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Development of Psychometrically Equivalent Speech Audiometry Materials for Testing Children in Mongolian

Meghan Elizabeth Caldwell
Brigham Young University - Provo

DEVELOPMENT OF PSYCHOMETRICALLY EQUIVALENT SPEECH AUDIOMETRY MATERIALS FOR TESTING CHILDREN IN MONGOLIAN

by

Meghan Elizabeth Caldwell

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GRADUATE COMMITTEE APPROVAL

of a thesis submitted by

Meghan Elizabeth Caldwell

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

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

BRIGHAM YOUNG UNIVERSITY

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Date	Shawn L. Nissen Chair, Graduate Committee

Accepted for the Department

Date	Ron W. Channell Graduate Coordinator

Accepted for the College

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

ABSTRACT

DEVELOPMENT OF PSYCHOMETRICALLY EQUIVALENT SPEECH AUDIOMETRY MATERIALS FOR TESTING CHILDREN IN MONGOLIAN

Meghan Elizabeth Caldwell

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The purpose of this study was to develop, digitally record, evaluate, and equate Mongolian monosyllabic and bisyllabic child-appropriate words which can be used in the measurement of word recognition scores and speech-reception threshold (SRT) in children who are native speakers of Mongolian. Based on data collected from a survey of Mongolian child language professionals, a subset of child-appropriate materials was adapted from a set of materials developed for Mongolian adults. Two lists of 50 monosyllabic words and four half-lists of 25 words each were developed for testing the word recognition abilities of Mongolian children. The developed lists and half-lists were found to be statistically equivalent in terms of audibility and psychometric slope, with average psychometric function slopes (at 50% intelligibility) of 6.41 %/dB for the male recordings and 5.84 %/dB for the female recordings. Given the structure and limitations

of the study, a valid set of child-appropriate SRT materials could not be developed. It is likely that the inability to obtain a subset of SRT words was due in part to large differences between the mean PTA of the subjects and the threshold for 50% intelligibility, as well as the inability to represent most of the selected words pictographically. However the information gained from this study provides additional insight that may aid the future development of child-appropriate Mongolian SRT materials. Digital recordings of the resulting psychometrically equivalent child-appropriate speech audiometry materials are available on compact disc.

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Table of Contents

List of Tables

List of Figures

Figure Page

List of Appendices

Introduction

According to estimates of the World Health Organization (WHO), approximately 278 million people worldwide present with a disabling hearing impairment. Since a great number of these hearing impairments can be eliminated or reduced through rehabilitation, the WHO has set a strategic goal to "eliminate 50% of the burden of avoidable hearing loss by the year 2010" (World Health Organization, 2008, ¶ 2). Due to infectious diseases such as measles, meningitis, rubella, mumps, and chronic otitis media, children are also significantly impacted by the disabling effects of hearing impairment, especially in developing countries. It has been estimated that in Mongolia, the largest magnitude of school participation deficit is found among children with a hearing or visual disability (Filmer, 2005). Disability was found to have a greater impact on school participation than gender, geographic area, and even poverty level.

Appropriate rehabilitation of any hearing impairment should begin with a complete audiological assessment to determine the presence, type, and degree of impairment. Although pure-tone testing, the presentation of sinusoidal frequencies, is a common method for measuring an individual's hearing ability, audiological evaluations are generally considered incomplete without the assessment of an individual's ability to perceive and process speech. Speech audiometry is a type of hearing testing which evaluates a person's ability to perceive words or sentences. However, in order for such testing to be a valid and accurate evaluation, individuals should be tested with materials that are appropriate for their age and are in their native language (Ramkissoon, 2001).

Speech audiometry materials have been developed in other languages such as Arabic, Brazilian Portuguese, Italian, Polish, Russian, and Spanish (Aleksandrovsky, McCullough, & Wilson, 1998; Ashoor & Prochazka, 1985; Christensen, 1995; Greer, 1997; Harris, Goffi, Pedalini, Gygi, & Merrill, 2001; Harris, Nielson, McPherson, & Skarzynski, 2004a, 2004b; Harris et al., 2007; Ramkissoon, 2001; Ramkissoon, Proctor, Lansing, & Bilger, 2002), as well as many languages in the Asian Pacific region (Harris, Kim, & Eggett, 2003a, 2003b; Nissen, Harris, Jennings, Eggett, & Buck, 2005a, 2005b; Nissen, Harris, & Slade, 2007). However, child-appropriate materials are limited or are nonexistent for the Mongolian language. Thus, this study intends to select, digitally record, evaluate, and psychometrically equate word recognition (WR) and speech-reception threshold (SRT) materials for children who are native speakers of Mongolian. It is hoped that these materials will assist audiologists in the United States and around the world in their efforts to eliminate the disabling effects of hearing loss in children who are native speakers of Mongolian.

Review of Literature

This review of literature describes the prevalence of disability worldwide and the consequences of hearing disabilities in developing countries such as Mongolia. In addition, the importance of speech audiometry in a comprehensive hearing evaluation and the adaptations made for testing children were reviewed, as well as the linguistic nature of the Mongolian language.

Impairment, Disability, and Handicap

In 1980, the WHO established a system for the classification of impairments, disabilities, and handicaps (ICIDH). They defined *impairment* as an abnormality of a structure or function, a *disability* as the functional consequence of impairment, and a *handicap* as the social consequence of impairment (American Speech-Language Hearing Association [ASHA], n.d.). When the definitions of impairment, disability, and handicap are applied to individuals, variations are made known and divisions are more apparent. These distinctions are meant to describe how a particular individual functions as a result of his or her impairment (ASHA, n.d.).

The WHO has since revised and broadened the ICIDH into an International Classification of Functioning, Disability, and Health (ICF). The ICF was agreed upon by 191 WHO Member States in May 2001 (WHO, 2008) and released to the public in November 2002 (WHO, 2001). The purpose of the ICF is to broaden how we describe and measure health and disability in individuals. With this change, classification of disability by the WHO no longer focused on mortality rates in populations, but refocused on how people live with their specific health ailment. The ICF recognizes that any individual can have and experience a loss or decline in their health status and that disability is a universal human experience, an experience which must be measured by its impact, not its cause.

Disability in Developing Countries

Approximately 80 percent of people with a disability worldwide live in underdeveloped countries. It is calculated that approximately 625 million children and adolescents around the world exhibit a disability. Disabilities not only impact the individual, but they can also have a strong emotional, mental, and financial impact on their family and society. Many families in developing countries simply do not have the financial means or opportunity to appropriately address a child's disability (Filmer, 2005).

The State Research Center on Maternal and Child Health, the WHO, and the Ministry of Health of Mongolia conducted a study of over 186,000 school-aged children from Ulaanbaatar, Mongolia. Of the total number of students residing in that area, 9.2 percent were reported as having a disability, which was defined broadly as any restriction, limitation, or impairment lasting at least a period of six months or more. The most common disabilities experienced by children in the study were visual, hearing, speech, locomotor, or mental disabilities. Speech and hearing disabilities were reported to occur at a rate of 17.6 per every 1,000 children surveyed and accounted for 19.1 percent of the total disabilities reported (Radnaabazar et al., 2006).

A study by Filmer (2005) examined the presence of disability, household poverty status, and participation in school for children in several developing countries. Data collected in the Filmer study was drawn from eleven household surveys from nine different countries which included Jamaica, Romania, Cambodia, Indonesia, Mozambique, Burundi, Myanmar, Mongolia, and Sierra Leone. The majority of surveys had a sample size between 4,000 and 25,000 households. It is important to note that the definition of what constitutes a disability varied between surveys. For example, the survey conducted in Mongolia included visual and hearing impairments in the definition of disability but did not include speech, physical, or mental disabilities, whereas the study conducted in Jamaica included visual, hearing, speech, physical, and mental impairments in the definition of disability.

When compared to other developing countries, Mongolia was found to have the highest prevalence of disability. According to Filmer's analysis, 245 youth in Mongolia were reported as having a disability out of a total of 7,645 individuals surveyed, or a disability prevalence rate of 3.2 percent. However it is possible that the data presented by Filmer (2005) under-represents the actual prevalence of disability in Mongolia. Estimates of the prevalence of disability from survey data are often incomplete or inaccurate. Additional studies (e.g., Al-Abduljawad & Zakzouk, 2003; Picavet & Hoeymans, 2002) have reported higher rates of disability in developed countries. For example, the prevalence of physical disability was reported to be 12.6% for individuals living in the Netherlands (Picavet & Hoeymans, 2002) and the prevalence for sensorineural hearing impairment was 13% in Saudi children (Al-Abduljawad & Zakzouk, 2003).

