DEVELOPMENT AND EVALUATION OF PSYCHOMETRICALLY EQUIVALENT TRISYLLABIC WORDS FOR SPEECH AUDIOMETRY IN FANTE

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DEDICATION

I dedicate this work to my parents, Mr Nicholas Honu & Rose Awude and all my siblings especially Francis and Kafui.

DECLARATION

I **CYRIL MAWULI HONU-MENSAH**, do hereby declare that this dissertation being submitted in partial fulfilment of the requirements for Master of Science (MSc) degree in Audiology is my own independent research work performed under supervision and that, except where otherwise other sources which are acknowledged and duly referenced, this work has not previously been accepted in substance for any degree, and is not being concurrently submitted in candidature for any degree.

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LIST OF ABBREVIATIONS

AAST	Adaptive Auditory Speech Test
CHSS	Centre for Hearing and Speech Services
HAC	Hearing Assessment Centre
KATH	Komfo Anokye Teaching Hospital
KBTH	Korle Bu Teaching Hospital
NARC	National Assessment & Resource Centre
PTA	Pure Tone Average
RMS	Root mean square
SDS	Speech Discrimination Score
SDT	Speech Detection Threshold
SRT	Speech Recognition Threshold or Speech Reception Threshold
WRS	Word Recognition Score
MLV	Monitored Live Voice

ABSTRACT

Background: Speech is pervasively used for communication purposes but can also be used to measure the hearing of individuals, for hearing aids evaluation and for differential diagnoses of cochlea and retrocochlear disorders. Hence, there is the need for the existence of appropriate speech tests to adequately assess speech and predict the degree of hearing impairment.

Aim: The aim of this research was to develop and evaluate digitally recorded speech materials that can be used for speech audiometry in Fante.

Methods: A quantitative research approach which employed a three-phase cross-sectional study design was adopted for this study. Purposive sampling technique was used in selecting samples throughout the three phases of this study. Fifty-one (51) familiar trisyllabic words were selected from 107 commonly used trisyllabic Fante words, digitally recorded and edited to yield the same RMS as the 1 kHz calibration tone. Listener evaluation was done by 20 native Fante speakers with normal hearing thresholds. Logistic regression was then used to calculate the slope, intercepts and psychometric function slope at 50%/dB and from 20-80%/dB for all the words. To increase homogeneity of the thresholds of the selected words, the intensity of each was digitally adjusted so that the 50% threshold of each word was equal to the mean PTA of the subjects.

Results: A final list of 25 familiar homogenous words having the same tone patterns with slopes greater than 7%/dB were finally selected and recorded unto a CD for speech audiometry in Fante.

Conclusion: Psychometrically equivalent trisyllabic words for speech audiometry in Fante were developed and evaluated. The need to develop speech audiometry materials in other spoken languages in Ghana is recommended.

Keywords: Speech audiometry, homogeneity, psychometric function, familiarity.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

Speech is pervasively used in daily activities in education, trade, conversation and in giving or receiving instructions. In Ghana, the most popular medium of instruction in the classroom is oral and involves the use of speech to share information, ask questions and provide answers to questions. The far-flung usage of speech has made it necessary for clinicians to assess individuals' ability to hear and understand speech. Apart from communication purposes, speech can be used to measure the hearing of individuals. Martin and Clark (2012) have stated that thresholds derived or inferred from the pure-tone audiogram cannot depict beyond the grossest generalizations, the degree of disability in speech communication caused by a hearing loss. Hence, it is logical that hearing function tests should be performed with speech stimuli which can be used to measure the speech detection threshold (SDT) as well as the understanding of speech. Furthermore, speech is used in hearing aids evaluation. In light of this, there is the need for the existence of appropriate speech tests to adequately assess speech and predict the degree of hearing impairment (Davis & Silverman, 1970).

In audiology, one of the recommended practices is to verify the gain and/or output of hearing aids with speech or speech-shaped signals (Stelmachowicz et al., 1996; Scollie & Seewald, 2002; Henning & Bentler, 2005). These practices underscore the importance of speech audiometry. Gadagbui (2003) stated that a speech test of hearing is important because speech is widely used for interpersonal communications through which people express their feelings and share experiences of day-to-day activities of life. Furthermore, Berger (1977) suggested that since the human voice was the most perfect conceivable measure of hearing, it was needful to have standard ways of assessing speech. McArdle and Hnath-Chisolm (2015) suggested that speech audiometry involves the assessment of sensitivity for speech as well as assessment of clarity when speech is heard. Although pure-tone testing is a quick and reliable means for measuring frequency-specific information about a patient's hearing impairment, audiological evaluations are generally considered incomplete without measuring an individual's ability to perceive and process speech (Harris et al., 2007). Besides, speech is made up of more complex signals than the simple tones used in pure-tone audiometry. Understanding speech therefore involves a more complex process than detecting pure-tones, and so speech tests cater for the in-between frequency tones when testing (Taylor, 2012)

Some widely accepted methods of evaluating speech are through the SDT and speech recognition threshold (SRT) tests. The SDT test is a very important part of the conventional test battery used in audiological assessment because speech audiometry is used to measure a patient's ability to be aware of the presence of speech stimuli. In speech detection, the focus is on the ability of the patient to be aware of the presence of speech stimuli and not to correctly identify the presented stimuli. Clinically, SDTs are used to establish the level for awareness of speech stimuli of infants, young children, or adults who cannot respond verbally or whose speech recognition ability is so poor that they are unable to recognize spondaic words which are words with 2 syllables or disyllabic in nature. Spondaic words are pronounced with equal emphasis on 1st and 2nd syllables for example, words like baseball, toothbrush and airplane are used to obtain SRT results (McArdle & Hnath-Chisolm, 2015).

Speech recognition threshold is explained as the minimum intensity in decibels (dB) at which a patient can understand 50% of spoken words and its testing involves estimation of a threshold at which a person has the ability to repeat back speech stimuli presented via the audiometer 50% of the time. Measurement of SRT of a patient is necessary because the SRT quantifies the listener's hearing level for speech and also serves as a check for validity of pure tone audiometry results. Speech recognition is very essential because the ability of an individual to discriminate speech cannot be determined by the pure-tone audiogram alone. The implications are that a patient may hear sounds well enough but when the neural signals malfunction, the sound may become unintelligible.

Many speech materials have been developed and improved over the years to assess different aspects of speech; for example, speech recognition thresholds, speech pattern identification and speech reception in noise (Elliot & Katz, 1980; Erber, 1974; Goldman, Fristoe, & Woodcock, 1970; Jerger, Lewis, Hawkins, & Jerger, 1980; Ross & Lerman, 1970; Tillman & Carhart, 1966). Abdulhaq (2006) suggests that widely used speech audiometry materials that are clinically relevant in the test and diagnoses of hearing loss include the Central Institute for the Deaf W-22 (CID W-22) by Hirsh et al., (1952), Northwestern University Auditory Test No. 6 (NU-6) by Tillman & Carhart (1966), Phonetically Balanced Kindergarten Test (PBK-50) by Haskins (1949) and Northwestern University Children’s Perception of Speech (NU-CHIPS) by Elliot & Katz (1980).

Various speech audiometry materials are also available in different languages for testing various aspects of speech. These speech materials although pervasively used in other countries however cannot be used in Ghana because of their inappropriateness. Firstly, items on these speech materials are not familiar to Ghanaians and hence when administered it becomes a test of intelligence or comprehension rather than its intended purpose of speech recognition. Also, pronunciation of the words in Ghanaian English compromises the integrity of the speech materials since research has shown that due to the tonality of Ghanaian languages such as Fante, Asante Twi or Akuapem, the effect is carried over to English language which results in differences between Ghanaian speakers of English and the native

English speakers (Offei, 2013; Gadagbui, 1985) and this results in differences in listener performance (Nissen et al., 2013). This is because the perception and processing of auditory stimuli is different for listeners of different languages (Bhatara et al., 2013).

In Ghana, some speech hearing tests have been developed in Eʋe, Fante, Ga and Asante Twi by Gadagbui (2003) that used live voiced bisyllabic and trisyllabic words. Gadagbui (1993), in a study developed 11 pairs of near minimal pair words for Eʋe. Spectrographic analysis and frequency of phonemes were found to be highly correlated with the parent language and as such, these words could be used for assessing hearing abilities of children as well as for screening purposes. Later Gadagbui (2003) developed 13 pairs of near minimal pair words for Fante, 7 pairs of near minimal pair words for Asante Twi and 13 pairs of minimal pair words for Ga respectively. However, the drawback in the use of these tests in Asante Twi, Fante and Ga is that the psychometric properties of the bisyllabic and trisyllabic words selected for these test were not measured and documented as in the case of the Eʋe words. Norm data was not also collected for these speech stimuli and this could possibly be the reason why these tests were not clinically used in Ghana (Offei, 2013).

Current methodology of selecting words for speech tests make use of the statistical analysis procedure of logistic regression to determine the performance intensity functions of each word, resulting in a more accurate estimation of the individual word thresholds (Keller, 2009). This technique was however not employed to select the words for inclusion in Gadagbui (2003)'s study. This probably explains why these tests were not widely used in hearing assessment centres across the country. Furthermore, it seems that test materials were not administered on Ghanaian children because they were not widely circulated to audiologists and hearing assessment centres after development.

Offei (2013) also adapted a diagnostic speech test known as the Adaptive Auditory Speech Test (AAST) as a test of identification and discrimination of speech into 3 Akan dialects namely Asante Twi, Akuapem and Fante. This study, which was adapted from the original German version, used a closed set of 6 trisyllabic words for Asante Twi, Fante and Akuapem. These words satisfied the criteria of familiarity, phonemic dissimilarity and all the words selected had the similar tone patterns. Offei (2013) found the psychometric properties of the selected words to be consistent with results from other studies in English and German and therefore suggested that Fante, Asante Twi and Akuapem trisyllabic words with equal psychometric properties could be used as a diagnostic test in audiometry. The AAST can be used for predicting the pure tone average of individuals as well as in speech recognition threshold (SRT) testing by means of electronic software which automatically calculates these values and presents it as a single digit.

In speech audiometry, stimuli can be presented to patients via monitored live voice (MLV) or digital recordings. However, MLV can present some inconsistencies during testing and this can affect the outcome of speech audiometry. Some inconsistencies exist in the live voice testing such as the differences between male and female speakers due to rate of speaking, vocal pitch and quality, and pronunciation. Other conditions such as upper respiratory tract infections can also affect the voice of the tester during presentation of speech materials. Furthermore, Carhart (1965) states that linguistic barriers such as phonetic, melodic and intonational peculiarities prohibit the generalisation of speech materials used for speech audiometry. The implication is that one speech audiometry material developed for a language may not be useful in speech testing of another language. Gadagbui (2003) asserts that children with asymetrical hearing loss as well as those with slight hearing losses can escape detection when speech materials used for assessment have inconsistencies hence it would be appropriate to have speech materials that overcome this challenge.

In order to overcome these inconsistencies, recorded speech audiometry materials are preferable to MLV testing. This is because digitally recorded speech materials provide a consistent level for all test items and consistent speech patterns between patients (McArdle & Hnath-Chisolm, 2015). The current study therefore seeks to select and digitally record familiar trisyllabic words with same tone patterns and equal psychometric properties onto a compact disc (CD) which can be easily used in any audio playing device and connected to an audiometer in order to conduct speech assessment. The development of this speech material will also overcome the challenges presented by MLV testing.

In order to recognize and understand the test words used in speech audiometry, the individual being tested should be familiar with the test words (Lyregaard, 1987). Balkisson (2001) is of the opinion that the best way to achieve accuracy of test materials is to present the materials in a language in which the individual is most familiar with. This means that test materials should be in the first language of the individual. Furthermore, Nissen et al., (2005a) and Nissen et al., (2005b) confirmed this assertion by stating that testing patients with materials recorded in a language other than their native tongue would "adversely affect performance and interpretation of results". Therefore, one of the most important characteristics of SRT materials and SRT testing is familiarity of stimuli to the client (Carhart, 1965; Ramkissoon, 2000; Øygarden, 2009).

Currently in Ghana, out of about eight assessment centres in the country, four assessment centres reported conducting speech audiometry using English SRT words. The SRT wordlists currently used at this facility is the CID W-1 and W-2 spondee wordlist. The challenges in using this wordlist is that majority of the words found in this list are unfamiliar to the Ghanaian, for instance, greyhound, inkwell, hotdog, duckpond, baseball and cupcake. Similarly, some of these words may not also be age appropriate for Ghanaian children and some adults as the words on the CID W-1 and W-2 spondee list may not be found in the vocabulary range of Ghanaians. In effect, local materials are being sought after because of the cultural differences of words and age inappropriateness of materials currently being used for speech audiometry. Generally, parents and children communicate with local language at home hence the use of these foreign words affects the integrity of the results obtained from the speech testing. Therefore, Nissen, et al., (2005a) asserted that because language is dynamic and not static, it is very essential for SRT test materials to be chosen from frequently used words because familiarity enhances test validity. Furthermore, stress on words varies from individual to individual because of the dialectical differences that exist in languages. The effect is that speech items may be pronounced differently by speakers of the language which in effect compromises the reliability and validity of tests administered.

The lack of adequate and carefully developed Ghanaian speech test materials has resulted in some audiologists either omitting speech audiometry from the initial test battery or that speech audiometry is performed using the standard English material which is the CID W-l and W-2 spondee word list (John, 1990). Kim (2007) suggests that audiologists will usually use available materials even though they may not be in the native language of the patient. However, clinical decisions based on testing done in a language other than the native language must be carefully examined as test bias may present a real challenge to testing (Rudmin, 1987) in terms of performance on test and the interpretation of results (Nissen et al., 2005a, 2005b). Also, the diversity of languages in Ghana has also been a setback to the development and use of local speech audiometry materials (Essel, 1984). The use of linguistically inappropriate test material will thus reduce the validity of the test conducted, thereby doing a disservice to the patients being tested. It is in this regard that this study seeks to identify and digitally record words which are familiar to native speakers of Ghana for speech audiometry.

1.2 PROBLEM STATEMENT

Ghanaian-based developed and digitally recorded materials for speech audiometry in Ghanaian languages are not available for speech recognition threshold testing. Currently, the Adaptive Auditory Speech Test (AAST), which is the only local-based test for assessing SRT in Ghanaian languages, is not being used by audiologists or hearing assessment centres in the country. This has led to audiologists in Ghana either skipping speech audiometry during evaluation or using the CID W-1 wordlists as substitutes. This could undermine the results of speech audiometry as it becomes a test of intelligence rather than a test of speech reception and discrimination, which is essential in determining the benefits derived from amplification. This is because most of the words on the wordlist are not available in the vocabulary of Ghanaian languages. Besides, the use of monitored live voice in testing can affect test results since dialectical influences may alter the accent and general intelligibility of words presented during testing. In an ideal audiometric clinical setting, speech audiometry is used to verify whether an individual can benefit from amplification such as hearing aids or cochlea implants (Fu, Zu & Wang, 2011). Kimball (2013) states that speech audiometry helps the clinician in the determination of proper gain and maximum outputs for hearing aids. Hence, the availability of appropriate speech materials will enhance this practice in Ghana even though other means such as Verifit could be used to fit hearing aids to patients.

According to the American Speech and Hearing Association (ASHA), speech audiometry may play an important role as an early indication of a variety of conditions including pseudohypacusis, central auditory disorder, etc. (ASHA, 1988). It is also used in determining site of lesion and development of rehabilitation strategies (Thibodeau, 2007). Therefore a lack of appropriate speech materials in Ghana hampers audiological diagnosis, rehabilitation and habilitation.

1.3 AIM OF THE STUDY

The aim of this research was to develop and evaluate digitally recorded speech materials that can be used in speech audiometry in Ghana.

1.4 OBJECTIVES OF THE STUDY

The objectives of this study were to:

- Select familiar but phonemically dissimilar Fante trisyllabic words with the same tone pattern for speech audiometry in Fante.
- Measure the psychometric properties of the Fante words in the wordlist.
- Measure the homogeneity of the words with respect to audibility of the Fante words.

1.5 RESEARCH QUESTIONS

- Which familiar trisyllabic Fante words with the same tone pattern but phonemically dissimilar can be selected from among 107 commonly used words for speech audiometry in Fante?
- How can the psychometric properties and homogeneity with respect to audibility of the selected Fante words in the wordlist be obtained?

1.6 SIGNIFICANCE OF THE STUDY

SRT wordlists obtained from the study will aid accurate results in the SRT and testing of individual Fante speakers. The study will also form the basis for the creation of speech audiometry materials for other local languages in Ghana. Finally, this study will be a credible addition to the body of knowledge in the area of speech audiometry.

1.7 DEFINITION OF TERMS

Speech Audiometry: Speech audiometry refers to audiometry test procedures that use speech stimuli to assess auditory function.

Speech Detection Threshold (SDT): an estimate of the level at which an individual perceives speech to be present 50% of the time and it is reported in decibels hearing level-dB HL

Speech Recognition Threshold (SRT): Speech recognition threshold involves the ability of the patient to repeat back words presented via the audiometer 50% of the time.

Word Recognition Score (WRS) or Speech Discrimination Score (SDS): A person's ability not to only hear words but to correctly identify them. The word recognition score (WRS) is the percentage of words correctly identified.

