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Psychometrically Equivalent Monosyllabic Words for Word Recognition Testing in Mongolian.

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PSYCHOMETRICALLY EQUIVALENT MONOSYLLABIC WORDS FOR WORD RECOGNITION TESTING IN MONGOLIAN

by

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ABSTRACT

PSYCHOMETRICALLY EQUIVALENT MONOSYLLABIC WORDS FOR WORD RECOGNITION TESTING IN MONGOLIAN

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The purpose of this study was to record a set of Mongolian monosyllabic word lists that could be used to obtain a word recognition score. A word list was developed of 190 frequently used monosyllabic words which had been selected by a group of raters. Native male and female Mongolian talkers were utilized to make digital recordings. The 190 words were divided into 10 lists of 19 words. The lists were presented to 20 normally hearing subjects at 10 different intensity levels ranging from -5 to 40 dB HL in 5 dB increments. An S-curve distribution was used to divide the words among three lists based upon the results of the word recognition testing. Word lists were assembled formulating 3 lists of 50 words and 6 half-lists of 25 words using an S-curve distribution. Logistic regression was used to calculate the psychometric functions for each list. The mean psychometric function slopes for the male and female word lists were 6.19%/dB and

5.17%/dB respectively. The 50% threshold was 14.47 dB HL for the final adjusted male and female lists.

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Introduction

The first visit to the audiologist is often the result of a person's difficulty hearing speech. Since a hearing impairment affects perception of speech, which is the primary mode of communication for many individuals, hearing tests need to be performed using speech stimuli (Brandy, 2002). The affects of hearing and actively interacting in society are highly intertwined (Hagerman, 1993). Speech is needed in order to transfer ideas and concepts from one individual to another; however, before the person can receive the auditory signal the speech mechanism and auditory system need to be functioning properly. During an audiological examination a pure-tone audiogram can be obtained to find hearing thresholds. The pure-tone examination does not easily relate to an individual's ability to understand speech (Egan, 1979). Therefore, in order to find out an individual's ability to understand speech, the person needs to be tested using speech stimuli (Gelfand, 2001).

Audiologic evaluations are needed to determine an individual's hearing abilities. The tests in a routine audiological evaluation are pure-tone testing which include air-conduction and bone conduction testing, speech stimuli testing including speech reception testing and word recognition scores, tympanometry, and acoustic reflex testing. The pure-tone examination is often used for testing hearing since it is considered to be reliable, valid, and a simple process. The pure-tone evaluation determines an individual's hearing threshold for sinusoids presented at specific intensity levels. Threshold is considered the lowest level of the stimulus where an individual can hear a tone at least 50% of the time. Testing can be performed with the use of air-conduction measurements beginning at 250 Hz and through subsequent octaves up to 8000 Hz, mid-octaves can also be used in certain circumstances. Bone-conduction testing is another form of testing involving the placement of a bone-conduction vibrator on the mastoid process or forehead. Bone-conduction testing presents stimulus at octaves from 250 Hz through 4000 Hz (ASHA, 1978).

A pure-tone audiometric examination provides information about the hearing mechanism; it does not indicate an individual’s ability to understand speech which is an essential element of their ability to interact within a family, community and a society in general. Since individuals do not communicate through a series of tones but through speech then the auditory system must be suitable for processing speech in order for people to interact with one another (Brandy, 2002).

Speech needs to be heard, but at the same time speech needs to be comprehended and used within an individual’s social interactions. Pure-tone audiological evaluations are designed for identification of hearing sensitivity using quick and efficient procedures (ASHA, 1985). In comparison, more time and effort are needed to perform a speech audiometric evaluation in relation to that of a pure-tone evaluation. Speech audiometry can provide information about an individual’s hearing abilities using a speech stimuli. A more appropriate form of testing of an individual’s ability to comprehend speech is through the use of speech audiometry (ASHA, 1977).

Audiologists understand the necessity of performing speech audiometry as part of a comprehensive examination, currently about 99% of audiologists use speech audiometry as part of a routine examination (Martin, Armstrong, & Champlin, 1994). Many individuals that have a hearing impairment have difficulty understanding speech, a possible explanation would be that many of the consonants produced in speech are attenuated due to high frequency hearing impairment (Bess & Townsend, 1977). In order for an audiologist to help individuals with a hearing impairment communicate more effectively, then appropriate hearing aids need to be selected. Speech audiometry can assist in determining hearing aid candidacy and improvement in communication abilities while wearing hearing aids. Speech audiometric testing also has been found to be beneficial in diagnosing peripheral and central auditory disorders (Hagerman, 1984; Harris & Reitz, 1985).

Materials for performing speech audiological tests in the Mongolian language are limited. Thus, the main purpose of the current research study is to develop, digitally record, and evaluate speech audiometry material in the Mongolian language that can be used to test word recognition scores (WRS). A native male and female Mongolian were selected as talkers for the digital recordings. The word lists and recordings to be produced will be available for audiologists to test word recognition scores in the Mongolian language.

Review of Literature

History of Speech Audiometry

During initial testing of speech perception, before instrumentation and materials were standardized, there was only the use of informal measures to help guide professionals in making predictions about the person's hearing of speech. Speech testing was often performed by having someone speaking and whispering at set distances in relation to the listener (ASHA, 1988). There was a need to quantify the measure of hearing to add precision to the gross estimates that were being collected. Better precision was obtained with the development of the Western Electric 4A test which was used to determine hearing for speech using a phonographic record. The phonographic record allowed for presentation of spoken numbers to the patient at a consistent intensity level (ASHA, 1988; Fletcher & Steinberg, 1930).

Numerous speech audiometry tests were developed during and shortly after World War II. Increased intelligibility was of great concern during war time due to the need for various types of military communications. The Psycho-Acoustic Laboratory (PAL) at Harvard University developed 20 lists, known as the PAL PB-50, each list contained 50 phonetically balanced monosyllabic words to test intelligibility (Egan, 1948). Further, the word lists developed contained words that did not present cues as to the word type, such as is found in conversation. At the same time, the PAL PB-50 were not lists of words that were considered to be nonsense syllables, but were words that were commonly used in the English language (Carhart, 1965). The PAL PB-50 lists allowed for speech audiometry testing using word lists to appropriately test the individual's comprehension of speech. Further tests such as the PAL Auditory Test No. 9 and 12 were also tests developed to assess the speech reception threshold using spondaic words and sentences respectively. These sentences and spondaic words were recorded on phonograph records and made available to the military and public (Hirsh et al., 1952).

The PAL Auditory Test No. 9 was eventually improved upon by having the spondaic words presented at descending levels and recorded on magnetic tapes; the changes resulted in Central Institute for the Deaf Auditory Test W-2 (Hirsh et al., 1952). Also, PAL Auditory Test No. 14 was recorded as a version called CID Auditory Test W-1. The CID Auditory Test W-1 contained spondaic words presented at a consistent level compared to the CID Auditory Test W-2 which contained spondaic words presented at descending levels (Hirsh et al., 1952). The CID Auditory Test W-1 is composed of 36 spondaic words that were considered familiar to English speakers. The words that were included in the CID Auditory Test W-1 are frequently occurring in the English language and were familiar to English American speakers (Ramkissoon, Proctor, Lansing, & Bilger, 2002). The CID auditory Tests W-1 and W-2 were created at the Central Institute for the Deaf, and were modifications of the PAL Auditory tests.

The CID also developed monosyllabic word lists, producing four lists of 50 words each. These phonetically balanced lists were referred to as CID Auditory Test W-22 (Hirsh et al., 1952). These lists were composed of familiar words, typically understood by the typical American English speaker, and could be used for WRS testing (Egan, 1948).

Methods of Presentation

A speech audiology examination includes the use of speech recognition threshold and WRS (Aleksandrovsky, McCullough, & Wilson, 1998). For English the speech recognition threshold (SRT) is the lowest level at which an individual can correctly identify 50% of spondaic words. There are three main purposes of SRT testing according to the research by Hagerman (1979). These purposes are to confirm the pure-tone audiogram, to evaluate the need for audiological testing for insurance purposes, and to calculate the social impact that the hearing disability has on the individual (Hagerman, 1979). Like SRT testing, the WRS is effective for fulfilling these three principles. Thus, the main focus of the current research study is contained within the development of word recognition testing.

According to the ASHA (1988) standards, the word recognition score (WRS) establishes the suprathreshold level at which an individual is able to understand and repeat a list of words. The WRS is also known as speech discrimination score or the speech identification score. In essence, the WRS determines speech comprehension by presenting a list of words loud enough to overcome any hearing impairment (Epstein, 1978).

McCullough and Wilson (2001) describe a method of testing for the WRS when working with an individual who is a speaker of a foreign language. The foreign language speaking individual distinguishes between a target word and three rhyming words or a closed-set response list. The auditory stimulus was presented through a previously recorded computer simulated word list. The language barrier was controlled by having the audiologist score the picture selection made by the patient instead of having the audiologist determine if the oral response was accurate (McCullough & Wilson, 2001). The presentation of the material needed to be controlled by having the word lists either read aloud directly by an audiologist, an interpreter, or presented by a recording. When the word list was presented in an unfamiliar language, the word stimulus was similar to the presentation of a nonsense word, thus making the task more difficult for the listener.

Research by Arkebauer, Mencher, and McCall (1971) incorporated the use of the WRS for testing of amplification for individuals with a bilateral sensorineural hearing impairment. By occluding the poorer ear, the scores obtained from the WRS testing helped to determine if there was an improvement or not with amplification. When comparing hearing using both ears to that of the occlusion of the poorer ear; it was found that the word recognition score improved 2-18%. Overall, Arkebauer et al. found that when the pure-tone averages between the two ears yields the largest difference, the largest improvement in word recognition testing was obtained by occluding the poorer ear (Arkebauer, Mencher, & McCall, 1971). Studies such as these would not have been possible without the use of word recognition testing.