Filmer (2005) also examined the relationship between the prevalence of a disability nationwide and the economic status of the region from which a respondent resided. General trends indicated a negative association between the rate of disability prevalence and a region's economic status. Not surprisingly, as the level of regional economic status increased there was a corresponding decrease in the rate of disability. Filmer noted that "disability is both a determinant of poverty as it lowers earning power and consumption expenditures and a consequence of poverty as the cumulative depravations of poverty can manifest themselves in disability (e.g., infant and child development, exposure to dangerous working conditions)" (p. 7).

After determining the presence of a disability, the author investigated possible relationships between disability, household poverty status, and school participation. Generally, Filmer (2005) found that the presence of a disability influenced whether the child began or attended school more than the poverty level of their household.

Child Hearing Disability

Incidence and etiology. According to estimates by the WHO (2006), approximately 278 million people worldwide have a bilateral moderate-to-profound hearing loss. Due to an aging population and improved methods of identifying a hearing impairment or disability, the estimates of hearing impairment prevalence throughout the world are rising. Eighty percent of the total number of individuals who are deaf or have a hearing impairment live in low- or middle-income countries, and less than 1 in 40 individuals with a hearing impairment who would benefit from a hearing aid have access to them (WHO).

Smith (2001) outlined ten major causes of hearing impairment and deafness. They include (a) inherited causes such as diseases passed from mother to child during pregnancy (e.g., rubella, cytomegalovirus infection, toxoplasmosis, syphilis, and herpes simplex); (b) perinatal and neonatal factors such as birth asphyxia or hypoxia, trauma at birth, jaundice, and excessive noise; (c) nutritional causes such as cretinism; (d) bacterial meningitis; (e) ototoxic drugs; (f) chronic otitis media; (g) infections such as measles, mumps, Lassa fever, HIV, and Lyme disease; (h) wax and foreign bodies; (i) premature birth; and (j) trauma or head injury. A major cause of hearing impairment in children is chronic otitis media which is considered to be the main cause of mild-to-moderate hearing loss in children living in developing and developed countries (WHO, 1996).

The WHO (2006) also estimated that half of the prevalence of deafness and hearing impairment is avoidable and manageable through preventative measures, early detection, and proper management of the hearing loss. A study by Smith (2001) estimates that 50% or more of the amount of hearing impairment and deafness in developing countries is preventable and further asserts that the prevalence of hearing impairment in children is likely underestimated because of the lack of surveys completed in certain regions. Unfortunately, hearing impairments in developing countries are frequently "forgotten and often invisible problems" (Smith, 2001, p. 93). If left untreated, a child's hearing impairment can subsequently have a negative effect on job performance later in life (Smith, 2001). According to Jauhiainen (2001), most children who are hearing impaired live in developing countries without access to or have restricted access to audiology services.

Consequences of hearing disability. The consequences of hearing impairment and deafness in children are many and varied. A hearing impairment can delay a child's speech, language, and cognitive development and impact their performance and progress in school. Although most hearing difficulties are identified in adulthood, children should be specifically targeted for rehabilitation so that difficulties in language development and school performance might be avoided (Smith, 2001).

In a study by Radnaabazar et al. (2006), surveys from 1,411 schools indicated that hearing impairment is the second leading cause of disability among children who attend school in developing countries, with approximately one quarter of children presenting with a hearing disability. These statistics did not account for the children who do not attend school, possibly due to their hearing impairment. Filmer (2005) estimated that the greatest number of children who do not attend school in Mongolia are children with a hearing or visual disability. It was found that only 41 percent of Mongolian children aged 6 to 11 years with a reported disability were enrolled in school, whereas 58 percent of children without a disability were found to be enrolled in school. In children 12 to 17 years of age, 47 percent of children with a disability were reported to be in school, while 72.6 percent of children without a disability were enrolled. Also of note, many children reported as having a disability were found to never have attended school. From Filmer's research, it can be concluded that Mongolian children with disabilities are less likely to be enrolled in school and therefore have lower levels of educational training.

Regarding the social and economic burden of hearing loss and deafness, the WHO (2006) has taken the following position:

> Hearing impairment and deafness are serious disabilities that can impose a heavy social and economic burden on individuals, families, communities and countries. Children with hearing impairment often experience delayed development of speech, language and cognitive skills, which may result in slow learning and difficulty progressing in school. In adults, hearing impairment and deafness often make it difficult to obtain, perform, and keep employment. . . .
>
> The burden of hearing impairment and deafness falls disproportionately on the poor, because they are unable to afford the preventative and routine care necessary to avoid hearing loss, or to afford hearing aids to make the condition manageable. Hearing impairment can also make it more difficult to escape

> poverty by slowing progress in school and the workplace, and placing people in social isolation. (¶ 4-5)

Because there is such a great financial and social burden on those with a hearing impairment and the possibility that hearing impairments can be decreased or eliminated through aural rehabilitation, the WHO (2008) has made a goal to eliminate 50% of the burden of avoidable hearing loss by the year 2010. Specifically regarding prevention, the WHO has designed activities for prevention of deafness and hearing impairment; their goal is to "assist countries to reduce and eventually eliminate avoidable hearing impairment and disability through appropriate preventive measures" (WHO, 2006, ¶ 8).

Recently, many countries have put in place preventative measures to relieve the burden of disability from hearing loss, such as immunizations for both children and adults, improving antenatal and perinatal care, avoiding ototoxic drugs, referral of babies with jaundice to the proper professionals for diagnosis and treatment, and avoiding or reducing exposure to loud noises (WHO, 2006). In many developing countries adjustments have been made in health and educational services to provide appropriate service-delivery for children with disabilities.

Hearing Testing

Avoidable hearing disability can be decreased through appropriate identification and rehabilitation, both of which are based upon a comprehensive hearing evaluation. Hearing evaluations are conducted to determine the presence, type, and degree of a hearing impairment. Two important components of a hearing evaluation are pure-tone audiometry and speech audiometry. Pure-tone audiometry generally determines the hearing threshold of an individual through air-conduction and bone-conduction measurements at octave and half-octave levels from 125 Hz to 8000 Hz (ASHA, 1978).

Speech audiometry is used to determine the ability of an individual to hear and recognize speech stimuli and is often used to confirm or disprove pure-tone testing results (ASHA, 1988). The comprehension of speech stimuli is a vital function of hearing (Hagerman, 1993), thus it stands to reason that a comprehensive hearing evaluation would not be complete without the assessment of an individual's ability to process and comprehend speech (Egan, 1979; Martin, Champlin, & Perez, 2000; Mendel, 2008; Ramkissoon et al., 2002; Weisleder & Hodgson, 1989; Wilson & McArdle, 2005). According to Egan (1979), the use of speech audiometry is a necessary step in the rehabilitation of an individual's hearing impairment. Important decisions regarding hearing aids, cochlear implants, as well as language and speech intervention for young children are often based on speech audiometry results.

Speech Audiometry

Speech audiometry in adults. The purpose of speech audiometry is to determine an individual's threshold for hearing speech stimuli; to do this, measurements are taken regarding an individual's most comfortable loudness level (MCL), uncomfortable loudness level (UCL), range of comfortable loudness, ability to recognize speech sounds as such, and ability to differentiate between speech sounds (Martin & Clark, 2006). Two types of measurements used to evaluate an individual's ability to recognize and discriminate speech is SRT and WR testing.

The SRT is the lowest threshold where an individual can understand a speech signal 50 percent of the time and is most often obtained through the use of spondaic words. The SRT has generally been obtained using 1 or 2 dB step increments, but can also be obtained using 5 dB step increments (Chaiklin & Ventry, 1964; Martin & Clark, 2006). Familiarization is used to accustom the individual to the word lists, ensuring that the words are well known and understandable to the listener. Research has indicated that familiarization lowers an individual's SRT by 4 to 5 dB (Tillman & Jerger, 1959).

WR testing involves presenting lists of words to an individual at a suprathreshold level. WR values were originally obtained using phonetically balanced (PB) words (Martin & Clark, 2006), but this practice has been questioned; when researchers compared WR scores that were obtained through the use of PB words to scores that were obtained with words that were not PB, they found little difference in the scores, and so questioned the need for the use of PB words in WR testing (Martin et al., 2000).

Speech audiometry in children. Testing young children can become difficult because their responses are not consistently valid, reliable, and may become an imprecise and flawed approximation of the child’s real abilities (Mendel, 2008). A child’s speech audiometry results are also influenced by several factors, which include the child’s vocabulary, language competency, age, and cognition. It is also influenced by the type of response task. There are three types of responses allowed in speech audiometry; they include oral responses, written responses, and picture or object identification responses. Although each has its advantages and disadvantages, picture or object identification is often used when testing young children, who frequently cannot respond another way or are not cooperative (Martin & Clark, 2006). In addition, whether reinforcement was used or not and the inherent memory load of the task can also affect the validity of a child's responses (Kirk, Diefendorf, Pisoni, & Robbins, 1997).