CHAPTER TWO

LITERATURE REVIEW

2.1. INTRODUCTION

A review of the literature relevant to the study is presented in this Chapter. The literature was reviewed from research articles, journals, and books on speech audiometry following sub-headings described below:

- Speech audiometry
- General considerations in selecting material for speech audiometry
- Native language testing
- Research gap

2.2 SPEECH AUDIOMETRY

Speech audiometry plays a very significant role in the diagnoses of cochlea and retrocochlear disorders and is thus widely used globally. In an audiological clinical setting, speech audiometry serves the purpose of measuring a patient's ability to perceive speech. It is also used to confirm pure tone audiometry (PTA) results and also measure the outcomes of hearing aid evaluation. Berger (1977) reported that G. W. Pfingsten was the first person known to have confirmed the ability of people to hear speech sounds in 1802. On that basis, he classified speech sounds as vowels, voiced consonants and voiceless consonants. In the initial stages, speech tests were performed with spoken or whispered messages which were presented at measured distances between the speaker and the patient. The drawback of these tests were that it was not easy to quantify test outcomes as they could only give gross estimates of a person's ability to hear speech (ASHA, 1988). Clinical measures were thus developed to overcome the challenges of these initial speech tests by presenting more accurate measurements.

The first clinical speech test was developed in 1904 by Bryant and was recorded on a phonograph. This test comprised monosyllables which were recorded on wax cylinders at a constant level. The words were played on a phonograph enclosed in a sound-treated box and coupled to the listener's ear through a stethoscope type tube. The test was never commonly administered primarily due to the primitive recording equipment (Hudgins, et al., 1947). Crandall later revised nonsense syllables which were developed by Campbell (1910) by using consonant vowel (CV), vowel-consonant (VC) and consonant-vowel-consonant (CVC) syllables. This was known as the Standard Articulation Test (Berger, 1977). This New Standard Articulation Test was then developed after Crandall's words were modified to include only CVC syllables.

Berger (1977) reported that by 1929, other speech materials had been developed and were already in use at Bell Telephone Laboratories by Fletcher and Steinberg (1929). It was realized however that variability on scores existed especially for untrained listeners. In 1926, the first recorded auditory test which was widely used was the Western Electric 4A (later 4C) test which was a phonographic recording of spoken digits (Dukes, 2006). This was also developed at Bell Telephone Laboratories and was sometimes called the Fading Numbers Test (Fletcher, 1929). According to Berger (1977), other speech tests that were developed included the New Standard Testing Lists by Munro and Ewing in 1939, Wengel Audio-Selective Hearing Test in 1938, West Test Word list in 1938, Fry and Kerridge Sentence Tests for Deaf People in 1939 among others.

During World War II, a lot of effort went into the development of tests which would aid in evaluating various types of military communication equipment. These tests were developed at Harvard University's Psycho-Acoustic Laboratory (PAL), and some of them turned out to be applicable for use in clinical hearing evaluations (Hudgins et al., 1947). These tests were the PAL auditory test No. 9 and No. 14. In particular, the PAL No. 9 measured the threshold of hearing for words using two lists of 42 spondaic words each. With time, new lists were developed which had greater clinical use, as the PAL tests were found to be deficient in word familiarity and phonetic balance (Hirsh et al., 1952). These issues were addressed in modifications to the PAL lists resulting in the CID W-1 and W-2 Auditory Tests, both of which are spondaic word lists (ASHA, 1988).

PAL PB-50 lists was developed by Egan (1948). Word recognition was evaluated by way of phonetically balanced (PB) monosyllabic word lists which were developed using the PAL system. Twenty lists consisting of 50 words each of which were phonetically balanced or equivalent were found to be clinically useful for measuring discrimination loss. However, the lists contained some words unfamiliar to patients that affected patient performance and the overall reliability (Dennis & Neely, 1991; Hirsh et al., 1952). Another set of monosyllabic word lists called the CID auditory test W-22 and consisting of 200 words arranged into four lists of 50 words each was created at PAL by Hirsh et al., (1952). These materials were developed to create lists with increased listener familiarity, greater phonetic balance, and better clarity through the use of magnetic tape (Epstein, 1978; Gelfand, 1997).

The CID W-22 test was successful in that the word familiarity was markedly greater in these lists than the PAL PB-50 lists; however neither list was found to be practical in providing prognostic information regarding an individual's ability to follow content in running speech (Dukes, 2006). Campbell (1965) rearranged Hirsh recordings of the CID W-22 lists based on difficulty of words and redistributed the 200 words into eight 25-word lists. Campbell's (1965) list was thought to be better at separating normal hearing from mild and moderate hearing loss. Interestingly, Campbell's follow-up experiments indicated that phonemic balance had only minimal clinical effects on test validity (Dukes, 2006).

Berger (1977) further reported that other speech audiometry materials developed after CID W-22 included A.B. Short Word Lists for the North Central States by Van der Haiden (1951), Northwestern University Auditory Test No. 6 by Lehiste and Peterson (1959), Northwestern University Auditory Test No. 4 by Tillman et al., (1963), Gardner High-Frequency Consonant Discrimination Word list by Gardner (1971), and Glaser High Frequency Word List by Glaser (1974).

2.2.1 Speech Audiometry in Ghana

In Ghana, Essel (1984) suggested in a research report that non-speech materials in the form of C-V, V-C-V, and C-V-C syllables should be used for word recognition score testing. Essel (1984) suggested the use of non-speech materials because of the variability of the local languages in Ghana. Gadagbui (2003) later developed speech tests of hearing in Eʋe, Fante, Asante Twi and Ga patterned after McCormick Toy Discrimination Test (1977) for children of mental age 2½ years and above. These test stimuli were mainly bisyllabic near minimal pair words and were used for discrimination, screening and diagnosing of hearing loss among school children as well. Offei (2013) also adapted the AAST diagnostic speech test from the original German version into 3 Akan dialects namely Asante Twi, Akuapem and Fante as a test of identification and discrimination of speech for children using a closed set of six trisyllabic words.

2.3 TYPES OF SPEECH AUDIOMETRY

Speech audiometry comprises measurement of a person's ability to detect, identify and discriminate speech. Speech audiometry thus refers to procedures that use speech stimuli to assess auditory function (Konkle & Rintelmann, 1983; McGrath, 2010; Kimball, 2013). It has been well documented that speech understanding cannot be accurately predicted based upon pure tone thresholds (McGrath, 2010). According to Martin and Clark (2012), hearing impairment inferred from a pure-tone audiogram cannot on its own depict the degree of disability in speech communication caused by a hearing loss, and because difficulties in hearing and understanding speech forms the basis of most complaints from patients with hearing impairments, it is logical that tests of hearing function should be performed with speech stimuli in order for appropriate interventions to be made. Currently, speech threshold testing is used in the evaluation of paediatric and difficult to test patients (Schoepflin, 2012). The SDT and SRT tests are part of the speech audiometry protocols used in hearing assessment. Based on the test material used and the response required from patients, the speech threshold testing can be in the form of identification or recognition as used in SRT, and mere detection or notice of presence versus absence of the stimulus in the case of SDT.

2.3.1 Speech Detection Threshold Testing

Speech-detection threshold (SDT), also known as speech awareness threshold (SAT) was defined by Martin and Clark (2012) as the lowest level, in decibels, at which a patient can barely detect the presence of speech and identify it as speech. The American Speech-Language-Hearing Association(ASHA) also defined SDT as an estimate of the level at which an individual perceives speech to be present 50% of the time and should be reported in decibels hearing level (dB HL) (ASHA, 1988). McArdle and Hnath-Chisolm (2015) indicated that SDTs are commonly used to establish the level for awareness of speech stimuli in infants, young children, or adults who cannot respond verbally or whose speech recognition ability is so poor that they are unable to recognize spondaic words to obtain an SRT result. In speech detection, the focus is on the ability of the patient to be aware of the presence of speech stimuli and not to correctly identify the presented stimuli. Cold running speech or sentences are used in the performance of SDT tests and they involve the rapid presentation of words or phrases monotonously, which are quite often uninteresting and do not necessarily make sense to the patient.

2.3.2 Speech Recognition testing

Speech recognition testing presents two vital clinical evaluations which are SRT and WRS. Indeed, SRT sometimes referred to as speech reception threshold test involves the ability of the patient to repeat back words presented via the audiometer 50% of the time. Typically, spondaic words are used in the performance of this test. Recent studies by Keller (2009), Bunker (2008); Conklin (2007); Harris et al., (2007); Nissen, Harris & Slade (2007); Dukes (2006) and Mangum (2005) have however shown that bisyllabic words and trisyllabic words can accurately be used to perform this test.

Clinically, in interpreting audiometric results, a difference between pure-tone and speech reception results can be very useful in the identification of an attempted exaggeration of a hearing impairment as well as to validate pure tone test results (ASHA, 1988; Egan, 1979; Epstein, 1978; Alfakhri, 2012) or could possibly indicate the presence of a retrocochlear disorder (Van Dijk, Duijndam & Graamans, 2000). Measurement of SRT of a patient is necessary because the SRT quantifies the listener's hearing level for speech and also serves as a check for validity of pure tone audiometry results. Furthermore, SRT provides diagnostic value for the total audiometric battery (Panday, 2006; Panday, Kathard, Pillay & Govender, 2007). Though the importance of SRT is to cross-check pure tone thresholds and to determine level of speech test at supra-threshold levels, it can provide diagnostic information about sensitivity for speech in paediatric and difficult-to-test patients. They are however used extensively on adult clients by many clinicians (Schoepflin, 2012).

2.3.3 Word Recognition Score

The evaluation of speech reception at supra-threshold levels is referred to as word recognition score (WRS) or speech discrimination score (SDS). In particular, WRS measures the person's ability to hear words and correctly identify them. Speech discrimination serves the purpose of estimating a person’s ability to follow everyday communication, to assess central auditory function, to evaluate candidacy for hearing aids and to select appropriate amplification (Berger, 1977; McGrath, 2010; Alfakhri, 2012). Essel (1984) stated results derived from speech discrimination tests formed the bases for habilitative and rehabilitative programs, in-depth testing for site of lesion, detection of non-organic hearing loss and in hearing aids dispensing. The procedure of WRS testing typically involves presentation of 50 selected monosyllabic words at an easily detectable intensity level. Groups of 20 or 25 words can also be used to perform this test.

Pathology of the inner ear, auditory nerve, and/or central auditory pathways can affect this score; hence speech discrimination plays a critical role in the battery of tests as it helps to identify a varied range of hearing conditions in the clinical setting. Speech discrimination is also essential because the ability of an individual to discriminate speech is not well predicted by the pure-tone audiogram. In effect, an individual may hear a sound well enough, but the neural signals may malfunction, and hence renders sound unintelligible. Such persons might even have poor speech discrimination clinically. For this reason, there must exist a standard way of measuring the levels at which such persons perceive and understand speech so that appropriate intervention can be given to them. Currently in Ghana, due to unavailability of such a set of words in local languages, WRS is often skipped as part of the audiological test battery. This is because all the available speech materials are originally in English language. Even though English is the official language in Ghana, there are several people who are not familiar with the items on these wordlists and as such administration of these words may undermine test results. It is therefore imperative that sets of words required for use in speech audiometry are developed specifically for Ghanaian languages.

2.4 CONSIDERATIONS IN SELECTING SPEECH AUDIOMETRY MATERIAL

Selection and administration of speech audiometry materials are affected by certain factors that influence the quality of speech materials. They include familiarity, phonemic dissimilarity, homogeneity with respect to audibility (Hudgins et al., 1947), and method of presentation (McArdle & Hnath-Chisolm, 2015). One of the most essential components to consider in selecting speech audiometry is familiarity because it will ensure test validity (Nissen et al., 2005a).

2.4.1 Familiarity

Familiarity is debatably the most important aspect to consider when choosing speech stimuli because it ensures the validity of the test as well as increasing its homogeneity (Epstein, 1978; Ramkissoon, 2001; Durankaya, Şerbetçioğlu, Dalkılıç, Gürkan, & Kırkım, 2014). Kruger (2010) stated that the effect of familiarity of words on speech perception performance is greater than the phonetic balance of the word lists. Martin (2000) indicated that phonetic balance is not the only, or the main, factor in word list equivalence. When hearing assessments were performed with unfamiliar words the validity of the speech measurement was seriously compromised (Rudmin, 1987; Tsai, Tseng, Wu & Young, 2009; Shi & Sánchez, 2011). Owens (1961) studied the effect of word familiarity on word recognition and found that listeners were more likely to make errors on less familiar words, and their responses were more likely to be familiar words when errors were made.

Gelfand (2001) suggested that the frequency of occurrence of a word determines the familiarity of the word. The words that frequently occur are more easily recognised, and have a well-established effect on performance. In a test situation, it is easier to identify familiar words than less familiar and unfamiliar words, and therefore tests that required the use materials familiar only to native English speakers could put non-native English speakers at a disadvantage (Danhauer, Crawford, & Edgerton, 1984). Mangum (2005) therefore suggested that speech materials in other languages are developed so that non-English speaking individuals and non-native English speaking individuals are disadvantaged. Since the main aim of speech testing is to measure auditory sensitivity and not intelligence, words which are selected should be as familiar as possible to the patient (Egan, 1979; Young et al., 1982; ASHA, 1988; Ramkissoon, 2001). To ensure familiarity of test stimuli selected for the present study, words were selected from Fante reading textbooks for primary school children. This current study further ensured that all words which were selected were rated by three linguistic experts as most familiar to native speakers of Fante.

2.4.2 Phonemic Dissimilarity

Phonemic dissimilarity in a word list prevents confusion between words (Silman & Silverman, 1991). In effect, test stimuli must vary in terms of consonant and vowel combinations within the language being tested (Hudgins et al., 1947, Kumar & Mohanty, 2012). Words such as minimal pairs are similar phonemically and may result in the client identifying the words due to their good discrimination ability. For instance, words such as *plowboy* and *cowboy* differ in only one sound, hence if both words are included on a word list, it would increase the test's difficulty by demanding a finer discrimination (Ratcliff, 2006). It however seems that this criterion has not gained much consideration as others such as familiarity and homogeneity of audibility. Panday (2006) and Panday et al., (2007) suggest that, this could perhaps be related to the difficulty in satisfying this criterion in languages that have fewer consonant and vowel combinations. To satisfy phonemic dissimilarity in this study, selected words were unique with respect to phonemic dissimilarity. All words selected had different vowel-consonant combination in this regard and had unique meanings. In effect, all words with the same pronunciation but had more than one meaning were eliminated.

A study by Dirks, Takayanagi and Moshfegh (2001) determined that frequencies of occurrence of a word as well as the number of words that are phonemically similar to the target word affect the speed and accuracy of recognition. This is because finer discrimination abilities are required when words are too similar, as in lists of rhyming words and this makes the task more difficult without improving its effectiveness (Epstein, 1978; Hudgins et al., 1947; Young et al., 1982). It may also supply unintended auditory cues for the task at hand (Ramkissoon, 2001). Phonemic dissimilarity is particularly essential when testing patients with hearing impairment. Hearing impairment may impose significant restrictions on a person's ability to identify specific phonemes; therefore, in the presence of high phonemically similar words, the task of identifying the target word becomes even more difficult (Bell & Wilson, 2001). Another essential factor to consider in the selection of speech stimuli is homogeneity.

2.4.3 Homogeneity with Respect to Audibility

Homogeneity means that all speech materials must be equally recognizable at the same stimulus presentation level. Homogeneity has been identified as another important factor when creating stimuli to be used for speech audiometry and as such words need to be homogenous with respect to audibility and psychometric function slope (Wilson & Strouse, 1999; Wilson & Carter, 2001; Neumann et. al., 2012). Silman and Silverman (1991) as cited in Panday (2006) defined homogeneity as the ease at which words are understood when spoken at a constant intensity and this is explained by psychometric curves of the words. Wilson and Carter (2001) further defined psychometric function as the “relation between the change in correct recognition performance and the change in the presentation level of the signal”. Beattie, Svihovee & Edgerton (1975) as cited in Panday (2006) suggests that homogeneity can be achieved in two ways: it can obtained by selecting only those words that reach the listener's ear at the same intensity or by recording the individual words in such a way that they all tend to be heard at the same level of production.

Homogeneity is commonly determined by computing the psychometric performance intensity functions for each word. Since the 50% intelligibility level can vary from word to word, it is important to know the rate for which each word becomes intelligible (Young et al., 1982). This study ensured this by adjusting the intensities of all the selected words so that the 50% threshold of each word was equal to the mean PTA of the subjects, suggesting that all selected words had the same difficulty level (Offei, 2013). Smits, Kapteyn and Houtgast, (2004) proposed that equal intelligibility of test material and steep discrimination functions are important hallmarks for any reliable test.