Criterion Affecting Performance of Speech Audiometry Materials

Word recognition lists are sometimes created using phonetically balanced monosyllabic words. A phonetically balanced list is one in which the occurrence or frequency of the phonemes approximate the language from which the phonemes are derived; in many occasions the syllables contain a consonant-vowel-consonant formation (Brandy, 2002). A list of words that has true phonetic balance is difficult to construct and often unachievable by researchers. The difficulty of obtaining a truly balanced word list and the possibility that a phonetically balanced word list is not needed for a word recognition list has been an area of focus. In particular, a study performed by Martin, Champlin, and Perez (2000) was used to assess the possibility of not using a phonetically balanced word list. Within the study eight different word lists were composed, half with phonetically balanced words from the Northwestern University Test No. 6 (NU-6) and the other half with randomly selected words from a dictionary (Tillman & Carhart, 1966). The results of the study did not find a difference among lists when used clinically to obtain a psychometric function (Martin, Champlin, & Perez, 2000). Martin et al. helped formulate the current belief that phonetically balanced word lists will not affect the WRS since the results of the study found the same scores with and without the use of phonetically balanced lists (Aleksandrovsky et al., 1998).

The word lists used for measuring the hearing loss of an individual need to be restricted on the type of vocabulary in order to improve word familiarity within audiological testing (Hirsh et al., 1952). The words that have the highest frequency of occurrence within a language allows for increased familiarity with the patient. Further increases in word familiarity can be obtained when the word lists are composed of a representative sample of English sounds produced regularly in speech (Ramkissoon et al., 2002). Thus, increasing word familiarity allows for ease in testing the client's audiological abilities. When the speech stimuli are not familiar to the listener, there is the possibility of having errors as the result of testing. The errors can occur when the listener is required to interpret a non-familiar language or when they are required to repeat the language. This causes difficulties in scoring, since errors could either be scored as incorrect due to a hearing impairment or incorrect due to phonological errors (McCullough, Wilson, Birck, & Anderson, 1994).

Comstock and Martin (1984) further established that the word lists used for word recognition testing are often altered for differing groups of individuals. Children, for example, need to be evaluated using a list of words composed of vocabulary appropriate for their age. The use of pictures has also been incorporated within the words lists to help maintain attention. With the use of a specially developed word list, children were able to be tested more effectively; with adults the word lists can be modified to improve testing for non-native speaking individuals. Lists that have the appropriate linguistic features improve familiarity which will help improve the listener's ability to discriminate among words (Comstock & Martin, 1984).

Many of the people in the world today do not have speech audiometry materials developed in their native language. Research efforts have begun to develop speech audiology materials in many different languages. Languages such as Polish (Harris, Nielson, McPherson, & Skarzynski, 2004), Russian (Harris et al., 2007), Mandarin

(Nissen, Harris, Jennings, Eggett, & Buck, 2005a, 2005b), and others have already been developed. However, speech audiometry materials are lacking in many languages such as Mongolian. Therefore there is a need for research to further develop speech audiometry materials in all languages to ensure that everyone is receiving the testing that they need.

Recorded Versus Live Voice Presentation of the Material

There are two different presentation modes available for presentation of stimuli during an audiological assessment. These include either recorded method of presentation or live voice presentation of materials (ASHA, 1988). Even though either method can be used, the preferred method is to utilize recorded materials. The main reason pre-recorded materials are preferred by most audiologist is because of the reduced variability even after multiple audiological examinations (ASHA, 1988). A word list is presented to the listener with improved consistency and precision when recorded speech materials are used, as compared to live voice presentation (Carhart, 1965). Also, the process for presentation of words is standardized and consistent across patients, audiological testing, and examination when recorded materials are used.

Live voice presentation is at times useful when working with some difficult to test patients who will require additional time to respond to stimuli. Live voice presentation offers greater flexibility when presenting the words to the patient, allowing for more time to respond to a stimulus. Therefore, live voice presentation does have clinical usefulness, but does not allow for consistency in the presentation of the words across patients and situations, making this form of testing difficult to use consistently in a clinical setting (ASHA, 1988; Brandy, 1966).

While previous examination procedures used the phonograph and tape recordings, recorded material presented from a phonograph and tape recording is not ideal for continual testing of an individual's hearing. The signal can become distorted as an increased amount of noise is introduced to the recordings after multiple presentations to patients, thus compromising the results of the hearing test. The increased sound degradation reduces the validity and reliability of the hearing evaluation and render the results of the hearing evaluation inaccurate. Therefore, audiological testing has become more effective through the use of the compact disc which reduces sound degradation.

Further testing of hearing can be performed with the addition of masking noise during testing. With the addition of masking, while presenting speech audiological materials, representations of everyday situations can be emulated. According to a study by Beattie (1989) there are two main benefits of using masking noise during speech audiometry testing. These include increasing the sensitivity of the test allowing for increased ability to distinguish among hearing impairments and electroacoustic systems, and making test situations resemble what the patient will typically encounter outside of the sound booth (Beattie, 1989).

Characteristics of the Mongolian Language

The main dialect of the Mongolian Republic is Khalkha. The Khalkha dialect of the Mongolian language is spoken by about seven million people (Poppe, 1970). Approximately 2.5 million people are from the Mongolian People's Republic, 3.7 million are from the Inner Mongolian Autonomous Region of the People's Republic of China, and half a million from Buryat and Kalmyk Republic and elsewhere in Russia (Poppe, 1970). As Mongolians live in a variety of diverse areas, a wide range of dialects are observed. The differences that are observed among the dialects do not affect the vast majority of Mongolian speaking individuals, as they can converse intermittently with those of another dialect of the Mongolian language (Poppe, 1970). The Mongolian language is derived from *Uralic* and *Altaic* languages. The majority of individuals who speak the Mongolian language come from the Mongolian Republic, parts of China, Siberia, Kyrgyzstan, and parts of Russia (Bosson, 1964; Poppe, 1955, 1970; Sanders & Bat-Ireedui, 1999).

The Mongolian language forms a part of a group of languages termed the *Altaic* languages. The Altaic languages are found to have three main features in common. These include agglutination, a nominal feature of the verbs, and a common vocabulary. In particular, the Mongolian language is grammatically found to lack gender, consist of postpositions, contain vowel harmony to formulate sound productions, and use agglutinative word formation (Poppe, 1970).

The Mongolian language is considered to be agglutinative, meaning the language contains words with suffixes added to them. The suffixes help to build complex words from a simple root word. There are eight main cases used in the Mongolian language; these include nominative, genitive, dative, accusative, ablative, instrumental, comitative, and directional (Onorbayan, 1988; Poppe, 1970). Also, within the Altaic language, the verbs are nominal which means that the origin is from a noun.

The lingual positioning of the vowels used in the Mongolian language are classified as front and back vowels. Vowel harmony, found within the Mongolian language, is the placement of the vowels when restricted by rules affecting their position within a word. Within vowel harmony each vowel within close proximity to another vowel would be assimilated or have similar placement or production as the previous vowel; therefore presenting a harmony between the two sounds (Poppe, 1970). To further explain the placement of these vowels, consider the two different types of vowels as being pharyngeal and non-pharyngeal. These two groups together form a total of six vowels, plus the vowel /i/ which is considered neutral in placement. Each vowel can further be described as being either short or long in production. Short vowels are found in the middle and final positions of words; while the long vowels are only in the initial positions. In addition to the total seven vowels that are used there are also four different diphthongs which include /ui/, /ʊi/, /ɔi/, and /ai/ (Denwood, Franzé, Karlsson, Svantesson, & Tsendina, 2005). The total number of consonants is 28 (Poppe, 1970). The letters of the Mongolian Cyrillic script are taken from the Russian alphabet plus the letters ө and у (Sanders & Bat-Ireedui, 1999).

A modified Cyrillic alphabet is currently used to form the written language for Mongolia (Sanders & Bat-Ireedui, 1999). The original form of writing was the classical script which was adapted from the Uyghur form of writing in the year 1208 and continued to evolve into what was to become the Mongolian Script. The Mongolian script which is currently referred to the classical script was introduced under the reign of Genghis Khan. The classical Mongolian script was written vertically and contained 30 letters (Sanders & Bat-Ireedui, 1999). The classical Mongolian form of writing was replaced by the Latin alphabet for a short period. The Latin script was finally replaced by the current form of writing in the 1930s, the Cyrillic alphabet. Since over six million individuals speak and use the Mongolian language, audiological material produced in that language is a necessity.

Method

Participants

A total of 20 subjects (10 male and 10 female) participated in evaluating the Mongolian monosyllabic words. The individuals who participated in this study were native talkers of Mongolian, all originating from Mongolia. Only three subjects were not raised in the capital city of Ulaanbaatar. In addition, all participants self-reported speaking Mongolian as is commonly used in broadcast news media, and indicated that they have continued to speak Mongolian on a daily basis. All participants exhibited pure-tone air-conduction thresholds ≤ 15 dB HL at octave and mid-octave frequencies from 125 to 8000 Hz and static acoustic admittance between 0.3 and 1.4 mmhos with peak pressure between -10 and +50 daPa (ASHA, 1990; Roup, Wiley, Safady, & Stoppenbach, 1998). Summary statistics of the subject thresholds are presented in Table 1.