Mendel (2008) recommends that accommodations should be made of children depending on their alertness, motivation, and fatigue. In particular, testing accommodations can assist children who have a hearing impairment, auditory processing disorder, or have developmental disabilities. In addition, materials used to test the hearing of children should be both linguistic and age appropriate. Currently, appropriate testing materials for Mongolian children are limited or nonexistent.

The Mongolian Language

The Mongolian language belongs in the Altaic language family, which also includes Buriat, Dagur, Monguor, Santa, Paongan, Yellow Uighur, Moghol, Oirat, and Kalmyk. Altaic languages are agglutinative; that is, the word formation and inflection are executed by adding suffixes to word stems (Poppe, 1970). Each Altaic language is considered to be mutually unintelligible, in that monolingual speakers of one language cannot readily communicate with another. Mongolian is spoken in the Mongolian People's Republic (MPR), Inner Mongolia (IM), and in neighboring parts of Manchuria (Poppe, 1970).

The Mongolian language includes both consonant and vowel phonemes. Consonants can be divided by manner (stops, affricates, fricatives, nasals, and liquids), place (labial, dental, and velar), as well as the voice characteristics of the consonant. Many consonants are also divided according to their tense and lax qualities. A consonant cannot necessarily occur in all positions of a word; for example, some consonants cannot occur in the initial position of a word. Additionally, consonant clusters generally do not begin a word (Poppe, 1970).

Vowels can be a single phoneme or a diphthong, but must agree with each other within a word and so are restricted in where they can be placed within a word; this agreement has been termed "vowel harmony." Vowels are generally represented by a single phoneme (Poppe, 1970).

Khalkha, often referred to as Modern Mongolian, is the most popular Mongolian dialect and is the official state language of the MPR. It is recognized orally and written and is used in education, administration, media, and everyday communication. Of the 4.3 million people who reside in the MPR, approximately 2 million people speak the Khalka dialect, while the other 2.3 million people residing there are quickly adopting this dialect. Inner Mongolia as well as Mongolian-speaking parts of China, speak Mongolian but do not have a common dialect, although Khalka greatly influences these dialects (Janhunen, 2003).

Cyrillic is the most commonly used alphabet in Mongolia and was introduced in 1941. Cyrillic originates from the Orthodox Church and is also used to represent several other languages, including Russian, Ukrainian, Bulgarian, and Serbian. It contains 34 letters, most of which are also included in the modern Russian alphabet. Cyrillic is not phonemic in nature; in that one phoneme is not necessarily represented graphically by a single symbol (Poppe, 1970).

Purpose of this Study

Currently there is a lack of age and linguistically appropriate speech audiometry materials for children who are native speakers of Mongolian. Thus, the purpose of this study is to develop, evaluate, equate, and digitally record materials that can be used to measure the WR and speech-reception threshold (SRT) abilities in quiet for child speakers of Mongolian. Specifically, this study will have the following aims: (a) utilize feedback from a series of surveys to create a series of words and word lists for SRT and WR testing that are familiar to native Mongolian children, (b) identify both a native male and female Mongolian speaker who use a standard dialect of Mongolian to serve as talkers for the recordings, (c) psychometrically equate the resulting materials, and (e) create high-quality digital recordings of the Mongolian speech audiometry materials.

Method

This study was part of a larger project which developed SRT and WR materials for native adult speakers of Mongolian. Following the development of the adult speech audiometry materials, eight surveys were sent to professionals in the area of child development to determine the appropriateness of the words for school-aged children native to Mongolian. The results of these surveys were then utilized to create materials appropriate for children. The initial portion of the methods section that follows describes the methodology used to create the adult materials, with the latter portion focusing on the methodology employed to adapt these materials for Mongolian children.

Development of Adult Materials

Participants. A total of 20 listeners evaluated the auditory performance of the Mongolian monosyllabic and bisyllabic words. The listeners were native speakers of Mongolian and self-reported speaking Mongolian on a regular basis. All participants had pure-tone air-conduction thresholds ≤ 15 dB HL at octave and mid-octave frequencies from 125 to 8000 Hz and had static acoustic admittance between 0.3 and 1.4 mmhos with peak pressure between -100 and +50 daPa (ASHA, 1990; Roup, Wiley, Safady, & Stoppenbach, 1998). Additionally, each participant exhibited an ipsalateral acoustic reflex of 95 dB HL or better in the test ear at 1000 Hz and signed an informed consent form. Summary statistics of the subject thresholds are presented in Table 1.

Word evaluation. Monosyllabic words were used to develop the WR materials. A word list of 10,000 most frequently used words developed by Scannell (2007) was used to select the original list of 250 monosyllabic words. A subset of 50 monosyllabic words were then eliminated prior to listener evaluation for the following reasons: (a) thought to be culturally insensitive, (b) considered to be unfamiliar, (c) thought to possibly represent

Table 1

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

Frequency (Hz)	*M*	*Minimum*	*Maximum*	*SD*
125	1.0	-10	10	5.8
250	-1.8	-10	10	5.4
500	-1.3	-10	5	4.8
750	0.3	-10	10	5.7
1000	1.0	-5	10	4.5
1500	2.5	-5	15	6.6
2000	2.0	-5	10	4.4
3000	1.0	-10	15	6.2
4000	0.5	-5	10	4.6
6000	-0.3	-10	15	5.7
8000	-0.5	-10	15	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, or (d) had the same pronunciation but different meanings. Due to experimental error an additional 10 words were omitted from evaluation, resulting in a corpus of 190 monosyllabic words for listener evaluation. Using similar methodology, the SRT materials were developed from a corpus of 90 initially stressed and highly familiar or commonly used bisyllabic Mongolian words.

Talkers. Initial test recordings were made using 8 native Mongolian-speaking individuals, 4 males and 4 females. All talkers self-reported speaking Mongolian on a daily basis. After the initial recordings were made, a panel of 6 Mongolian judges evaluated the performance of each talker, rank ordering the talkers from best to worst based on vocal quality, Mongolian accent, and pronunciation. The highest ranked male and female talkers were selected as the talkers for all subsequent recordings.

Recordings. All recordings were made in a double-walled sound suite designed for audiological testing located on the Brigham Young University campus in Provo, Utah, USA, which meets or exceeds American National Standards Institute (ANSI) S3.1 standards for maximum permissible ambient noise levels for the ears not covered condition using one-third octave bands (American National Standards Institute [ANSI], 1999). A Larson-Davis model 2541 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 preamp, which was coupled to a Larson-Davis model 2200C preamp power supply. The signal was digitized by 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 monosyllabic and bisyllabic 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, unless either token was judged to be the best pronunciation of the word by a native Mongolian judge. Any word that was judged to be a poor recording (e.g., peak clipping, extraneous noise), mispronounced, or produced with unnatural intonation was rerecorded. Repetitions of each word were then rated by a native judge for perceived quality of the production. The best perceived production was then selected for inclusion in the set of bisyllabic words to be evaluated by the native Mongolian listeners.

After the word selection process, the intensity of each monosyllabic and bisyllabic word to be included in the test materials was edited as a single utterance using Adobe Audition (Adobe Systems Incorporated, 2006) and Sadie Disk Editor software (Studio Audio & Video Limited, 2004) to yield the same average RMS power as that of a 1000 Hz calibration tone in an initial attempt to equate test word threshold audibility (Harris et al., 2004a; Wilson & Strouse, 1999). Each of the individually recorded and edited words was then saved as 24-bit *wav* files.

Procedures. 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 participants via a single TDH-50P headphone. All testing was carried out in a double-walled sound suite that met or exceeded ANSI S3.1 standards for maximum permissible ambient noise levels for the ears not covered condition using one-third octave-bands (ANSI, 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 ANSI S3.6 specifications (ANSI, 2004). No changes in calibration were necessary throughout the course of data collection.

Each participant attended two or three test sessions after passing a screening exam. The sessions included listening to and evaluating monosyllabic WR stimuli recorded by both the male and the female talker and listening to the bisyllabic SRT stimuli. The talkers were presented and evaluated separately, and the sequence of the presented lists was randomly selected for each subject. Each subject was allowed several rest periods during each test session.

Evaluation of monosyllabic words. The subjects were not familiarized with the monosyllabic words before testing commenced. The 190 monosyllabic words were randomly grouped into ten lists of 19 words each. These lists were presented to and evaluated by the first half of the listeners at 10 presentation levels ranging from -5 to 40 dB HL. The corpus of words was then randomly regrouped into 10 different lists, which were evaluated by the remaining listeners at the 10 pre-described presentation levels. The order of the presentation of the lists and the order of the words within each list were randomized for each subject, with 4 s of silence between words. Thus, each word was presented twice at each of the 10 intensity levels across the entire subject population. Prior to administering the monosyllabic words, the following instructions were given:

> 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?