2.4.4 Psychometric Function Curves

Psychometric functions define the probability of a listener's response as a function of the magnitude of the particular sound characteristic. A psychometric function is a graph which shows the relation between the hearing performance and stimulus characteristics (Konkle & Rintelmann, 1983). Words with steeper psychometric function curves indicate greater homogeneity (Wilson & Carter, 2001). In order to meet the criterion of homogeneity with respect to audibility, the percentage of words correctly identified must increase rapidly with a relatively small increase in intensity, that is, the performance-intensity function of the word must be calculated. This is usually illustrated through the use of the principle of performance intensity function or what is traditionally known as the articulation gain curve (Silman & Silverman, 1991; Brandy, 2002). The performance-intensity function graphically shows the rate of intelligibility for a word or list of words. Percentage of correct recognition is plotted as a function of intensity at which the score was obtained (Hudgins et al., 1947; Ramkissoon, 2001). When the homogeneity of selected words is increased, it becomes easier to equate the basic audibility of the testing materials (Epstein, 1978). Also, by ensuring homogeneity of psychometric slope and audibility, test-retest variability will decrease and test time is likely to be reduced (Wilson & Carter, 2001; Wilson & Strouse, 1999). This will reduce fatigue during testing for both the tester and the patient, and therefore enhance the validity of the test results.

To ensure homogeneity of the speech material, words with relatively steep psychometric function curves are chosen as part of the final wordlist. There are several advantages of having a homogenous wordlist. Words can be split into smaller lists without altering the properties of the full list. The essence of this is to decrease the testing time (Hudgins et al., 1947; Young et al., 1982), while ensuring accuracy of patient scores. Another factor which can affect speech stimuli is whether the test material is administered via MLV or recorded.

2.4.5 Monitored Live Voice and Recorded Materials

Ramkisson (2001) suggests that digital recordings are fast becoming standards in speech audiometry. Speech materials can be in the form of printed or written materials or in the form of recorded materials. Such materials are typically stored on CD for later use or can be saved as audio files on a computer. Printed or written materials require the clinician or audiologist to say the words through a microphone. This is referred to as monitored live voice testing (MLV). The loudness of the voice of the tester in this test situation is monitored visually by a

VU meter on the audiometer. The advantage of using MLV is that it reduces the test duration and also makes the clinician flexible during the test. A study by Mendel and Owen (2011) revealed that the difference between presentations of speech materials via MLV for a 50-item wordlist was one minute faster than using CD recorded materials although this was not clinically significant. Although there are many advantages of recorded speech material, only 1% of audiologists report using CDs (Martin et al., 1998) because MLV was quicker, more convenient and have greater control over the materials (Mendel & Owen, 2011). However, one disadvantage of speech audiometry in MLV mode is that it can only be done when the patient is isolated in a single or double test room.

Mikolai, and Mroz (2010) stated that the biggest challenge in using MLV for speech testing is the lack of uniformity in test presentation, as the presentation levels of the tester using monitored live voice may be different (Mendel & Owen, 2011). Some testers may say the words rapidly while others may try to speak clearly, deliberately, or even both depending on the nature of listener responses (Kruger, 2010), and this can significantly affect word intelligibility (Picheny, Durlach, & Braida, 1985). In recorded speech materials, digits, words or sentences are digitally recorded and saved for later use on CD. The recorded CD is played through a player routed through the speech audiometer to the headphones of the audiometer. Research suggests that digitally recorded speech materials improve the accuracy of the intrasubject and intersubject threshold and suprathreshold measures as well as quality diagnoses and treatment (Wiley et al., 1995). This is because digitally recorded speech materials provide a consistent level for all test items and consistent speech patterns between patients (McArdle & Hnath-Chisolm, 2015).

Harris et al., (2007) suggest that when speech audiometry is presented via recordings, it allows standardization of the composition and the presentation of materials. It thus ensures a better control over the intensity of the presentation of the material to the patient. Martin and Clark (2012) confirmed this assertion by stating that recorded speech materials provide a consistency of presentation that is independent of the expertise of the clinician. The use of recorded speech materials also overcomes the challenge of difference in presentation since the reliability of speech materials may vary across speakers and across test time for a single speaker or for different speakers. Other advantages of recorded speech materials as suggested by other researchers include increased channel separation, increased dynamic range, improved signal-to-noise ratio, reduced harmonic distortion, longer storage life without degradation (Harris et al., 2007; Ridgway, 1986; Kamm, Carterette, Morgan, & Dirks, 1980).

In Ghana, most test rooms consist of single rooms as in the case at CHSS-Winneba, KATH and NARC-Achimota. Other assessment centres have double rooms as in the case of KBTH Assessment Centre. It is therefore imperative that speech materials developed should be recorded in order to overcome the challenge presented with monitored live voice testing.

In the literature, Asher (1958) and Hirsh et al., (1954) found variability in recognition performance as a function of speaker–list interactions for even same words. In effect, a speaker may pronounce the same words differently during testing and this could affect the recognition scores of the patient. Also, the same wordlist spoken by two different speakers will yield different recognition score (Bess, 1983; Abdulhaq, 2006; Kruger, 2010) and the use of different speech materials has the same effects (Doyne & Steer, 1951; Carhart, 1965; Nissen et. al., 2013). Roeser and Clark (2008) also found significant differences in performance when the same subjects were tested via recorded materials and MLV. Roeser and Clark (2008) however suggested that patients performed better in MLV mode than with recorded materials. In particular, MLV also has advantages when dealing with difficult-to-test population, persons with special needs or when recorded versions of speech audiometry materials are not readily available. Another factor which affects speech audiometry materials is whether listeners are expected to respond from open response sets or closed response sets.

2.4.6 Open and Closed Response Sets

Open response sets requires a listener to repeat the presented stimuli without "prior knowledge" (Gelfand, 2001). The listener is expected to give responses from an infinite set of responses and as such, guessing is highly encouraged when using open response sets. Examples of speech audiometry materials which use the open response set are the CID W-22 and NU-6. Closed response sets however require the listener to choose their responses from a discrete number of answers such as a designated list, closed response sets are mostly appropriate to children and other individuals needing special considerations. Examples of the most well-known closed set word recognition tests include the Rhyme Test (Fairbanks, 1958), California Consonant Test (Owens & Schubert, 1977), Picture Identification Task (PIT; Wilson & Antablin, 1980), Word Intelligibility by Picture Identification (WIPI; Ross; Lerman, 1970), Monosyllable, Prochee and Polysyllable Test (MTP), The Digit Triplets Test (DTT) Northwestern University Children's Perception of Speech (NUCHIPS) test (Elliot & Katz, 1980) and Adaptive Auditory Speech Test-AAST (Offei, 2013).

One problem found with using closed sets is that when set size is substantially reduced, there is a measured improvement in the SRT that is clinically significant (Punch & Howard, 1985). If a systematic improvement of the SRT results from reducing the set size of the stimuli, then making this type of modification would result in an inaccurate and unreliable measurement of the SRT that overestimates the ability of the listener. Reducing set size is therefore not an acceptable modification for individuals with limited English proficiency. In addition to all the above factors, test material should be presented with standard audiometric equipment (Neumann et al., 2012) to ensure test validity and reliability.

2.4.7 Native Language Testing

Speech audiometry recordings from a speaker with a non-regional dialect, even if mutually intelligible in ideal listening conditions, may be relatively more difficult for listeners when presented at low-intensity levels or in the presence of noise (Nissen, Harris & Slade, 2007; Weisleder & Hodgson, 1989). Therefore, to ensure the accuracy and validity of speech audiometry, Ramkisson (2001) stated that testing should be done in the patient's native language. Harris et al., (2007) further indicated that when recording materials for speech audiometry, native speakers who exhibited a standard accent of the target language must be employed to do so. This is because evaluations of word recognition using voice recordings in a non-native language accent may significantly reduce performance at presentation levels less than 50dBSPL (Wilson & Moodley, 2000).

For this reason, audiologists and other researchers have recognized the need for linguistically appropriate diagnostic tools and have developed speech audiometry tests in languages such as Arabic, Brazilian, Italian, Japanese, Korean, Polish, Portuguese, Russian, and Spanish (Mangum, 2005; Harris et al., 2001, 2003, 2004; Ramkissoon et al., 2002; Ramkissoon, 2001; Aleksandrovsky et al., 1998; Greer, 1997; Christensen, 1995; Ashoor & Prochazka, 1985). Therefore, in order to avoid variations in accent of the Fante talkers, both male and female talkers who recorded the speech materials had a standard Fante accent as confirmed by linguistic experts. This was done to overcome the challenges that present with differences in accent of speakers.

2.5 RESEARCH GAP

From the foregoing, it can be observed that wordlists are available for speech audiometry in other languages apart from English language (Taylor, 2012; Fu, Zhu & Wang, 2011; Nissen et. al, 2011; Garolla, Scollie & Martinelli Iório, 2007; Kim, 2007; Wang, Mannell, Newall, Zhang & Han, 2007; Harris et.al, 2007; Abdulhaq, 2006; Nissen et. al. 2005a; 2005b). There is however inadequate data on the development of such materials in Ghanaian local languages. It is based on this necessity that this current study seeks to develop words with similar psychometric properties which will be ideal in speech audiometry testing of people who speak Fante in Ghana.

CHAPTER THREE

METHODOLOGY

3.1 INTRODUCTION

This Chapter presents the methods and techniques used in carrying out the study. It includes research approach, research design, population, sample, sampling technique, research instrument, data collection procedure and data analysis

3.2 RESEARCH APPROACH

In this study, a quantitative approach was adopted because the study yielded numeric data which was analyzed using descriptive statistics (mean, median, and standard deviation) and inferential statistics (kappa agreement, logistic regression) with the Statistical Package for the Social Sciences (SPSS) version 20.0 code. According to McMillan and Schumacher (1997), a quantitative approach emphasizes objectivity and quantification of a phenomenon. As a result, it maximizes objectivity by using numbers and statistics structure. Creswell (2005) also views the quantitative approach to studies as a method that provides for decisions on what to study, asking of specific, narrow questions, collection of numeric (numbered) data, statistical analysis of numbers, and conducting inquiries in an unbiased, objective manner.

3.3 RESEARCH DESIGN

The study adopted a three-phase cross-sectional design. Chernick and Friis (2003) define cross-sectional study design as a design in which the study is referenced about a single point in time. In effect, the reference point for both the exposure and outcome variables is the present time. In this study, subjects with normal hearing listened to recorded words of both male and female talkers at a single point in time. Data collection and analysis occurred in specific steps within each stage. This design therefore facilitated in-depth analysis of the performance-intensity functions of each word for each listener.

3.4 STUDY SITES

The study was conducted in a double walled acoustically treated test booth of the Hearing Assessment Centre (HAC) located at the Korle Bu Teaching Hospital (KBTH). Pure tone audiometry, immittance and speech audiometry were also done at the Hearing Assessment Centre of KBTH. Digital recording was done at an acoustically treated testing room located at Centre for Hearing and Speech Services of the University of Education, Winneba. These sites were used for the study because they are equipped with testing rooms and instrumentation calibrated to meet ANSI standards for speech audiometry.

3.5 STUDY POPULATION

Population of this study consisted of all post-graduate linguistics students studying Fante at the University of Education, Winneba and all native Fante speaking subjects who lived in and around the School of Biomedical and Allied Health Sciences (UG-SBAHS), Korle Bu. A total of 154 subjects comprising four (4) post-graduate linguistics students studying Fante at the University of Education, Winneba and 150 native Fante speakers formed the population for this study.

3.6 SAMPLE AND SAMPLING TECHNIQUE

Sample size was phase specific; however, purposive sampling technique was employed throughout all the three phases of the study. In Phase I, 107 commonly used trisyllabic words were selected and rated by 3 linguistic experts based on familiarity and phonemic dissimilarity and tone pattern. Fifty one most ranked trisyllabic words were purposively selected as the sample for the study in Phase I.

In Phase II, 4 adult Fante speaking post-graduate linguistics students comprising 2 males and 2 females were purposively recruited from the Applied Linguistics Department of the University of Education, Winneba by word of mouth to digitally record the 51 most ranked words selected in Phase 1. Subjects were selected because they possessed adequate knowledge of phonetics and in-depth knowledge of Fante, and could thus produce more accurate recordings. Preliminary 2-minute recordings of continuous speech were made for the purpose of judgment of dialect and clarity of speech. Three different adult Fante natives were asked to judge the speakers using two criteria, i.e., the dialect as a general Fante dialect, and the ease of understanding the speaker's speech as rated on a 3-point scale to help in statistical analysis. The highest top ranked male and female Fante speakers completed the final recording of the words. The homogeneity with respect to audibility of the Fante words selected in Phase I was measured.

In Phase III, purposive sampling technique was used to select all 20 subjects for the study. . All 20 subjects for Phase III were recruited from in and around UG-SBAHS Korle Bu. The digitally recorded wordlist was used to measure the SRT of 20 native Fante speakers who use Fante language in communication on a daily bases. This was made up of 10 adult males and 10 adult females. Fuller (1987) recommended that in speech audiometry, a normal response curve should be established with a minimum of 20 normal hearing people, who are native to the local area and have not been exposed to the test stimuli. Brandy (2002) reported that one way of evaluating how well various speech materials perform in terms of hearing is to assess how normal hearing subjects listened to the words at varying intensity levels. Due to the interest in gathering information about using Fante words for measurement of the SRT of individuals, subjects who understood and spoke Fante words on a daily basis were purposively selected Psychometric properties of the words obtained in the wordlist were measured and compared with ANSI standards for SRT.

3.7 INCLUSION AND EXCLUSION CRITERIA

All subjects for the study met the following criteria:

3.7.1 Inclusion criteria

- Native Fante speaking individuals aged older than 18 years and having no history of any ear or hearing related pathology.
- Subjects with hearing threshold of < 20dBHL at the time of testing and passed OAE test
- Subjects whose tympanometry results showed normal peak compensated static admittance and ear canal volumes on the day of testing.
- Additionally, each subject had an ipsilateral acoustic reflex present in the test ear at 1 kHz

3.7.2 Exclusion Criteria

The following criteria were used to exclude non-participants:

- Non-native Fante speakers
- Individuals aged younger than 18 years
- Participants with histories of any ear or hearing related pathology.
- Participants with hearing threshold of >20 dBHL at the time of testing
- Participants whose tympanometry results show no normal peak compensated static admittance and ear canal volumes.
- Any participant referred by the OAE test

3.8 INSTRUMENTATION

A GSI TympStar Version 2 tympanometer was used for all impedance measures. A 226Hz tympanometry was performed to ensure the subjects had peak compensated static admittance and ear canal volumes within normal limits ruling out any middle ear pathology. Acoustic reflex measures were taken for each subject as well. If the tympanogram showed normal middle-ear function with acoustic reflexes present within normal limits, then pure tone audiometry using Interacoustics AC33 audiometer with TDH-39 supra aural headphones was performed subsequently. Pure tone air conduction thresholds at octave and mid-octave frequencies (250, 500, 1000, 2000, 3000, 4000, 6000, 8000Hz) were measured using a modified Houghson-Westlake (10-dB down, 5-dB up) method. Hearing status was determined using pure tone average thresholds of 500Hz, 1000Hz and 2000Hz. A pure tone average threshold of 20 dB HL or less on the day of testing was considered normal. All tests were conducted in an acoustically treated double walled chamber at the Hearing Assessment Centre (HAC) of the Korle Bu Teaching Hospital, Accra. Both study sites were calibrated to meet standards for maximum permissible ambient noise levels at the time of the study. A schematic diagram of the procedure involved in speech audiometry and the immitance device used is shown in Figure 3.1 and 3.2 respectively.

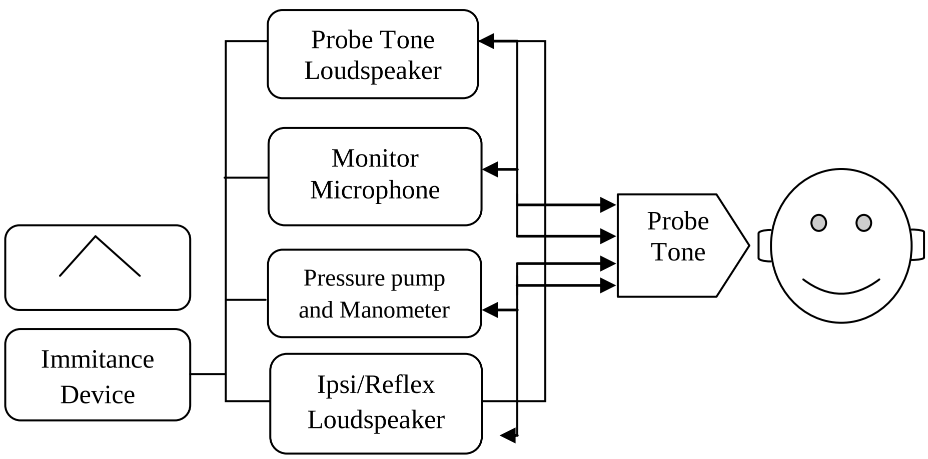

Figure 3.1: Diagrammatic representation of the immitance device

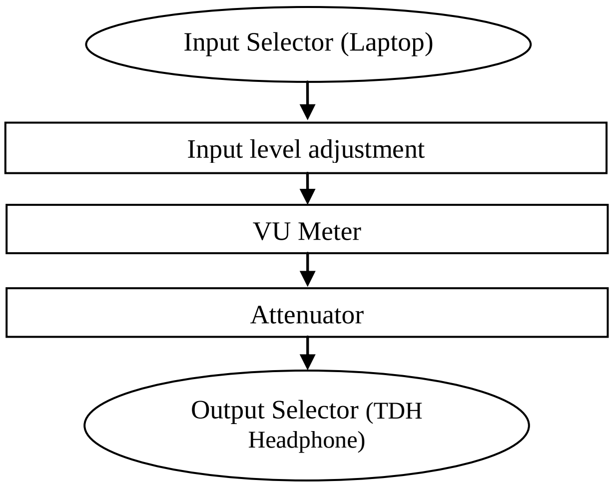

Fig. 3.2: Diagrammatic representation of the procedure involved in speech audiometry.