Materials

Words. Initially, a list of Mongolian monosyllabic words was selected from a word list of 10,000 most frequently used words from an electronic corpus of 5.7 million words (Scannell, 2007). This list was subsequently reviewed by three native talkers of Mongolian to ensure that the list was representative of familiar words in modern Mongolian. These words were then rated by three additional native judges on a scale of 1 to 5, based on how familiar a word would be to a native speaker of Mongolian (1 = extremely, 2 = very, 3 = average, 4 = seldom used, 5 = rarely used). Only words with an average familiarity rating of 1-2 were selected for recording, the majority of the words received a rating of 1. In addition, words that were judged by 20 university students to be culturally insensitive, considered to be unfamiliar, or thought to possibly represent

Table 1

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

Frequency (Hz)	*M*	*Minimum*	*Maximum*	*SD*
125	1.0	-10.0	10.0	5.8
250	-1.8	-10.0	10.0	5.4
500	-1.3	-10.0	5.0	4.8
750	0.3	-10.0	10.0	5.7
1000	1.0	-5.0	10.0	4.5
1500	2.5	-5.0	15.0	6.6
2000	2.0	-5.0	10.0	4.4
3000	1.0	-10.0	15.0	6.2
4000	0.5	-5.0	10.0	4.6
6000	-0.3	-10.0	15.0	5.7
8000	-0.5	-10.0	15.0	6.5
PTA[a]	0.6	-6.7	6.7	3.6

[a]PTA = arithmetic average of thresholds at 500, 1000, & 2000 Hz

inappropriate content by any of the judges were eliminated from the study prior to listener evaluation. From the original list, 190 monosyllabic words were selected for recording and evaluation in this study.

Talkers. Initial test recordings were made using eight native Mongolian-speaking individuals, four male and four female talkers. All talkers were from Mongolia, who self-reported speaking the Khalkha dialect of the Mongolian language. After the initial recordings were made, a panel of seven Mongolian judges (university students originating from Mongolia) evaluated the performance of each talker, rank ordering the talkers from best to worst based on vocal quality, Mongolian dialect, and pronunciation. The male and female talkers with the best vocal quality, Mongolian dialect, and pronunciation were selected as the talkers for all subsequent recordings.

Recordings. All recordings were made in a double-walled sound booth (77 cm x 119 cm x 111 cm) located on the Brigham Young University campus in Provo, Utah, USA which meets ANSI standards for maximum permissible ambient noise levels for the ears in uncovered conditions (American National Standards Institute, 1999). A Larson-Davis model 2541 microphone was utilized for all recordings. The microphone was positioned approximately 15 cm from the talker at a 0° azimuth and was covered by a 7.62 cm windscreen. The microphone was connected to a Larson-Davis model 900B microphone preamplifier, which was coupled to a Larson-Davis model 2200C preamplifier power supply. The signal was digitized using an Apogee AD-8000 24-bit 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, the talker was asked to pronounce each word at least four times with a slight pause between each production. Talkers were asked to speak at a natural rate with normal intonation patterns. To avoid possible list effects, the first and last repetition of each word were excluded from the study. Finally, a native judge (a university student from Ulaanbaatar) rated the medial repetitions of each word for perceived quality of production, and the best production of each word was then selected for inclusion in the Mongolian speech audiometry monosyllabic test words. Any word that was judged to be a poor recording (peak clipping, extraneous noise, etc.), mispronounced, or produced with an unnatural intonation pattern was rerecorded or eliminated from the study prior to listener evaluation.

After the word selection process, a Butterworth 10^{th} order high-pass filter with a 65 Hz cut-off frequency was used. Next, the intensity of each word to be included in the test material was evaluated and edited as a single utterance using Adobe Audition version 2.0 (Adobe Audition, 2005) to yield the same average RMS power as that of a 1000 Hz calibration tone in an attempt to equate test word audibility (Harris, Nielson et al., 2004; Wilson, 1994). Each of the individually recorded and edited words were then saved as a 24-bit *wav* file.

Procedure

Custom software was used to control randomization and timing of the presentation of the words from the 24-bit wav files to the external input of a Grason Stadler model 1761 audiometer. The stimuli were routed from the audiometer to the subject via a single TDH-50P headphone. All testing was carried out in a double-walled sound suite that met American National Standards Institute S3.1 standards for maximum permissible ambient noise levels for the ears not covered condition using one-third octave-bands (American National Standards Institute, 1999).

Prior to testing each subject, the external inputs to the audiometer were calibrated to 0 VU using a 1000 Hz calibration tone. The audiometer was calibrated prior to, weekly during, and at the conclusion of data collection. Audiometric calibration was performed in accordance with American National Standards Institute S3.6 specification (American National Standards Institute, 2004). No changes in calibration were necessary throughout the course of data collection.

The subjects were not familiarized with the monosyllabic words prior to testing. The 190 monosyllabic words were randomly grouped into ten lists of 19 words each. These ten lists were presented to the first ten participants. The 190 words were then randomly regrouped in ten different lists for presentation to the next group of ten participants. Ten presentation levels were selected for evaluation of the lists: -5 to 40 dB HL in 5 dB increments. One list was presented at each intensity level. The order of presentation of the lists and the order of the words within the list were randomized for each subject. Each word was presented an equal number of times at each intensity level across the entire participant population. Each verbal response had to match the presented stimuli in both lexical tone and pronunciation across both syllables to be scored as correct. Prior to the administration of the word recognition test, each participant was given the following instructions in English:

> You will hear monosyllabic words at several different loudness levels. At the very soft levels it may be difficult for you to hear the words. Please listen carefully and repeat the words you hear. If you are unsure of the word, you are encouraged to

guess. If you have no guess, please remain quiet until the next word is presented.

Do you have any questions?

Results

The results of the listener evaluations were analyzed using descriptive and inferential statistical methods. From the results of the word recognition testing, the 190 words were rank-ordered according to audibility across all intensity levels. The 40 lowest ranked words from each list were removed and the 150 words with the highest rate of listener identification were then divided into three balanced lists of 50 words using an S-curve distribution pattern. The S-curve distribution was performed by randomly placing each of the first three words from the list of 150 ranked order words into one of the three randomly selected lists and then proceeding in reverse order for the next three words. The following three words will begin the process again. The process continues until each list contains 50 words for both the male and female talkers. The three Mongolian monosyllabic word lists are presented in Tables 2 (male) and 3 (female). Tables 2 and 3 present the lists in character (Cyrillic) form and Table 4 and 5 present the equivalent lists in Romanization.

Following the creation of three equally balanced word lists, six more half-lists were made, each with 25 words per list. Half-lists were formed from the full lists previously mentioned. Within the full lists, the first words were placed in rank order by S-curve distribution pattern in order to assign either an A or B to the word. The following word on the half-list would then receive the remaining letter, not previously used. The random assignment ensured that appropriate counterbalancing occurred for all words. The Cyrillic forms of the three half-lists for both the male and female Mongolian talkers

Table 2

Mongolian Male Monosyllabic Lists (Cyrillic) in Rank Order from Most Difficult to Easiest

List 1		List 2		List 3	
бут	үүл	дур	сайн	мөр	хөө
шуур	үс	явц	сар	тэнд	гэр
эрч	чиг	зээл	айл	нэгж	сүм
дунд	шог	шинэ	шүлс	лаа	ээж
урт	бод	ийм	үг	харь	таг
цай	тэд	тус	алс	шиг	зааг
он	арьс	тоос	уул	хүү	хямд
унд	суух	цаг	цонх	мэс	сүүл
та	гол	уг	шүд	төв	шид
цол	жил	яг	юм	дуу	хар
зун	ганц	ам	цус	өмд	оч
өвс	хань	мэнд	зүүд	шил	хөрш
сэр	айх	ус	аав	ах	гал
доош	уух	бэр	хад	тоо	нар
мөч	мөс	цог	мал	цуг	хийх
хий	байр	дарс	зам	дээш	алт
зүс	гар	амт	маш	өөр	ном
бие	мах	эм	хүн	муу	сул
зар	хөл	завь	зул	бор	товч
сууц	зах	ор	хөөх	даах	хэл
эгч	сур	эмч	хөх	зай	хүч
харц	хурц	муур	түүх	хур	ааш
од	хог	уур	морь	ой	хонь
оймс	цас	тод	яс	хоол	шал
улс	шат	жимс	багш	хот	ач

Table 3

Mongolian Female Monosyllabic Lists (Cyrillic) in Rank Order from Most Difficult to Easiest

List 1		List 2		List 3	
лаа	эмч	зул	суух	маань	буух
сул	сар	үүд	эрч	наана	чиг
дур	мөч	муур	бор	бэр	уур
шинэ	хөөх	уг	аав	ам	сур
гай	нар	мэс	энх	мэнд	тус
бат	хур	харь	эгч	эм	яс
урт	хий	тод	түүх	бөөн	дарс
сууц	шог	дээш	дуу	сайн	хямд
муу	ор	хөө	шүлс	бүс	хонь
онц	үг	оймс	ах	нэгж	шат
зүүд	хийх	ус	мөр	тоос	ач
үүр	амт	товч	байр	дүү	үс
өмд	зам	ийм	зай	бут	ном
доод	хүү	хос	ой	явц	шал
шил	мөс	заан	зар	даах	уух
хар	жил	зуур	гал	жимс	цус
бүл	хурц	од	хог	багш	доош
арьс	өвс	ганц	шүд	харц	нуур
гуйх	гар	шид	доор	ээж	ааш
ав	цонх	цаг	хөл	завь	сүүл
уул	оч	яг	мал	бэх	өөр
бие	мах	айх	юм	зааг	хоол
зүс	хэл	сүм	хөх	алт	маш
цуг	үүл	зах	морь	зун	гол
дунд	хөрш	хад	хүн	шиг	хүч