Evaluation of bisyllabic words. The bisyllabic words were presented to each of the participants beginning at 6 dB below their PTA and ascending in 2 dB increments until one of the following criteria had been met: (a) the participant responded correctly to 100% of the test items, or (b) the presentation level reached 16 dB HL. The sequence of the words was randomized prior to presentation at each intensity level. Each subject listened to both the male and female talker recordings of all bisyllabic words, in a sequence determined randomly. Subjects repeated words verbally which were scored as being correct or incorrect by a native Mongolian judge. Each subject was allowed to have several rest periods during each test session. Prior to the evaluation of the bisyllabic words, each individual was given the following instructions:

> You will hear bisyllabic words, which become louder or softer in intensity. At the very soft levels it may be difficult for you to hear the words. Please listen carefully and repeat the words that you hear. If you are unsure of a word, you are encouraged to guess. If you have no guess, please be quiet and listen for the next word. Do you have any questions?

Adaptation of Adult Materials for Children

Following initial word evaluation, eight native speakers of Mongolian evaluated the compiled word materials to determine their appropriateness for use with elementary age children. The judges originated from the country of Mongolia and self-reported speaking Mongolian on a regular basis. All of the judges self-reported having knowledge of what words would be familiar to school-aged children, with five of the judges being educational or clinical professionals who are familiar with Mongolian child language development. The words were rated on a scale of 1 to 5 based on how familiar and child-appropriate a word would be to an elementary school-aged child from Mongolia (1 = *extremely*, 2 = *very*, 3 = *average*, 4 = *seldom used*, 5 = *rarely used*).

Results

Monosyllabic WR Materials

The 100 words were rank-ordered according to the rate of listener identification and child appropriateness. These words were then divided into two balanced lists of 50 words each using an S-curve distribution. The S-curve distribution was accomplished by randomly assigning the first word to one of the two randomly selected lists and then placing the second word in the remaining list. This process was then reversed and repeated until two lists with 50 words each were constructed. The Mongolian pediatric word lists in Cyrillic form are presented in Tables 2 (male) and 4 (female), and equivalent romanized word lists are presented in Tables 3 (male) and 5 (female).

After the two balanced word lists were compiled, four half-lists of 25 words each were constructed. The first word in each full list was randomly assigned to either half-list A or B, with the remaining words in the list being assigned to a half-list using an S-curve pattern of distribution. The Mongolian pediatric half-lists are presented in Cyrillic form in Tables 6 (male) and 8 (female). The romanization of the Mongolian pediatric half-lists are presented in Tables 7 (male) and 9 (female), respectively.

Following the construction of monosyllabic lists and half-lists, regression slopes and regression intercepts were calculated via logistic regression for each of the two lists and four half-lists for both the male and female talker recordings. The regression slopes and intercept values were analyzed using a modified logistic regression equation (Equation 1). The equation was utilized to calculate percentage of correct performance at any specified intensity level. The percent of correct values which were yielded from Equation 1 were subsequently used to construct psychometric functions.

Table 2

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

List 1		List 2	
шинэ	арьс	урт	тэд
шиг	уул	ийм	хямд
цай	цонх	хүү	сүүл
унд	суух	цаг	гол
та	хар	дуу	шүд
зун	юм	яг	жил
ам	цус	шил	ганц
ус	оч	сэр	хөрш
ах	айх	тоо	зүүд
дээш	аав	цуг	гал
амт	хад	өөр	нар
эм	уух	муу	мөс
зар	хийх	бор	мал
эгч	зам	ор	байр
од	маш	уур	гар
хоол	ном	ой	сул
тод	мах	оймс	хүн
хот	хөл	жимс	товч
үүл	хөх	сайн	зах
гэр	хүч	хөө	түүх
сар	хог	үс	хурц
сүм	морь	айл	хонь
ээж	яс	шүлс	шал
бод	цас	шог	шат
үг	ач	таг	багш
хямд	хүч	дуу	хүн

Table 3

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

List 1		List 2	
shine	arĭs	urt	ted
shig	uul	iym	hyamd
tsay	tsonh	hüü	süül
und	suuh	tsag	gol
ta	har	duu	shüd
dzun	yüm	yag	jil
am	tsus	shil	gants
us	och	ser	hörsh
ah	ayh	too	dzüüd
deesh	aav	tsug	gal
amt	had	öör	nar
em	uuh	muu	mös
dzar	hiyh	bor	mal
egch	dzam	or	bayr
od	mash	uur	gar
hool	nom	oy	sul
tod	mah	oyms	hün
hot	höl	jims	tovch
üül	höh	sayn	dzah
ger	hüch	höö	tüüh
sar	hog	üs	hurts
süm	morĭ	ayl	honĭ
eej	yas	shüls	shal
bod	tsas	shog	shat
üg	ach	tag	bagsh

Table 4

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

List 1		List 2	
лаа	ор	наана	шог
муур	шүлс	үүд	хонь
ам	ах	шинэ	шат
урт	үг	эм	хийх
тод	ач	сайн	мөр
оймс	үс	муу	байр
онц	зам	зүүд	амт
дүү	зай	ус	ном
үүр	ой	ийм	шал
шил	хүү	доод	мөс
жимс	уух	хар	зар
багш	цус	од	гал
гуйх	хурц	ээж	жил
ав	хог	цаг	доош
уул	шүд	яг	нуур
айх	өвс	бэх	гар
зун	сүүл	зах	доор
хад	хөл	цуг	цонх
шиг	мал	эмч	оч
сар	өөр	суух	хоол
бор	мах	уур	юм
нар	хөх	аав	маш
тус	морь	яс	гол
түүх	үүл	эгч	хөрш
хямд	хүч	дуу	хүн

Table 5

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

List 1		List 2	
laa	or	naana	shog
muur	shüls	üüd	honĭ
am	ah	shine	shat
urt	üg	em	hiyh
tod	ach	sayn	mör
oyms	üs	muu	bayr
onts	dzam	dzüüd	amt
düü	dzay	us	nom
üür	oy	iym	shal
shil	hüü	dood	mös
jims	uuh	har	dzar
bagsh	tsus	od	gal
guyh	hurts	eej	jil
av	hog	tsag	doosh
uul	shüd	yag	nuur
ayh	övs	beh	gar
dzun	süül	dzah	door
had	höl	tsug	tsonh
shig	mal	emch	och
sar	öör	suuh	hool
bor	mah	uur	yüm
nar	höh	aav	mash
tus	morĭ	yas	gol
tüüh	üül	egch	hörsh
hyamd	hüch	duu	hün

Table 6

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

1A	1B	2A	2B
шиг	шинэ	ийм	урт
цай	унд	хүү	цаг
зун	та	яг	дуу
ам	ус	шил	сэр
дээш	ах	цуг	тоо
амт	эм	өөр	муу
эгч	зар	ор	бор
од	хоол	уур	ой
хот	тод	жимс	оймс
үүл	гэр	сайн	хөө
сүм	сар	айл	үс
ээж	бод	шүлс	шог
арьс	үг	тэд	таг
уул	цонх	хямд	сүүл
хар	суух	шүд	гол
юм	цус	жил	ганц
айх	оч	зүүд	хөрш
аав	хад	гал	нар
хийх	уух	мал	мөс
зам	маш	байр	гар
мах	ном	хүн	сул
хөл	хөх	товч	зах
хог	хүч	хурц	түүх
морь	яс	хонь	шал
ач	цас	багш	шат

Table 7

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

1A	1B	2A	2B
shig	shine	iym	urt
tsay	und	hüü	tsag
dzun	ta	yag	duu
am	us	shil	ser
deesh	ah	tsug	too
amt	em	öör	muu
egch	dzar	or	bor
od	hool	uur	oy
hot	tod	jims	oyms
üül	ger	sayn	höö
süm	sar	ayl	üs
eej	bod	shüls	shog
arĭs	üg	ted	tag
uul	tsonh	hyamd	süül
har	suuh	shüd	gol
yüm	tsus	jil	gants
ayh	och	dzüüd	hörsh
aav	had	gal	nar
hiyh	uuh	mal	mös
dzam	mash	bayr	gar
mah	nom	hün	sul
höl	höh	tovch	dzah
hog	hüch	hurts	tüüh
morĭ	yas	honĭ	shal
ach	tsas	bagsh	shat

Table 8

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

1A	1B	2A	2B
лаа	муур	үүд	наана
урт	ам	шинэ	эм
тод	оймс	муу	сайн
дүү	онц	зүүд	ус
үүр	шил	доод	ийм
багш	жимс	хар	од
гуйх	ав	цаг	ээж
айх	уул	яг	бэх
зун	хад	цуг	зах
сар	шиг	эмч	суух
бор	нар	аав	уур
түүх	тус	яс	эгч
хямд	ор	шог	дуу
ах	шүлс	хонь	шат
үг	ач	мөр	хийх
зам	үс	байр	амт
зай	ой	шал	ном
уух	хүү	мөс	зар
цус	хурц	жил	гал
шүд	хог	доош	нуур
өвс	сүүл	доор	гар
мал	хөл	цонх	оч
өөр	мах	юм	хоол
морь	хөх	маш	гол
үүл	хүч	хүн	хөрш