3.8.1 Calibration

The audiometer was calibrated using a Larson Davis System 824 sound level meter and a 6cc coupler. Calibration was based on ANSI 2004 standards upon which measurements of sound levels at octave and half octave frequencies with a deviation range of -0.6 to +0.3 dB were based. The sound levels for speech through external inputs A and B were consistent with ANSI standard 2004 with a deviation of -0.5 to +0.1 dB. Repeated measurements of sound pressure level produced by the audiometer were within permissible ANSI tolerance level of +3dB for frequencies of 500 to 4000Hz and +5dB for 6000 to 8000 Hz.

3.8.2 Custom Software for Data Collection

The custom software wavPlayer v1.0.3 was used for data collection. It was used to control the playback of 1 kHz tone, randomization and word lists from wav files. The software also provides the documentation of data in an excel spread sheet with the following details: the date and time of presentation, participant assigned number, gender of participants and speakers, test ear, intensity level, signal to noise ratio, list name, time of recording per list, wav file, word (in this case in Fante), and the score. Prior to data collection, the VU meter was adjusted to 0 VU using 1 KHz tone.

3.9 PROCEDURE FOR DATA COLLECTION

Phase I Materials

Trisyllabic words were chosen for the SRT stimuli. Initially, 107 trisyllabic words were selected from Akan Dictionary (Department of Linguistics, UG, 2011; Agyekum, Osam & Sackey, 2011) and Fante readers for primary schools. Fifty-one words were kept as trisyllabic with respect to Fante dialect after transcription and were picked out for recording and evaluation. The other words were eliminated because they had the same pronunciation but different meanings or were represented by different characters. Additionally, words were eliminated from the original lists if they were considered by native Fante judges to be culturally insensitive, unfamiliar, and/or representative of inappropriate content. Four postgraduate students from the Department of Applied Linguistics who majored in Fante language jointly transcribed the selected words at the University of Education, Winneba. The transcriptions were then compared to equivalent transcriptions in the Akan dictionary to ensure consistency. Ratings of the words were done on three bases; familiarity, phonemic dissimilarity and tone pattern. On familiarity, the words were rated by three judges on a scale of 1 to 3 based on the how familiar a word would be to a Fante speaker (1 = extremely familiar, 2 = fairly familiar, 3 = very unfamiliar. The words were then rated on phonemic dissimilarity (1=Absolutely phonemically dissimilar, 2= Quite phonemically dissimilar, 3= Not phonemically dissimilar). On tone pattern, the words were rated on (1=W-W-S, 2=W-S-S, 3=W-S-W, 4=Others, W-weak syllable, S-strong syllable). Words which scored 1 across all the three criteria were included in the list of words to be recorded. Inter-rater agreement was then calculated for all the 51 words selected.

Phase II Recordings

Initial test recordings were made using 4 native Fante speakers (2 male and 2 female). All talkers were native Fante speakers from Winneba in the Central Region, who self-reported speaking Fante on daily basis. All Fante speakers had a minimum of a Bachelor's degree from a university. After the initial recordings were made, a panel of 3 Fante judges evaluated the performance of each talker. The panel of judges with a minimum qualification of Master of Philosophy (MPhil.) degree in linguistics were asked to rank order the speakers from best to worst based on vocal quality, standard dialect, and pronunciation. The highest ranked female and male speakers were selected as the talkers for all subsequent recordings.

All recordings were made in a sound-treated test room of the Centre for Hearing and Speech Services, located in the Department of Special Education, University of Education, Winneba, in order to reduce reverberation and sound reflection during recordings. All recordings were done using a Behringer dual diaphragm condenser microphone, which was positioned approximately 15cm from each talker at a 0˚azimuth. The microphone was connected through an M-Audio Fast Track Pro 4x4 Mobile USB preamp. A 44.1 kHz sampling rate with a 16-bit quantization was used for all recordings. All recorded words were saved on a laptop as wav files for later editing. During the recording of the words, talkers were instructed to repeat each trisyllabic word four times with a slight pause between each pronunciation. The first and last repetition of each word was excluded from the study to avoid possible list effects. The best quality recordings for the final word lists were then selected from the remaining medial recordings. Any words that were judged to be a poor recording (peak clipping, extraneous noise), mispronounced, or produced with an unnatural intonation pattern were recorded again or eliminated prior to evaluation. Later, the intensity of each word was edited as a single utterance using Adobe Audition CS6 version 5.0 (Adobe Systems Inc., 2012) to obtain the same average rms power as a 1000 Hz calibration tone in an initial attempt to equate test word audibility (Harris et al., 2004; Wilson & Strouse, 1999). After editing, words were saved individually as 16-bit wav files.

Phase III Evaluation of Trisyllabic Words

A custom software was used to control randomization, timing and presentation of the words by routing the 16-bit wavfiles to the external input of an Interacoustics AC33 audiometer. The stimuli were routed from the audiometer to the participant via a single TDH-39 headphone. All testing was carried out in a double-walled sound suite that met 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, the external inputs to the audiometer were calibrated to 0 VU using a 1000 Hz calibration tone. The audiometer was calibrated prior to 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 collections. The participants were familiarized with the trisyllabic words prior to testing.

Each subject listened to the entire list of trisyllabic words once at 50 dB HL to become familiar with the words before the testing commenced. The 51 trisyllabic words were presented to each of the Subjects beginning at -5dB ascending in 5 dB increments until one of the following criteria had been met: (a) the Subject responded correctly to 100% of the test items, or (b) the presentation level reached 40 dB HL. The order of the 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 subject population. Word order within the list was randomized prior to each presentation, and each list was presented beginning with the softest intensity and increasing in loudness to reduce learning effects. Each subject participated in two test sessions hence each subject listened to both the male and female recordings of the trisyllabic list. Prior to administration of the word recognition test, the following instructions were given to the subjects in English as follows:

> *You will hear Fante words at a number of different loudness levels. Each word is three syllables in length. At the very soft loudness levels, it may be difficult for you to hear the words. Please listen carefully and repeat out loud the word that you hear. If you are unsure of the word, you are encouraged to guess. If you have no guess, say, I don't know. Do you have any questions?*

3.10 DATA ANALYSIS

Data obtained from the study was analyzed using descriptive and inferential statistics such as mean, standard deviation, Cohen's kappa coefficient of agreement and regression coefficient.

3.11 ETHICAL CONSIDERATIONS

Ethical clearance was obtained from the Ethics and Protocol Review Committee of UG-SBAHS. Permission to commence the data collection was granted by the KBTH HAC and CHSS. Participation of subjects conformed to the required ethical guidelines regarding the use of human subjects. Written informed consent was sought from each subject before the collection of data. All subjects were made aware of the objectives and methods of the study and the testing process duly explained. Additionally, subjects were assured of strict confidentiality with regards to their bio-data and any data generated by the study.

CHAPTER FOUR

RESULTS

4.1 INTRODUCTION

This chapter presents demographics, tympanometry, acoustic reflex thresholds and pure tone threshold results obtained from the study. Statistically, the results are presented via descriptive statistics which provided the means and standard deviations of the research variables and inferential statistics which indicated outcomes of the test of significance of the variables.

4.2 RESULTS

4.2.1 Demographics

The demographic characteristics of subjects are shown in Table 4.1.

Table 4.1: Age, gender and education demographics

Demographic variable		Frequency	Percentage
	Age distribution		
Age (years)	22 – 25	7	35.0
	26 – 30	9	45.0
	30 – 35	4	20.0
	Gender distribution		
Gender	Male	10	50.0
	Female	10	50.0
	Educational background		
Educational background	Basic	2	10.0
	Secondary	3	15.0
	Tertiary	15	75.0

Source: Field data, 2015

From Table 4.1, the gender distribution of the subjects was 50% (*n*=10) males and 50% (*n*=10) females. The ages of the 20 subjects ranged between 22years to 35 years (M=26.90 ±3.34) years. The most prevalent age group was 26-30 years (*n*=9, 45%). Subjects, 25 years and below presented a prevalence of 35% (*n*=7) whiles subjects who were 30years and above in age presented a prevalence of 20% (*n*=4). Regarding education, 75% (*n*=15) had obtained a minimum education at the tertiary level, 15% (*n*=3) at the secondary level and 10% (*n*=2) at the basic educational level. Table 4.2 and 4.3 show the immitance results of the 20 Fante subjects. This comprised tympanometry and acoustic reflex results.

Table 4.2: Tympanometry Results of 20 Fante Subjects

Variable	Minimum	Maximum	Range	Mean ± s.d
ECV (ml)	0.80	1.60	0.80	1.22 ± 0.22
TM Compliance (ml)	0.20	1.40	1.20	0.63 ± 0.31
Pressure (daPa)	5.00	30.00	25.00	13.75 ± 6.66

Source: Field data, 2015

All subjects (*n*=20) had normal ear canal volume with a range of 0.80ml (M=1.22 ± 0.22). With respect to tympanic membrane compliance, all subjects (*n*=20) had normal compliance within with a range of 1.20 (M=0.63 ± 0.31). All subjects (*n*=20) had middle ear pressure within normal limits with a range of 25.00(M=13.75 ± 6.66).

Table 4.3: Acoustic Reflex thresholds of 20 Fante subjects

Frequency	Min	Max	Range	Mean ± s.d
500Hz	65	95	30	86.25 ± 8.56
1kHz	70	100	30	85.25 ± 7.86
2kHz	75	95	20	86.75 ± 6.13
4kHz	70	95	25	84.25 ± 7.30

Source: Field data, 2015

All subjects (*n*=20) presented acoustic reflexes within normal limits at 500 Hz with ranges of 30dBHL (M=86.25 ± 8.56), 30 dBHL (M=85.25 ±7.86) at 1 kHz, 20 dBHL (M=86.75 ± 6.13) at 2 kHz and 25 dBHL (M=84.25 ± 7.30) at 4 KHz.

Table 4.4: Pure Tone Thresholds for the 20 Fante Subjects.

Frequency	Min	Max	SD
250	0	15	8.25 ± 5.20
500	0	15	8.25 ± 3.73
1000	0	15	5.75 ± 3.73
2000	0	15	4.75 ± 5.25
3000	-5	15	5.00 ± 4.03
4000	-5	15	5.25 ± 5.25
6000	-5	15	8.50 ± 6.09
8000	0	15	7.25 ± 5.25
PTA[a]	1.67	11.67	6.25 ± 2.70

[a]PTA = arithmetic average of thresholds at 500, 1000, and 2000 Hz
Source: Field data, 2015

All subjects indicating 100% (*n*=20) had hearing thresholds within normal limits across all octaves and mid-octaves with a range of 1.67 dBHL to 11.67 dBHL (M=6.50 ± 2.70 dBHL) from 250 Hz-8 kHz.

4.3 INTER RATER AGREEMENT

Inter-rater agreement was calculated for the 51 words using Cohen's kappa. Kappa results for the 51 words indicated a high level of agreement among raters. For familiarity, inter-rater agreement produced a kappa value of 0.812 ($p < 0.001$). This indicated a very strong agreement between raters. For phonemic dissimilarity, kappa value was 0.639 ($p < 0.001$)

indicating a fairly strong agreement. For tone pattern, kappa was 0.847 ($p < 0.001$) indicating a very strong agreement between the raters. The 51 selected words are tabulated as follows:

Table 4.5: Fifty-one words for Fante trisyllabic SRT words in Fante

Actual Spelling	Definition	Part of speech
abaa	rod	noun
abɔdwe	chin	noun
abɛbu	proverb	noun
abofra	child	noun
abrɔbɛ	pineapple	noun
abrewa	old woman/ grandmother	noun
adɔyɛ	charity/ gift	noun
adzekan	reading	noun
adzesua	studying	noun
adzetɔn	Sales	noun
afena	matchet	noun
ahaban	farm	noun
ahoma	rope	noun
ahotɔ	comfort	noun
akoma	heart	noun
anadwe	evening	noun
anapa	morning	noun
anyigye	happiness	noun
apɔnkye	goat	noun
asɔfo	pastors	noun
aseda	thanksgiving	noun
atɔɛ	west	noun
atwer	ladder	noun
aware	marriage	noun
awoda	birthday	noun
awofo	parents	noun
bayer	yam	noun
borɔfo	English language/ Whiteman	noun
borɛdze	plantain	noun
dwumadzi	project	noun
eduaba	fruit	noun
edzinkra	traditional Akan symbols	noun
efir	trap	noun
eguafo	traders	noun
egudze	treasure (usually gold)	noun
ehina	pot	noun

ekutu	orange	noun
esisi	Cheating	noun
katɛkyi	brave or noble man	noun
mfaso	profit	noun
nhyira	blessings	noun
nkate	groundnut/ peanuts	noun
nkramo	Muslim	noun
nsapan	empty handedness	noun
nsisi	events (plural)	noun
ntɛkyerɛ	feathers of a bird	noun
nyansanyi	wise man	noun
obronyi	white man (singular)	noun
odwira	traditional Akan festival	noun
pofonyi	fisherman/ seaman	noun
sikadzi	the state of being spendthrift/ profligate	noun

Source: Field data 2015

4.4 Logistic Regression

Logistic regression was used to obtain the regression slope and intercept for each of the 51 trisyllabic words subsequent to data collection. These values were then inserted into a modified logistic regression equation that was designed to calculate the percent correct at each intensity level (Slade, 2006). The original logistic regression equation is as follows:

$$p = \left[1 - \frac{\exp(a+bi)}{1+\exp(a+bi)}\right] x100 \qquad 3.1$$

In equations 3.1 and 3.2, *p* is the proportion correct at any given intensity level, *a* is the regression intercept, *b* is the regression slope, and *i* is the intensity level in dB HL. When Equation 1 is solved for p and multiplied by100, Equation 3.2 is obtained:

$$i = \frac{\ln\left(\frac{p}{1-p}\right) - a}{b} = \frac{1}{b}\left[\ln\left(\frac{p}{1-p}\right) - a\right] \qquad 3.2$$

By inserting the regression slope, regression intercept, and intensity level into Equation 3.2, it is possible to predict the percentage correct at any specified intensity level. Percentage of correct recognition was calculated for each of the trisyllabic words for a range of -10 to 22dB HL in 1 dB increments.

In order to calculate the intensity level required for a given proportion, Equation 3.1 was solved for dB (see Equation 2). By inserting the desired proportions into Equation 3.2, it is possible to calculate the threshold (the intensity required for 50% intelligibility), and the slope (%/dB) at 50 % and from 20% to 80% for each psychometric function. When solving for the threshold, Equation 2 can be simplified to Equation 3:

$$50\% \quad threshold \quad in \quad dB = -\frac{a}{b} \qquad 3.3$$

Calculations of threshold (intensity required for 50% correct perception), slope at 50%, and slope from 20% to 80% were made for each trisyllabic word using the logistic regression slopes and intercepts. Thresholds for the 51 trisyllabic words ranged from -0.27 dB HL to 10.40 dB HL (mean= 3.88 dB HL) for the male talker words, and from -4.62 dB HL to 8.18 dB HL (mean= -0.37 dB HL) for the female talker words. Psychometric functions for each trisyllabic word were calculated with Equation 3.2 using the logistic regression intercept and slope values. The slopes at 50% ranged from 6.47 %/dB to 20.07 %/dB (mean= 11.19) for the male talker and from 4.82 %/dB to 16.10 %/dB (mean = 8.79) for the female talker. The slopes from 20-80% ranged from 5.60 %/dB to 17.37 %/dB (mean = 11.19) for the male talker and from 4.18 %/dB to 13.94 %/dB (mean = 7.61) for the female talker. Thus, the slopes at 50% threshold were steeper when compared to the slopes at 20-80%. Slopes of the psychometric functions and 50% thresholds for all trisyllabic words are presented in Table 4.6 (male talker) and 4.7 (female talker) respectively.

To decrease test time as well as improve reliability, words with steeper slopes are used. Wilson & Strouse (1999) suggested that words used to measure SRT should have relatively homogeneous and steep psychometric function slopes. Twenty-nine (29) words which had the steepest psychometric function slopes for both the male and female talker recordings (≥7.00 %/dB) and with enough available headroom for adjustment were selected for inclusion in the final list of trisyllabic words.

Twenty-nine (29) words were perceptually evaluated by four (4) audiologists and one (1) student audiologist from the School of Biomedical and Allied Health Sciences-Korle Bu, all with normal hearing as at the time of the perceptual evaluation. Four (4) words were eliminated because they were unanimously perceived to be too loud or too soft. This resulted in the final list of 25 words. The threshold, slope at threshold, and the slope from 20 to 80% for the 25 selected trisyllabic words are listed in Table 4.8 (male talker) and Table 4.9 (female talker) respectively.

Figure 3 (male talker) and Figure 4 (female talker) contain the psychometric performance intensity functions for each of the 25 words with the logistic regression slopes and intercepts. Figure 3 and 4 revealed less variability in the slope of the psychometric performance functions for the selected words when compared to the complete list of 51 words. The composite psychometric performance intensity functions for the 51 words and 25 selected words are shown in Figure 4.1, 4.2 4.3 and 4.4 respectively.

