, the majority of the world's population. Although English materials yield reliable and valid measures for native English speakers, they do not allow for reliable results for non-native English speakers. Consequently, there is a great need to create valid speech audiometry materials in other languages (Padilla, 2003; Ramkissoon, 2001).

Within the last ten to twenty years, speech audiometry materials have been developed in many other languages, but they still fail to serve a majority of the languages spoken throughout the world, and even in the United States (Ramkissoon, 2001). Due to the limited numbers of published materials in languages other than English, audiologists often have to test with English materials and are forced to interpret compromised test results. Increasing ethnic diversity in the United States has raised awareness of the necessity to develop speech audiometry materials that appropriately evaluate non-native English speakers. Although various methods have been suggested for testing non-native English speakers, testing in the speaker's native language is the preferred and suggested method to provide accurate and relevant results (McCullough, Wilson, Birck, & Anderson, 1994).

Although speech audiometry materials have been developed in some languages, there are currently not materials available in the Samoan language that would enable testing of hearing acuity in the Samoan language. Thus, the purpose of this study was to develop materials in Samoan that can be used to measure the SRT in individuals whose native language is Samoan. To accomplish this goal, this study (a) created a list of familiar trisyllabic Samoan words, (b) through a judging process, selected a male and female native speaker of Samoan to record the materials to be evaluated, (c) digitally recorded the list of words, (d) collected normative data from 20 participates identified with normal hearing to evaluate the psychometric function of each word, (e) used logistic regression to create a list of familiar and psychometrically equivalent words, (f) adjusted the intensity of 28 words to equate the 50% threshold performance for each with the mean PTA for the 20 participants, and (g) and developed a compact disc of the SRT materials that will be widely available for audiologists to use in testing native speakers of Samoan.

Review of Literature

Speech Audiometry

Traditionally, pure-tone testing has been used to evaluate hearing acuity because it yields reliable data and is easy to administer. However, the data derived from pure-tone testing does not provide diagnostically valuable information regarding an individual's ability to understand speech in everyday situations or noisy environments (Wilson & McArdle, 2005). Pure-tone thresholds do not provide a measurement of communication deficits. Speech audiometry, on the other hand, provides a measure for how well an individual is able to hear speech in their daily activities. Researchers learned the importance of using speech stimuli in testing to more accurately depict natural life experiences. Materials created for speech audiometry involve test stimuli that more closely resemble everyday listening tasks. In clinical practice, the tests allow for quantitative measures of hearing impairment for speech and discrimination loss. Speech audiometry adds validity to pure-tone thresholds and also provides diagnostic and prognostic information of an individual's ability to perceive speech (Hirsh et al., 1952). An individual's ability to hear and understand speech has become an integral part of a hearing test battery, and it is accomplished through speech audiometry measures.

Early in the 20th century, researchers understood the importance of speech audiometry and began to develop numerous materials. In 1929, the Western Electric 4A, consisting of spoken digits, was the first commonly used clinical measure (ASHA, 1988). It was later revised and became the Western Electric 4C test. Then, in 1947, Researchers at Harvard's Psycho-Acoustic Laboratory (PAL) developed a set of 42 spondaic words test that serves as today's clinical model for determining the speech thresholds. The words that were chosen were determined to be familiar spondees that were phonetically dissimilar, which reasonably represented the sounds of the English language, and were homogenous in regard to level of audibility (ASHA, 1988; Hudgins, Hawkins, Karlin, & Stevens, 1947). The PAL lists were recorded in two different formats; all the words were recorded at the same intensity in PAL Test No. 14, whereas they the words were attenuated by 4 dB after every sixth word on PAL Test No. 9 (Gelfand, 2001). After complaints of variability and word difficulty on the PAL lists, the Central Institute for the Deaf (CID) modified the lists to the 36 most familiar spondaic words and recorded them in a manner that made them homogenous in regard to difficulty (ASHA, 1988). These new word lists (CID Auditory Tests W-1 and W-2) would serve as the standard for sentence and word stimuli in speech audiometry materials (Hirsh et al., 1952).

In 1948, Davis proposed combining two measures with speech stimuli to estimate a person's ability to hear and understand speech. The two measures included the person's threshold of intelligibility as well as the discrimination of speech sounds at intensities suprathreshold, referred to today as word recognition score (WRS) and SRT (Davis, 1948). When the CID lists were produced in 1952, they provided the means for which measures of SRT and WRS could be made (Hirsh et al., 1952). After years of research and advancement in technology, SRT and WRS materials have improved as diagnostic tools. The measures derived from these speech audiometry tests are influential in the differential diagnosis of many disorders, including inner ear disorders, nonorganic hearing losses, and peripheral and central auditory disorders (Creston, Gillespie, & Krohn, 1966; Hood & Poole, 1977; Jerger, Speaks, & Trammell, 1968; Ostergard, 1983; Van Dijk, Duijndam, & Graamans, 2000).

Speech Recognition Threshold

The SRT is the most common measure for determining the level at which an individual can understand speech (Egan, 1979) and is one of the measures included in a speech audiometry assessment. The SRT, for English, is defined as the lowest level at which an individual can understand spondaic words at least 50% of the time. It also provides validity to pure-tone measures, because the measures of SRT often correlate to the pure-tone frequencies necessary to decipher speech sounds (Epstein, 1978). A discrepancy between the measures of SRT and pure-tone testing can indicate an exaggerated hearing loss, irregular sensitivity of the auditory system, or the presence of an auditory, cognitive, or central auditory disorder (ASHA, 1988; Carhart, 1952; Young, Dudley, & Gunter, 1982). The protocol for test administration involves the subject being presented with a closed set of test items and the individual being asked to repeat the stimuli or in some other way indicate that they recognize the speech material (ASHA, 1988).

Two methods of deriving the SRT in clinical testing have been approved and accepted by the American Speech-Language and Hearing Association (ASHA). A 2-dB method involves presenting the stimuli in 2 dB increments from an estimate of the threshold or correlating pure-tone-average (PTA); the PTA being the average threshold at 500, 1000, and 2000 Hz. In the 5 dB method, stimuli are presented in 5-dB increments, which accommodate audiometers that are not capable of adjusting the intensity of stimuli presentation in 2-dB increments (ASHA, 1988).

Word Recognition Score

The WRS is another test included in a speech audiometry assessment and helps provide useful diagnostic information. The measurement is taken at suprathreshold levels where the individual can better understand speech. The level of stimuli presentation is typically set at an intensity level 30 to 50 dB above the SRT, where it is believed to overcome the hearing impairment (Epstein, 1978). Typically, the stimuli for WRS are lists of monosyllabic, phonetically balanced words, which are presented in an open-set; in other words, the patient has not been familiarized with the word lists prior to testing as they are in SRT testing. As each word is presented, the patient repeats back what is believed to have been heard and the audiologist scores each response of the patient as either correct or incorrect. The final percentage of correctly repeated words is the WRS.

The WRS is clinically useful in assisting the audiologist in determining the type and extent of hearing impairment. For example, it is expected that an individual with normal hearing would achieve a WRS score of 90% to 100%. Typically, individuals with conductive impairments achieve a score of between 80% and 100%, or as low as 60% in cases such as glomus tumor. An individual with a sensorineural loss may have a WRS score anywhere from

0% to 100%, depending on the etiology and degree of impairment. An extremely low score may also be indicative of retrocochlear pathology (Gelfand, 2001).

Speech Recognition Threshold Test Material Criteria

A variety of test materials can be used for SRT testing; however, for English, it is recommended that spondaic words be used. Spondaic words are two syllable words which have equal stress (ASHA, 1988). Additionally, certain criteria have been deemed essential in the development of recorded speech audiometry material. Words should be selected and recorded based on familiarity, homogeneity, and phonetic dissimilarity (Hudgins et al., 1947; Ramkissoon, 2001). Research has also emphasized the importance of recording procedures (ASHA, 1988; Carhart, 1965a).

Familiarity. The purpose of SRT testing is to measure the threshold of speech intelligibility. Word familiarity is an important factor to consider because it will ensure test validity (Nissen, Harris, Jennings, Eggett, & Buck, 2005b). Generally, words more frequently used in the language are more intelligible than words less frequently used (Bell & Wilson, 2001). Thus, it is essential that the words be familiar to allow for the intended purpose of the test, testing of hearing acuity, rather than a measure of receptive vocabulary (Hudgins et al., 1947). This illustrates the importance of testing in their native tongue. If English materials are used for testing people with limited English proficiency or a deficiency in the English vocabulary, the results would cause a bias in their auditory testing and create an inaccurate representation of the individual's hearing ability (Ramkissoon, 2001). The stimuli for SRT testing are typically presented in a closed-set list, meaning that the patient has been familiarized with the words prior to testing to limit any bias due to vocabulary knowledge (ASHA, 1988).

The SRT is also influenced by several lexical factors. For example, performance level is impacted by the frequency of occurrence of the target word and frequency of other phonemically similar words to the target word in the lexicon. The Neighborhood Activation Model states that, "words that occur frequently and have few phonemically similar neighbors (lexically "easy" words) are recognized more accurately than words that occur less frequently but have a large number of phonemically similar neighbors (lexically "hard" words)" (Dirks, Takayana, & Moshfegh, 2001, p. 233). Normal-hearing and hearing-impaired individuals are more accurate at identifying lexically *easy* words than lexically *hard* words, and they have higher recognition performances with *easy* words (Dirks, Takayana, & Moshfegh, 2001).

Homogeneity. Homogeneity is achieved by matching the difficulty and intelligibility of each individual test item, or the list of items as a whole, as a function of intensity (Dillon, 1983). Referring to homogeneity of audibility, all test stimuli have equivalent audibility, and the listener is able to understand each test item at the same intensity level regardless of the method of delivery (Ramkissoon, 2001). Homogeneity of the test words allows the SRT to be established with the fewest number of word items as possible, thus increasing the precision of the SRT (Young et al., 1982). If homogeneity of SRT test words is not achieved, then an individual's scores may vary among tests, not allowing for comparisons to the normal distribution (Dillon, 1982). Additionally, homogeneity with respect to audibility will increase test-retest reliability and decrease the amount of time for testing because fewer test items will be needed to determine SRT (Wilson & Carter, 2001; Wilson & Strouse, 1999). A concern regarding homogeneity is expressed by some researchers in that homogeneity would not exist between male and female talkers. Several studies, however, illustrate that there is no significant difference between male and female talkers for test results between normal-hearing and hearing-impaired individuals (Cambron, Wilson, & Shanks, 1991; Penrod, 1979; Preece & Fowler, 1992).