Table 9

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

1A	1B	2A	2B
laa	muur	üüd	naana
urt	am	shine	em
tod	oyms	muu	sayn
düü	onts	dzüüd	us
üür	shil	dood	iym
bagsh	jims	har	od
guyh	av	tsag	eej
ayh	uul	yag	beh
dzun	had	tsug	dzah
sar	shig	emch	suuh
bor	nar	aav	uur
tüüh	tus	yas	egch
hyamd	or	shog	duu
ah	shüls	honĭ	shat
üg	ach	mör	hiyh
dzam	üs	bayr	amt
dzay	oy	shal	nom
uuh	hüü	mös	dzar
tsus	hurts	jil	gal
shüd	hog	doosh	nuur
övs	süül	door	gar
mal	höl	tsonh	och
öör	mah	yüm	hool
morĭ	höh	mash	gol
üül	hüch	hün	hörsh

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

The following is a description of Equation 1. P is a percentage of correct recognition, a is the regression intercept, b is the regression slope, i is the intensity level of presentation in dB HL. The percentage of correct WR at any specified intensity level is predictable when inserting the regression slope, regression intercept, and intensity level into Equation 1. Thus the percentage of correct WR was predicted through Equation 1 for each of the monosyllabic lists and half-lists. The range of presentation intensity levels was -5 to 40 dB HL in 5 dB increments. After the percentages were predicted using Equation 1, psychometric functions were constructed. Equation 2 was then used to find the threshold (presentation intensity required for 50% WR performance), the slope at threshold, and the slope from 20 to 80% for the two lists and four half-lists. The calculation was performed by inserting specific proportions into Equation 2.

$$i = \frac{\log \frac{p}{1 - p} - a}{b} \quad (2)$$

In Equation 2, i is the presentation level in dB HL, p is the proportion of correct recognition, a is the regression intercept, and b is the regression slope. Presented in Table 10 (male) and Table 11 (female) are the results for intensity threshold, slope at threshold, and slope from 20 to 80% for each list and half-list.

After the lists and half-lists were compiled, a two-way Chi-Square (χ^2) analysis (intensity and list as independent variables with response as the dependent variable) was completed in order to discern any statistically significant differences among the monosyllabic 50-word lists or 25-word half-lists. The results of the Chi-Square analysis

Table 10

Mean Performance of Mongolian Male Monosyllabic Pediatric Lists and Half-lists

List	a[a]	b[b]	Slope at 50% [c]	Slope 20-80%[d]	Threshold[e]	ΔdB[f]
1	2.86227	-0.24637	6.16	5.33	11.62	-1.77
2	3.03225	-0.26650	6.66	5.77	11.38	-2.01
M	2.94726	-0.25644	6.41	5.55	11.50	-1.89
Minimum	2.86227	-0.26650	6.16	5.33	11.38	-2.01
Maximum	3.03225	-0.24637	6.66	5.77	11.62	-1.77
Range	0.16998	0.02013	0.50	0.44	0.24	0.24
SD	0.12019	0.01423	0.36	0.31	0.17	0.17
1A	2.52804	-0.22099	5.52	4.78	11.44	-1.95
1B	3.31258	-0.28106	7.03	6.08	11.79	-1.61
2A	3.18541	-0.27739	6.93	6.00	11.48	-1.91
2B	2.89360	-0.25671	6.42	5.56	11.27	-2.12
M	2.97991	-0.25904	6.48	5.61	11.50	-1.90
Minimum	2.52804	-0.28106	5.52	4.78	11.27	-2.12
Maximum	3.31258	-0.22099	7.03	6.08	11.79	-1.61
Range	0.78454	0.06007	1.50	1.30	0.51	0.51
SD	0.34859	0.02754	0.69	0.60	0.21	0.21

[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 (13.39 dB HL).

Table 11

Mean Performance of Mongolian Female Monosyllabic Pediatric Lists and Half-lists

List	a[a]	b[b]	Slope at 50%[c]	Slope 20-80%[d]	Threshold[e]	ΔdB[f]
1	3.35089	-0.21927	5.48	4.75	15.28	1.89
2	3.78866	-0.24777	6.19	5.36	15.29	1.90
M	3.56978	-0.23352	5.84	5.05	15.29	1.89
Minimum	3.35089	-0.24777	5.48	4.75	15.28	1.89
Maximum	3.78866	-0.21927	6.19	5.36	15.29	1.90
Range	0.43777	0.02850	0.71	0.62	0.01	0.01
SD	0.30955	0.02015	0.50	0.44	0.01	0.01
1A	3.46665	-0.22680	5.67	4.91	15.29	1.89
1B	3.24429	-0.21235	5.31	4.60	15.28	1.89
2A	3.87532	-0.25177	6.29	5.45	15.39	2.00
2B	3.70595	-0.24398	6.10	5.28	15.19	1.80
M	3.57305	-0.23373	5.84	5.06	15.29	1.89
Minimum	3.24429	-0.25177	5.31	4.60	15.19	1.80
Maximum	3.87532	-0.21235	6.29	5.45	15.39	2.00
Range	0.63103	0.03942	0.99	0.85	0.20	0.20
SD	0.27594	0.01766	0.44	0.38	0.08	0.08

[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 (13.39 dB HL).

indicated that there were no significant differences among the 50-word lists for the male and female talkers, $\chi^2(1, N = 20) = 0.28$, $p = 0.595$ and $\chi^2(1, N = 20) = 1.54$, $p = 0.215$, respectively. Results also indicated that there were no significant differences found among the 25-word half-lists for the male and female talkers, $\chi^2(3, N = 20) = 3.81$, $p = 0.283$ and $\chi^2(3, N = 20) = 1.88$, $p = 0.598$. When the slopes of the psychometric functions for the 50-word male lists were compared, there were no statistically significant differences among psychometric function slopes for the male half-lists; $\chi^2(1, N = 20) = 0.72$, $p = 0.397$ nor for the 50-word female lists $\chi^2(1, N = 20) = 2.28$, $p = 0.517$. Statistical analysis for the 25-word female half-lists found no statistically significant differences among the slope values; $\chi^2(3, N = 20) = 4.64$, $p = 0.200$. The slopes of the psychometric functions for the 25-word male half-lists were also analyzed and no statistically significant differences among slopes were found; $\chi^2(1, N = 20) = 2.28$, $p = 0.517$. There were no significant intensity by list interactions, which indicated that there were minimal differences among the psychometric function slopes for the lists and half-lists.

Although there were not any statistically significant differences among the word lists or half-lists, intensity level adjustments were digitally completed by way of Adobe Audition 2.0 (Adobe Systems Incorporated, 2006) in order to increase the psychometric equivalency for the lists as well as the half-lists. The intensity of each word from the male and female monosyllabic lists and half-lists was adjusted digitally so that the 50% threshold of each list was equal to the midpoint (13.39 dB HL) between the mean threshold of the four male half-lists and the mean threshold of the four female half-lists. Presented in Table 10 (male) and Table 11 (female) are the intensity adjustments which were made to each word in the four lists and eight half-lists. Figure 1 exhibits the psychometric functions for the male talker and female talker monosyllabic lists and half-lists prior to the intensity adjustments. Figure 2 represents the mean psychometric functions for the female talker and male talker monosyllabic lists and half-lists after the intensity adjustments were performed to produce 50% performance at 13.39 dB HL. Figure 3 shows the mean psychometric functions for the combined male and female talker monosyllabic lists both before and after the intensity adjustments.

The predicted psychometric functions and those created after the intensity adjustments differed between both the male and female talker lists. The adjustments needed to equate the 50-word lists and 25-word half-lists were less than 2.2 dB for both the male and female talker recordings (see Figure 3).