To increase homogeneity of the thresholds of the final 25 words, the intensity of each was digitally adjusted so that the 50% threshold of each word was equal to the mean PTA of the subjects (6.25 dBHL). Adjustments for each selected word for both talker recordings are presented in Table 4.7 (male talker) and Table 4.8 (female talker). Figure 4.5 and 4.6 showed predicted psychometric performance-intensity functions for the selected words after adjusting intensity to equate 50% thresholds for the male talker and female talker respectively.

Table 4.6: Mean performance for 51 Fante male trisyllabic SRT words

#	Word	a[a]	b[b]	Slope at 50% [c]	Slope 20-80%[d]	Threshold[e]	ΔdB[f]
1	ɔsɔfo	0.91777	-0.53201	13.30	11.51	1.73	-4.52
2	abɛbu	1.57308	-0.41861	10.47	9.06	3.76	-2.49
3	abɔdwe	1.65173	-0.41160	10.29	8.91	4.01	-2.24
4	abaa	0.37965	-0.53316	13.33	11.54	0.71	-5.54
5	abofra	0.81057	-0.41357	10.34	8.95	1.96	-4.29
6	abrɔbɛ	0.81057	-0.41357	10.34	8.95	1.96	-4.29
7	abrewa	0.98278	-0.49653	12.41	10.75	1.98	-4.27
8	adɔyɛ	1.00591	-0.37042	9.26	8.02	2.72	-3.53
9	adzekan	1.22593	-0.49217	12.30	10.65	2.49	-3.76
10	adzesua	0.91777	-0.53201	13.30	11.51	1.73	-4.52
11	adzetɔn	1.22593	-0.49217	12.30	10.65	2.49	-3.76
12	afena	1.50059	-0.33147	8.29	7.17	4.53	-1.72
13	ahaban	1.17786	-0.43046	10.76	9.32	2.74	-3.51
14	ahoma	1.22593	-0.49217	12.30	10.65	2.49	-3.76
15	ahotɔ	0.82201	-0.47755	11.94	10.33	1.72	-4.53
16	akoma	1.97336	-0.49119	12.28	10.63	4.02	-2.23
17	anadwe	0.85121	-0.58042	14.51	12.56	1.47	-4.78
18	anapa	1.31367	-0.40502	10.13	8.76	3.24	-3.01
19	anyigye	2.40881	-0.43462	10.87	9.41	5.54	-0.71
20	apɔnkye	1.16297	-0.51988	13.00	11.25	2.24	-4.01
21	aseda	1.71330	-0.45551	11.39	9.86	3.76	-2.49
22	atɔɛ	1.27255	-0.31821	7.96	6.89	4.00	-2.25
23	atwer	1.04731	-0.46927	11.73	10.16	2.23	-4.02
24	aware	1.13429	-0.32633	8.16	7.06	3.48	-2.77
25	awoda	1.22593	-0.49217	12.30	10.65	2.49	-3.76
26	awofo	0.48672	-0.41115	10.28	8.90	1.18	-5.07
27	bayer	2.37412	-0.47234	11.81	10.22	5.03	-1.22
28	borɛdze	0.95385	-0.42913	10.73	9.29	2.22	-4.03
29	borɔfo	0.67562	-0.46199	11.55	10.00	1.46	-4.79
30	dwumadzi	2.75469	-0.40228	10.06	8.71	6.85	0.60
31	eduaba	-0.16079	-0.59476	14.87	12.87	-0.27	-6.52
32	edzinkra	0.52560	-0.54519	13.63	11.80	0.96	-5.29
33	efir	2.34058	-0.26124	6.53	5.65	8.96	2.71
34	eguafo	1.73440	-0.40631	10.16	8.79	4.27	-1.98
35	egudze	4.36040	-0.48933	12.23	10.59	8.91	2.66
36	ehina	1.81039	-0.25885	6.47	5.60	6.99	0.74
37	ekutu	1.24482	-0.41641	10.41	9.01	2.99	-3.26
38	esisi	2.30472	-0.53941	13.49	11.67	4.27	-1.98
39	katɛkyi	1.71330	-0.45551	11.39	9.86	3.76	-2.49
40	mfaso	0.93741	-0.34696	8.67	7.51	2.70	-3.55
41	nhyira	0.98278	-0.49653	12.41	10.75	1.98	-4.27
42	nkate	1.59238	-0.35174	8.79	7.61	4.53	-1.72
43	nkramo	3.11480	-0.36695	9.17	7.94	8.49	2.24
44	nsapan	2.68955	-0.44445	11.11	9.62	6.05	-0.20
45	nsisi	3.50517	-0.55940	13.98	12.11	6.27	0.02

46	ntɛkyerɛ	1.66245	-0.31249	7.81	6.76	5.32	-0.93
47	nyansanyi	2.68955	-0.44445	11.11	9.62	6.05	-0.20
48	obronyi	4.93449	-0.80262	20.07	17.37	6.15	-0.10
49	odwira	3.64263	-0.46317	11.58	10.02	7.86	1.61
50	pofonyi	3.70134	-0.35574	8.89	7.70	10.40	4.15
51	sikadzi	2.01233	-0.39941	9.99	8.64	5.04	-1.21
	M	1.66500	-0.44741	11.19	9.68	3.88	-2.37
	Min	-0.16079	-0.80262	6.47	5.60	-0.27	-6.52
	Max	4.93449	-0.25885	20.07	17.37	10.40	4.15
	Range	5.09528	0.54377	13.59	11.77	10.67	10.67
	SD	1.04284	0.09282	2.32	2.01	2.38	2.38

[a]*a* = regression intercept. [b]*b* = regression slope. [c]Psychometric function slope (%/dB) at 50% was calculated from 49.999 to 50.001%. [d]Psychometric function slope (%/dB) from 20-80%. [e]Intensity required for 50% intelligibility. [f]Change in intensity required to adjust the threshold of a word to the mean PTA of the subjects

Table 4.7: Mean performance for 51 Fante female trisyllabic SRT words

#	Word	a[a]	b[b]	Slope at 50% [c]	Slope 20-80%[d]	Threshold[e]	ΔdB[f]
1	ɔsɔfo	-1.21844	-0.26391	6.60	5.71	-4.62	-10.87
2	abɛbu	1.14653	-0.35056	8.76	7.59	3.27	-2.98
3	abɔdwe	-0.99431	-0.46603	11.65	10.09	-2.13	-8.38
4	abaa	-0.45395	-0.38520	9.63	8.34	-1.18	-7.43
5	abofra	-1.65791	-0.47399	11.85	10.26	-3.50	-9.75
6	abrɔbɛ	-1.04336	-0.27683	6.92	5.99	-3.77	-10.02
7	abrewa	-1.05292	-0.35799	8.95	7.75	-2.94	-9.19
8	adɔyɛ	0.56575	-0.29688	7.42	6.42	1.91	-4.34
9	adzekan	-1.10037	-0.53156	13.29	11.50	-2.07	-8.32
10	adzesua	-0.68767	-0.28511	7.13	6.17	-2.41	-8.66
11	adzetɔn	0.26118	-0.26270	6.57	5.68	0.99	-5.26
12	afena	0.09656	-0.25323	6.33	5.48	0.38	-5.87
13	ahaban	-0.54013	-0.35601	8.90	7.70	-1.52	-7.77
14	ahoma	0.75607	-0.38269	9.57	8.28	1.98	-4.27
15	ahotɔ	-1.61545	-0.50971	12.74	11.03	-3.17	-9.42
16	akoma	-0.16841	-0.30552	7.64	6.61	-0.55	-6.80
17	anadwe	-0.98609	-0.38477	9.62	8.33	-2.56	-8.81
18	anapa	-1.05292	-0.35799	8.95	7.75	-2.94	-9.19
19	anyigye	-0.56139	-0.38940	9.73	8.43	-1.44	-7.69
20	apɔnkye	-0.25952	-0.46244	11.56	10.01	-0.56	-6.81
21	aseda	-0.60821	-0.30542	7.64	6.61	-1.99	-8.24
22	atɔɛ	0.84818	-0.28476	7.12	6.16	2.98	-3.27
23	atwer	-0.78924	-0.64410	16.10	13.94	-1.23	-7.48
24	aware	-1.57473	-0.55061	13.77	11.92	-2.86	-9.11
25	awoda	-0.02730	-0.27486	6.87	5.95	-0.10	-6.35
26	awofo	-1.04336	-0.27683	6.92	5.99	-3.77	-10.02
27	bayer	0.96237	-0.42873	10.72	9.28	2.24	-4.01
28	borɛdze	-0.09497	-0.28876	7.22	6.25	-0.33	-6.58
29	borɔfo	-0.62205	-0.33068	8.27	7.16	-1.88	-8.13
30	dwumadzi	0.04161	-0.35740	8.94	7.73	0.12	-6.13
31	eduaba	-1.49728	-0.41073	10.27	8.89	-3.65	-9.90
32	edzinkra	0.37950	-0.33109	8.28	7.16	1.15	-5.10
33	efir	1.13989	-0.20610	5.15	4.46	5.53	-0.72
34	eguafo	-0.17882	-0.28628	7.16	6.20	-0.62	-6.87
35	egudze	0.44342	-0.31771	7.94	6.88	1.40	-4.85
36	ehina	1.60434	-0.26693	6.67	5.78	6.01	-0.24
37	ekutu	-0.86395	-0.37420	9.36	8.10	-2.31	-8.56
38	asɔfo	-0.54013	-0.35601	8.90	7.70	-1.52	-7.77
39	katɛkyi	-0.51532	-0.24730	6.18	5.35	-2.08	-8.33
40	mfaso	-0.05533	-0.35442	8.86	7.67	-0.16	-6.41
41	nhyira	-1.32817	-0.38799	9.70	8.40	-3.42	-9.67
42	nkate	-0.51791	-0.30373	7.59	6.57	-1.71	-7.96
43	nkramo	0.52242	-0.36214	9.05	7.84	1.44	-4.81
44	nsapan	-0.60821	-0.30542	7.64	6.61	-1.99	-8.24
45	nsisi	1.82524	-0.22314	5.58	4.83	8.18	1.93
46	ntɛkyerɛ	0.11785	-0.33646	8.41	7.28	0.35	-5.90
47	nyansanyi	0.89700	-0.45060	11.26	9.75	1.99	-4.26

48	obronyi	0.62249	-0.42269	10.57	9.15	1.47	-4.78
49	odwira	-0.54013	-0.35601	8.90	7.70	-1.52	-7.77
50	pofonyi	0.47644	-0.19299	4.82	4.18	2.47	-3.78
51	sikadzi	1.28316	-0.33803	8.45	7.32	3.80	-2.45
	M	-0.21192	-0.35146	8.79	7.61	-0.37	-6.62
	Min	-1.65791	-0.64410	4.82	4.18	-4.62	-10.87
	Max	1.82524	-0.19299	16.10	13.94	8.18	1.93
	Range	3.48315	0.45111	11.28	9.76	12.80	12.80
	SD	0.87719	0.09037	2.26	1.96	2.73	2.73

[a]*a* = regression intercept. [b]*b* = regression slope. [c]Psychometric function slope (%/dB) at 50% was calculated from 49.999 to 50.001%. [d]Psychometric function slope (%/dB) from 20-80%. [e]Intensity required for 50% intelligibility. [f]Change in intensity required to adjust the threshold of a word to the mean PTA of the subjects

Table 4.8: Mean performance for 25 selected Fante male trisyllabic SRT words

#	Word	a[a]	b[b]	Slope at 50% [c]	Slope 20-80%[d]	Threshold[e]	ΔdB[f]
1	abɛbu	1.57308	-0.41861	10.47	9.06	3.76	-2.49
2	abɔdwe	1.65173	-0.41160	10.29	8.91	4.01	-2.24
3	abaa	0.37965	-0.53316	13.33	11.54	0.71	-5.54
4	abrewa	0.98278	-0.49653	12.41	10.75	1.98	-4.27
5	adɔyɛ	1.00591	-0.37042	9.26	8.02	2.72	-3.53
6	adzekan	1.22593	-0.49217	12.30	10.65	2.49	-3.76
7	adzesua	0.91777	-0.53201	13.30	11.51	1.73	-4.52
8	ahaban	1.17786	-0.43046	10.76	9.32	2.74	-3.51
9	ahotɔ	0.82201	-0.47755	11.94	10.33	1.72	-4.53
10	akoma	1.97336	-0.49119	12.28	10.63	4.02	-2.23
11	anadwe	0.85121	-0.58042	14.51	12.56	1.47	-4.78
12	anapa	1.31367	-0.40502	10.13	8.76	3.24	-3.01
13	apɔnkye	1.16297	-0.51988	13.00	11.25	2.24	-4.01
14	aseda	1.71330	-0.45551	11.39	9.86	3.76	-2.49
15	abofra	0.81057	-0.41357	10.34	8.95	1.96	-4.29
16	borɛdze	0.95385	-0.42913	10.73	9.29	2.22	-4.03
17	borɔfo	0.67562	-0.46199	11.55	10.00	1.46	-4.79
18	eduaba	-0.16079	-0.59476	14.87	12.87	-0.27	-6.52
19	eguafo	1.73440	-0.40631	10.16	8.79	4.27	-1.98
20	ekutu	1.24482	-0.41641	10.41	9.01	2.99	-3.26
21	mfaso	0.93741	-0.34696	8.67	7.51	2.70	-3.55
22	nhyira	0.98278	-0.49653	12.41	10.75	1.98	-4.27
23	nkate	1.59238	-0.35174	8.79	7.61	4.53	-1.72
24	nsapan	2.68955	-0.44445	11.11	9.62	6.05	-0.20
25	ntɛkyerɛ	1.66245	-0.31249	7.81	6.76	5.32	-0.93
	M	1.19497	-0.45155	11.29	9.77	2.79	-3.46
	Min	-0.16079	-0.59476	7.81	6.76	-0.27	-6.52
	Max	2.68955	-0.31249	14.87	12.87	6.05	-0.20
	Range	2.85034	0.28227	7.06	6.11	6.32	6.32
	SD	0.56461	0.07082	1.77	1.53	1.44	1.44

[a]*a* = regression intercept. [b]*b* = regression slope. [c]Psychometric function slope (%/dB) at 50% was calculated from 49.999 to 50.001%. [d]Psychometric function slope (%/dB) from 20-80%. [e]Intensity required for 50% intelligibility. [f]Change in intensity required to adjust the threshold of a word to the mean PTA of the subjects (6.25)

Table 4.9: Mean performance for 25 selected Fante female trisyllabic SRT words

#	Word	a[a]	b[b]	Slope at 50% [c]	Slope 20-80%[d]	Threshold[e]	ΔdB[f]
1	abɛbu	1.14653	-0.35056	8.76	7.59	3.27	-2.98
2	abɔdwe	-0.99431	-0.46603	11.65	10.09	-2.13	-8.38
3	abaa	-0.45395	-0.38520	9.63	8.34	-1.18	-7.43
4	abrewa	-1.05292	-0.35799	8.95	7.75	-2.94	-9.19
5	adɔyɛ	0.56575	-0.29688	7.42	6.42	1.91	-4.34
6	adzekan	-1.10037	-0.53156	13.29	11.50	-2.07	-8.32
7	adzesua	-0.68767	-0.28511	7.13	6.17	-2.41	-8.66
8	ahaban	-0.54013	-0.35601	8.90	7.70	-1.52	-7.77
9	ahotɔ	-1.61545	-0.50971	12.74	11.03	-3.17	-9.42
10	akoma	-0.16841	-0.30552	7.64	6.61	-0.55	-6.80
11	anadwe	-0.98609	-0.38477	9.62	8.33	-2.56	-8.81
12	anapa	-1.05292	-0.35799	8.95	7.75	-2.94	-9.19
13	apɔnkye	-0.25952	-0.46244	11.56	10.01	-0.56	-6.81
14	aseda	-0.60821	-0.30542	7.64	6.61	-1.99	-8.24
15	abofra	-1.65791	-0.47399	11.85	10.26	-3.50	-9.75
16	borɛdze	-0.09497	-0.28876	7.22	6.25	-0.33	-6.58
17	borɔfo	-0.62205	-0.33068	8.27	7.16	-1.88	-8.13
18	eduaba	-1.49728	-0.41073	10.27	8.89	-3.65	-9.90
19	eguafo	-0.17882	-0.28628	7.16	6.20	-0.62	-6.87
20	ekutu	-0.86395	-0.37420	9.36	8.10	-2.31	-8.56
21	mfaso	-0.05533	-0.35442	8.86	7.67	-0.16	-6.41
22	nhyira	-1.32817	-0.38799	9.70	8.40	-3.42	-9.67
23	nkate	-0.51791	-0.30373	7.59	6.57	-1.71	-7.96
24	nsapan	-0.60821	-0.30542	7.64	6.61	-1.99	-8.24
25	ntɛkyerɛ	0.11785	-0.33646	8.41	7.28	0.35	-5.90
	M	-0.60458	-0.36831	9.21	7.97	-1.52	-7.77
	Min	-1.65791	-0.53156	7.13	6.17	-3.65	-9.90
	Max	1.14653	-0.28476	13.29	11.50	3.27	-2.98
	Range	2.80444	0.24645	6.16	5.33	6.92	6.92
	SD	0.66194	0.07171	1.79	1.55	1.67	1.67