Homogeneity can be established by plotting the psychometric performance-intensity functions for each word. The slopes of the psychometric performance-intensity functions illustrate the rate at which a spondaic word becomes intelligible. The slopes of the psychometric functions illustrate the individual's ability to comprehend the stimuli as a function of presentation level. This is important to evaluate because the intensity level at which words become 50% intelligible may vary with each word (Young et al., 1982). The presence of steep slopes on the psychometric performance-intensity functions signifies homogeneity among the items (Dillon, 1983; Wilson & Carter, 2001). Digital technology is used to achieve homogeneity by adjusting the words to make them equally audible, resulting in similar threshold levels and less variability (Epstein, 1978).

Phonetic dissimilarity. The purpose of speech testing is to determine an individual's ability to hear and understand speech in everyday speaking situations. It is therefore essential that the stimuli represent the natural phoneme distribution of the language present in everyday speaking situations (Hirsh et al., 1952). In addition, advantages occur and test scores improve when phonetically dissimilar words are used in testing. Words considered to be lexically *easy* occur frequently in the language and have few phonetically similar words. This is important to consider when testing individuals with diminished hearing because the hearing impairment limits their ability to discriminate between phonemes, which causes difficulty in distinguishing between phonetically similar words (Bell & Wilson, 2001). Using lexically *easy* words results in steeper slopes of psychometric performance-intensity functions (Dirks et al., 2001). It is important that the test words are both high frequency words and have few phonetically similar words, because being a high frequency word alone was actually found to reduce the SRT (Luce, 1986).

Presentation of the test material. Test materials may be presented through readily available recorded materials or via monitored live voice (MLV). Administration of recorded materials standardizes the procedure and allows for consistency of word intensity and speech pattern of the talker between patients and also reduces test time (ASHA, 1988; Stach, vis-Thaxton, & Jerger, 1995). MLV involves the talker speaking the words into a microphone and monitoring their voice on the audiometer's VU meter. In order for MLV to maintain a standard and consistent signal, it requires careful control of talker's vocal effort throughout testing (Stach et al., 1995). Using MLV presentation it is impossible to present each spondaic word to every patient in the exact same manner; thus, use of recorded material is the preferred method of presentation. However, despite this limitation, approximately 90% of audiologists report still using MLV for SRT testing (Martin, Champlin, & Chambers, 1998). Yet, MLV does have clinical usefulness by allowing for flexibility in the selection of test words and rate of presentation. MLV is useful when testing patients who may be difficult to test or require additional time to respond to the stimuli (ASHA, 1988).

The manner in which the test materials are presented, whether through recorded stimuli or MLV, should be noted in the test results. Guidelines for the presentation of SRT test materials established by ASHA does, however, recommend using recorded stimuli for speech audiometry testing (ASHA, 1988). A standard and uniform method of instrument calibration is necessary in order to achieve accurate test results and be able to compare results from one person to another (Tucci, Ruth, Schoeny, Rupp, & Stockdell, 1980). Use of digital recordings allows for standardization and consistency in the presentation of words within and across test sessions (Carhart, 1965b).

Speech Audiometry for Non-English Speakers

A variety of English speech audiometry materials for SRT are digitally-recorded and available for use. Since SRT test stimuli should be linguistically familiar to the listener it is not appropriate to use English materials with people who are not native speakers of English. In order for the speech audiometry tests to be valid, it is necessary that the test materials be administered in the individual's native language. Clearly there is a worldwide need for development of speech audiometry materials in languages other than English, but there is also an increased demand for these materials in the United States. In a survey conducted by Martin and Sides (1985) it was reported by 37% of American audiologists that speech audiometry is performed in languages other than English. In another study by Martin et al. (1998), it was reported that only about 30% of the audiologists fluently spoke a language other than English, and only half of those actually conducted testing in a language other than English. For the monolingual English speaking audiologists, testing was reported to be administered in English, with a family member present for translating to the patient's native language (Martin et al., 1998). This procedure is concerning among professionals because the results of testing could be due to phonological limitations, hearing impairment, or both (McCullough et al., 1994). This conflict provides further support for the need of speech audiometry materials to be developed in languages other than English.

A critical element to developing any word list is the test population's familiarity with the words contained in the list. When testing a non-native English speaker with English materials it is essential that the patient be familiar with the test stimuli. However, establishing familiarity to

English words, when English is not the patient's native language, can be extremely difficult and produce measures that are not useful clinically (Rudmin, 1987), even for non-American English dialects (Wilson & Moodley, 2000). This challenge was initially approached by using English digits, which were deemed to be the most familiar English words for a non-native speaker. Several studies demonstrated the practicality of using digits as the test stimuli for SRT testing (Ramkissoon, Proctor, Lansing, & Bilger, 2002; Rudmin, 1987). Digits were determined to be highly familiar as well as intelligible. However, the use of digits reduced the difficulty of the test, reducing sensitivity (Dillon, 1983). When the test stimuli are too familiar there is an increased chance that the patient is guessing correctly (Bell & Wilson, 2001).

Another alternative for an English speaking audiologist is to use a picture identification response where the patient selects the corresponding picture from a closed set instead of repeating the presented word. Some research has found the picture identification response to be an acceptable option (Martin & Hart, 1978; McCullough et al., 1994). On the other hand, others to do not support picture identification as an alternative method (Owens, Benedict, & Schubert, 1971).

It has been determined that non-native English speakers perform poorly when tested with English materials (Crandell & Smaldino, 1996; Padilla, 2003; Werker, Gilbert, Humphrey, & Tees, 1981). Also, significant performance level differences can be found at the phonemic, word, and sentence level (Padilla, 2003; Werker et al., 1981). When tested with English materials in noisy situations, non-native English speakers perform especially poor (von Hapsburg & Pena, 2002) as compared to being tested in quiet environments (Padilla, 2003; von Hapsburg & Bahng, 2006). However, for those individuals whose second language becomes dominant over the native language, it is still unclear whether testing in their more proficient second language would be beneficial and the preferred method of testing (von Hapsburg & Pena, 2002).

Currently speech audiometry materials have been developed in other languages; including Afrikaans (Theunissen, 2008), Greek (Iliadou, Fourakis, Vakalos, Hawks, & Kaprinis, 2006), Japanese (Mangum, 2005), Mandarin (Nissen, Harris, Jennings, Eggett, & Buck, 2005a; Nissen et al., 2005b), Polish (Harris, Nielson, McPherson, Skarzynski, & Eggett, 2004a, 2004b), French (Nelson, 2004), Korean (Harris, Kim, & Eggett, 2003a, 2003b), Brazilian Portuguese (Harris, Goffi, Pedalini, Gygi, & Merrill, 2001; Harris, Goffi, Pedalini, Merrill, & Gygi, 2001), Russian (Aleksandrovsky, McCullough, & Wilson, 1998; Harris et al., 2007; Pola, 2003), Italian (Greer, 1997), Spanish (Harris & Christensen, 1996), Danish (Elberling, Ludvigsen, & Lyregaard, 1989), Cantonese (Lau & So, 1988), and Arabic (Ashoor & Prochazka, 1985). Materials in these languages have allowed audiologists around the world to effectively evaluate the hearing of individuals native to that language. Currently, despite the availability of materials in these languages, there continues to be a lack of resources in many languages, including Samoan.

Speech audiometry materials for English SRT testing traditionally include a list of bisyllablic words. Languages such as Spanish, Portuguese, and Italian have few monosyllabic words. Speech materials developed in these languages have less steep psychometric performance-intensity function slopes for bisyllabic words compared to the traditional English materials (Harris, Goffi, Pedalini, Gygi et al., 2001; Harris, Goffi, Pedalini, Merrill et al., 2001; Nissen et al., 2005a, 2005b). Research has shown that SRT materials developed in these languages have slopes of psychometric performance-intensity function on trisyllabic words as steep as the slopes for English bisyllabic words (Harris & Christensen, 1996; Harris, Goffi, Pedalini, Gygi et al., 2001; Harris & Greer, 1997). Steeper slopes for psychometric performance-intensity function are preferred for increased homogeneity. Since Samoan has few monosyllabic words, similar to the previously mentioned languages, trisyllabic words were used to develop the SRT material in this study.

It is evident that there is a need for SRT materials to be developed in the Samoan language. Digitally recording the words may facilitate an efficient administration and yield valid and reliable results. The stimulus material should allow audiologists to evaluate and quantify hearing loss in Samoan speaking individuals.

Characteristics of Samoa

The Samoan islands are located near the equator between latitudes 13 and 16 degrees south in the heart of the South Pacific. The islands, formed by well-erupted volcanoes, are located 3700 km south-west of Hawaii, north of Tonga, west of the northern Cook Islands, and south of the Tokelau Islands. The 171st meridian divides the Samoan islands into the United States territory of American Samoa on the east and independent Western Samoa on the west. Although the two places differ in atmosphere, geographies, and characters; the people speak the same language, have the same customs, and pass on similar traditions (Swaney, 1990).

American Samoa is described as having a South Pacific American style, characterized by fast food restaurants, sports cars, and high-school football, where there is a struggle to preserve the Samoan way. American Samoa is made of four rugged volcanic peaks, the main island Tutuila and the three smaller but widely steep islands of the Manu'a group, as well as the small crater island of 'Aunu'u and two coral atolls, Swains Island and Rose Atoll. The total land area is 197 square km, with 145 km belonging to Tutuila. The island of Tutuila is home to Pago Pago Harbor, Pago Pago International Airport, and the village of Leone (Swaney, 1990). According to the 2000 census, American Samoa has a total population of 57,291 people with 93% of those reportedly being Native Hawaiian or Pacific Islander. A small percentage of the total population is Asian, Caucasian, or a combination of two or more ethnic origins or races. On the island of American Samoa 91% of the population speaks Samoan at home. Other languages reportedly spoken at home include English, Tongan, other Pacific Island languages, or another language (Cooper, 2003).

Western Samoa, the larger of the two areas, has maintained much of the traditional Polynesian society typical of the Pacific islands. Despite changes brought about by the 20th century, it is thought of as a quiet and gentle place, relatively unchanged since ancient times. Western Samoa became an independent sovereign state in January 1962, becoming the first sovereign state of the South Pacific. In 1997, the prefix Western was dropped and the country was renamed to the Independent State of Samoa (Swaney, 1990). For tradition's sake, this area will be referred to as Western Samoa in this paper.

Lying in a group of islands within the South Pacific Ocean, Western Samoa consists of two large islands, Savaii, 1700 square km, and Upolu, 1115 square km, and two small islands, Manono and Apolima. According to the 2001 Population and Housing Census the islands of Western Samoa have a total population of 176,848. The census lists North Western Upolu as the most populated region with a population of 52,714 and Savaii, the largest of the islands, with a population of 42,848. The Samoan ethnicity makes up 92.6% of the people, with persons of European and Polynesian blood making up 7% of the population and Europeans comprising only 0.4% (Government of Samoa).