Bisyllabic SRT Materials

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

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

In Equation 3, 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 3 is solved for p and multiplied by 100, Equation 4 is obtained where P is percent correct recognition:

$$P = \left(1 - \frac{\exp(a + b \times i)}{1 + \exp(a + b \times i)}\right) * 100 \qquad (4)$$

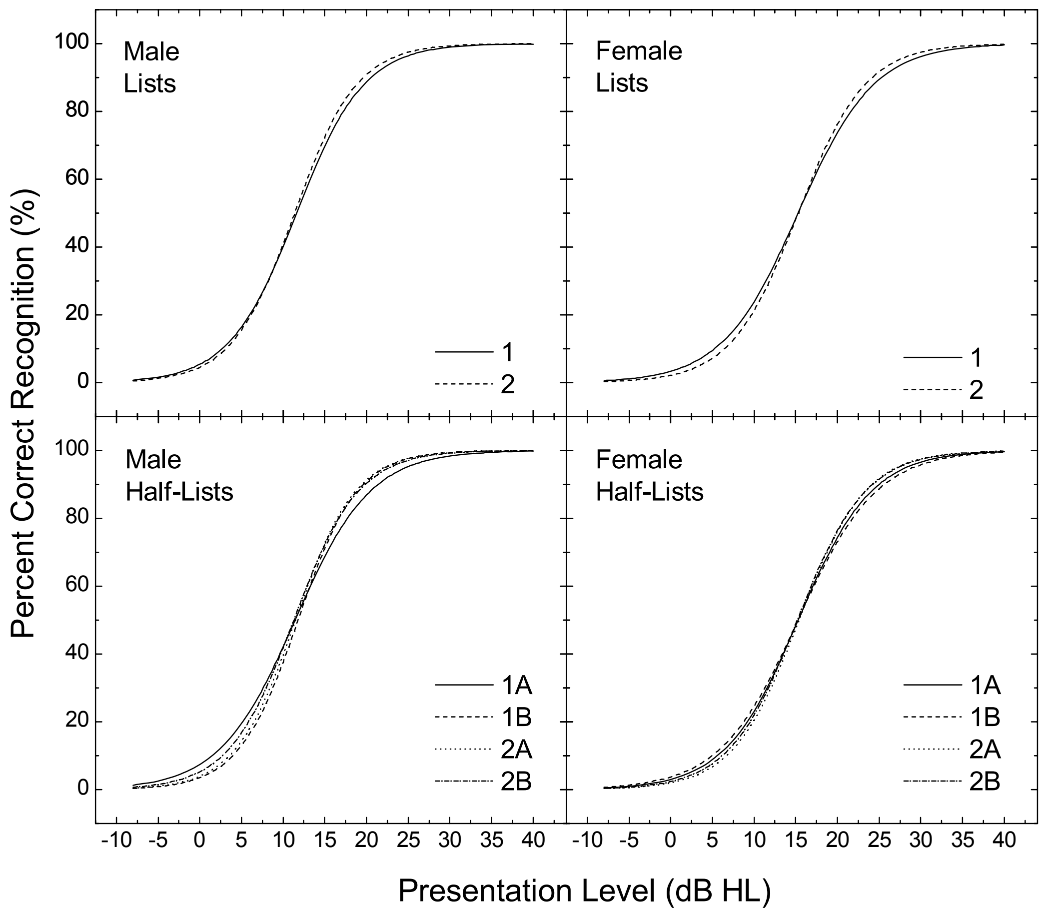

Figure 1.

Psychometric functions for the two Mongolian pediatric monosyllabic lists and four half-lists for male talker and female talker recordings before intensity adjustments.

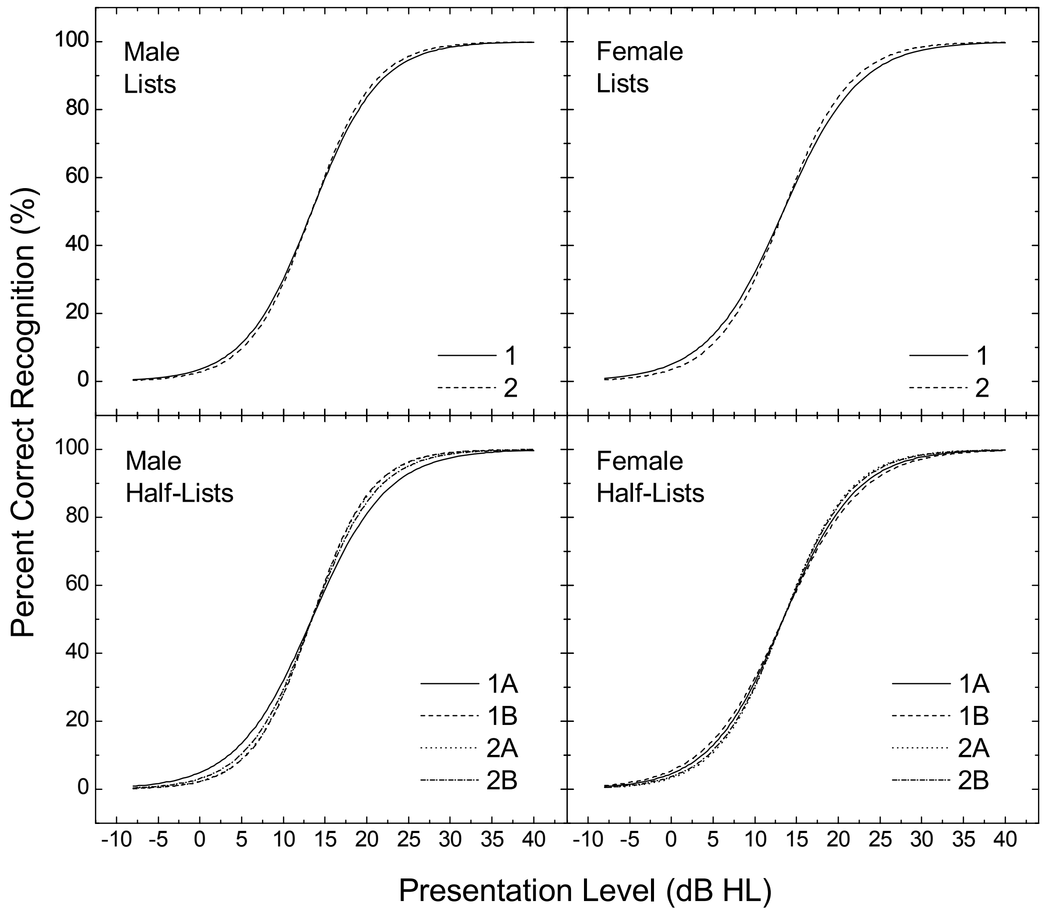

Figure 2.

Psychometric functions for the two Mongolian pediatric monosyllabic lists and four half-lists for male talker and female talker recordings after intensity adjustments to produce 50% performance at 13.39 dB HL.

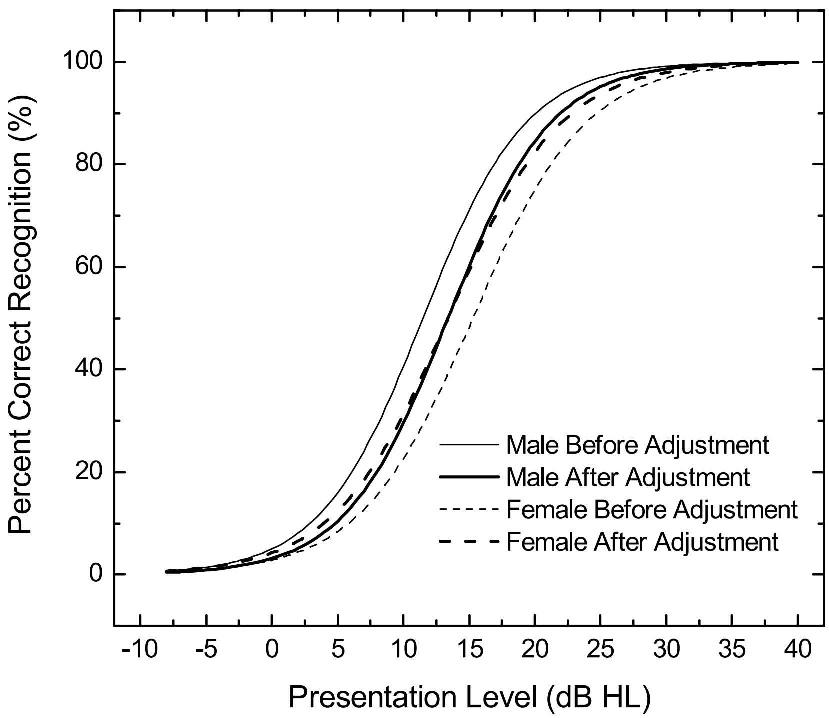

Figure 3.

Mean psychometric functions for male and female Mongolian talker pediatric monosyllabic word lists before and after intensity adjustment. Intensity adjustments were made to each list and half-list to produce 50% correct performance at 13.39 dB HL.

By inserting the regression slope, regression intercept, and presentation level into Equation 4, it is possible to predict the percentage correct at any specified intensity level. Percentage of correct recognition was calculated for each of the bisyllabic 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 3 was solved for *i* (see Equation 5). By inserting the desired proportions into Equation 4, 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 5 can be simplified to Equation 6:

$$i = \frac{\log \frac{p}{1-p} - a}{b} \tag{5}$$

$$i = \frac{-a}{b} \tag{6}$$

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

The intent of this analysis was to select a final set of child-appropriate SRT words based on the steepness of their relevant psychometric slopes, information from the surveys indicating if a particular word is highly familiar to young children, and the ability to represent the word pictographically. However, adherence to each of these criteria did not result in a sufficient number of bisyllabic child-appropriate SRT words to be used to test a child's hearing in a valid and reliable manner. The inability to obtain a subset of

SRT words was due in part to large differences between the mean PTA of the subjects and the threshold for 50% intelligibility, as well as the inability to represent most of the selected words pictographically.