[a]*a* = regression intercept. [b]*b* = regression slope. [c]Psychometric function slope (%/dB) at 50% was calculated from 49.999 to 50.001%. [d]Psychometric function slope (%/dB) from 20-80%. [e]Intensity required for 50% intelligibility. [f]Change in intensity required to adjust the threshold of a word to the mean PTA of the subjects (6.25)

4.4 Psychometric function curves

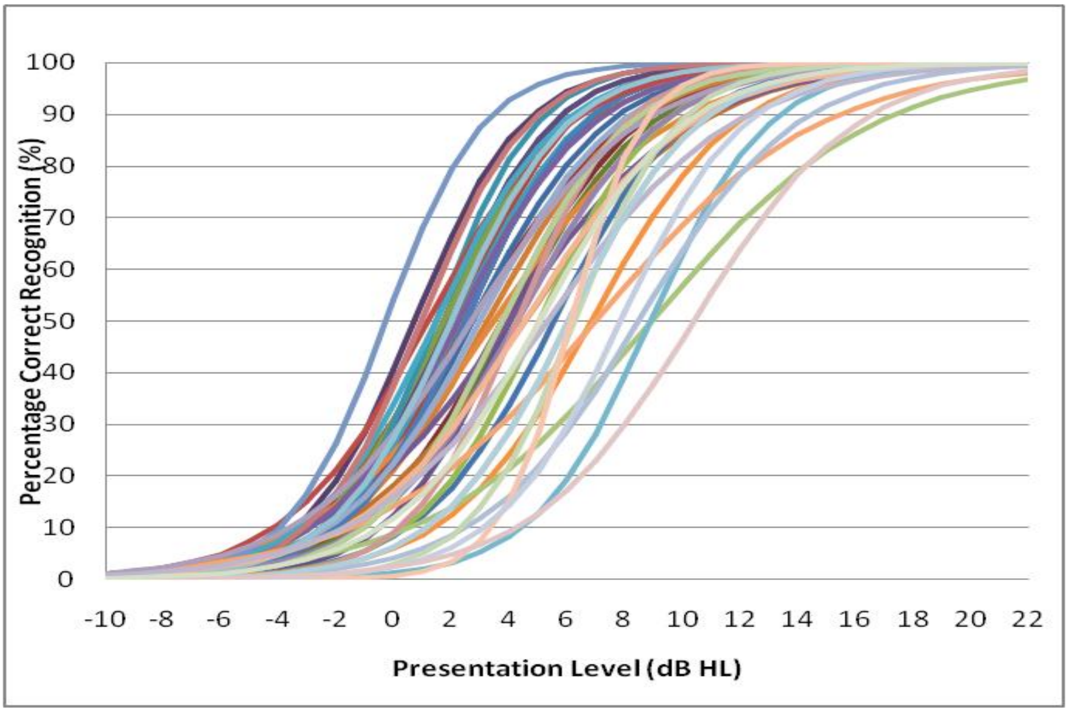

Figure 4.1 Psychometric functions for all 51 Fante male talker trisyllabic SRT words

***Source*: Field data, 2015**

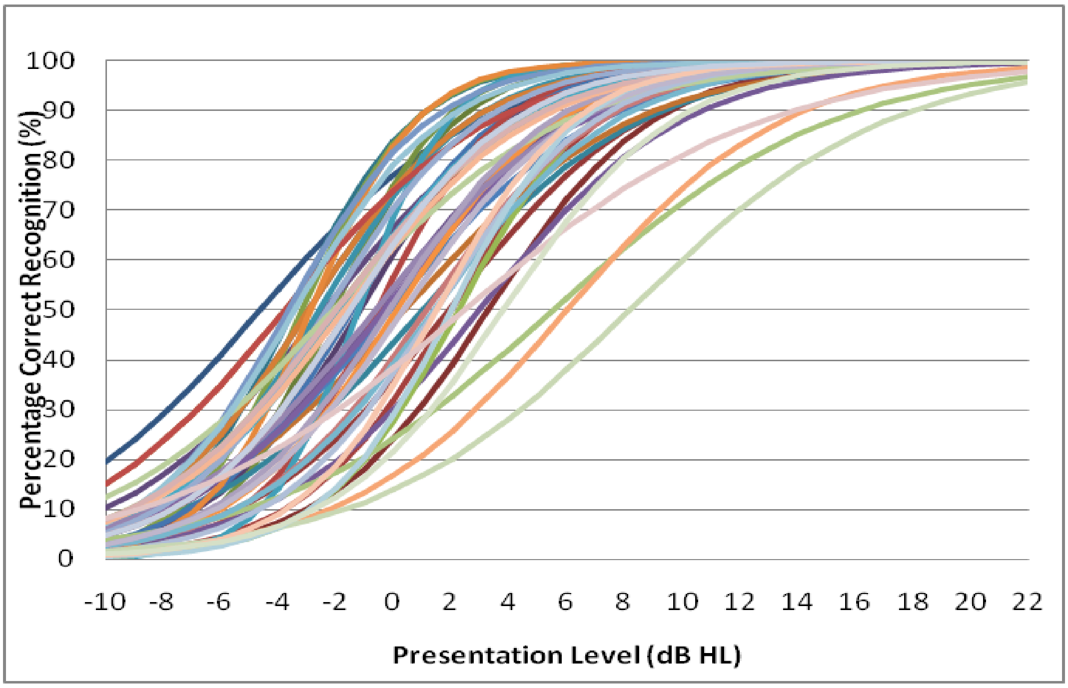

Figure 4.2 Psychometric functions for all 51 Fante female talker trisyllabic SRT words. *Source*: Field data, 2015

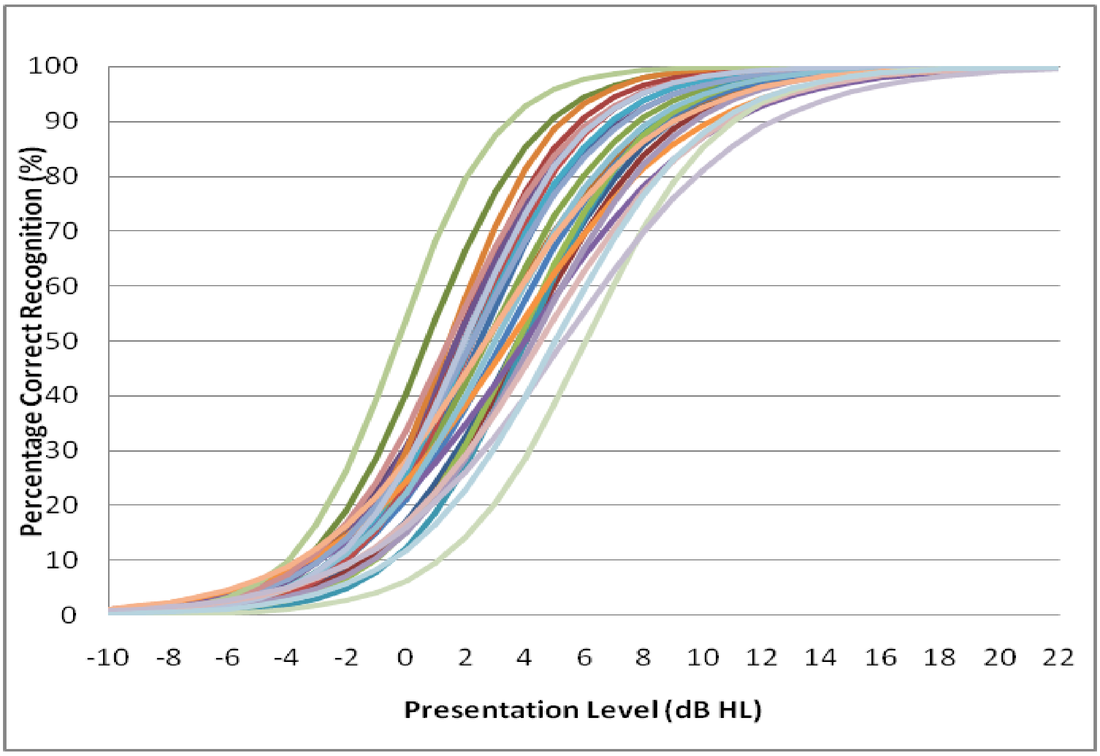

Figure 4.3 Psychometric functions for 25 selected Fante male talker trisyllabic SRT words. *Source*: Field data, 2015

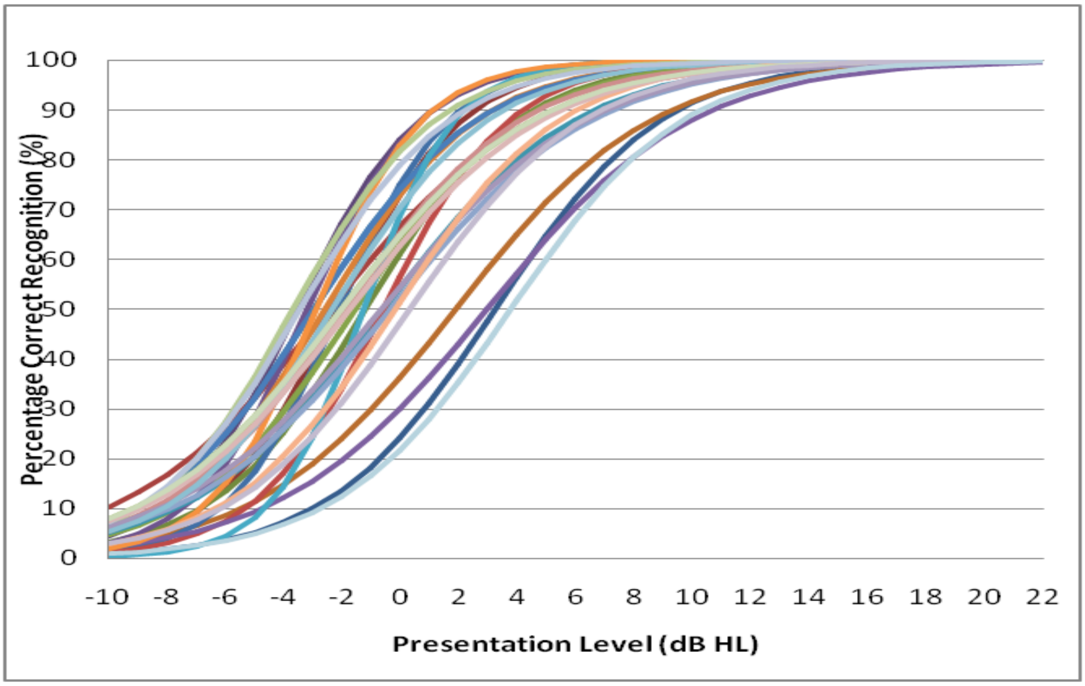

Figure 4.4 Psychometric functions for 25 selected Fante female talker trisyllabic SRT words. *Source*: Field data, 2015

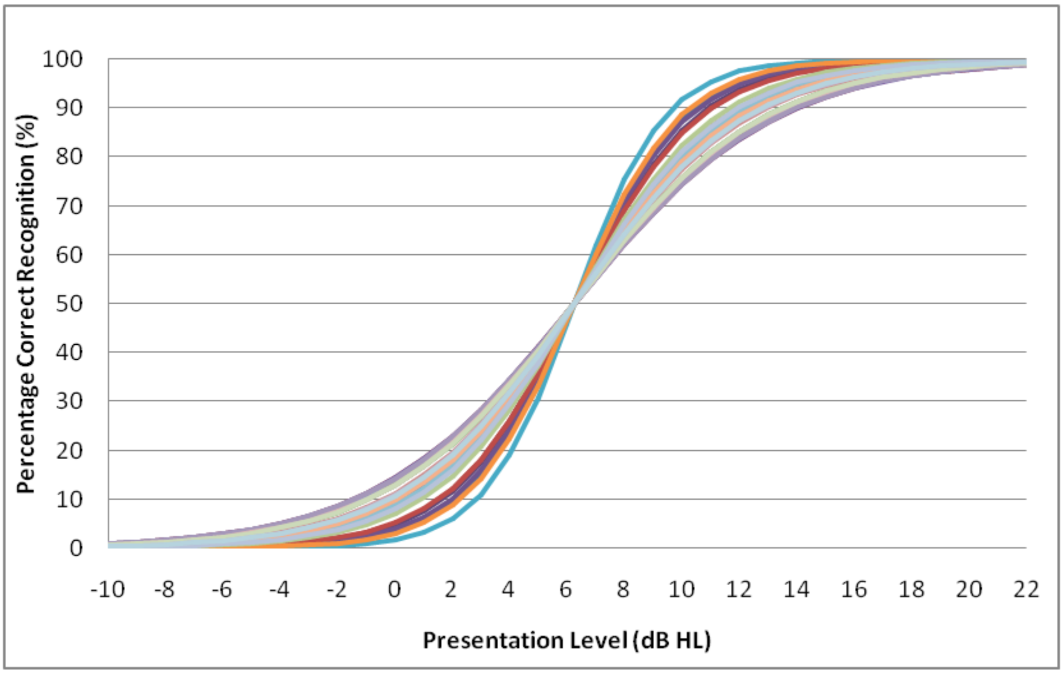

Figure 4.5 Psychometric functions for 25 selected adjusted Fante male talker trisyllabic SRT words. ***Source*****: Field data, 2015**

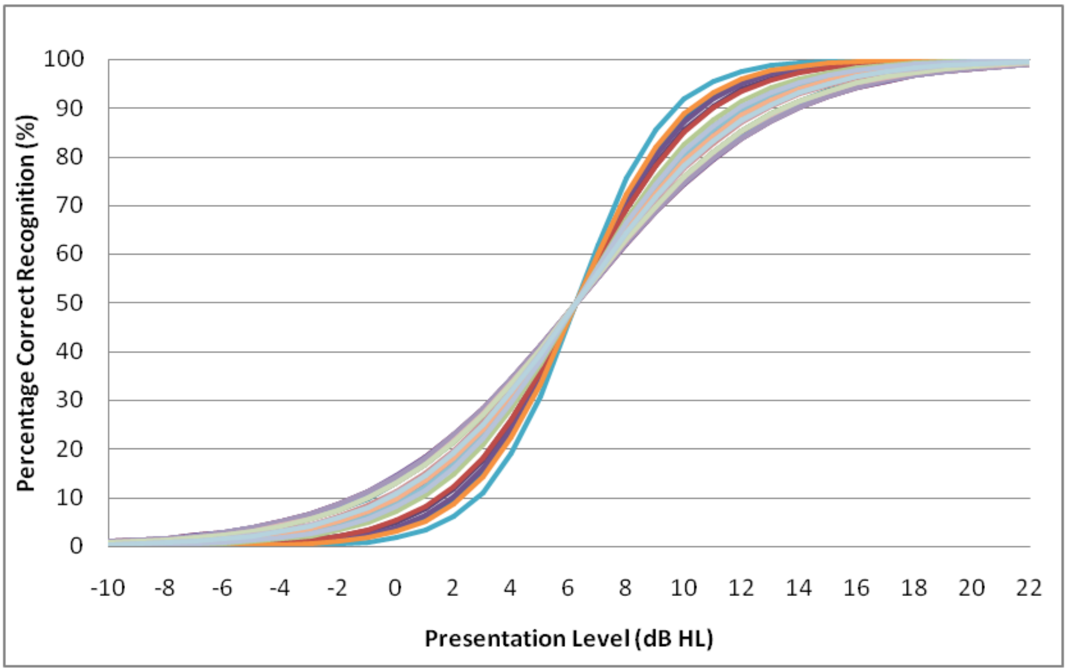

Figure 4.6 Psychometric functions for 25 selected adjusted Fante female talker trisyllabic SRT words. ***Source*****: Field data, 2015**

CHAPTER FIVE

DISCUSSION OF RESULTS

5.1 INTRODUCTION

This study was aimed at developing and evaluating digitally recorded speech materials that can be used in speech audiometry in Fante. Twenty-five (25) trisyllabic words with steep psychometric function slope and relative homogeneity with respect to audibility were finally selected to be included in the list of words. These words were recorded by male and female native Fante speakers. A CD was then created and included with this study. This section presents answers to research questions raised in Chapter Four as well as the major findings of this study.