Table 4

Mongolian Male Monosyllabic Lists (Romanized) in Rank Order from Most Difficult to Easiest

List 1		List 2		List 3	
but	üül	dur	sayn	mör	höö
shuur	üs	yavts	sar	tend	ger
erch	chig	dzeel	ayl	negj	süm
dund	shog	shine	shüls	laa	eej
urt	bod	iym	üg	harĭ	tag
tsay	ted	tus	als	shig	dzaag
on	arĭs	toos	uul	hüü	hyamd
und	suuh	tsag	tsonh	mes	süül
ta	gol	ug	shüd	töv	shid
tsol	jil	yag	yüm	duu	har
dzun	gants	am	tsus	ömd	och
övs	hanĭ	mend	dzüüd	shil	hörsh
ser	ayh	us	aav	ah	gal
doosh	uuh	ber	had	too	nar
möch	mös	tsog	mal	tsug	hiyh
hiy	bayr	dars	dzam	deesh	alt
dzüs	gar	amt	mash	öör	nom
biyö	mah	em	hün	muu	sul
dzar	höl	dzavĭ	dzul	bor	tovch
suuts	dzah	or	hööh	daah	hel
egch	sur	emch	höh	dzay	hüch
harts	hurts	muur	tüüh	hur	aash
od	hog	uur	morĭ	oy	honĭ
oyms	tsas	tod	yas	hool	shal
uls	shat	jims	bagsh	hot	ach

Table 5

Mongolian Female Monosyllabic Lists (Romanized) in Rank Order from Most Difficult to Easiest

List 1		List 2		List 3	
laa	emch	dzul	suuh	maanĭ	buuh
sul	sar	üüd	erch	naana	chig
dur	möch	muur	bor	ber	uur
shine	hööh	ug	aav	am	sur
gay	nar	mes	enh	mend	tus
bat	hur	harĭ	egch	em	yas
urt	hiy	tod	tüüh	böön	dars
suuts	shog	deesh	duu	sayn	hyamd
muu	or	höö	shüls	büs	honĭ
onts	üg	oyms	ah	negj	shat
dzüüd	hiyh	us	mör	toos	ach
üür	amt	tovch	bayr	düü	üs
ömd	dzam	iym	dzay	but	nom
dood	hüü	hos	oy	yavts	shal
shil	mös	dzaan	dzar	daah	uuh
har	jil	dzuur	gal	jims	tsus
bül	hurts	od	hog	bagsh	doosh
arĭs	övs	gants	shüd	harts	nuur
guyh	gar	shid	door	eej	aash
av	tsonh	tsag	höl	dzavĭ	süül
uul	och	yag	mal	beh	öör
biyö	mah	ayh	yüm	dzaag	hool
dzüs	hel	süm	höh	alt	mash
tsug	üül	dzah	morĭ	dzun	gol
dund	hörsh	had	hün	shig	hüch

are presented on Table 6 and 7. The Romanization of the three half-lists for both the male and female Mongolian talkers are presented on Table 8 and 9.

Following the creation of the monosyllabic lists and half-lists, for both male (Table 2 and 6) and female (Table 3 and 7) talkers, three lists and six half-lists were used to establish regression slopes and regression intercepts using logistic regression. Using a modified logistic regression equation (Equation 1) the regression slope and intercept values could calculate percentage of correct performance for any given intensity level. Psychometric functions could then be constructed from the percentage of correct values achieved from Equation 1.

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

Equation 1 breaks down as follows: P is percentage correct recognition, a is regression intercept, b is regression slope, and i is presentation intensity level in dB HL. With all necessary values inserted (a, b, and i) the percentage correct recognition (P) can be obtained. Using the lists and half-lists, percentage of correct word recognition was estimated using Equation 1 for intensity ranges of -5 to 40 dB HL using 5 dB increments. Using the estimated percentage of correct word recognition, psychometric functions were established.

The threshold (presentation intensity required for 50% word recognition performance), the slope at the threshold, and the slope from 20-80% were calculated for the monosyllabic word lists and half-lists by inserting specific proportions into Equation 2. Table 10 (male) and Table 11 (female) contain the logistic regression intercepts and slopes, the psychometric function slopes at 50% and 20-80% as derived

Table 6

Mongolian Male Monosyllabic Half-lists (Cyrillic) in Rank Order from Most Difficult to Easiest

1A	1B	2A	2B	3A	3B
шуур	бут	дур	явц	мөр	тэнд
эрч	цай	зээл	шинэ	шиг	нэгж
дунд	он	ийм	цаг	мэс	лаа
урт	унд	тус	уг	төв	харь
цол	та	тоос	яг	дуу	хүү
өвс	зун	ус	ам	шил	өмд
сэр	доош	бэр	мэнд	ах	цуг
зүс	мөч	цог	дарс	тоо	дээш
бие	хий	амт	эм	өөр	муу
сууц	зар	эмч	завь	бор	даах
эгч	харц	уур	ор	ой	зай
од	улс	жимс	муур	хоол	хур
оймс	үс	сайн	тод	хот	ээж
үүл	чиг	сар	айл	хөө	зааг
тэд	шог	алс	шүлс	гэр	хямд
суух	бод	уул	үг	сүм	сүүл
гол	арьс	цонх	шүд	таг	хар
хань	жил	цус	юм	шид	хөрш
айх	ганц	аав	зүүд	оч	гал
уух	мөс	хад	мал	алт	нар
мах	байр	зам	хүн	ном	хийх
хөл	гар	маш	зул	сул	товч
зах	сур	хөөх	хөх	хүч	хэл
хог	хурц	түүх	морь	хонь	ааш
шат	цас	яс	багш	шал	ач

Table 7

Mongolian Female Monosyllabic Half-lists (Cyrillic) in Rank Order from Most Difficult to Easiest

1A	1B	2A	2B	3A	3B
лаа	сул	зул	үүд	маань	наана
дур	шинэ	муур	уг	ам	бэр
урт	гай	мэс	тод	мэнд	эм
муу	бат	харь	дээш	сайн	бөөн
онц	сууц	оймс	хөө	бүс	тоос
зүүд	доод	товч	ус	нэгж	бут
үүр	шил	заан	ийм	дүү	даах
өмд	хар	зуур	хос	явц	жимс
гуйх	бүл	ганц	од	ээж	багш
ав	арьс	шид	яг	завь	харц
уул	бие	цаг	айх	алт	бэх
цуг	зүс	зах	сүм	зун	зааг
дунд	эмч	хад	эрч	шиг	буух
сар	хөөх	суух	бор	уур	чиг
мөч	нар	эгч	аав	сур	тус
хий	хур	дуу	энх	яс	дарс
шог	үг	шүлс	түүх	хонь	хямд
ор	хийх	ах	мөр	үс	шат
амт	хүү	зар	байр	ном	ач
зам	мөс	гал	зай	шал	уух
өвс	жил	шүд	ой	цус	доош
оч	хурц	доор	хог	нуур	ааш
мах	гар	мал	хөл	сүүл	хоол
хэл	цонх	юм	хөх	өөр	маш
үүл	хөрш	морь	хүн	хүч	гол

Table 8

Mongolian Male Monosyllabic Half-lists (Romanized) in Rank Order from Most Difficult to Easiest

1A	1B	2A	2B	3A	3B
shuur	but	dur	yavts	mör	tend
erch	tsay	dzeel	shine	shig	negj
dund	on	iym	tsag	mes	laa
urt	und	tus	ug	töv	harĭ
tsol	ta	toos	yag	duu	hüü
övs	dzun	us	am	shil	ömd
ser	doosh	ber	mend	ah	tsug
dzüs	möch	tsog	dars	too	deesh
biyö	hiy	amt	em	öör	muu
suuts	dzar	emch	dzavĭ	bor	daah
egch	harts	uur	or	oy	dzay
od	uls	jims	muur	hool	hur
oyms	üs	sayn	tod	hot	eej
üül	chig	sar	ayl	höö	dzaag
ted	shog	als	shüls	ger	hyamd
suuh	bod	uul	üg	süm	süül
gol	arĭs	tsonh	shüd	tag	har
hanĭ	jil	tsus	yüm	shid	hörsh
ayh	gants	aav	dzüüd	och	gal
uuh	mös	had	mal	alt	nar
mah	bayr	dzam	hün	nom	hiyh
höl	gar	mash	dzul	sul	tovch
dzah	sur	hööh	höh	hüch	hel
hog	hurts	tüüh	morĭ	honĭ	aash
shat	tsas	yas	bagsh	shal	ach

Table 9

Mongolian Female Monosyllabic Half-lists (Romanized) in Rank Order from Most Difficult to Easiest

1A	1B	2A	2B	3A	3B
laa	sul	dzul	üüd	maanĭ	naana
dur	shine	muur	ug	am	ber
urt	gay	mes	tod	mend	em
muu	bat	harĭ	deesh	sayn	böön
onts	suuts	oyms	höö	büs	toos
dzüüd	dood	tovch	us	negj	but
üür	shil	dzaan	iym	düü	daah
ömd	har	dzuur	hos	yavts	jims
guyh	bül	gants	od	eej	bagsh
av	arĭs	shid	yag	dzavĭ	harts
uul	biyö	tsag	ayh	alt	beh
tsug	dzüs	dzah	süm	dzun	dzaag
dund	emch	had	erch	shig	buuh
sar	hööh	suuh	bor	uur	chig
möch	nar	egch	aav	sur	tus
hiy	hur	duu	enh	yas	dars
shog	üg	shüls	tüüh	honĭ	hyamd
or	hiyh	ah	mör	üs	shat
amt	hüü	dzar	bayr	nom	ach
dzam	mös	gal	dzay	shal	uuh
övs	jil	shüd	oy	tsus	doosh
och	hurts	door	hog	nuur	aash
mah	gar	mal	höl	süül	hool
hel	tsonh	yüm	höh	öör	mash
üül	hörsh	morĭ	hün	hüch	gol

from Equation 2, the threshold for 50% intelligibility, and the change in intensity required to adjust the threshold to the mean threshold for male and female. In Equation 2, *p* is the percentage of correct recognition, *a* is the regression intercept, *b* is the regression slope, and *i* is the presentation level in dB HL.