Discussion

The current study aimed to develop age and linguistically appropriate speech audiometry materials for children who are native speakers of Mongolian. These materials were developed to assist audiologists in the United States and around the world in their efforts to eliminate the disabling effects of hearing loss. Although a list of child-appropriate bisyllabic words for SRT testing was not able to be developed, two lists of 50 monosyllabic words and four half-lists of 25 words for WR testing were developed for clinical use.

For the monosyllabic WR lists, the audibility and psychometric function slopes (Figures 1-3) were relatively homogeneous with respect to psychometric slope and 50% threshold for normal hearing participants within a double-walled sound booth. Homogeneity among word lists increases the validity and reliability during audiological testing, thus reducing the likelihood that any differences in performance would be due to the nature of the word lists.

The average for the psychometric function slopes at 50% for the monosyllabic lists and half-lists was 6.41 %/dB for the male recordings and 5.84 %/dB for the female recordings as displayed in Tables 10 (male) and 11 (female). The average psychometric function slopes at the 20-80 %/dB for the monosyllabic lists and half-lists was 5.55 %/dB for the male recordings and 5.05 %/dB for the female recordings.

The mean psychometric function slopes obtained for the Mongolian child-appropriate word lists exhibited slightly higher percentages than WR materials developed in English for adults. Beattie, Edgerton, and Svihovec (1977) found psychometric function slopes of 4.2 %/dB for the NU-6 words lists and 4.6 %/dB for the CID W-22 word lists when measured from 20-80%. Wilson and Oyler (1997) described slightly higher mean slopes for both the NU-6 word lists (*M* = 4.4 %/dB) and the CID W-22 word lists (*M* = 4.8 %/dB) when recordings were used from the Auditec of St. Louis CD. The differences found in the Mongolian and English slopes for the word lists and half-lists were insignificant and thereby support the feasibility of using the Mongolian word lists among Mongolian speaking children.

Wilson and Oyler (1997) also looked at the mean psychometric function slopes for hearing impaired individuals; their results showed mean percentages of 2.3 %/dB for the NU-6 lists and 2.2 %/dB for the CID-22 lists. Further testing is needed for the current word lists to verify the use of the Mongolian child-appropriate word lists among hearing-impaired children native to Mongolian.

Difference Between Mean PTA of Subjects and Intelligibility Thresholds

For both the monosyllabic and bisyllabic materials, significant differences were found between the mean PTA of the subjects and the threshold for 50% intelligibility. The inability to obtain a subset of SRT words was due in part to large differences between the mean PTA of the subjects and the threshold for 50% intelligibility. For the bisyllabic adult word lists, the change in intensity required for a threshold to be adjusted to the mean PTA of the subjects was 7.3 dB for the male talker and 8.5 dB for the female talker (Gilbert, 2009). Studies involving other Asian Pacific languages have required relatively smaller adjustment to be psychometrically equivalent. For example, Tongan materials reported a 3.3 dB change for the male talker and a -0.1 dB change for the female talker (Bunker, 2008). Thai materials reported a 0.2 dB change for the male talker and a -1.6 dB change for the female talker (Hart, 2008). Due to the limited amount of headroom in the recordings, many of the selected bisyllabic words could not be digitally adjusted 7.3 or 8.5 dB and therefore were not able to be used.

For the monosyllabic word lists, the mean threshold for 50% intelligibility was 11.5 dB HL for the male lists and 15.3 dB HL for the female lists, whereas the reported mean PTA for the subjects was 0.6 dB HL. Research with other Asian languages have reported thresholds lower than those found in this study involving Mongolian. For example, Japanese WR lists reported a mean threshold of 11.6 dB HL for the male lists and 7.3 dB HL for the female lists (Harris, Crawford, & Mastny, 2004), and Mandarin word lists reported a 5.4 dB HL threshold and 3.5 dB threshold for male and female word lists, respectively (Nissen et al., 2005a).

There are several possible reasons for the relatively large differences between the mean PTA thresholds of the subjects and thresholds for 50% intelligibility of the Mongolian materials developed in this study. One factor may be the difference in dialect between the talkers and the listeners. The male talker was from the capital city of Mongolia, Ulaanbaatar, while the female talker was from a western city in Mongolia, Khovd. Although they both reported speaking the Khalka dialect, regional linguistic variation may be present in the talker recordings. The subjects were also from various places in Mongolia. Of the total 20 subjects who were native to Mongolia, 17 were from Ulaanbaatar, 2 from other eastern cities, and 1 was from a western city. Thus, three of the twenty subjects did not originate from the capital city.

Research concerning the effect of regional dialect on WR and SRT measures is mixed. Studies by Richardson (2008) and Garlick (2008) reported that regional dialect differences are not likely to result in clinically significant differences in WR and SRT results. However, a study by Weisleder and Hodgson (1989) reported that as lower intensities were presented, listeners whose dialect was similar to that of the talker's scored better than did listeners whose dialect was different, although mutually understood.

Another possible reason for the relatively large differences between mean listener PTA and threshold of 50% intelligibility may be due to the linguistic nature of the Mongolian language. Vowels in the Mongolian language are abundant, and according to a study conducted by Hoopingarner (2004), the perception of a vowel is influenced by the linguistic context. In this study, the bisyllabic words for SRT testing were presented in an isolated context, thus listeners performance may improve with additional linguistic context. This study may have been improved had bisyllabic and trisyllabic words been used for SRT words lists, instead of the chosen monosyllabic and bisyllabic. Using a different type of word, an additional amount of context would have been present. This would make it easier for the listeners to identify the word due to the fact that there is more acoustical information to listen to. Having more context and acoustic information may have also dropped the threshold of 50% intelligibility closer to the mean PTA of the subjects.

Further Research

There is a need for further research of these particular materials, as well as supplemental research in speech audiometry material development in Mongolian. These word lists should be tested on typically developing school-aged children with normal hearing to further determine their familiarity to native Mongolian speaking children. There are few studies that have attempted to create or investigate child-appropriate speech audiometry materials in languages other than English (Abdulhaq, 2006; Ashoor & Prochazka, 1985). This is the first study to develop child-appropriate speech audiometry materials for the Mongolian language, and so further research, investigation, and replication is needed to determine the validity and reliability of the words chosen for the word lists as well as the performance of the judges' ratings.

A limitation of this study was that many of the words selected, especially for the purposes of SRT testing, were not easily represented by pictures. Although familiar in the language at large, many of the words were adjectives and verbs and not nouns that could be represented pictorially in a salient manner. Instead of first choosing words that were frequently used in the language and then selecting a subset of words that were child-appropriate, perhaps this study should have begun with a larger set of words that could be represented by concrete pictures (e.g., tree, table, house, airplane).

A further limitation was a lack of consistency across the eight judges used to rate how familiar a word would be to a child. The judges who were not child language development professionals were quite consistent in their ratings, whereas the five judges who were self-reported professionals in child language development were not consistent in their ratings. This variability and inconsistency could be due to a number of reasons. The instructions on the survey may have been lacking in specificity, or a more descriptive rating scale may be needed. In addition, the professional judges may have had differing levels of expertise. Lastly, it would be valuable to increase the number of surveys used to select the child-appropriate words, with additional professionals in the area of child language development.

Conclusions

In summary, the goals of this study were to develop child-appropriate WR and SRT materials to be used clinically for native speakers of the Mongolian language. For the WR materials, both the lists and half-lists were created to be relatively homogeneous with respect to audibility and psychometric function slope. Given the structure and limitations of this study, a valid set of child-appropriate SRT materials could not be developed. The inability to obtain a subset of SRT words was due in part to large differences between the mean PTA of the subjects and the threshold for 50% intelligibility, as well as the inability to represent most of the selected words pictographically.

Despite the limitations of this study, it is anticipated that the materials created in this study will aid in the accurate evaluation of hearing in Mongolian children, thereby helping to eliminate the disabling effects of hearing loss in children. The WR materials developed in this study are digitally recorded onto a CD and are available for scientific evaluation and clinical speech audiometry testing for native Mongolian children.

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Appendix A

Informed Consent

Consent to be a Research Subject

Introduction
This research study is being conducted by Meghan Caldwell, a graduate student in speech-language pathology at Brigham Young University. This work will be supervised by Dr. Shawn Nissen, who is a member of the faculty in the Department of Communication Disorders at Brigham Young University. You were selected to participate because you are a native Mongolian speaker with a background in child education.

Procedures
Participation in this study will involve approximately 15-30 minutes of your time. You will be asked to rate Mongolian monosyllabic and bisyllabic words on a scale of 1 to 5 based on how appropriate and familiar each word would be to a child starting elementary school.

Risks/Discomforts
There are minimal risks for participation in this study.

Benefits
There are no direct benefits to subjects. However, it is hoped that through your participation researchers will develop testing and calculation of hearing thresholds using word-recognition scores and speech reception thresholds that use child-appropriate and linguistically appropriate word lists for native child speakers of the Mongolian language.