The main language of both American Samoa and Western Samoa is Samoan, although a majority of the people speak English as a second language. Samoan is considered a Polynesian language similar to Tongan, Maori, Hawaiian, and Tahitian, all of which belong to the Austronesian or Malayo-European family of languages. This family also includes Malay, Malagasy, and Melanesian dialects. Many Samoan words are quite similar to Malay, serving as evidence that the Polynesian islands were settled by immigrants from South-East Asia (Swaney, 1990).

The Samoan language is considered to be a language of the people. It is the language of a relatively sheltered group of Pacific Islands that has developed a unique culture and way of life. The people enjoy a rich social and political life centered on the art of the orator. Most traditions of Samoan culture are not written down, but rather considered to be prodigious and are handed down orally. Thus, the language can be studied not only through literature, but also in action. However, many of the speeches made before the chiefs and orators are not made public to the young, the inexperienced, or the outside investigator. Thus, studying the Samoan oratory is difficult and rather formidable (Milner, 1966).

The Samoan people have uniquely adapted to their habitat and have a wide range of daily village life activities. Each skilled or semi-skilled activity has its own vocabulary, reflecting Samoans need to rely on the land and sea for resources. Knowledge of Samoan materials, fauna and flora, and certain plants and animals are important in understanding their proverbs. The use of proverbs in oratory has preserved many of their unique traditions and materials of the land (Milner, 1966).

A distinctive feature of the Samoan language is the vocabulary of respect, used to address Chiefs or when speaking about them, whether in their presence or absence. As is the case in many languages, Samoan has stylistic gradations of words in which one form may be vulgar, slang, ordinary, polite, or respectful. In Samoan, ordinary words are not used when a person speaks to or about a Chief. However, when referring to himself, the speaker uses ordinary words (Milner, 1966).

When considering Samoan phonology it is important to consider the two phonological systems, one being a *formal* and the other a *colloquial* pronunciation. Formal pronunciation is used as the model for children, students, and foreign visitors to follow. It represents the earlier and purer form of the language. Formal pronunciation is used regularly when ministers perform religious services, when teachers give instruction, when natives speak to foreigners, and when Samoans address God. On the other hand, the vast majority of Samoans use colloquial pronunciation in their private and public relations. Colloquial pronunciation is also frequently heard in many semi-formal and formal occasions despite the fact that Samoans regard it as being the vulgar form. Traditionally, Samoans view formal pronunciation as a sign of good education and good breeding and they view foreigners' attempts to adopt the colloquial pronunciation with disdain and highly discourage it. Based on these considerations, the dictionary used in this review to define the words chosen as stimuli, focuses on formal pronunciation (Milner, 1966).

Samoan is composed of 14 letters, five vowels and nine consonants. Phonemes of formal pronunciation include three unaspirated voiceless stops: bilabial, alveolar, and glottal /p/, /t/, and /'/, three voiced nasals: bilabial, alveolar, and velar /m/, /n, and /g/, two labio-dentals, one voiceless and one voiced /f/ and /v/, one voiced lateral /l/, and one voiceless alveo-palatal spirant /s/. Additionally, three other consonants appear in loan-words, which are (a) an unaspirated voiceless velar stop /k/, (b) a voiceless glottal spirant /h/, and (c) a voiced alveolar continuant /r/. Colloquial pronunciation differs from formal pronunciation in that it only has three voiceless stops, bilabial, velar, and glottal, and only two nasals, bilabial and velar (Milner, 1966).

Vowels of Samoan formal pronunciation consist of a close front, mid-front, open, mid-back, and close back (i, e, a, o, u). When these vowels occur in unstressed positions, they exhibit slight allophonic variations. All five vowels may be phonetically short or long depending on if they are stressed or not. When they are long they may be heard with or without a medial pulse of rearticulation (Milner, 1966).

The phonemic structure of a syllable may occur as V or CV. However, in the case of /h/ and /r/, occurring only in loan-words, vowels and consonants have an unrestricted amount of occurrence. The glottal stop is represented by an inverted comma and is often used sporadically and inconsistently by writers, even within the same work. The general principles for its use are that it is usually omitted before a capital and is often used in circumstances where its absence could create a misunderstanding despite the contextual support. These same principles exist for the macron which is used to represent a cluster of two identical short vowels, which may be recognized phonetically as one long vowel but actually belong to two separate syllables (Milner, 1966).

Overall, phonetic length is not significant when used for emphasis; however, minimal pairs can be established based on the presence or absence of phonetic length, or vocalic reduplication. Also, glottalization is not significant when the initial syllable of the utterance is a V rather than a CV shape (Milner, 1966).

An utterance is signified by silence or lack of vocalic activity. The onset of vocalic activity, following a temporary absence of activity, marks the beginning of an utterance. Syllables may be produced with a strong stress (primary), a relatively less strong stress (secondary), or a weak stress. A weak stress is described as unstressed. The penultimate syllable of each utterance is marked by a primary stress. The majority of utterances, including statements, commands, and specific questions are described as having *falling* intonation (Milner, 1966) and the stress is usually placed on the second to last syllable in the word (Swaney, 1990).

Samoan Speech Audiometry

Lists of Samoan words for speech audiometry testing are currently being used by audiologists in LBJ Tropical Medical Center located in Pago Pago. Compiled by Dr. Ellen McNeil (Audiologist), Paul Strauss (Audiologist), and with the help of Ear, Nose, Throat specialists in the area, three lists of 20 monosyllabic and bisyllabic words are currently being used for SRT testing and two lists of 50 words for speech discrimination testing. Also, a list of 48 monosyllabic and bisyllabic words are used to measure WRS, where a score 44-48 is considered within normal limits. The tests are administered in the MLV method, thus limiting the validity and reliability of the materials. No known standardized speech audiometry materials are published and available in Samoan; therefore, there is a need for such materials to be produced. Digitally recording and standardizing these materials according to established protocols would allow testing to be more reliable and produce valid hearing thresholds for all native speakers.

Method

Participants

A total of 20 native speakers (9 male and 11 female) of Samoan participated in the evaluation of SRT materials developed in this study. The participants ranged from 18 to 39 years of age with a *M* age of 27.2 years and *SD* of 6.3 years. Participants had lived in the United States on average for 195.7 months, ranging from 36 to 408 months (*SD* = 101.8 months). Samoan was reported to be spoken daily. All participants demonstrated pure-tone air-conduction thresholds $\leq$15 dB at 125, 250, 500, 1000, 1500, 2000, 3000, 4000, 6000, and 8000 Hz. The participants had a *M* pure-tone average of 5.3 dB HL with a SD of 5.1 dB HL. They exhibited static acoustic admittance between 0.3 and 1.4 mmhos at a peak pressure between -100 and +50 daPa (ASHA, 1990; Roup, Wiley, Safady, & Stoppenbach, 1998). Each participant passed a screening which included an ipsilateral acoustic reflex of ≥95 dB in the test ear at 1000 Hz. A summary of these descriptive statistics for the audiometric data is presented in Table 1. Additionally, the 20 participants each signed an informed consent form approved by Brigham Young University Institutional Review Board for human subjects.

Materials

Word lists. A preliminary word corpus of trisyllabic words was compiled based upon examination of a corpus of high frequency Samoan words identified by Hunkin (2001). The collected words were rated by three native speakers of Samoan based on how familiar the words would be to a native speaker of Samoan. Each word received a score from all three raters between 1 and 5 (1 = rarely used, 2 = infrequently used, 3 = somewhat familiar, 4 = very familiar, and 5 = extremely familiar). From the original corpus, words were eliminated for one or more of the following reasons: (a) received a familiarity rating of ≤ 3 from the native judges, (b) thought to possibly represent inappropriate content, (c) have the same pronunciation but different meanings, or (d) thought to be culturally insensitive. The remaining 90 trisyllabic words were included in this study for evaluation.

Talkers. Initially, six native speakers of Samoan (three male and three female), were recorded speaking the test materials. These initial recordings were judged by a panel of eight native speakers of Samoan and ranked from best to worst. The eight raters judged the quality of the recording based on pronunciation, voice quality, and standard dialect. The male and female talkers that received the best ranking were chosen as the talkers for all remaining recordings.

Table 1

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

kHz	*M*	*Minimum*	*Maximum*	*SD*
0.125	0.5	-10	10	5.8
0.25	1.3	-10	10	7.0
0.5	4.5	-10	15	6.7
0.75	4.8	-5	15	6.0
1.0	5.0	-10	15	5.8
1.5	7.8	-5	15	5.7
2.0	6.5	-5	15	5.4
3.0	4.3	-5	15	6.5
4.0	5.0	-5	15	6.1
6.0	3.0	-10	15	6.4
8.0	3.0	-10	15	6.2
PTA[a]	5.3	-6.7	11.7	5.1

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

Recordings. All test materials were recorded in a double-walled sound suite located at Brigham Young University in Provo, Utah, USA. A Larson-Davis model 2541, 1.27 cm microphone was placed 15 cm from the talker with a 0 azimuth and covered by a 7.62 cm windscreen. The microphone met these specifications for all speech recordings. The microphone signal was amplified by a Larson-Davis model PRM902 microphone preamp and coupled to a Larson-Davis 2221 microphone preamplifier power supply. A 441.1 kHz sampling rate with 24-bit quantization was implemented for all recordings. A Benchmark ADC1 analog-to-digital converter was used to digitize the signals which were then stored on a hard drive for future editing. An average long term spectrum was calculated for all six talkers.

The talkers were instructed to produce each trisyllabic word four times with normal vocal effort. The first and last production of each word was excluded to avoid any possible list effects. Then a single native Samoan speaker ranked the remaining recordings of each word for the quality of production. The best recording of each word, as rated by the judge, was selected to be included in the production of speech materials to be evaluated in this study. All other recordings of the words were eliminated from the study. The remaining words, chosen to be included in the study based on best perceived quality, were saved as a single utterance and edited by Sadie Disk Editor software (Studio & Video, 2007) to have the same level equivalent (Leq) as a 1 kHz calibration tone. After editing, each word was saved as a 24-bit *wav* file.

Procedures

Custom software was used to randomize the trisyllabic words for presentation. The custom software was also used in scoring and recording the performance data. The speech stimuli were routed from a computer hard drive to a Grason Stadler model 1761 audiometer. A single TDH-50P headphone was then used to deliver the stimuli from the audiometer to the participant. The participant was seated in a double-walled sound suite meeting American National Standards Institute (ANSI) S3.1 standards (1992) for maximum permissible ambient noise levels for the ears not covered condition using one-third octave-band measurements. All inputs to the audiometer were calibrated to 0 VU using the 1 kHz calibration tone through customized computer software. The audiometer was calibrated according to ANSI S3.6 standards (2004) prior to any testing, during and at the conclusion of data collection.