$$i = \frac{\log \frac{p}{1-p} - a}{b} \tag{2}$$

A two-way Chi-Square (χ^2) analysis was performed on the lists and half-lists with intensity and list as independent variables, and response as the dependent variable. The results of the analysis indicated that there were no significant differences among the 50-word lists for the male and female talkers; $\chi^2(2, N = 20) = 1.55, p = 0.461$ and $\chi^2(2, N = 20) = 0.22, p = 0.896$ respectively. Results also indicated that there was no significant differences found among the 25-word half-lists for the male and female talkers; $\chi^2(5, N = 20) = 0.33, p = 0.846$ and $\chi^2(5, N = 20) = 2.68, p = 0.749$ respectively. Comparison of the slopes of the psychometric functions for the 50-word female lists found no statistically significant difference among psychometric function slopes; $\chi^2(2, N = 20) = 0.33, p = 0.846$ and for the 50-word male lists $\chi^2(2, N = 20) = 2.07, p = 0.355$. Statistical analysis for the 25-word female half lists found no statistically significant differences among slopes; $\chi^2(5, N = 20) = 0.46, p = 0.994$. The slopes of the psychometric functions for the 25-word male half lists were analyzed and no statistically significant differences among slopes were found; $\chi^2(5, N = 20) = 4.00, p = 0.549$. There were no significant intensity lists interactions, indicating that the differences among the psychometric function slopes for the lists or half-lists were minimal. To increase the psychometric equivalency for both the lists and half-lists, the use of Adobe Audition 2.0

Table 10

Mean Performance of Mongolian Male Monosyllabic Lists and Half-lists

List	a[a]	b[b]	Slope at 50% [c]	Slope 20-80%[d]	Threshold[e]	ΔdB[f]
1	2.97019	-0.23916	5.98	5.18	12.42	-2.05
2	3.32319	-0.26726	6.68	5.78	12.43	-2.03
3	2.94658	-0.23634	5.91	5.11	12.47	-2.00
M	3.07999	-0.24759	6.19	5.36	12.44	-2.03
Minimum	2.94658	-0.26726	5.91	5.11	12.42	-2.05
Maximum	3.32319	-0.23634	6.68	5.78	12.47	-2.00
Range	0.37661	0.03092	0.77	0.67	0.05	0.05
SD	0.21095	0.01710	0.43	0.37	0.02	0.02
1A	2.93827	-0.24345	6.09	5.27	12.07	-2.40
1B	3.00879	-0.23561	5.89	5.10	12.77	-1.70
2A	3.08676	-0.24354	6.09	5.27	12.67	-1.79
2B	3.64778	-0.29920	7.48	6.47	12.19	-2.28
3A	2.98593	-0.23755	5.94	5.14	12.57	-1.90
3B	2.90816	-0.23517	5.88	5.09	12.37	-2.10
M	3.09595	-0.24909	6.23	5.39	12.44	-2.03
Minimum	2.90816	-0.29920	5.88	5.09	12.07	-2.40
Maximum	3.64778	-0.23517	7.48	6.47	12.77	-1.70
Range	0.73962	0.06403	1.60	1.39	0.70	0.70
SD	0.27728	0.02483	0.62	0.54	0.28	0.28

[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 threshold to the mean threshold for male and female lists (14.47 dB HL).

Table 11

Mean Performance of Mongolian Female Monosyllabic Lists and Half-lists

List	a[a]	b[b]	Slope at 50%[c]	Slope 20-80%[d]	Threshold[e]	ΔdB[f]
1	3.81671	-0.23210	5.80	5.02	16.44	1.98
2	3.81644	-0.23138	5.78	5.01	16.49	2.03
3	3.67137	-0.22193	5.55	4.80	16.54	2.08
M	3.76817	-0.22847	5.71	4.94	16.49	2.03
Minimum	3.67137	-0.23210	5.55	4.80	16.44	1.98
Maximum	3.81671	-0.22193	5.80	5.02	16.54	2.08
Range	0.14534	0.01017	0.25	0.22	0.10	0.10
SD	0.08383	0.00568	0.14	0.12	0.05	0.05
1A	3.74989	-0.22736	5.68	4.92	16.49	2.03
1B	3.88763	-0.23713	5.93	5.13	16.39	1.93
2A	3.81644	-0.23138	5.78	5.01	16.49	2.03
2B	3.81644	-0.23138	5.78	5.01	16.49	2.03
3A	3.68624	-0.22351	5.59	4.84	16.49	2.03
3B	3.65697	-0.22039	5.51	4.77	16.59	2.13
Minimum	3.65697	-0.23713	5.51	4.77	16.39	1.93
Maximum	3.88763	-0.22039	5.93	5.13	16.59	2.13
Range	0.23066	0.01674	0.42	0.36	0.20	0.20
SD	0.08757	0.00605	0.15	0.13	0.06	0.06

[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 threshold to the mean threshold for male and female lists (14.47 dB HL).

utilized to adjust the intensity levels (Adobe Audition, 2005). The intensity of each word from the male and female bisyllabic lists and half-lists was adjusted digitally so that the 50% threshold of each list was equal to the midpoint (14.47 dB HL) between the mean threshold of the six male half-lists and the mean threshold of the six female half-lists. The intensity adjustments are presented in Table 10 (male) and Table 11 (female); these tables present the adjustments made to each word in the three lists and six half-lists. Figure 1 displays the psychometric functions for the male talker and female talker bisyllabic lists and half-lists prior to the intensity adjustments. Figure 2 presents the psychometric functions for the female talker and male talker bisyllabic lists and half-lists after the intensity adjustments were performed to produce 50% performance at 14.47 dB HL. Figure 3 shows the mean psychometric functions for male and female Mongolian talker monosyllabic word lists before and after intensity adjustment. Intensity adjustments were made to each list and half-list to produce 50% correct performance at 14.47 dB HL.

The psychometric functions and those created after the intensity adjustments differed between the male and female talker lists. The adjustments needed to equate the 50-word lists and 25-word half-lists were less than 2.5 dB for the male lists and less than 2.2 dB for the female lists. Figure 1 and Figure 2 contain the adjustments previously mentioned. The combined pre- and post- adjustments can be found in Figure 3.

Discussion

The current study was conducted to develop male and female 50-word lists and 25-word half lists in the Mongolian language which may be used to measure WRS ability for Mongolian speaking individuals. With regards to the audibility and psychometric function slopes (Figures 1-3), the lists that were created were homogeneous with respect

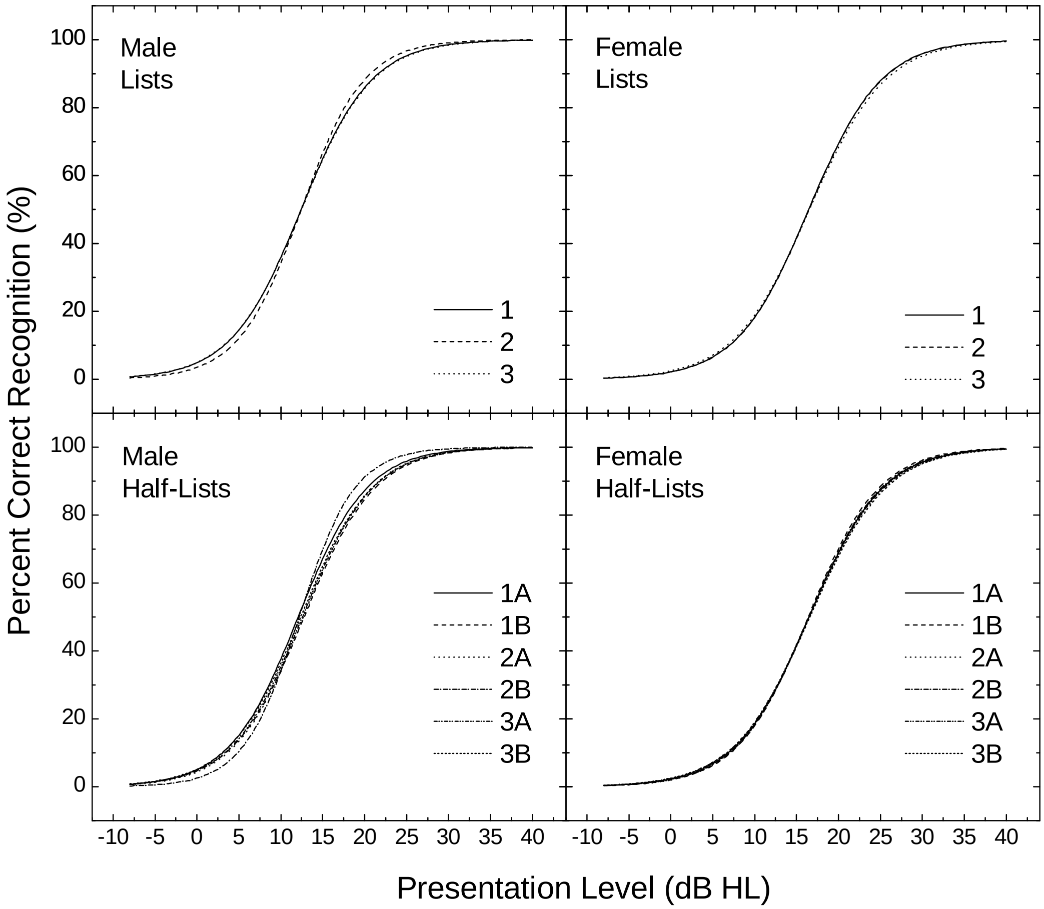

Figure 1.