Confidentiality
All information provided will remain confidential and will only be reported as group data with no identifying information. All data will be kept in a locked storage cabinet and only those directly involved with the research will have access to them.

Compensation
No monetary compensation is offered. However, a summary of the findings of the study will be provided to you upon request.

Participation
Participation in this research study is voluntary. You have the right to withdraw at anytime or refuse to participate entirely.

Questions about the Research
If you have questions regarding this study, you may contact Meghan Caldwell at (714) 251-4953, meghanej514@gmail.com or Dr. Shawn Nissen at (801) 422-5056, Shawn_Nissen@byu.edu.

Questions about your Rights as Research Participants
If you have questions regarding your rights as a research participant, you may contact Christopher Dromey, PhD, Institutional Review Board (IRB) Chair, 422-6461, 133 TLRB, Brigham Young University, Provo, UT 84602, Christopher_Dromey@byu.edu.

I have read, understood, and received a copy of the above consent and desire of my own free will and volition to participate in this study.

Signature:____ Date:________

Printed Name:____

Судалгаанд Хамрагдагчийн Зөвшөөрөл

Танилцуулга
Энэхүү судалгаа нь Brigham Young-ийн Их Сургуулийн яриа хэл зүйн магистерийн дамжааны оюутан Meghan Caldwell-ээр хөтлүүлэн явагдах юм. Энэхүү хөтөлбөр нь тус сургуулийн Харилцааны Эмгэг Согогын Тэнхимийн гишүүн доктор Shawn Nissen-ий хяналтан дор явагдана. Таний сонгогдон оролцож буйн учир нь та хэрэгцээтэй хэлний шаардлагуудийг (таний төрөлх хэл буюу Монгол хэл, хүүхдийн хөгжил, боловсрол, хэл ярианы хөгжил дахь туршлага) хангасан байна.

Журамууд
Энэхүү судалгаанд ойролцоогоор 15-30 минут зарцуулагдана. Та нэг болон хоёр үетэй Монгол үгсийг сургуулийн насны хүүхдэд хэр тохиромжтой гэдгээр нь 1-5 аар дугаарлаж дүгнэнэ.

Эрсдэл/Сөрөг үр дагаварууд
Энэхүү судалгаанд оролцоход ямар нэгэн эрсдэл, сөрөг үр дагавар байхгүй.

Ашиг тус
Судалгаанд оролцогсдод ямар нэгэн ашиг тус байхгүй. Гэвч та энэхүү судалгаанд хамрагдсанаар судлаачдад үг таних, хэл яриа хүлээж авах зэрэг дүгнэлтүүд болон төрөлхийн Монголоор ярьдаг хүүхдүүдэд тохирсон хэл зүй, үгсийн санг ашиглаж, сонсгол, хэл ярианы шинжилгээ мөн дүгнэлтийг сайжруулж, хөгжүүлнэ гэж найдаж байна.

Хувийн нууцлал
Бидэнд олгогдсон бүх мэдээлэлүүд нууцлагдаж үлдэх ба зөвхөн нэгдмэл судалгааны баримт болж ямарч таних, тодорхойлох мэдээлэлгүйгээр хийгдэнэ. Таний хариулсан бүх мэдээлэл болон дижитал бичлэгүүд цоожтой шүүгээнд хадгалагдах бөгөөд түүнд зөвхөн судалгаанд шууд хамрагдаж буй хүмүүс л нэвтрэх боломжтой.

Цалин хөлс
Ямар нэгэн цалин хөлс олгогдохгүй. Харин судалгааны талаархи дүгнэлт мэдээлэлүүдийг та хүсэлтийнхээ дагуу авч болно.

Хамрагдалт
Энэхүү судалгаанд хамрагдагсад сайн дураар оролцох юм. Та энэ судалгаанаас ямар ч үед гарах, оролцохоо зогсоох эрхтэй бөгөөд таний хичээл, анги, сургуульд ямар нэгэн нөлөө үзүүлэхгүй.

Судалгааны талаархи асуултууд
Хэрэв танд судалгааны талаар асуулт байвал та Meghan Caldwell-тэй (714) 251-4953, meghanej514@gmail.com эсвэл доктор Shawn Nissen-тэй (801) 422-5056, Shawn_Nissen@byu.edu зэрэг дугаар болон e-mail хаягуудаар холбогдож болно.

Судалгаанд оролцогчидын эрхийн тухай асуултууд
Хэрэв судалгаанд оролцогчийн хувьд, танд өөрийн эрхийн тухай асуух зүйлүүд байвал та Сургалт Хяналтын Тэнхимийн тэргүүн профессор Christopher Dorney-той (801) 422-6461 дугаараар мөн 133 TURB Brigham Young University, Provo, UT 84602, Christopher_Dromey@byu.edu хаягаар холбогдоно уу.

Би дээрхи зүйлүүдийг уншиж, ойлгон мөн нэг хувь хуулбар хүлээн авч өөрийн эрх мэдэл, сайн дур, хүсэлтийн дагуу зөвшөөрч энэхүү судалгаанд оролцож буй болно.

Гарын үсэг____ Огноо_______

Appendix B

Selected Monosyllabic Word Definitions

Romanization	Cyrillic	Grammatical Category	Definition
beh	бэх	noun	ink
bod	бод	noun	horses, camels, and cattle
bor	бор	adjective	brown
bagsh	багш	noun	teacher
bayr	байр	noun	apartment, residence
deesh	дээш	adjective	upwards or more than
dood	доод	noun	below, bottom
door	доор	adjective	below, beneath, down, under
doosh	доош	adjective	downward
düü	дүү	noun	younger brother or sister, younger
duu	дуу	noun	song
dzüüd	зүүд	noun	dream
dzun	зун	noun	summer
dzah	зах	noun	edge, border, market
dzam	зам	noun	path, road, route, way
dzar	зар	noun	announcement or advertisement
dzay	зай	noun	space, gap, distance, length or battery
eej	ээж	noun	mother, mummy, mom
egch	эгч	noun	elder sister
em	эм	noun	medicine
emch	эмч	noun	physician, doctor
ger	гэр	noun	home, house
gol	гал	noun	river, and main, core
guyh	гуйх	verb	to ask for, beg
gants	ганц	adjective	alone, single
gol	гол	noun	river, and main, core
gar	гар	noun	hand, arm, and get out
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
hool	хоол	noun	food, meal
hörsh	хөрш	noun	neighbour
hot	хот	noun	city, town
hüch	хүч	noun	power, force
hün	хүн	noun	human, person
hüü	хүү	noun	boy, son
hurts	хурц	adjective	sharp
hyamd	хямд	adjective	cheap
had	хад	noun	cliff
har	хар	adjective	black, dark
iym	ийм	adjective	such
jil	жил	noun	year

jims	жимс	noun	fruit
laa	лаа	noun	candle
mör	мөр	noun	row, shoulder, trace, track,
morĭ	морь	noun	horse
mös	мөс	noun	ice
muu	муу	adjective	bad
muur	муур	noun	cat
mah	мах	noun	flesh, meat
mal	мал	noun	livestock
mash	маш	adjective	very
nom	ном	noun	book
nuur	нуур	noun	lake
nar	нар	noun	sun
naana	наана	adverb	on this side, closer to this side, before
och	оч	noun	spark
od	од	noun	star
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
ser	сэр	verb	wake up
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
shal	шал	noun	floor
shat	шат	noun	stairs
süm	сүм	noun	monastery, church
süül	сүүл	noun	tail, end
sul	сул	verb	loose, vacant, unoccupied, weak
suuh	суух	verb	to sit
sar	сар	noun	moon, month
sayn	сайн	adjective	good, well
ted	тэд	personal pronoun	they
tod	тод	adjective	clear or bright
too	тоо	noun	count, number, numeral
tovch	товч	noun	button or brief
tsonh	цонх	noun	window
tsug	цуг	adverb	together
tsus	цус	noun	blood
tsag	цаг	noun	time, hour, clock
tsas	цас	noun	snow
tsay	цай	noun	tea
tüüh	түүх	noun	to collect, history, story
tus	тус	noun	help
ta	та	personal pronoun	you
tag	таг	noun	hood, lid
üg	үг	noun	word
üs	үс	noun	hair, fur
üüd	үүд	noun	door, gate
üül	үүл	noun	cloud
üür	үүр	noun	dawn, nest

und	унд	noun	beverage, meal
urt	урт	noun	long
us	ус	noun	water
uuh	уух	verb	to drink
uul	уул	noun	mountain
uur	уур	noun	steam, vapor, anger
yüm	юм	noun	thing
yag	яг	adjective	exact
yas	яс	noun	bone
ach	ач	noun	grandson, granddaughter
ah	ах	noun	brother, elder
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
aav	аав	noun	father, dad