Hearing screenings were passed by each participant prior to the three testing sessions. Participants were allowed several rest periods throughout the testing period. Initially, each participant was familiarized with the list of the selected 90 trisyllabic words at a comfortable listening level of 50 dB. The words were played in alphabetical order and the participant was able to read along with a provided printed word list. The following text is the instructions spoken in English to each participant prior to the familiarization of the test stimuli:

> You will now hear the list of words we will use in this part of the research study. These words will be presented at a comfortable listening level. Please read the list of words silently as you hear them to make sure you are familiar with all the words. Do you have any questions?

After the familiarization was done, each participant was presented the complete list of the selected 90 trisyllabic words at a possibility of 15 different intensity levels, ranging from -10 to 18 dB HL in 2 dB increments. The starting level at which testing began was decided by the participated pure-tone-average, as determined in the hearing screening, minus 6 dB. Testing continued in ascending increments of 2 dB. The sequence of the words was randomized prior to the presentation at each intensity level. Each participant listened to both a male and female speaker, in which the order of presentation was determined randomly. The participants were instructed to repeat the words verbally and their productions were scored as either correct or incorrect by a native speaker of Samoan. Once the word was scored, the next word was immediately presented. If the initial starting level did not result in the desired 0% correct, then the intensity decreased by 2 dB until a level of 0 words were scored correct. The potential for learning effects was reduced by the randomization order of the speech stimuli, the stimuli being presented from low to high intensity, and the relatively large list of trisyllabic words evaluated by each participant. Each participant was given the following instructions in English prior to the evaluation of trisyllabic words:

> You will hear Samoan words at a number of different loudness levels. Each word is three syllables in length. At the very soft loudness levels, it may be difficult for you to hear. For each word, listen carefully to the word, and then repeat what you think the word was. If you are not sure, you may guess. If you have no guess simply say, "I don't know," or wait silently for the next word. Do you have any questions?

Results

After the raw data were collected, logistic regression was used to obtain the regression slope and intercept for each of the 90 trisyllabic 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 follows:

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

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

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

By inserting the regression slope, regression intercept, and presentation level into Equation 2, it is possible to predict the percentage correct at any specified intensity level. Percentage of correct recognition was calculated for each of the trisyllabic words for a range of -10 to 18 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 trisyllabic word using the logistic regression slopes and intercepts. The words with the steepest psychometric performance intensity function slopes for both male and female takers were included in the final list of trisyllabic words.

Thresholds for the male talker of the 90 trisyllabic words ranged from 4.7 dB HL to 27.7 dB HL (M = 12.7), and for the female talker from 2.6 dB HL to 23.3 dB HL (M = 11.5). Psychometric performance-intensity functions were calculated for each trisyllabic word with Equation 2 using the logistic regression intercepts and slope values. The slopes at 50% ranged from 4.2 %/dB to 15.7 %/dB (M = 8.6) for the male talker and from 3.8 %/dB to 11.9 %/dB (M = 7.1) for the female talker. The slopes from 20-80% ranged from 3.6 %/dB to 13.6 %/dB (M = 7.5) for the male talker and from 3.3 %/dB to 10.3 %/dB (M = 6.2) for the female talker. The slopes at 50% threshold were steeper compared to the slopes at 20-80%. Slopes of the psychometric performance-intensity functions and 50% thresholds for all trisyllabic words are presented in Table 2 (male talker) and Table 3 (female talker).

As determined by previous research, SRT test stimuli need to be relatively homogeneous with steep psychometric performance-intensity function slopes in order to reduce test time and improve reliability (Wilson & Strouse, 1999). Therefore, only the words with the steepest psychometric performance-intensity function slopes of ≥ 7.0 %/dB, for both male and female talkers, which had enough available headroom for adjustment were included in the final list of trisyllabic words. Additional words were eliminated after being perceptually rated by three judges as too soft or too loud, resulting in a total of 28 selected words. The threshold, slope at threshold, and the slope from 20% to 80% for the 28 selected trisyllabic words are listed in Table 4 (male talker) and Table 5 (female talker). Figure 1 illustrates that there is less variability in the

Table 2

Mean Performance for 90 Samoan Male Trisyllabic SRT words

#	Word	a[a]	b[b]	Slope at 50%[c]	Slope 20-80%[d]	Threshold[e]	ΔdB[f]
1	'a'ano	3.31708	-0.24210	6.1	5.2	13.7	8.4
2	'aemaise	4.34877	-0.41228	10.3	8.9	10.5	5.2
3	'ailoga	2.52192	-0.24988	6.2	5.4	10.1	4.8
4	'aulotu	2.70639	-0.26610	6.7	5.8	10.2	4.8
5	'avatu	2.14986	-0.21897	5.5	4.7	9.8	4.5
6	'oloa	3.87879	-0.29645	7.4	6.4	13.1	7.8
7	agāga	7.70587	-0.40074	10.0	8.7	19.2	13.9
8	alofa	2.73389	-0.36364	9.1	7.9	7.5	2.2
9	aoauli	4.64698	-0.31321	7.8	6.8	14.8	9.5
10	ātoa	3.13897	-0.37057	9.3	8.0	8.5	3.1
11	ātonu	3.47474	-0.28502	7.1	6.2	12.2	6.9
12	atua	4.86247	-0.35896	9.0	7.8	13.5	8.2
13	fa'atau	1.95906	-0.28000	7.0	6.1	7.0	1.7
14	fafine	7.54866	-0.46990	11.7	10.2	16.1	10.7
15	fāgota	2.89360	-0.27261	6.8	5.9	10.6	5.3
16	faigatā	2.50366	-0.32482	8.1	7.0	7.7	2.4
17	faipule	6.21615	-0.42490	10.6	9.2	14.6	9.3
18	fanua	3.87692	-0.25516	6.4	5.5	15.2	9.9
19	fausia	3.44128	-0.26146	6.5	5.7	13.2	7.8
20	fīlēmū	4.25811	-0.37273	9.3	8.1	11.4	6.1
21	fofoga	4.90530	-0.33639	8.4	7.3	14.6	9.3
22	fōliga	3.93985	-0.33676	8.4	7.3	11.7	6.4
23	gagana	4.21804	-0.31901	8.0	6.9	13.2	7.9
24	iloa	4.71603	-0.31544	7.9	6.8	15.0	9.6
25	kalapu	2.53495	-0.23913	6.0	5.2	10.6	5.3
26	komiti	6.18883	-0.34219	8.6	7.4	18.1	12.8
27	lagona	3.46337	-0.31910	8.0	6.9	10.9	5.5
28	lāpisi	4.79454	-0.43367	10.8	9.4	11.1	5.7
29	līpoti	4.10557	-0.33824	8.5	7.3	12.1	6.8
30	loloto	3.81307	-0.28485	7.1	6.2	13.4	8.1
31	māe'a	1.91500	-0.22955	5.7	5.0	8.3	3.0
32	māfua	4.90530	-0.33639	8.4	7.3	14.6	9.3
33	māketi	5.19754	-0.36216	9.1	7.8	14.4	9.0
34	malie	7.36205	-0.49642	12.4	10.7	14.8	9.5
35	mālosi	1.61923	-0.34733	8.7	7.5	4.7	-0.7
36	mamafa	3.21378	-0.31501	7.9	6.8	10.2	4.9
37	manatu	3.14871	-0.30494	7.6	6.6	10.3	5.0
38	manino	6.80796	-0.32526	8.1	7.0	20.9	15.6
39	manu'a	5.93221	-0.45522	11.4	9.9	13.0	7.7
40	masini	6.94802	-0.43654	10.9	9.4	15.9	10.6
41	matagi	6.95182	-0.37628	9.4	8.1	18.5	13.1
42	mativa	4.80771	-0.35785	8.9	7.7	13.4	8.1

#	Word	a[a]	b[b]	Slope at 50% [c]	Slope 20-80%[d]	Threshold[e]	ΔdB[f]
43	matua	5.85969	-0.40206	10.1	8.7	14.6	9.2
44	maulalo	3.15072	-0.31206	7.8	6.8	10.1	4.8
45	mīnute	9.25249	-0.62958	15.7	13.6	14.7	9.4
46	molimau	3.93540	-0.38393	9.6	8.3	10.3	4.9
47	mūsika	6.04108	-0.46390	11.6	10.0	13.0	7.7
48	nūmera	6.88187	-0.52197	13.0	11.3	13.2	7.9
49	ōlaga	2.70275	-0.30751	7.7	6.7	8.8	3.5
50	palolo	2.29952	-0.20637	5.2	4.5	11.1	5.8
51	papa'e	6.08344	-0.35058	8.8	7.6	17.4	12.0
52	pasene	5.90416	-0.32268	8.1	7.0	18.3	13.0
53	pūlea	5.04101	-0.32747	8.2	7.1	15.4	10.1
54	sāmoa	1.52626	-0.24542	6.1	5.3	6.2	0.9
55	sāuniga	5.62958	-0.32988	8.2	7.1	17.1	11.7
56	sēleni	4.06157	-0.30283	7.6	6.6	13.4	8.1
57	setema	6.14801	-0.38431	9.6	8.3	16.0	10.7
58	soso'o	4.15930	-0.42361	10.6	9.2	9.8	4.5
59	suafa	2.23526	-0.37707	9.4	8.2	5.9	0.6
60	suiga	7.47528	-0.48069	12.0	10.4	15.6	10.2
61	susuga	6.14260	-0.44132	11.0	9.6	13.9	8.6
62	tagata	5.01856	-0.38863	9.7	8.4	12.9	7.6
63	talavou	3.68091	-0.45601	11.4	9.9	8.1	2.7
64	tālofa	2.09032	-0.32138	8.0	7.0	6.5	1.2
65	tamaiti	6.17588	-0.42916	10.7	9.3	14.4	9.1
66	tapa'a	3.63217	-0.26076	6.5	5.6	13.9	8.6
67	tatala	7.47818	-0.34834	8.7	7.5	21.5	16.1
68	tatalo	4.09733	-0.30278	7.6	6.6	13.5	8.2
69	taugatā	1.85794	-0.27058	6.8	5.9	6.9	1.5
70	taulaga	4.33940	-0.40322	10.1	8.7	10.8	5.4
71	tāumafa	2.29800	-0.27167	6.8	5.9	8.5	3.1
72	taunu'u	5.77892	-0.43543	10.9	9.4	13.3	7.9
73	tausaga	3.67424	-0.39928	10.0	8.6	9.2	3.9
74	tausiga	4.11405	-0.34569	8.6	7.5	11.9	6.6
75	tautua	2.66800	-0.33203	8.3	7.2	8.0	2.7
76	tete'e	4.63970	-0.16722	4.2	3.6	27.7	22.4
77	tiute	5.48826	-0.33721	8.4	7.3	16.3	10.9
78	tofiga	5.50334	-0.45958	11.5	9.9	12.0	6.6
79	tomai	3.87682	-0.25806	6.5	5.6	15.0	9.7
80	toto'a	5.04669	-0.31493	7.9	6.8	16.0	10.7
81	totogi	4.41676	-0.20401	5.1	4.4	21.6	16.3
82	totonu	2.99697	-0.19230	4.8	4.2	15.6	10.3
83	tūla'i	4.36226	-0.34728	8.7	7.5	12.6	7.2
84	tūlaga	4.99591	-0.38329	9.6	8.3	13.0	7.7
85	tūsia	7.18658	-0.48392	12.1	10.5	14.9	9.5
86	vāega	3.04487	-0.27825	7.0	6.0	10.9	5.6
87	vaiaso	3.06336	-0.39039	9.8	8.4	7.8	2.5
88	vailā'au	2.45675	-0.33722	8.4	7.3	7.3	2.0