Psychometric functions for the three Mongolian monosyllabic lists and six half-lists for male talker and female talker recordings before intensity adjustments.

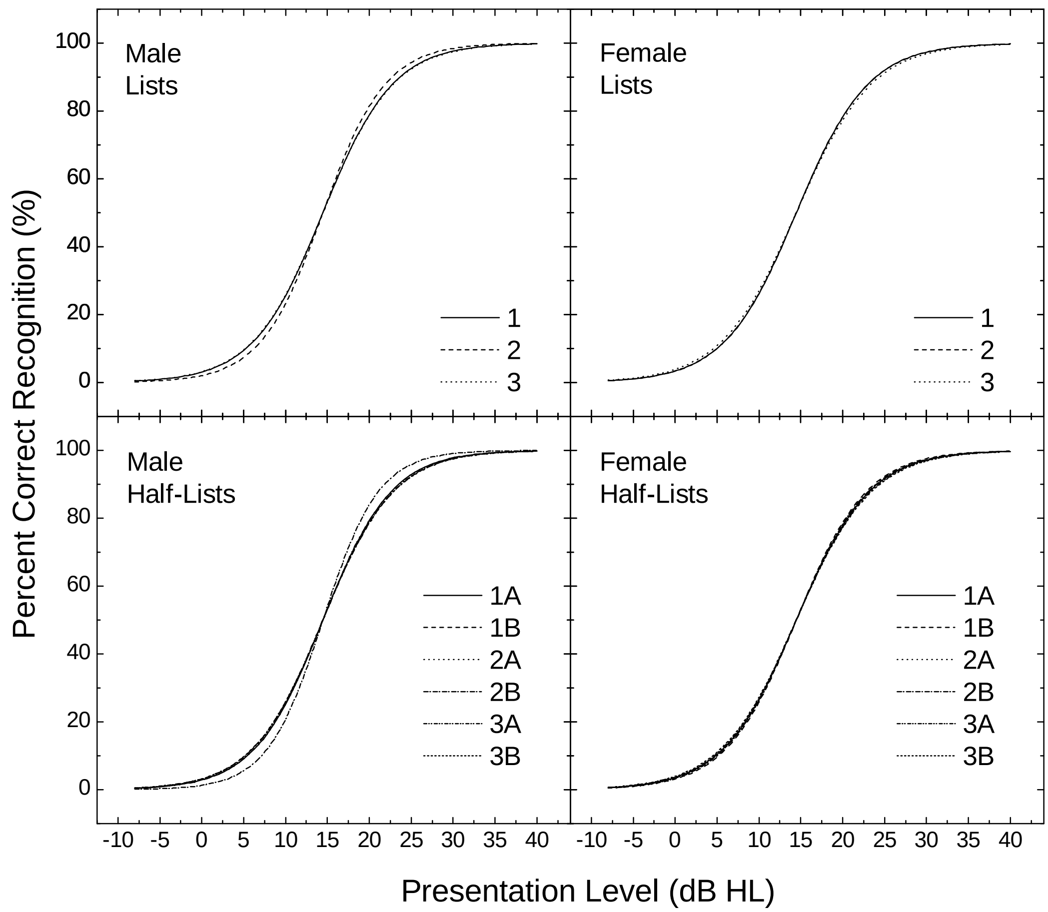

Figure 2.

Psychometric functions for the three Mongolian monosyllabic lists and six half-lists for male talker and female talker recordings after intensity adjustments to produce 50% performance at 14.47 dB HL.

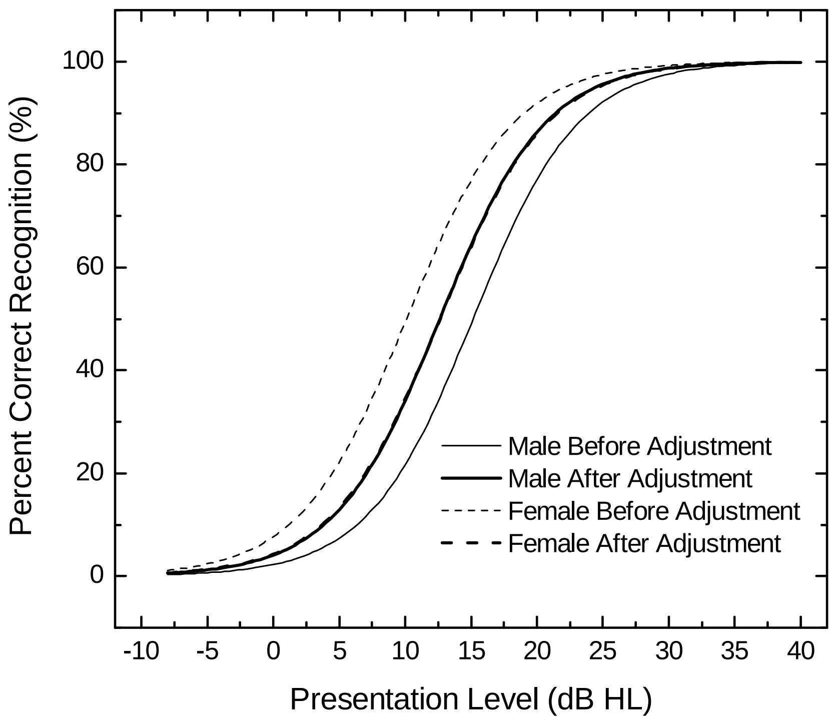

Figure 3.

Mean psychometric functions for male and female Mongolian talker monosyllabic word lists before and after intensity adjustment. Intensity adjustments were made to each list and half-list to produce 50% correct performance at 14.47 dB HL.

to psychometric slope and 50% threshold for normal hearing participants within a double-walled sound booth. Homogenity among lists increases the validity and reliability during audiological testing, therefore reducing the possibility that any differences in performance during an audiological examination would be from the word lists.

The psychometric function slopes at 50% for the monosyllabic lists and half-lists ranged from 5.91 to 6.68 %/dB (*M* = 6.19 %/dB) for the male recordings and from 5.55 to 5.80 %/dB (*M* = 5.71 %/dB) for the female recordings as displayed in Table 10 (male) and 11 (female). The psychometric function slopes at the 20-80%/dB for the monosyllabic lists and half-lists ranged from 5.11 to 5.78 %/dB (*M* = 5.36 %/dB) for the male recordings and from 4.80 to 5.01 %/dB (*M* = 4.94 %/dB) for the female recordings.

The study performed on the English monosyllabic word recognition lists resulted in psychometric function slopes of 4.2%/dB for the NU-6 word lists and 4.6%/dB for the CID W-22 word lists when measured from 20-80% (Beattie, Edgerton, & Svihovec, 1977; Wilson & Oyler, 1997). The study by Beattie et al. also found both the CID W-22 and NU-6 lists to be equivalent which allowed clinicians to use these lists interchangeably; since, the results were within 0.4%/dB between the CID W-22 and NU-6 lists. The mean psychometric function slopes obtained for the English word lists, CID W-22 and NU-6, in comparison to the Mongolian word lists were slightly lower percentages compared to the mean slopes for the Mongolian monosyllabic lists. However, the difference contained within the Mongolian and English slopes for the word lists and half-word lists were negligible suggesting the possibility for the use of the Mongolian word lists to be used among the Mongolian speaking population as the English lists are used among English speaking individuals.

Another research study performed by Wilson and Oyler (1997) used the Auditec of St. Louis compact disc to test the CID W-22 and NU-6 lists on individuals with normal and sensorineural hearing impairment. Wilson and Oyler (1997) found among normal hearing individuals the psychometric function slopes of the CID W-22 lists to be 4.8%/dB and the NU-6 psychometric function slopes to be 4.4%/dB. For individuals with a hearing impairment the mean psychometric function slopes for the CID W-22 was 2.2%/dB and the NU-6 had a mean slope of 2.3%/dB (Wilson & Oyler, 1997). While the Wilson and Oyler study looked at hearing impairment for individuals, further testing is needed to verify the use of the Mongolian word lists among the hearing-impaired populations.

The thresholds found for Japanese word lists had a mean of 11.6 dB HL for the male lists and 7.3 dB HL for the female lists (Harris, Crawford, & Mastny, 2004), the mean for the Mandarin language was 5.4 dB HL for the males lists and 3.5 dB HL for the female lists (Nissen et al., 2005a).The results of these two studies had lower means in comparison to the 12.4 dB HL for the male lists and 16.5 dB HL for the female lists found for the Mongolian language. In addition the pure tone averages (PTA) of the subjects within the study was found to be 0.6 dB HL which is lower than the mean thresholds obtained for the Mongolian male and female lists. The higher thresholds from could have been the result of three subjects within the current Mongolian study not speaking the main dialect or differences in phonological cues of the Mongolian language in comparison to other Asian languages. Another possibility is the monosyllabic nature of the Mongolian words made listener identification increasingly more difficult than Japanese bisyllabic word lists.

The word lists created in the current research study will help to test Mongolian speaking individuals in their native language. Increases in familiarity will improve the validity of the audiological testing since the Mongolian speaker will have a better understanding of words within their native language, allowing for more correct responses. In addition the development of a compact disc (CD) with the recordings of the word lists will help audiologists to present Mongolian words at a consistent presentation level and will improve randomization of the word lists during speech audiometry testing (Nissen et al., 2005b).