5.2 RESEARCH QUESTIONS

5.2.1 Research question one: *Which familiar trisyllabic Fante words with the same tone pattern but are phonemically dissimilar be selected from among 107 commonly used words for speech audiometry in Fante?*

This question enquired whether familiar words which were phonemically dissimilar and had the same tone pattern could be selected for inclusion in the wordlist for speech audiometry in Fante. Results of the study indicated that 25 unique words were selected for inclusion in the final list of words for speech audiometry in Fante. All selected words were independently judged and rated as very familiar, had absolute phonemic dissimilarity and had the same tone pattern (W-W-S syllable). The final list of words which were selected at the end of the study was as follows:

abɛbu	adzekan	anadwe	borɛdze	mfaso
abɔdwe	adzesua	anapa	borɔfo	nhyira
abaa	ahaban	apɔnkye	eduaba	nkate
abrewa	ahotɔ	aseda	eguafo	nsapan
adɔyɛ	akoma	abofra	ekutu	ntɛkyerɛ

5.2.2 Research question two: *How can the psychometric properties and homogeneity with respect to audibility of the selected Fante words in the wordlist be obtained?*

This question sought to find out if the psychometric properties of the selected words could be measured. Results from the study indicated that final 25 trisyllabic words which were selected were more homogenous with respect to audibility and had steeper psychometric function slope compared to the original 51 unadjusted trisyllabic words. The mean slopes from 20 to 80% for the psychometric performance-intensity functions of the trisyllabic words ranged from 6.76%/dB to 12.87%/dB (mean = 9.77) for male talker and 6.17%/dB to 11.50%/dB (mean=7.97) for female talker. The study revealed that the means for the slopes of the psychometric functions were consistent with the means for speech materials that have been reported in other languages. The mean slopes for Portuguese SRT materials were 9.1%/dB for a male talker and 8.8%/dB for a female talker (Harris et al., 2001). For Japanese, the mean slope for SRT materials from 20 to 80% were reported at 8.4%/dB for the male speaker and 6.7%/dB for the female speaker (Mangum, 2005). Also, the mean slope for spondaic words in English has generally been reported between 7.2 %/dB and 10.0 %/dB (Hirsh et al., 1952; Hudgins, Hawkins, Karlin, & Stevens, 1947; Wilson & Strouse, 1999; Young et al., 1982), but has been as high as 12.0 %/dB (Beattie, Svihovee & Edgerton 1977; Ramkissoon, 2001). Similar slopes have resulted from 20 to 80% for the trisyllabic psychometric performance- intensity functions for both male and female talkers in materials created for other languages.

Materials developed for Spanish speakers, have been reported to have slope values of 11.1 %/dB for a male talker and 9.7 %/dB for a female talker (Christensen, 1995). In Japanese, the mean slope for trisyllabic words developed for SRT measurement had a slope of 8.9 %/dB for a male talker and 7.6 %/dB for a female talker recording (Mangum, 2005).The mean slopes from 20 to 80% in Putonghua (Nissen et al., 2005) were reported as 9.7 %/dB for the male talker and 10.5 %/dB for the female talker, reflecting a concurrence between Taiwan Mandarin and Putonghua. The mean slopes from 20 to 80% in Tongan (Bunker, 2008) were reported as 7.8 %/dB for the male talker and 7.0 %/dB for the female talker and 8.7%/dB for Tagalog (Taylor, 2012) as well.

The study results further established that the mean slope at 50%/dB for the male talker (mean =11.29%/dB) was steeper than the mean slope at 50%/dB of the female talker (mean = 9.21%/dB) compared with studies in Tagalog 9.9%/dB (Taylor, 2012), Japanese trisyllabic words 9.6%/dB for male talker and 7.7%/dB (Mangum, 2005), Spanish trisyllabic words, 10.1%/dB for male talker and 8.7%/dB for female talker (Keller, 2009), Taiwan Mandarin trisyllabic words, 11.3%/dB for male talker and 11.7%/dB for female talker (Slade, 2006) and 5.986%/dB in Kwa-Zulu (Panday, 2006). Keller (2009) speculated that differences in slopes could be caused by a variety of factors, including the individual differences between the talkers, the degree of the bilingualism of the subjects, dialect differences, and word selection.

Bradlow, Nygaard, and Pisoni (1999) also found that speaker rate has an effect on the recognition of words. They suggested that it was easier for listeners to accurately identify words on a list with the same speaker rate than that on a list of words with different speaker rates. It is therefore probable that the individual rate of speech of each talker affected the ability of the listeners to accurately identify the words. This could account for the differences in slopes. To increase homogeneity of the thresholds of the final 25 words, the intensity of each word was digitally adjusted so that the 50% threshold of each word was equal to the mean PTA of the subjects (6.25 dBHL).

Other studies have reported that gender of talkers produces no clinically significant difference in recognition threshold scores for normal-hearing and hearing impaired individuals (Cambron, Wilson, & Shanks, 1991; Penrod, 1979; Preece & Fowler, 1992). This means that any of the wordlists of either the male or female talker can be used for any clinical assessment. The inclusion of words from both the male and female talkers will add preference and convenience to the tester during the assessment.

5.3 LIMITATION OF THE STUDY

The limitation of this speech material is that the sample population may not match the intended testing population. The sample population consisted of normal hearing individuals while the intended test population is individuals with diagnosed and undiagnosed hearing impairments, and as a result may be a challenge to the use of the material (Jerger, 2006). McArdle and Wilson (2006) found that materials which were homogenous on a normal hearing population demonstrated significant variability when tested on individuals with hearing impairment. A future study examining this limitation would be beneficial both clinically and empirically.

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 INTRODUCTION

This Chapter presents the summary of the study, findings and recommendations.

6.2 SUMMARY

The aim of this research was to develop and evaluate digitally recorded speech materials that can be used in speech audiometry in Ghana. The specific objectives of the study were to:

- To produce a digitally recorded version of Fante wordlist.
- To measure the homogeneity of the words with respect to audibility of the Fante words selected in objective one.
- To measure the psychometric properties of the words in the wordlist.

Fifty-one trisyllabic words with equal psychometric properties were selected from 107 commonly used trisyllabic Fante words, digitally recorded and edited to yield the same RMS as the 1kHz calibration tone. Listener evaluation was done by 20 native Fante speakers with normal hearing thresholds. Logistic regression was used to calculate the slope and intercepts for all the words. A modified equation was used to calculate psychometric function slope at 50%/dB and from 20-80%/dB. Twenty-nine words with slopes greater than 7%/dB were selected. To increase homogeneity of the thresholds of the selected 29 words, the intensity of each word was digitally adjusted so that the 50% threshold of each word was equal to the mean PTA of the subjects (6.25 dBHL). The threshold variability for the trisyllabic words was significantly reduced after intensity adjustments were made for the individual words.

Perceptual evaluation led to the elimination of 4 words because they were thought to be too loud or too soft. A final list of 25 familiar words which are homogenous with respect to audibility having the same tone patterns and have steep psychometric slopes were finally selected and recorded unto a CD for speech audiometry in Fante.

6.3 CONCLUSION

The creation of speech audiometry materials in other languages in Ghana is very necessary for the development of audiological assessment. Even though the process of developing speech materials is very stressful, it is worthwhile because the resulting materials will aid appropriate diagnoses of hearing disorders in the field of audiology in Ghana.

6.4 RECOMMENDATIONS

The following recommendations have been made:

- Additional research to determine the test-retest reliability of the selected stimuli would be important and beneficial to establish reliability, as well as validity (Ostergard, 1983) of the speech materials. Gelfand (1998) suggests that, if the materials were tested again, results should be highly correlated with no significant differences for the test to be considered to have test-retest reliability.
- Further research must be conducted to establish the variability of the speech materials when tested on individuals with hearing impairment.
- Speech audiometry materials should be developed in other dialects of Akan as well as other spoken languages in Ghana to enhance the practice of audiology in Ghana.

REFERENCES

Abdulhaq, N. M. A. (2006). *Speech perception test for Jordanian Arabic speaking children*. Ph. D. Dissertation. Florida: University of Florida. Retrieved 23/11/2014 from http http://ufdc.ufl.edu/UFE0013122/00001

Agyekum, K., Osam, E. K. & Sackey, A. (2011). *Akan Terminology: English-Akan linguistic and media glossary*. Accra: University of Ghana, Department of Linguistics

Aleksandrovsky, I. V., McCullough, J. K., & Wilson, R. H. (1998). Development of suprathreshold word recognition test for Russian-speaking patients. *Journal of the American Academy of Audiology, 9*, 417-425

Alfakhri, M. (2012). *Speech audiometry*. [online]. Retrieved on 04/05/15 from http://fac.ksu.edu.sa/sites/default/files/Speech_Audiometry.pdf

American National Standards Institute (2004). *Specification for Audiometers. ANSI S3.6-2004.* New York: ANSI.

American Speech-Language Hearing Association, ASHA. (1988). Guidelines for determining threshold level for speech. *ASHA, 30*(3), 85-89.

Asher, J. W. (1958). Intelligibility tests: A review of their standardization, some experiments and a new test. *Speech monographs, 25,* 14-28

Ashoor, A. A., & Prochazka, T. Jr. (1985). Saudi Arabic speech audiometry for children. *British Journal of Audiology, 19*, 229-238.

Bradlow, A. R., Nygaard, L. C., & Pisoni, D. B. (1999). Effects of talker, rate and amplitude variation on recognition memory for spoken words. *Perception & Psychophysics, 61* (2), 206-219

Balkisson, Y. (2001). *Speech discrimination testing: Towards the development of wordlists for Zulu-first language speaking children*. Unpublished undergraduate dissertation. University of Durban-Westville, Durban, South Africa

Beattie, R. C., Svihovee, B. C., & Edgerton, B. J. (1975).Relative intelligibility of the CID spondees as presented via monitored live-voice. *Journal of Speech and Hearing Disorders,* 40, 84-91.

Bell, T. S., & Wilson, R. H. (2001). Sentence recognition materials based on frequency of word use and lexical confusability. *Journal of the American Academy of Audiology, 12*, 514-522.

Berger, K. W. (1977). *The KSU speech discrimination test*. Kent, Ohio: Herald Publishing.

Bess, F. H. (1983). Clinical assessment of speech recognition. In Konkle, D. F., & Rintelmann, W. F. (1983) (Eds.). *Principles of speech audiometry*. Baltimore: University Park Press.

Bhatara, A., Boll-Avetisyan, N., Unger, A., Nazzi, T., & Hohle, B. (November 2013). *Journal Acoustical Society of America, 134*(5), 3828–3843

Brandy, W. T. (2002). Speech audiometry. In J. Katz (Ed.), *Handbook of Clinical Audiology*. Baltimore: Williams and Wilkins.

Bunker, L. D. (2008). *Development of Tongan Materials for Determining Speech Recognition Thresholds.* [MSc dissertation, paper 1391]. Utah: Brigham Young University. Retrieved from http://scholarsarchive.byu.edu/etd/1391

Cambron, N. K., Wilson, R. H., & Shanks, J. E. (1991). Spondaic word detection and recognition functions for female and male speakers. *Ear and Hearing, 12*, 64-70.

Campbell, R. A. (1965). Discrimination test word difficulty. *Journal of Speech and Hearing Research, 8*, 13-22.

Carhart, R. (1965). Problems in the measurement of speech discrimination. *Archives of Otolaryngology, 82*, 253-260.

Chernick, M. R. & Friis, R.H. (2003). *Introduction to biostatistics for health sciences: modern applications including bootstrap*. New Jersey: John Wiley & Sons

Christensen, L. K. (1995). *Performance intensity functions for digitally recorded Spanish speech audiometry*. Unpublished master's thesis. Brigham Young University, Provo, UT.

Conklin, B. K. (2007). *Psychometrically equivalent Cantonese bisyllabic word recognition materials spoken by male and female talker*. [MSc dissertation, paper 1283]. Utah: Brigham Young University. Available at http://scholarsarchive.byu.edu/etd/1283

Creswell, J. W. (2005). *Educational research: Planning, conducting and evaluating quantitative and qualitative research* (4th Edition). Boston: Pearson

Danhauer, J. L., Crawford, S., & Edgerton, B. J. (1984). English, Spanish and bilingual speakers' performance on a nonsense Syllable Test (NST) of speech sound discrimination. *Journal of Speech and Hearing disorders, 49*, 164-169

Davis, H., & Silverman, S. R. (1970). *Hearing and deafness* (3rd ed.). New York: Holt Reinehart & Winston

Dennis, J. M., & Neely, J. G. (April, 1991). Basic hearing tests. *Otolaryngologic Clinics of North America., 24*(2), 253-76.

Department of Linguistics, University of Ghana, Legon (2011). *Akan dictionary: Pilot project – 1530 words* (2nd ed.). Accra: Department of Linguistics, UG.

Dirks, D. D., Takayanagi, S., & Moshfegh, A. (2001). Effects of lexical factors on word recognition among normal-hearing and hearing-impaired listeners. *Journal of the American Academy of Audiology, 12,* 233-244.

Doyne, M. P., & Steer M.D. (1951). Studies in speech reception testing. *Journal of Speech and Hearing Disorders, 16,* 132-139.

Dukes, A. J. (2006). *Psychometrically equivalent bisyllabic word lists for word recognition testing in Taiwan Mandarin*. [MSc dissertation]. Utah: Brigham Young University

Durankaya, S.M., Şerbetçioğlu, B., Dalkılıç, G., Gürkan, S., & Kırkım, G. (2014). Development of a Turkish monosyllabic word recognition test for adults. *Journal of International Advanced Otology, 10*(2), 172-80

Egan, J. (1948). Articulation testing methods. *Laryngoscope, 58*, 955-991.

Egan, J. J. (1979). Basic aspects of speech audiometry. *Ear, Nose, & Throat Journal, 58,* 190-193.

Elliot, L., & Katz, D. R. (1980). *Northwestern University Children's Perception of Speech (NU-CHIPS).* St Louis: Auditec

Epstein, A. (1978). Speech audiometry. *Otolaryngologic Clinics of North America, 11*, 667-676.

Erber, N. P. (1974). Pure-tone thresholds and word-recognition abilities of hearing impaired children. *Journal of Speech and Hearing Research, 17*, 194-202

Essel, J. (1984). *Estimating speech discrimination scores using non-speech stimuli (with specific reference to Ghana).* Illinois: University of Carbondale

Fletcher, H., & Steinberg, J.C. (1929). Articulation testing methods. *Bell System Technical Journal, 8,* 806-854.

Fletcher, H. (1929). *Speech and Hearing*. New York: D. Van Nostrand Company.

Fuller, H. (1987). Equipment for speech audiometry and its calibration. In M. Martin (ed.). *Speech audiometry*. London: Taylor and Francis Ltd.

Fu, Q. J., Zhu, M., & Wang, X. (June, 2011). Development and validation of the Mandarin speech perception test. *Journal of the Acoustical Society of America. 129* (6), 267-73

Gadagbui, G. Y. (2003). *Screening for hearing & speech impairment in children*. Winneba: Department of Special Education, UEW.

Gadagbui, G. Y. (1993). *A speech test of hearing for Eve children of Ghana*. Manchester: University of Manchester

Gadagbui, G. Y. (1985). *A plan for the construction of an articulation test in the Eve language*. Illinois: Southern Illinois University

Garolla, L.P., Scollie, S.D., & Martinelli Iório, M.C. (August, 2013). Development of the speech test signal in Brazilian Portuguese for real-ear measurement. *International Journal of Audiology*, *52*(8), 572-6

Gelfand, S. A. (1997). *Essentials of audiology*. New York: Thieme Medical Publishers

Gelfand, S. A. (1998). Optimizing the reliability of speech recognition scores. *Journal of Speech, Language, and Hearing Research, 41*, 1088-1102.

Gelfand, S. A. (2001). *Essentials of audiology*. New York: Thieme Medical Publishers

Goldman, R., Fristoe, M., & Woodcock, R. (1970). *Goldman-Fristoe-Woodcock Test of Auditory Discrimination*. American Guidance Service, Inc. USA.

Greer, L. F. (1997). *Performance intensity functions for digitally recorded Italian speech audiometry materials*. Unpublished master's thesis. Brigham Young University, Provo, UT

Harris, R. W., Goffi, M. V. S., Pedalini, M. E. B., Merrill, A., & Gygi, M. A. (2001). Psychometrically equivalent Brazilian Portuguêse bisyllabic word recognition materials spoken by male and female talkers. *Pró-Fono, 13*, 249-262.

Harris, R., Kim, E., & Eggett, D. (2003). Psychometrically equivalent Korean bisyllabic words spoken by male and female talkers. *Korean Journal of Communication Disorders, 8*(1), 244-270.

Harris, R. W., Nissen, S. L., Pola, M. G., McPherson, D. L., Tavartkiladze, G. A., & Eggett, D. L. (January, 2007). Psychometrically equivalent Russian speech audiometry materials by male and female talkers. *International Journal of Audiology, 46*, 47- 66

Henning, R.W., & Bentler, R. (August, 2005). Compression-dependent differences in hearing aid gain between speech and non-speech input signals. *Ear Hear, 26*(4), 409-422

Hirsh, I. J., Davis, H., Silverman, R., Reynolds, E.G., Eldert, E., & Benson, R. (1952). Development of materials for speech audiometry. *Journal of Speech and Hearing Disorder, 17*, 321-337.

Hirsh, I. J., Reynolds, E. G., & Joseph, M. (1954). Intelligibility of different speech materials. *Journal of Acoustical Society of America, 26*, 530-538

Hudgins, C. V., Hawkins, J. E. Jr., Karlin, J. E., & Stevens, S.S. (1947). The development of recorded auditory tests for measuring hearing loss for speech. *Laryngoscope, 57*, 57-89

Jerger, S., Lewis, S., Hawkins, J., & Jerger, J. (1980). Pediatric speech intelligibility test: Generation of test materials. *International Journal of Pediatric Otorhynolaryngology, 2*, 217-230

Jerger, J. (2006). Are some more equal than others? *Journal of the American Academy of Audiology, 17*, 156.

John, D. C. (1990). *A comparison of spondee threshold and digit thresholds obtained in a sample of normal hearing English and Zulu speaking students.* Unpublished undergraduate research, University of Durban Westville, Durban, South Africa.