#	Word	a[a]	b[b]	Slope at 50%[c]	Slope 20-80%[d]	Threshold[e]	ΔdB[f]
89	vala'au	1.55812	-0.23380	5.8	5.1	6.7	1.3
90	vasega	5.57500	-0.45753	11.4	9.9	12.2	6.9
	M	4.39241	-0.34523	8.6	7.5	12.7	7.4
	Min	1.52626	-0.62958	4.2	3.6	4.7	-0.7
	Max	9.25249	-0.16722	15.7	13.6	27.7	22.4
	Range	7.72623	0.46236	11.6	10.0	23.1	23.1
	SD	1.70096	0.08203	2.1	1.8	3.9	3.9

[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 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 (5.33 dB HL).

Table 3

Mean Performance for 90 Samoan Female Trisyllabic SRT words

#	Word	a[a]	b[b]	Slope at 50% [c]	Slope 20-80%[d]	Threshold[e]	ΔdB[f]
1	'a'ano	3.18067	-0.25271	6.3	5.5	12.6	7.3
2	'aemaise	1.98352	-0.31273	7.8	6.8	6.3	1.0
3	'ailoga	3.01887	-0.26087	6.5	5.6	11.6	6.2
4	'aulotu	2.33033	-0.26204	6.6	5.7	8.9	3.6
5	'avatu	2.94961	-0.25132	6.3	5.4	11.7	6.4
6	'oloa	2.80157	-0.20435	5.1	4.4	13.7	8.4
7	agāga	4.09869	-0.28801	7.2	6.2	14.2	8.9
8	alofa	1.19091	-0.23612	5.9	5.1	5.0	-0.3
9	aoauli	1.83179	-0.24088	6.0	5.2	7.6	2.3
10	ātoa	1.09909	-0.33498	8.4	7.2	3.3	-2.0
11	ātonu	4.19173	-0.27760	6.9	6.0	15.1	9.8
12	atua	4.44837	-0.27942	7.0	6.0	15.9	10.6
13	fa'atau	1.68508	-0.27885	7.0	6.0	6.0	0.7
14	fafine	4.34331	-0.36985	9.2	8.0	11.7	6.4
15	fāgota	2.52133	-0.21536	5.4	4.7	11.7	6.4
16	faigatā	1.82494	-0.33279	8.3	7.2	5.5	0.2
17	faipule	3.78859	-0.29798	7.4	6.4	12.7	7.4
18	fanua	3.72834	-0.34150	8.5	7.4	10.9	5.6
19	fausia	3.15524	-0.22536	5.6	4.9	14.0	8.7
20	fīlēmū	2.55121	-0.31451	7.9	6.8	8.1	2.8
21	fofoga	2.15499	-0.21127	5.3	4.6	10.2	4.9
22	fōliga	2.67121	-0.33788	8.4	7.3	7.9	2.6
23	gagana	3.61071	-0.26776	6.7	5.8	13.5	8.2
24	iloa	3.63716	-0.31920	8.0	6.9	11.4	6.1
25	kalapu	3.21914	-0.23373	5.8	5.1	13.8	8.4
26	komiti	3.97204	-0.29852	7.5	6.5	13.3	8.0
27	lagona	4.30324	-0.28038	7.0	6.1	15.3	10.0
28	lāpisi	2.65151	-0.24257	6.1	5.2	10.9	5.6
29	līpoti	2.59613	-0.24288	6.1	5.3	10.7	5.4
30	loloto	3.73110	-0.22014	5.5	4.8	16.9	11.6
31	māe'a	1.87673	-0.21917	5.5	4.7	8.6	3.2
32	māfua	3.16955	-0.30072	7.5	6.5	10.5	5.2
33	māketi	2.70442	-0.28994	7.2	6.3	9.3	4.0
34	malie	4.66966	-0.35998	9.0	7.8	13.0	7.6
35	mālosi	1.58477	-0.26403	6.6	5.7	6.0	0.7
36	mamafa	1.04481	-0.27060	6.8	5.9	3.9	-1.5
37	manatu	3.02934	-0.25891	6.5	5.6	11.7	6.4
38	manino	6.28779	-0.37966	9.5	8.2	16.6	11.2
39	manu'a	4.63440	-0.35045	8.8	7.6	13.2	7.9
40	masini	4.09414	-0.26984	6.7	5.8	15.2	9.8
41	matagi	4.54527	-0.29305	7.3	6.3	15.5	10.2
42	mativa	2.68316	-0.20665	5.2	4.5	13.0	7.7

#	Word	a[a]	b[b]	Slope at 50%[c]	Slope 20-80%[d]	Threshold[e]	ΔdB[f]
43	matua	4.81542	-0.29780	7.4	6.4	16.2	10.8
44	maulalo	3.44321	-0.32441	8.1	7.0	10.6	5.3
45	mīnute	3.77307	-0.29359	7.3	6.4	12.9	7.5
46	molimau	3.20802	-0.40957	10.2	8.9	7.8	2.5
47	mūsika	5.17623	-0.42771	10.7	9.3	12.1	6.8
48	nūmera	3.68082	-0.25646	6.4	5.5	14.4	9.0
49	ōlaga	2.35929	-0.37951	9.5	8.2	6.2	0.9
50	palolo	1.89324	-0.21170	5.3	4.6	8.9	3.6
51	papa'e	3.15524	-0.22536	5.6	4.9	14.0	8.7
52	pasene	5.16105	-0.26672	6.7	5.8	19.4	14.0
53	pūlea	3.82638	-0.29216	7.3	6.3	13.1	7.8
54	sāmoa	0.67611	-0.25741	6.4	5.6	2.6	-2.7
55	sāuniga	2.90452	-0.29741	7.4	6.4	9.8	4.4
56	sēleni	2.76252	-0.29994	7.5	6.5	9.2	3.9
57	setema	3.12863	-0.23398	5.8	5.1	13.4	8.0
58	soso'o	3.61098	-0.28543	7.1	6.2	12.7	7.3
59	suafa	1.87199	-0.23876	6.0	5.2	7.8	2.5
60	suiga	7.22287	-0.40306	10.1	8.7	17.9	12.6
61	susuga	4.79518	-0.24819	6.2	5.4	19.3	14.0
62	tagata	2.16100	-0.29084	7.3	6.3	7.4	2.1
63	talavou	3.43322	-0.38234	9.6	8.3	9.0	3.6
64	tālofa	0.97425	-0.20187	5.0	4.4	4.8	-0.5
65	tamaiti	1.64452	-0.26371	6.6	5.7	6.2	0.9
66	tapa'a	2.62359	-0.18527	4.6	4.0	14.2	8.8
67	tatala	4.04978	-0.26334	6.6	5.7	15.4	10.0
68	tatalo	2.49943	-0.30017	7.5	6.5	8.3	3.0
69	taugatā	2.32803	-0.37480	9.4	8.1	6.2	0.9
70	taulaga	2.14493	-0.25086	6.3	5.4	8.6	3.2
71	tāumafa	3.55153	-0.28919	7.2	6.3	12.3	7.0
72	taunu'u	4.87208	-0.47711	11.9	10.3	10.2	4.9
73	tausaga	1.75771	-0.23505	5.9	5.1	7.5	2.1
74	tausiga	2.93857	-0.26209	6.6	5.7	11.2	5.9
75	tautua	2.74349	-0.27371	6.8	5.9	10.0	4.7
76	tete'e	3.54674	-0.15209	3.8	3.3	23.3	18.0
77	tiute	7.99067	-0.44866	11.2	9.7	17.8	12.5
78	tofiga	4.17984	-0.36945	9.2	8.0	11.3	6.0
79	tomai	3.38836	-0.21506	5.4	4.7	15.8	10.4
80	toto'a	4.47697	-0.29086	7.3	6.3	15.4	10.1
81	totogi	4.64497	-0.24464	6.1	5.3	19.0	13.7
82	totonu	4.03125	-0.29443	7.4	6.4	13.7	8.4
83	tūla'i	3.22261	-0.26524	6.6	5.7	12.1	6.8
84	tūlaga	2.94174	-0.30850	7.7	6.7	9.5	4.2
85	tūsia	5.57222	-0.32229	8.1	7.0	17.3	12.0
86	vāega	2.38752	-0.23919	6.0	5.2	10.0	4.7
87	vaiaso	3.19459	-0.35574	8.9	7.7	9.0	3.7
88	vailā'au	1.07778	-0.25853	6.5	5.6	4.2	-1.2

#	Word	a[a]	b[b]	Slope at 50%[c]	Slope 20-80%[d]	Threshold[e]	ΔdB[f]
89	vala'au	2.14274	-0.20710	5.2	4.5	10.3	5.0
90	vasega	4.05627	-0.23985	6.0	5.2	16.9	11.6
	M	3.24040	-0.28451	7.1	6.2	11.5	6.1
	Min	0.67611	-0.47711	3.8	3.3	2.6	-2.7
	Max	7.99067	-0.15209	11.9	10.3	23.3	18.0
	Range	7.31456	0.32502	8.1	7.0	20.7	20.7
	SD	1.31076	0.06018	1.5	1.3	4.1	4.1

[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 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 (5.33 dB HL).