While the current lists would be appropriate for the testing of many Mongolian speaking individuals. The word lists may be more appropriate for testing adults than for children. Words such as онц, which is interpreted as *exclusive,* or нэгж which is interpreted as *unit,* were included in the word lists created for the current study. While these words could be recognized quickly by an adult listener, the same words maybe difficult for a child to recognize. Words such as these would affect the results of tests among children causing the audiological testing to be less reliable. Therefore, a need still exists for word lists to be developed specifically for audiological testing of children.

In order to increase the reliability of the Mongolian word lists further, analysis of the test-retest reliability should be assessed. As described in the research by Gelfand (1998), the test-retest reliability of a sensorineural hearing impairment and individuals with normal hearing where presented with word recognition test items and then subsequently retested with similar test items. The results indicated no significant difference between the scores for the first and second test. These results help to establish test-retest reliability by reducing any outliers (Gelfand, 1998). Similarly, to improve the word lists created, further testing of the Mongolian word lists is needed to establish no significant difference among test items following experimentation using test-retest criterion. The test-retest reliability was not established in the current study because each test item was only presented to each subject once.

Participants in the current research study were tested within a double walled sound booth. Many individuals with a hearing impairment are not presented with sound stimuli in a quiet setting such as a sound booth; instead, speech is produced in a conversational setting in which environmental noises are present. As most studies, such as this one, are performed in the quiet setting of a sound booth and not in the noisy realistic environment the results of the study cannot be effectively extended to all speech situations. Therefore, the current word lists need to also be tested in the presence of background noise. The effect of background noise for individuals with a sensorineural hearing impairment often will be at a greater disadvantage for hearing as compared to those with normal hearing to the extent of 10 to 15 dB difference (Wilson & McArdle, 2005). While testing in the presence of background noise will add to the length of an audiological evaluation, Wilson and McArdle (2005) advocate the use of testing with background noise. This will help to address the main complaint of individuals with a hearing impairment which is their inability to hear speech in a noisy environment. While testing with the presence of noise is important to an audiological evaluation, it was not included in the extent of this research study.

To ensure reliability of the word lists, testing should investigate the word lists across different individuals with a variety of differing types and degrees of hearing impairment to ensure continuity among the results (McArdle & Wilson, 2006). As the current study was performed on individuals found to have hearing levels that were 15 dB HL or better in one or both ears, the current test results cannot effectively be applied to individuals with a hearing impairment.

Mongolian speaking individuals can be found in many different geographical locations such as the Mongolian Republic, parts of China, Siberia, Kyrgyzstan, and parts of Russia (Poppe, 1970). The variety of different geographical locations results in many different dialects spoken by the Mongolian people; even though these dialectical differences are subtle, the differences can affect audiological testing. The current study focused on the Khalkha dialect, but further speech audiological material maybe needed to appropriately test individuals within their native dialect of Mongolian to make the audiological testing more accurate.

In conclusion, the main objective of this research study was to develop lists of homogenous and psychometrically evaluated lists of Mongolian words in the dialect of Khalkha. The word lists contained frequently used monosyllabic words with three lists of 50 words and six lists of 25 words being recorded. The final word lists were digitally recorded by both a male and female talker and placed onto CDs to be utilized by audiologists to test the word recognition scores for Mongolian speaking individuals.

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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 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 have any questions regarding this research project you may contact Dr. Richard W. Harris, 131 TLRB, Brigham Young University, Provo, Utah 84602; phone (801) 422-6460. If you have any questions regarding your rights as a participant in a research project you may contact Dr. Christopher Dromey, Chair of the Institutional Review Board, TLRB, Brigham Young University, Provo, UT 84602; phone (801) 422-5490.

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

Evaluation Sheet for Mongolian Talkers

Judge's name____________________

During the first listening stage, please evaluate each of the following talkers according to their voice quality and accent. If you decide the accent or the overall acceptance is unacceptable, please explain why. The second time you listen to all the talkers, please rank them best to worst.

Talker # 1

Pleasantness of voice	least pleasant –1 2 3 4 5 6 7 8 9 10- most pleasant	
Articulation & intelligibility	unclear—1 2 3 4 5 6 7 8 9 10 – very clear	
Accent	acceptable	unacceptable (why?)
Overall acceptance	acceptable	unacceptable (why?)

Talker # 2

Pleasantness of voice	least pleasant—1 2 3 4 5 6 7 8 9 10—most pleasant	
Articulation & intelligibility	unclear —1 2 3 4 5 6 7 8 9 10–very clear	
Accent	acceptable	unacceptable (why?)
Overall acceptance	acceptable	unacceptable (why?)

Talker # 3

Pleasantness of voice	least pleasant—1 2 3 4 5 6 7 8 9 10—most pleasant	
Articulation & intelligibility	unclear —1 2 3 4 5 6 7 8 9 10 –very clear	
Accent	acceptable	unacceptable (why?)
Overall acceptance	acceptable	unacceptable (why?)

Talker # 4

Pleasantness of voice	least pleasant—1 2 3 4 5 6 7 8 9 10—most pleasant	
Articulation & intelligibility	unclear —1 2 3 4 5 6 7 8 9 10 –very clear	
Accent	acceptable	unacceptable (why?)
Overall acceptance	acceptable	unacceptable (why?)

Rank order:	talker #1	talker #2	talker #3	talker #4
	( )	( )	( )	( )

Appendix C

Description of BYU Mongolian Speech Audiometry Materials CD

Track 1 1 kHz calibration tone.

Track 2 Trisyllabic words for use in measuring the SRT in alphabetical order for familiarization purposes.

Track 3 Trisyllabic words for use in measuring the SRT in random order, repeated in blocks for a total duration of 5 minutes.

Track 4 Speech Discrimination List 1 – 50 monosyllabic words in random order.

Track 5 Speech Discrimination List 2 – 50 monosyllabic words in random order.

Track 6 Speech Discrimination List 3 – 50 monosyllabic words in random order.

Track 7 Speech Discrimination List 4 – 50 monosyllabic words in random order.

Track 8 Speech Discrimination List 1A – 25 monosyllabic words in random order.

Track 9 Speech Discrimination List 1B – 25 monosyllabic words in random order.

Track 10 Speech Discrimination List 2A – 25 monosyllabic words in random order.

Track 11 Speech Discrimination List 2A – 25 monosyllabic words in random order.

Track 12 Speech Discrimination List 3A – 25 monosyllabic words in random order.

Track 13 Speech Discrimination List 3B – 25 monosyllabic words in random order.

Track 14 Speech Discrimination List 4A – 25 monosyllabic words in random order.

Track 15 Speech Discrimination List 4A – 25 monosyllabic words in random order.

Track 16 Яриа хүлээж авах болон үгээр хариулах заавар: **Танд янз бүрийн дууны өнгөтэй бүлэг үгнүүдийг сонсгох гэж байна. Үг бүрийг сонссоныхоо дараа давтаж хэлнэ үү. Хэрвээ сонсож байгаа үгэндээ итгэлтэй биш байгаа бол таамаглан хэлж болно.**

Instructions for speech reception 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 17	Үгийг ялгаж амаар хариулах заавар. **Танд тогтмол хэмнэлттэй бүлэг үгнүүдийг сонсгох гэж байна. Үг бүрийг сонссоныхоо дараа давтаж хэлнэ үү. Хэрвээ итгэлтэй биш байгаа бол таамаглаж хэлж болно.**

Instructions for word recognition-verbal response: "You are going to hear a series of words that will be given at a constant 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 18	Сонсгол хэмжигч багжаар нэг чихэнд шуугиан өгч нөгөө чихийг шалгах үед үгээээр хариулах заавар: **Тестийн энэ хэсэгт та нэг чихээрээ шуугиант авиа, нөгөө чихээрээ үгнүүд сонсох болно. Шуугианыг үл анзааран сонсч байгаа үгнүүдээ давтана уу.**

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 19	Танд тогтмол дууны хэмнэлттэй бүлэг үгнүүдийг сонсгох гэж байна. **Үг бүрийг сонссон даруйдаа бичнэ үү. Хэрвээ сонсч байгаа үгэндээ итгэлтэй биш байвал таамаглаж бичиж болно.**

Instructions for speech audiometry-written response: "The purpose of this test is to determine how well you can understand words when they are presented at a constant 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."

Track 20	Нэг чихэнд шуугиан өгч нөгөө чихний сонсголыг шалгахад бичгээр хариулах заавар: **Энэхүү сонсгол шалгах үед та нэг чихэндээ шуугиан нөгөө чихэндээ үгнүүд сонсоно. Шуугианыг үл анзааран сонссон үгнүүдээ бичнэ үү.**

Instructions for speech audiometry-masking in nontest ear-written 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 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."

Track 21	Цэвэр дууны өнгөөр сонсгол шалгахад гар өргөж хариулах заавар: **Танд дууны хүчээрээ ялгаатай бүлэг үгнүүдийг сонсгох гэж байна. Дууны өнгийг сонссон даруйдаа гараа өргөнө үү. Дуу сонсогдохоо болихоор**

гараа буулгана уу. Хэрвээ та дууны өнгө сонслоо гэж бодож байгаа бол гараа өргөнө үү, өөртөө итгэлтэй биш байгаа ч гэсэн гараа өргөөрэй.