Table 4

Mean Performance for28 Selected Samoan Male Trisyllabic SRT words

#	Word	a[a]	b[b]	Slope at 50% [c]	Slope 20-80%[d]	Threshold[e]	ΔdB[f]
1	alofa	2.73389	-0.36364	9.1	7.9	7.5	2.2
2	aoauli	4.64698	-0.31321	7.8	6.8	14.8	9.5
3	ātoa	3.13897	-0.37057	9.3	8.0	8.5	3.1
4	atua	4.86247	-0.35896	9.0	7.8	13.5	8.2
5	fa'atau	1.95906	-0.28000	7.0	6.1	7.0	1.7
6	faigatā	2.50366	-0.32482	8.1	7.0	7.7	2.4
7	fīlēmū	4.25811	-0.37273	9.3	8.1	11.4	6.1
8	fōliga	3.93985	-0.33676	8.4	7.3	11.7	6.4
9	lagona	3.46337	-0.31910	8.0	6.9	10.9	5.5
10	lāpisi	4.79454	-0.43367	10.8	9.4	11.1	5.7
11	līpoti	4.10557	-0.33824	8.5	7.3	12.1	6.8
12	malie	7.36205	-0.49642	12.4	10.7	14.8	9.5
13	mālosi	1.61923	-0.34733	8.7	7.5	4.7	-0.7
14	manu'a	5.93221	-0.45522	11.4	9.9	13.0	7.7
15	matua	5.85969	-0.40206	10.1	8.7	14.6	9.2
16	molimau	3.93540	-0.38393	9.6	8.3	10.3	4.9
17	mūsika	6.04108	-0.46390	11.6	10.0	13.0	7.7
18	ōlaga	2.70275	-0.30751	7.7	6.7	8.8	3.5
19	soso'o	4.15930	-0.42361	10.6	9.2	9.8	4.5
20	suafa	2.23526	-0.37707	9.4	8.2	5.9	0.6
21	talavou	3.68091	-0.45601	11.4	9.9	8.1	2.7
22	tālofa	2.09032	-0.32138	8.0	7.0	6.5	1.2
23	taunu'u	5.77892	-0.43543	10.9	9.4	13.3	7.9
24	tautua	2.66800	-0.33203	8.3	7.2	8.0	2.7
25	tofiga	5.50334	-0.45958	11.5	9.9	12.0	6.6
26	vāega	3.04487	-0.27825	7.0	6.0	10.9	5.6
27	vaiaso	3.06336	-0.39039	9.8	8.4	7.8	2.5
28	vailā'au	2.45675	-0.33722	8.4	7.3	7.3	2.0
	M	3.87643	-0.37425	9.4	8.1	10.2	4.9
	Min	1.61923	-0.49642	7.0	6.0	4.7	-0.7
	Max	7.36205	-0.27825	12.4	10.7	14.8	9.5
	Range	5.74282	0.21817	5.5	4.7	10.2	10.2
	SD	1.47522	0.05958	1.5	1.3	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 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 (5.33 dB HL).

Table 5

Mean Performance for 28 Selected Samoan Female Trisyllabic SRT words

#	Word	a[a]	b[b]	Slope at 50%[c]	Slope 20-80%[d]	Threshold[e]	ΔdB[f]
1	'aemaise	1.98352	-0.31273	7.8	6.8	6.3	1.0
2	ātoa	1.09909	-0.33498	8.4	7.2	3.3	-2.0
3	fa'atau	1.68508	-0.27885	7.0	6.0	6.0	0.7
4	fafine	4.34331	-0.36985	9.2	8.0	11.7	6.4
5	faigatā	1.82494	-0.33279	8.3	7.2	5.5	0.2
6	fanua	3.72834	-0.34150	8.5	7.4	10.9	5.6
7	fīlēmū	2.55121	-0.31451	7.9	6.8	8.1	2.8
8	fōliga	2.67121	-0.33788	8.4	7.3	7.9	2.6
9	iloa	3.63716	-0.31920	8.0	6.9	11.4	6.1
10	malie	4.66966	-0.35998	9.0	7.8	13.0	7.6
11	mamafa	1.04481	-0.27060	6.8	5.9	3.9	-1.5
12	mīnute	3.77307	-0.29359	7.3	6.4	12.9	7.5
13	molimau	3.20802	-0.40957	10.2	8.9	7.8	2.5
14	ōlaga	2.35929	-0.37951	9.5	8.2	6.2	0.9
15	pūlea	3.82638	-0.29216	7.3	6.3	13.1	7.8
16	sāmoa	0.67611	-0.25741	6.4	5.6	2.6	-2.7
17	sēleni	2.76252	-0.29994	7.5	6.5	9.2	3.9
18	tagata	2.16100	-0.29084	7.3	6.3	7.4	2.1
19	talavou	3.43322	-0.38234	9.6	8.3	9.0	3.6
20	tamaiti	1.64452	-0.26371	6.6	5.7	6.2	0.9
21	tatalo	2.49943	-0.30017	7.5	6.5	8.3	3.0
22	taugatā	2.32803	-0.37480	9.4	8.1	6.2	0.9
23	taulaga	2.14493	-0.25086	6.3	5.4	8.6	3.2
24	taunu'u	4.87208	-0.47711	11.9	10.3	10.2	4.9
25	tautua	2.74349	-0.27371	6.8	5.9	10.0	4.7
26	tofiga	4.17984	-0.36945	9.2	8.0	11.3	6.0
27	vaiaso	3.19459	-0.35574	8.9	7.7	9.0	3.7
28	vailā'au	1.07778	-0.25853	6.5	5.6	4.2	-1.2
	M	2.71867	-0.32508	8.1	7.0	8.2	2.9
	Min	0.67611	-0.47711	6.3	5.4	2.6	-2.7
	Max	4.87208	-0.25086	11.9	10.3	13.1	7.8
	Range	4.19597	0.22625	5.7	4.9	10.5	10.5
	SD	1.14261	0.05323	1.3	1.2	3.0	3.0

[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 (5.33 dB HL).

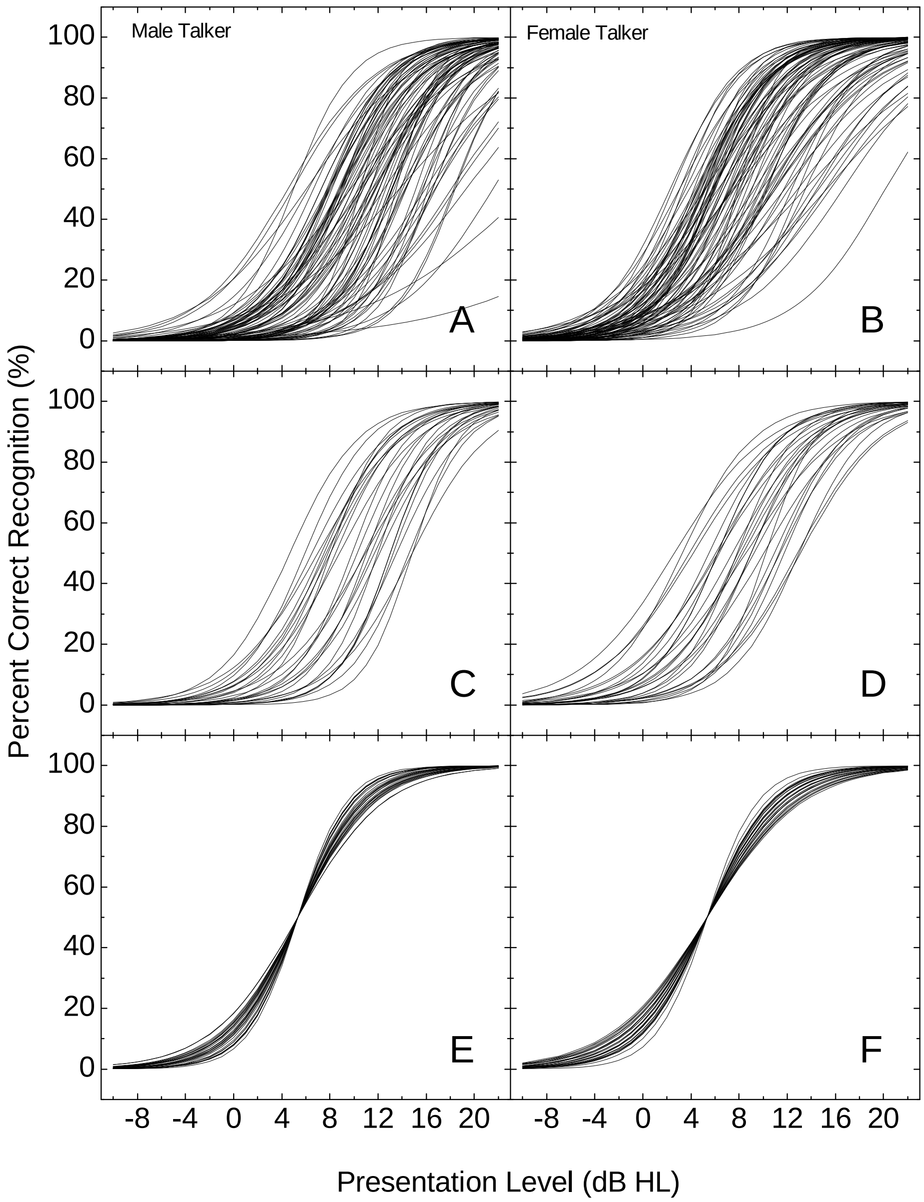

Figure 1.

Psychometric functions for Samoan trisyllabic 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 (5.33 dB HL) for the 20 normally hearing subjects.

slope of the psychometric performance-intensity functions for the selected words (C-D) when compared to the complete list of 90 words (A-B). Figure 2 (male talker) and Figure 3 (female talker) contain the psychometric performance-intensity functions for each of the 28 words with the logistic regression slopes and intercepts (see Table 4 and Table 5) implemented to fit the data. The composite psychometric performance-intensity functions for the selected words are shown in (C-D) of Figure 1. The psychometric performance-intensity function slopes for the 28 selected words, at 50% threshold, ranged from 7.0 %/dB to 12.4 %/dB ($M = 9.4$) for the recording by the male talker and from 6.3 %/dB to 11.9 %/dB ($M = 8.1$) for the recording by the female talker.

To decrease additional variability existing across the thresholds of the final 28 words, the intensity of each was digitally adjusted so that the 50% threshold of each word was equal to the mean PTA of the subjects (5.3 dB HL). The adjustments for each selected word for the male and female talker recordings are presented in Table 4 (male talker) and Table 5 (female talker). Panels E and F of Figure 1 show predicted psychometric performance-intensity functions for the selected words after adjusting intensity to equate 50% thresholds for the male talker (E) and female talker (F). The mean psychometric performance-intensity functions for the selected words (both male and female talkers) are shown in Figure 4, demonstrating a slightly steeper mean slope for the male talker recordings (9.4 %/dB) compared to the female talker recordings (8.1%/dB).

Discussion

The purpose of this study was to establish standardized SRT materials to be used in an audiometric evaluation of native speakers of the Samoan language. This was accomplished by recording, evaluating, and making a list of Samoan words that were found to be psychometrically

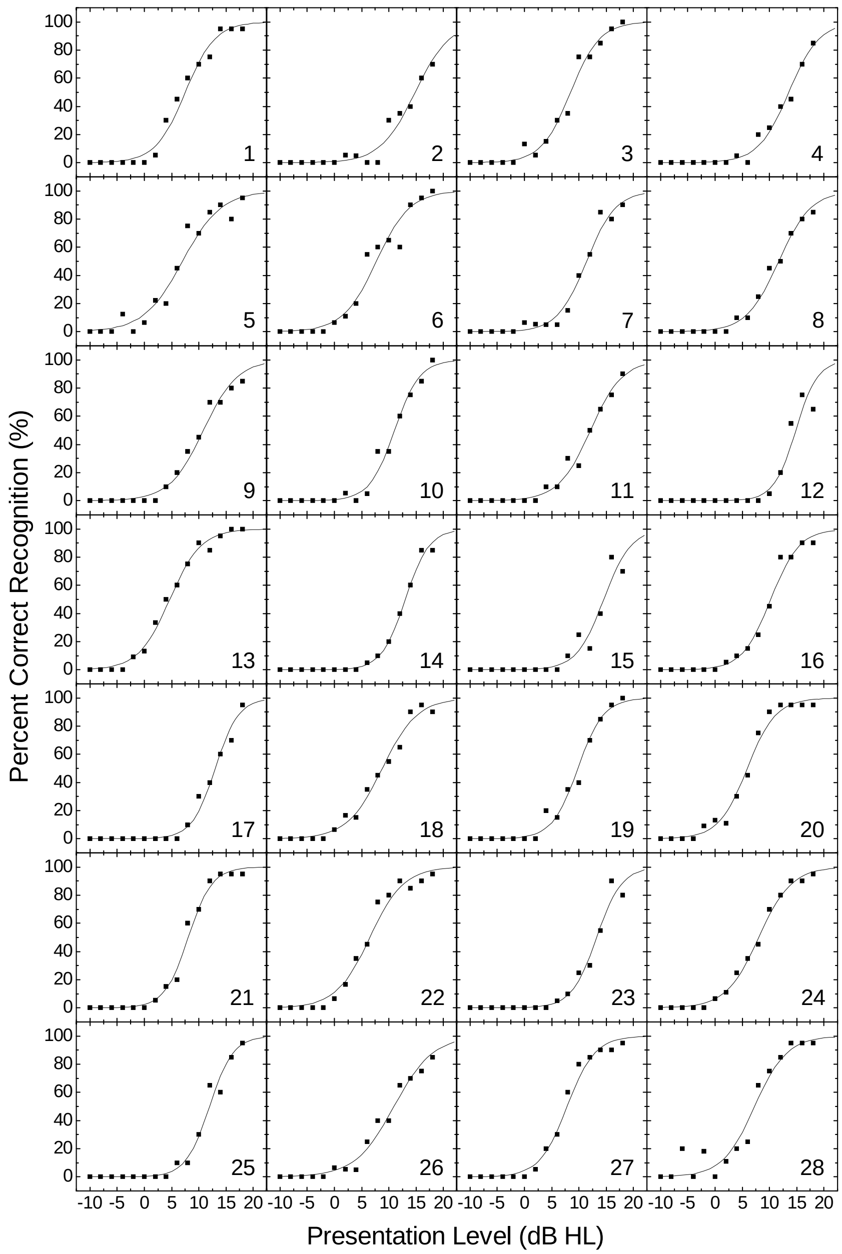

Figure 2.

Psychometric functions for the 28 selected unadjusted Samoan trisyllabic 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.

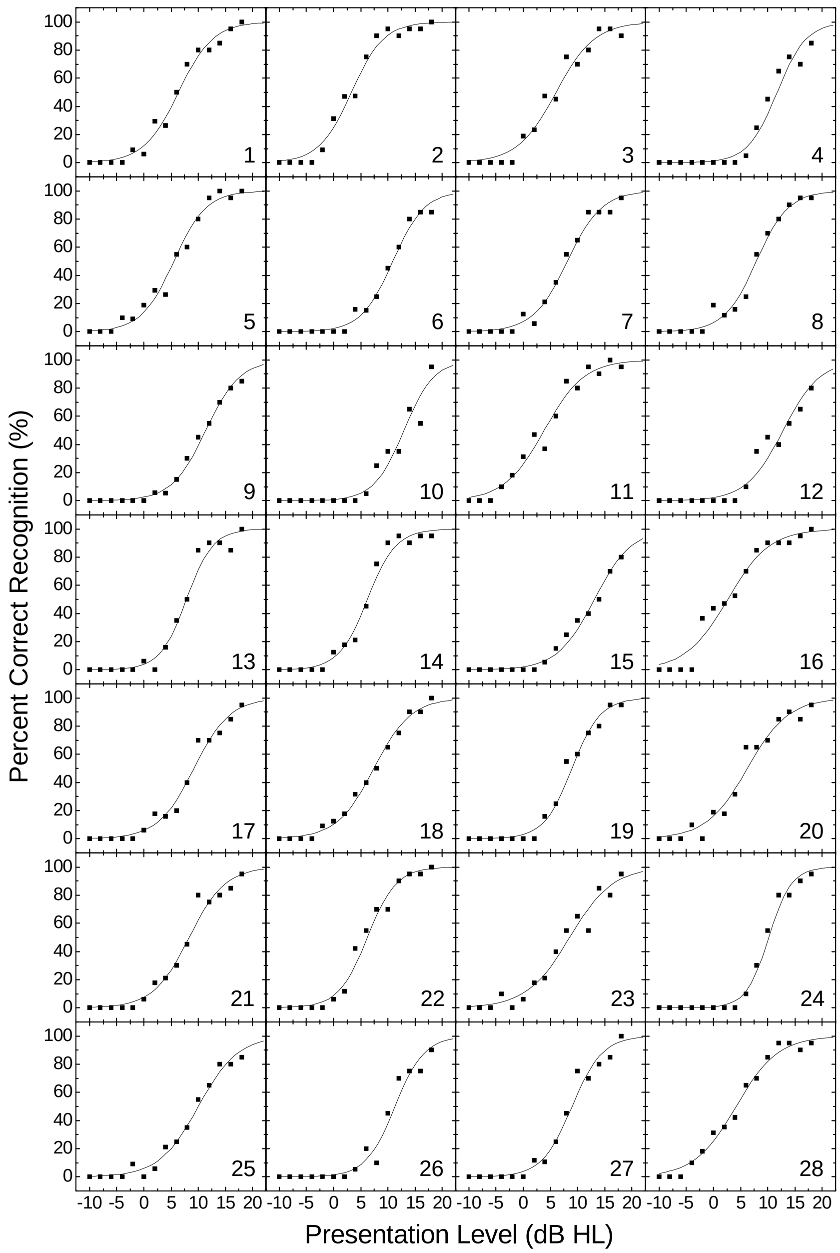

Figure 3.

Psychometric functions for the 28 selected unadjusted Samoan trisyllabic 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.

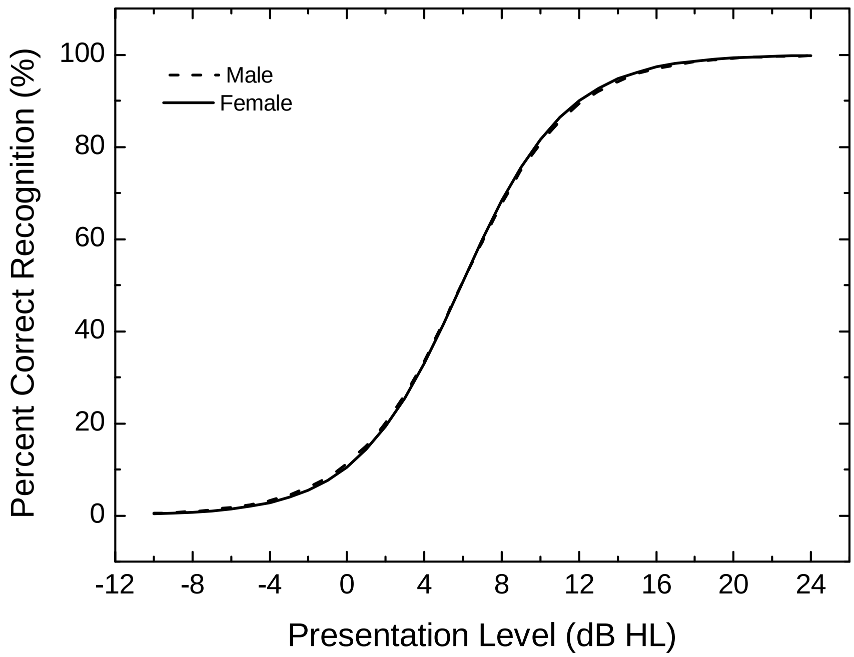

Figure 4.

Mean psychometric functions for 28 selected Samoan male and female talker trisyllabic words after intensity adjustment to equate 50% threshold performance to the mean PTA (5.33 dB HL) for the 20 normally hearing subjects.

equivalent. A final list of 28 words was determined to produce relatively homogeneous results in regard to audibility and psychometric performance-intensity function slope. These words were recorded in both female and male native Samoan voice onto a compact disc for distribution to audiologists worldwide.

Adjustments of intensity were made to the final 28 words to increase the homogeneity of audibility threshold and psychometric performance-intensity function slope. This increase of homogeneity can be seen in the slopes present in Figure 1. The mean slopes from 20 to 80% for the psychometric performance-intensity functions of the 28 trisyllabic words ranged from 6.0%/dB to 10.7%/dB (*M* = 8.1) for the male talker and 5.4%/dB to 10.3%/dB (*M* = 7.0) for the female talker. SRT materials in English have reported mean slopes for spondaic words between 7.2%/dB and 10%/dB (Hirsh et al., 1952; Hudgins et al., 1947). Materials created in other languages have also yielded similar mean slopes from 20 to 80% for the trisyllabic psychometric performance-intensity functions for both the male and female talkers (Harris, Goffi, Pedalini, Gygi et al., 2001; Nissen et al., 2005a). For example, the mean slopes for Portuguese SRT materials were 9.1 %/dB for a male talker and 8.8 %/dB for a female talker (Harris, Goffi, Pedalini, Gygi et al., 2001) and 9.7%/dB and 10.5%/dB for a male and female talker respectively of Mandarin Chinese (Nissen et al., 2005b). Mean slopes as high as 12%/dB have been reported by other studies (Beattie, Edgerton, & Svihovec, 1975; Ramkissoon, 2001).