Instructions for pure-tone audiometry-hand raising: "The purpose of this test is to determine the softest sounds you can hear. You are going to hear a series of tones, first in one ear and then in the other. Some of the tones will be easy to hear, but most of them will be very faint, and some of them may be too soft to hear. Your job is to raise your hand every time you hear a tone and keep it up for as long as you hear the tone. Put your hand down quickly when the tone goes off. Remember, raise your hand every time you hear a tone, no matter how soft it is."

Track 22 Цэвэр дууны өнгөөр нэг чихэнд шуугиан өгч нөгөө чихний сонсголыг шалгахад гар өргөж хариулах заавар: **Энэхүү сонсгол шалгах үед та нэг чихэндээ шуугиан, нөгөө чихэндээ дууны өнгө сонсох болно. Шуугианыг үл анзааран дууны өнгө сонсон даруйдаа гараа өргөнө үү.**

Instructions for pure-tone audiometry-masking in nontest ear-hand raising: "During this part of the test you will be listening for a tone in the presence of a background noise. The level of the noise may vary. Please ignore the noise and listen only for the tone. When you hear the tone, immediately raise your hand and keep it up for as long as you hear the tone. Put your hand down quickly when the tone goes off. Remember, raise your hand every time you hear a tone, no matter how soft it is."

Track 23 Цэвэр дууны өнгөөр сонсгол шалгах үед товчлуур дарж хариулах заавар: **Танд янз бүрийн дууны өнгөтэй бүлэг хөгнүүдийг сонсгох гэж байна. Чимээ сонссон даруйдаа товчлуурыг дарна уу. Чимээ сонсогдохоо боливол товчилуурыг дарахаа болиорой. Хэрвээ та чимээ сонсож байна гэж бодож байвал товчлуурыг дараарай, өөртөө итгэлтэй биш байгаа ч гэсэн дараарай.**

Instructions for pure-tone audiometry-button pressing: "The purpose of this test is to determine the softest sounds you can hear. You are going to hear a series of tones, first in one ear and then the other. Some of the tones will be easy to hear, but most of them will be very faint, and some of them may be too soft to hear. Your job is to press the button every time you hear a tone and keep it pressed for as long as you hear the tone. Release the button quickly when the tone goes off. Remember, press the button every time you hear a tone, no matter how soft it is."

Track 24 Үгийг таньж амаар хариулах заавар: **Энэхүү сонсгол шалгах зорилго нь та тогтмол сонсголын түвшинд үгнүүдийг хэр ойлгож байгааг тодорхойлох юм. Үг сонсох бүртээ давтаж хэлээрэй. Хэрвээ сонссон үгэндээ итгэлтэй биш байгаа бол таамаглаж хэлж болно. Хэрвээ үгийг ойлгоогүй болон тухайн үгийг таамаглаж чадахгүй байгаа бол чимээгүй байж дараагийн үгийг хүлээнэ үү.**

Instructions for pure-tone audiometry-masking in nontest ear-button pressing: “During this part of the test you will be listening for a tone in the presence of a background noise. The level of the noise may vary. Please ignore the noise and listen only for the tone. When you hear the tone, immediately press the button and keep it pressed for as long as you hear the tone. Put your hand down quickly when the tone goes off. Remember, press the button every time you hear a tone, no matter how soft it is.”

Appendix D

Selected Monosyllabic Word Definitions

Romanization	Cyrillic	Grammatical Category	Definition
aash	ааш	noun	character, behavior
aav	аав	noun	father, dad
ach	ач	noun	grandson, granddaughter
ah	ах	noun	brother, elder
als	алс	adverb	far
alt	алт	noun	gold
am	ам	verb	mouth
amt	амт	noun	taste, flavor
arĭs	арьс	noun	skin
av	ав	noun, verb	hunt, receive
ayh	айх	verb	afraid, frighten,horrify, scare
ayl	айл	noun	family
bagsh	багш	noun	teacher
bat	бат	noun	firm, steady
bayr	байр	noun	apartment, residence
beh	бэх	noun	ink
ber	бэр	noun	daughter-in-law
biyö	бие	noun	body
bod	бод	noun	horses, camels, and cattle
böön	бөөн	noun	pile
bor	бор	adjective	brown
bül	бүл	noun	family
büs	бүс	noun	area, belt, zone
but	бут	noun	bush, shrub
buuh	буух	verb	step down, landing
chig	чиг	noun	direction
daah	даах	verb	to be able to carry, to be able to stand, to support
dars	дарс	noun	wine
deesh	дээш	adjective	upwards or more than
dood	доод	noun	below, bottom
door	доор	adjective	below, beneath, down, under
doosh	доош	adjective	downward
dund	дунд	noun	middle, among, between, medium
dur	дур	noun	will, desire
duu	дуу	noun	song
düü	дүү	noun	younger brother or sister, younger
dzaag	зааг	noun	boundary, division
dzaan	заан	noun	elephant
dzah	зах	noun	edge, border, market
dzam	зам	noun	path, road, route, way
dzar	зар	noun	announcement or advertisement
dzavĭ	завь	noun	boat
dzay	зай	noun	space, gap, distance, length or battery
dzeel	зээл	noun	loan, credit
dzul	зул	noun	oil lamp
dzun	зун	noun	summer

dzüs	зүс	verb	cut
dzüüd	зүүд	noun	dream
dzuur	зуур	noun	while
eej	ээж	noun	mother, mummy, mom
egch	эгч	noun	elder sister
em	эм	noun	medicine
emch	эмч	noun	physician, doctor
enh	энх	noun	peace
erch	эрч	noun	energy, power
gal	гал	noun	fire
gants	ганц	adjective	alone, single
gar	гар	noun	hand, arm, and get out
gay	гай	noun	misfortune, bad luck,
ger	гэр	noun	home, house
gol	гол	noun	river, and main, core
guyh	гуйх	verb	to ask for, beg
had	хад	noun	cliff
hanĭ	хань	noun	mate
har	хар	adjective	black, dark
harĭ	харь	adjective	foreign, alien
harts	харц	noun	look, sight
hel	хэл	noun	tongue, language
hiy	хий	noun	air, gas
hiyh	хийх	verb	to do
hog	хог	noun	garbage, trash
höh	хөх	adjective	blue
höl	хөл	noun	foot, leg
honĭ	хонь	noun	sheep
höö	хөө	noun	soot
hööh	хөөх	verb	to chase, to drive out, to expel
hool	хоол	noun	food, meal
hörsh	хөрш	noun	neighbour
hos	хос	noun	pair, couple, double
hot	хот	noun	city, town
hüch	хүч	noun	power, force
hün	хүн	noun	human, person
hur	хур	noun	precipitation
hurts	хурц	adjective	sharp
hüü	хүү	noun	boy, son
hyamd	хямд	adjective	cheap
iym	ийм	adjective	such
jil	жил	noun	year
jims	жимс	noun	fruit
laa	лаа	noun	candle
maanĭ	маань	noun	prayer, chant or ours, mine, my
mah	мах	noun	flesh, meat
mal	мал	noun	livestock
mash	маш	adjective	very
mend	мэнд	noun	health, well beingor greeting
mes	мэс	noun	cutlery, knife
möch	мөч	noun	limb
mör	мөр	noun	row, shoulder, trace, track,
morĭ	морь	noun	horse
mös	мөс	noun	ice
muu	муу	adjective	bad
muur	муур	noun	cat

naana	наана	adverb	on this side, closer to this side, before
nar	нар	noun	sun
negj	нэгж	noun	unit
nom	ном	noun	book
nuur	нуур	noun	lake
och	оч	noun	spark
od	од	noun	star
ömd	өмд	noun	pants, trousers
on	он	noun	year
onts	онц	adjective	exclusive
öör	өөр	adjective	different, other
or	ор	noun	bed
övs	өвс	noun	grass
oy	ой	noun	anniversary or forest
oyms	оймс	noun	sock
sar	сар	noun	moon, month
sayn	сайн	adjective	good, well
ser	сэр	verb	wake up
shal	шал	noun	floor
shat	шат	noun	stairs
shid	шид	noun	magic
shig	шиг	adjective	similar to, as
shil	шил	noun	glass
shine	шинэ	adjective	new, fresh
shog	шог	noun	joke, humor
shüd	шүд	noun	tooth
shüls	шүлс	noun	saliva
shuur	шуур	noun	storm
sul	сул	verb	loose, vacant, unoccupied, weak
süm	сүм	noun	monastery, church
sur	сур	noun	leather strap
suuh	суух	verb	to sit
süül	сүүл	noun	tail, end
suuts	сууц	noun	residence, apartment
ta	та	personal pronoun	you
tag	таг	noun	hood, lid
ted	тэд	personal pronoun	they
tend	тэнд	adverb	there
tod	тод	adjective	clear or bright
too	тоо	noun	count, number, numeral
toos	тоос	noun	dust
töv	төв	noun	center
tovch	товч	noun	button or brief
tsag	цаг	noun	time, hour, clock
tsas	цас	noun	snow
tsay	цай	noun	tea
tsog	цог	noun	glowing coals, embers, sparks
tsol	цол	noun	rank, title
tsonh	цонх	noun	window
tsug	цуг	adverb	together
tsus	цус	noun	blood
tus	тус	noun	help
tüüh	түүх	noun	to collect, history, story
ug	уг	noun	original, source
üg	үг	noun	word
uls	улс	noun	country

und	унд	noun	beverage, meal
urt	урт	noun	long
us	ус	noun	water
üs	үс	noun	hair, fur
üüd	үүд	noun	door, gate
uuh	уух	verb	to drink
uul	уул	noun	mountain
üül	үүл	noun	cloud
uur	уур	noun	steam, vapor, anger
üür	үүр	noun	dawn, nest
yag	яг	adjective	exact
yas	яс	noun	bone
yavts	явц	noun	process
yüm	юм	noun	thing