The mean slopes for this project are slightly lower than those reported in recent studies of similar methodology. A reason for this is unclear and warrants for continued investigation. It can be assumed that a direct relationship exists between perception and the phonological characteristics of a language. Hoopingarner (2004) states that vowel perception is greatly influenced by context. Since the words evaluated in this study were presented in isolation, without contextual cues, the vocalic nature of the Samoan language may have been a contributing factor to the participants' performance. The vocalic density of the language may not have provided the same phonemic information as consonant rich trisyllabic words in other languages. The decreased slopes may also have been influenced by the limited number of consonants in Samoan, which reduces the amount of phonemic dissimilarity within the language. Words for this study were chosen based on number of syllables but future studies may choose words according to another characteristic, such as number of phonemes or consonant to vowel ratio.

The process of standardizing SRT materials involves carefully identifying, recording, and evaluating the words to be used in testing. There are many benefits to this standardization process. By following strict procedures for calibrating, recording, and testing the materials, the developers can ensure that the materials will produce an accurate and valid test measure to be included in a hearing test battery. Standardized materials also allow for clinical information to be shared without losing the validity of the measured results (Tucci et al., 1980). Digitally recording the standardized materials on to compact discs allows for easy distribution to areas of need as well as efficiency and efficacy in testing.

Development of speech audiometry materials in languages other than English is an important advancement in the field of audiology. Since no other standardized materials are known to exist in the Samoan language, the levels of validity and reliability for the SRT materials created in this study are unknown. For instance, additional research would need to be conducted to establish the test-retest reliability of the selected stimuli chosen in this study (Ostergard, 1983). For the establishment of test-retest reliability, the stimuli would need to be repeat tested and yield highly correlated results with no significant differences between the two test sessions (Gelfand, 1998).

Another important factor to consider for future research is bilingual versus monolingual speakers of Samoan. In this study, all participants were bilingual or multilingual, speaking minimally Samoan and English. Whether or not bilingualism has a significant effect on speech perception of the native language is unknown (von Hapsburg & Pena, 2002). Von Hapsburg and Pena (2002) suggest that future research be done regarding this concern and also regarding control for length of time for second language acquisition, learned language skills (reading, writing, speaking, etc.), and language pragmatics. If future research in this area does conclude that bilingualism has a significant impact on speech perception of the native language than this study would need to be repeated, controlling for bilingualism or using monolingual Samoan participants.

Future research may also establish validity of the test materials on participants with normal hearing as well as those with hearing impairment. This would allow for a more valid statement of the test materials allowing a measure to distinguish normal hearing from a hearing impairment (Ostergard, 1983). Testing materials on individuals with normal hearing when the test is intended to be used on individuals with hearing impairments can compromise the validity of its results. One such study found that materials established to be homogeneous for a population of normal hearing individuals did not demonstrate homogeneous results when tested on a population of individuals with sensorineural hearing impairments. The study yielded significantly variable results (McArdle & Wilson, 2006). Since the SRT materials created in this study are intended for testing the hearing of hearing impaired individuals, future research should test the materials on the intended population of hearing impaired native Samoan individuals.

The results of the present studied produced measures of better performance for the male talker recordings as compared to the female talker recordings. The cause of this difference is unknown and warrants future study. It is suggested that the difference in performance may be due to the rate of speech or harmonic differences between male and female voices or the recording and/or editing of the male and female voice recordings for this project. Future studies can investigate whether the gender of the talker affects SRT measures in Samoan.

In any remediation program early intervention is important. When it comes to hearing impairments, it is critical that children be identified quickly and begin receiving appropriate services as soon as possible. Considering the effectiveness of evaluation and treatment, using materials created for an adult population may inadequately reflect the child's receptive and expressive language abilities. Future research should address the need for standardized Samoan speech materials with stimuli appropriate for a child population. It is important to consider chronological age and language exposure when testing children to ensure that the test results are an accurate measure of hearing ability rather than a conflicting influence of language knowledge or ability. Alternate test stimuli may be necessary when considering the language skills and vocabulary of children (Jerger, Jerger, & Abrams, 1983; Meyer & Pisoni, 1999).

Additionally, receptive language skills in young children often exceed their expressive abilities. Thus, alternate non-verbal means of responding for SRT testing should be considered when evaluating young children (Diefendorf, 1983). The use of non-verbal responses also allows for a non-native speaker of the test stimuli to administer and score the test. Tests utilizing picture identification as the response mode have been created for pediatric testing in the Spanish language and have already been established for reliability (Comstock & Martin, 1984; Martin & Hart, 1978). Until appropriate materials are developed for the pediatric population, adult materials can be administered to children, following a set of pediatric norms which are established (Palva & Jokinen, 1975).

In summary, this study resulted in the digital recording of 28 trisyllabic words by both a female and male talker in the Samoan language for SRT testing in a speech audiometry evaluation. Each word was relatively homogeneous in regard to audibility and slope of psychometric performance-intensity function. Additionally, intensity adjustments were made to each word to decrease threshold variability among the 28 words. The 28 trisyllabic words are available on a compact disc to be used in clinical settings worldwide.

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Appendix A

Informed Consent

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. Lane Fischer, Chair of the Institutional Review Board, 340-L MCKB, Brigham Young University, Provo, UT 84602; phone (801) 422-8293, email: lane_fischer@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

Appendix B

Samoan Trisyllabic Word Definitions

1	'a'ano	noun	flesh, kernel, meat, gist, essence, heart; of words, speech etc, be full of substance, have a bite
2	'aemaise	particle	especially
3	'ailoga	adjective	(general phrase): it is doubtful, it is unlikely
4	'aulotu	noun	congregation
5	'avatu	verb	give (to person spoken to), take, help oneself to
6	'oloa	noun	goods, trade goods, riches, fortune, wealth
7	agāga	noun	soul, spirit
8	alofa	noun	love, affection, mercy, grace
9	aoauli	noun	midday, noon
10	ātoa	adjective	complete, all present.
11	ātonu	general phrase	perhaps, maybe, it is likely that
12	atua	noun	God, god (heathen)
13	fa'atau	verb	purchase, provoke, incite to fight, hold a debate who will be speaker
14	fafine	noun	woman
15	fāgota	verb; noun	fish; fishing
16	faigatā	verb, adjective	hard, difficult, critical dangerous
17	faipule	noun	authority, power, government
18	fanua	noun	land, field
19	fausia	verb	(perfective): make, construct
20	fīlēmū	verb; noun	be quiet, calm, mild, gentle, harmless; peace, silence
21	fofoga	noun, verb	face (or any other part of the face) (polite term), speak, talk
22	fōliga	verb; noun	appear, take after, resemble; appearance, expression, features (of face)
23	gagana	noun, verb	language, remark, comment
24	iloa	verb, noun	see spot, notice, recognize, know, be aware of, knowledge
25	kalapu	noun	club (as in a social or nightclub)
26	komiti	noun	committee
27	lagona	verb	feel, perceive, scent, suspect, be conscious, aware of (sentiment, feeling)
28	lāpisi	noun	rubbish
29	līpoti	noun	report
30	loloto	verb	deep
31	māe'a	verb	finished, complete, through
32	māfua	verb	originate from , caused by
33	māketi	noun	market
34	malie	noun; verb	general name for sharks;
35	mālosi	adjective	strong
36	mamafa	verb, noun	heavy, weighty, weight
37	manatu	verb	think, feel (thought, consideration, idea, suggestion, advice, considered)
38	manino	verb	transparent, limpid, clear, obvious
39	manu'a	noun, verb	wound, wounded, group of islands in Samoa
40	masini	noun	machine
41	matagi	noun	wind
42	mativa	verb; noun	(be) poor; poverty, lack, want
43	matua	verb; noun	mature (not ripe), adult, grown-up, older, elder, old, dense, thick, master builder; be loyal, owe allegiance (root, core of a sermon, speech)
44	maulalo	verb	(be) low, deep, humble, down
45	mīnute	noun	minute

46	molimau	noun; verb	witness, evidence; bear witness
47	mūsika	noun	music
48	nūmera	verb; noun	be numbered (in a series); arithmetic, sum
49	ōlaga	noun	life, existence
50	palolo	noun	kind of sea-annelid (Eunice sp) the preproductive segments of which appear annually at a certain period of the moon. They are collected for food.
51	papa'e	adjective	white, pale light, colored
52	pasene	noun	percent
53	pūlea	verb	govern, control
54	sāmoa	noun	Samoa
55	sāuniga	noun	church service, ceremony, arrangement, layout
56	sēleni	noun	shilling, quarter
57	setema	noun	September
58	soso'o	verb, noun	join, connect, be joined, be next to, adjoin, follow, succession
59	suafa	noun	name, title (term of respect)
60	suiga	noun	change
61	susuga	noun	style of address or reference: your honor (suitable for a chief)
62	tagata	noun	person
63	talavou	verb	(be) young, rising
64	tālofa	verb	interjection, general phrase: expression indicating pity or sympathy; form of general greeting
65	tamaiti	noun	(plural of tamaitiiti) child (not offspring), childhood
66	tapa'a	noun	tobacco plant, tobacco
67	tatala	verb	open, take off, undo
68	tatalo	verb, noun	pray, prayer
69	taugatā	verb, adjective	expensive, dear
70	taulaga	noun	offering, sacrifice, downtown
71	tāumafa	verb	eat
72	taunu'u	verb	reach one's destination, arrive, land, (of hope) come true, materialize
73	tausaga	noun	year, seasonal (yearly) crop of yams, (pl.) be so many years old
74	tausiga	noun	care, maintenance
75	tautua	noun; verb	service, serve, stone adze, tool; come late, arrive late
76	tete'e	verb	repulse, push back, reject, deny, object to, oppose to, resist (opposition, objection)
77	tiute	noun, verb	task, duty, customs duty, customs, be on duty
78	tofiga	noun	calling, profession, occupation
79	tomai	noun	skill
80	toto'a	verb, noun	(be) calm, steady, be too thick, too strong, calm
81	totogi	verb, noun	pay, contribute, donate, wages, pay, salary
82	totonu	adverb (locative), noun	inside, within, amoung, in the midst of, interior
83	tūla'i	verb	stand up, get up on one's feet
84	tūlaga	noun	position, location, status, rank, situation, state of affairs, platform, stage, mark, print, stepping notches cut into a tree
85	tūsia	verb	(perfective): point, draw, write, (letter, book, [pl] ledgers, pig reserved for a special purpose, register, resignation)
86	vāega	noun	section, division, part.
87	vaiaso	noun	week
88	vailā'au	noun	medicine, drugs, disinfectant, deodorant
89	vala'au	verb	call (animals or people at a distance), invite, invitation
90	vasega	noun	class, grade level