Kamm, C., Carterette, E. C., Morgan, D. E., & Dirks, D. D. (1980). Use of digitized speech materials in audiological research. *Journal of Speech and Hearing Research, 23*, 709-21

Keller, L. A. (2009). *Psychometrically equivalent trisyllabic words for speech reception threshold testing in Spanish*. [MSc dissertation, Paper 1949]. Utah: Brigham Young University. Available online at http://scholarsarchive.byu.edu/1949

Kim, M. N. (2007). *Psychometrically equivalent trisyllabic words for speech reception threshold testing in Cantonese*. [MSc Dissertation, paper 1872]. Utah: Brigham Young University. Available online at http://scholarsarchive.byu.edu/1872

Kimball, S. H. (July, 2013). *Speech audiometry*. [online]. Retrieved 30/01/2015 from http://emedicine.medscape.com/article/1822315-overview

Konkle, D. F., & Rintelmann, W. F. (1983). *Principles of speech audiometry*. Baltimore: University Park Press.

Kruger, E. L. (2010). *Samoan Speech Audiometry: Developing Word Recognition Materials for Native Speakers of Samoan.* [MSc dissertation, paper 2250]. Utah: Brigham Young University. Available at http://scholarsarchive.byu.edu/etd/2250

Kumar, S. B. R., & Mohanty, P. (February, 2012). Speech Recognition Performance of Adults: A proposal for a battery for Telugu. *Theory and Practice in Language Studies*, *2*(2), 193-204

Lyregaard, P. (1987). Towards a theory of Speech Audiometry Tests. In M. Martin (Ed.), *Speech Audiometry* (pp 34-62). London: Whurr Publishers.

McMillan, J. H. & Schumacher S. (1997). *Research in education: A conceptual introduction.* New York: Longman

Mangum, T. C. (2005). *Performance intensity functions for digitally recorded Japanese speech audiometry materials*. Utah: Brigham Young University

Martin, F. N., & Clark, J. G. (2012). *Introduction to Audiology* (11th ed.). Boston: Pearson

Martin, F. N., Champlin, C. A., & Chambers, J. A. (1998). Seventh survey of audiometric practices in the United States. *Journal of the American Academy of Audiology, 9*, 95-104

McArdle, R., & Hnath-Chisolm, T. (2015). Speech audiometry. In Katz. J., Chasin, M., English, K., Hood, L. J., & Tillery, K. L. (2015). *Handbook of clinical audiology* (7th ed.). Philadelphia: Wolters Kluwer Health

McGrath, A. P. (2010). *Speech Audiometry*. [online]. Retrieved 03/01/2015 from http://www.womenandinfants.org/Services/upload/speech-audiometry.pdf

Mendel, L. L., & Owen, R. S. (August, 2011). A study of recorded versus live voice word recognition. *International Journal of Audiology 50*(10), 688-693

Mikolai, T., & Mroz, A.C. (2010). Modern speech audiometry with integrated recorded speech materials. *Hearing Review*, *17*(12), 30-33

Neumann, K., Baumeister, N., Baumann, U., Sick, U., Euler, H. A., & WeiBgerber, T. (2012). Speech audiometry in quiet with the Oldenburg sentence test for children. *International Journal of Audiology*, *51*, 157-163

Nissen, S. L, Harris, R. W, Jennings, L. J., Eggett, D. L., & Buck, H. (2005a). Psychometrically equivalent Mandarin bisyllabic speech discrimination materials spoken by male and female talkers. *International Journal of Audiology, 44*(7), 379-390.

Nissen, S. L, Harris, R. W, Jennings, L. J., Eggett, D. L., & Buck, H. (2005b). Psychometrically equivalent trisyllabic words for speech reception threshold testing in Mandarin. *International Journal of Audiology, 44*(7), 391-399.

Nissen, S. L., Harris, R. W., Channell, R. W., Richardson, N.E., Garlick, J. A., & Eggett, D. L. (Dec, 2013). The Effect of dialect on speech audiometry testing. *American Journal of Audiology, 22* (2), 233-40

Nissen, S. L., Harris, R.W., & Slade, K.B. (August, 2007). Development of speech reception threshold materials for speakers of Taiwan Mandarin. *International Journal of Audiology*. *46*(8), 449-58.

Nissen, S. L., Harris, R.W., Channell, R.W., Conklin, B., Kim, M., & Wong, L. (March, 2011). *International Journal of Audiology, 50*(3), 191-201

Offei, Y. N. (2013). *Educational audiology in Ghana - developing screening tools for hearing in infants and children*. [PhD dissertation]. Köln: Universität zu Köln

Owens, E. (1961). Intelligibility of words varying in familiarity. *Journal of Speech and Hearing Research, 4*, 11-129

Owens, E., & Schubert, E.D. (1977). Development of the California Consonant Test. *Journal of Speech Language and Hearing Research, 20*, 463–474

Øygarden, J (2009). *Norwegian Speech Audiometry* [PhD thesis]. Trondheim Norway: Department of Language and Communication Studies, Norwegian University of Science and Technology. [electronic] Available at http://brage.bibsys.no/xmlui/bitstream/handle/11250/243984/214670_FULLTEXT01.pdf?sequence=1

Panday, S. (2006). *The development of a Zulu speech perception threshold test for Zulu first language speakers in Kwa Zulu-Natal (KZN)*. Kwa Zulu-Natal: University of Kwa Zulu-Natal

Panday, S., Kathard, H., Pillay, M., & Govender, C. (2007). Development of a Zulu speech reception threshold test for Zulu first language speakers in Kwa Zulu-Natal. *South African Journal of Communication Disorders, 54,* 111-22.

Penrod, J. P. (1979). Talker effects on word-discrimination scores of adults with sensorineural hearing impairment. *Journal of Speech and Hearing Disorders, 44*(3), 340-349.

Picheny, M.A., Durlach, N.I., & Braida, L.D. (1985). Speaking clearly for the hard of hearing-I: Intelligibility differences between clear and conversational speech. *Journal of Speech and Hearing Research, 28*, 96–103.

Preece, J. P., & Fowler, C. G. (1992). Relation between pure-tone threshold and speech recognition for two speakers. *Journal of the American Academy of Audiology, 3*, 221-224

Punch, J. L., &. Howard, M. T. (May, 1985). Spondee recognition threshold as a function of set size. *Journal of Speech and Hearing Disorders*, *50*, 120-125.

Ramkissoon, I. (2000). *Speech reception thresholds for non-native speakers of English: Digit pairs vs spondee words*. [Unpublished doctoral dissertation]. Illinois: University of Illinois, Urbana Champaign, Illinois

Ramkissoon, I. (2001). Speech recognition thresholds for multilingual populations. *Communication Disorders Quarterly*, *22*, 158-162.

Ramkissoon, I., Proctor, A., Lansing, C., Bilger, R. C. (2002). Digit speech recognition threshold (SRT) for non-native speakers of English. *American Journal of Audiology, 11*, 23-28

Ratcliff, E. R. (2006). *Psychometrically equivalent bisyllabic words for speech reception threshold testing in Arabic*. [MSc dissertation, paper 488]. Utah: Brigham Young University. Available at http://scholarsarchive.byu.edu/etd/488

Ridgway, J. (1986). Compact disks - A revolution in the making. *Canadian Library Journal, 43*, 23-29.

Roeser, R. J., & Clark, J. L. (2008). Live voice speech recognition audiometry - Stop the madness. *Audiology Today, 20*(1), 32-33.

Ross M., & Lerman, J. (1970). A picture identification task for hearing impaired children. *Journal of Speech and Hearing Research*, *13*, 44–53

Rudmin, F. (1987). Speech reception threshold for digits. *Journal of Auditory Research, 27*(1), 15-21.

Schill, S. (1985). Threshold for speech. In J. Katz (Ed.), *Handbook of Clinical Audiology*. Baltimore; Williams & Wilkins.

Schoeplin, J. R. (2012). *Back to basics: speech audiometry*. Adelphi University. Retrieved on 23/12/2014 from http://www.audiologyonline.com/articles/back-to-basics-speech-audiometry-6828

Scollie, S. D., & Seewald, R. C. (October, 2002). Evaluation of electroacoustic test signals I: comparison with amplified speech. *Ear Hear*, *23*(5), 477-87.

Shi, L. F., & Sánchez, D. (2011). The role of word familiarity in Spanish/English bilingual word recognition. *International Journal of Audiology; 50*, 66-76.

Silman, S., & Silverman, C. A. (1991). *Audiology diagnosis. Principles and practice*. New York: Academic Press Inc.

Slade, K. B. (2006). *Speech reception threshold materials for Taiwan Mandarin*. [MSc dissertation, paper 522]. Available at http://scholarsarchive.byu.edu/etd/522

Smits, C., Kapteyn, T. S., & Houtgast, T, (2004) Development and validation of an automatic speech-in-noise screening test by telephone. *International Journal of Audiology 43*, 15-28.

Stelmachowicz, P. G., Kopun, J., Mace, A. L., & Lewis, D. E. (December, 1996). *Ear Hear*, *17*(6), 520-7.

Taylor, B. D. (2012). *Development of psychometrically equivalent speech audiometry materials for measuring speech recognition thresholds in native Tagalog speakers*. [Theses and Dissertations. Paper 3348]. Available online at http:// http://scholarsarchive.byu.edu/etd/3348

Thibodeau, L. M. (2007). Speech audiometry. In R.J. Roeser, M. Valente, & H. Hosford-Dunn (Eds.), *Audiology diagnosis* (2nd ed., pp. 288-313). New York: Thieme

Tillman, T. W., & Carhart, R. (1966). An expanded test for speech discrimination utilizing CNC monosyllabic words: N.U. Auditory Test NO. 6. USAF School of Aerospace Medicine. *Report*, 55-66.

Tsai, K.S., Tseng, L.H., Wu, C.J., & Young, S. T. (2009). Development of a Mandarin monosyllable recognition test. *Ear Hear, 30*, 90-99.

Van Dijk, J. E., Duijndam, J., & Graamans, K. (2000). Acoustic neuroma: Deterioration of speech discrimination related to thresholds in pure-tone audiometry. *Acta Otolaryngologica, 120*, 627-632.

Wang, S., Mannell, R., Newall, P., Zhang, H., & Han, D. (2007). Development and evaluation of Mandarin disyllabic materials for speech audiometry in China. *International Journal of Audiology, 46*, 719-731.

Wiley, T. L., Stoppenbach, D. T., Feldhake, L. J., Moss, K. A., & Thordardottir, E. T. (1995). Audiologic practices: What is popular versus what is supported by evidence. *American Journal of Audiology*, *4*(1), 26-34

Wilson, R. H., & Antablin, J. K. (1980). A picture identification task as an estimate of the word-recognition performance of non-verbal adults. *Journal of Speech and Hearing Disorders, 45*, 223-238

Wilson, R. H., & Carter, A. S. (2001). Relation between slopes of word recognition psychometric functions and homogeneity of the stimulus materials. *American Academy Audiology, 12*, 7-14.

Wilson, R. H., & Strouse, A. (Dec, 1999). *Journal of Speech, Language and Hearing Research, 42* (6), 1336-46.

Wilson, W. J., & Moodley, S. (2000). Use of the CID W22 as a South African English speech discrimination test. *South African Journal of Communication Disorders, 47*, 57–62

Young, J. R., Dudley, B., & Gunter, M. B. (1982). Thresholds and psychometric functions of the individual spondaic words. *Journal of Speech and Hearing Research, 25*, 586-593

APPENDIX A: PARTICIPANT INFORMATION FORM

DEPARTMENT OF AUDIOLOGY
SCHOOL OF BIOMEDICAL AND ALLIED HEALTH SCIENCES
COLLEGE OF HEALTH SCIENCES, UNIVERSITY OF GHANA

Title of research: Development and evaluation of psychometrically equivalent trisyllabic words for speech audiometry in Fante

Principal Researcher: Cyril Mawuli Honu-Mensah

Mobile: 0206541466 **Email**: cylogh@yahoo.com

General Information about Research

Under the supervision of Dr Yaw Nyadu Offei and Ms Nana Akua Victoria Owusu, University of Ghana School, School of Biomedical and Allied Health Sciences, I, Cyril Mawuli Honu-Mensah, a post-graduate student in research of the Department of Audiology, am conducting research on development and evaluation of psychometrically equivalent trisyllabic words for speech audiometry in Fante. The purpose of the study is to develop digitally recorded speech wordlist that can be used to evaluate the Speech Recognition Threshold (SRT) of individuals who speak Fante in Ghana.

Possible Risks and Discomforts

There are no risks for participation in this study since the testing equipment and procedure are not invasive hence does not give any side effect.

Voluntary Participation and Right to Leave the Research

Participation in this research study is voluntary. You have the right to withdraw at any time or refuse to participate entirely without any jeopardy to you whatsoever**.**

Contacts for Additional Information

For any information, clarification or questions about the study, please contact the principal investigator, Cyril Mawuli Honu-Mensah on 0206541466.

Confidentiality

All information provided will remain confidential and will only be reported as group data with no identifying information. All data, including test results will be kept in a secure location and only those directly involved with the research will have access to them.

Alternatives to Participation

In the event of any noticed problem, participant will be referred for further testing and the necessary management as needed.

Your rights as a Participant

This research has been reviewed and approved by the Ethics and Protocol Committee of the School of Biomedical and Allied Health Sciences, College of Health Sciences, University of Ghana. If you have any questions about your rights as a research participant you can contact the EPC Office between the hours of 8am-5pm through the landline +233-302-687974/5 or postal addresses: Box KB 143, Korle-Bu, Accra. 66

APPENDIX B: VOLUNTEER AGREEMENT FORM

DEPARTMENT OF AUDIOLOGY
SCHOOL OF BIOMEDICAL AND ALLIED HEALTH SCIENCES
COLLEGE OF HEALTH SCIENCES, UNIVERSITY OF GHANA

The document describing the benefits, risks and procedures for the research: Development and evaluation of psychometrically equivalent trisyllabic words for speech audiometry in Fante, has been read and explained to me. I have been given an opportunity to have any questions about the research asked and answered to my satisfaction. I agree to participate as a volunteer.

__________________ ____________________________

Date **Signature of volunteer**

I certify that the nature and purpose, the potential benefits, and possible risks associated with participating in this research have been explained to the above individual.

__________________ ____________________________

Date **Signature of Researcher**

APPENDIX C: RESEARCH INFORMATION SHEET

DEPARTMENT OF AUDIOLOGY
SCHOOL OF BIOMEDICAL AND ALLIED HEALTH SCIENCES
COLLEGE OF HEALTH SCIENCES, UNIVERSITY OF GHANA

Title of research: Development and evaluation of psychometrically equivalent trisyllabic words for speech audiometry in Fante

Researcher: Cyril Mawuli Honu-Mensah

Telephone: 0206541466

Code:		**Age:**		**M/ F**		**Date:**		
	250	**500**	**1000**	**2000**	**3000**	**4000**	**6000**	**8000**
LEFT								
RIGHT								
TYMPANOMETRY	**RIGHT**	**LEFT**		**ACOUSTIC REFLEX**	**500**	**1K**	**2k**	**4K**
ECV (0.2-2.0 ml)				**RIGHT**				
PEAK COMPLIANCE (0.2-2.0 ml)				**LEFT**				
PEAK PRESSURE (-150-+100 daPa)								
OAE	**PASS**	**FAIL**						
RIGHT								
LEFT								

APPENDIX D: EXPERT EVALUATION FORM FOR FANTE TRI-SYLLABIC WORDS

DEPARTMENT OF AUDIOLOGY
SCHOOL OF BIOMEDICAL AND ALLIED HEALTH SCIENCES
COLLEGE OF HEALTH SCIENCES, UNIVERSITY OF GHANA

Title of research: Development and evaluation of psychometrically equivalent trisyllabic words for speech audiometry in Fante

Please consider the Fante words below and assess to what extent the words on the list are familiar to Fante speakers and are phonemically dissimilar.

Please give your rates on the numbered scale below:

Familiarity

1. Extremely familiar (It is very common and used very often)
2. Fairly familiar (It is common, used often, but not as often as words rated as l)
3. Very unfamiliar (It is not common, hardly ever used)

Phonemic dissimilarity

1. - Absolutely phonemically dissimilar
2. - Quite phonemically dissimilar
3. - Not phonemically dissimilar

Tone Pattern of word

1. W-W-S (e.g. abrɔbɛ)
2. W-S-S (e.g. ɔkyena)
3. W-S-W (e.g. semina)
4. Others (Please specify)

NB: “W=weak syllable S= Strong Syllable”. **Please add comments wherever applicable.**

APPENDIX E: EXPERT EVALUATION FORM FOR FANTE TRI-SYLLABIC WORDS

DEPARTMENT OF AUDIOLOGY
SCHOOL OF BIOMEDICAL AND ALLIED HEALTH SCIENCES
COLLEGE OF HEALTH SCIENCES, UNIVERSITY OF GHANA

Title of research: Development and evaluation of psychometrically equivalent trisyllabic words for speech audiometry in Fante

S/N	Word	Familiarity	Phonetic Dissimilarity	Tone pattern
1	abaa			
2	aba			
3	abɔdwe			
4	abɛbu			
5	abena			
6	abofra			
7	abowa			
8	abrɔbɛ			
9	adɔw			
10	adɔmba			
11	adɔyɛ			
12	adzekan			
13	adzesua			
14	adzetɔ			
15	adzetɔn			
16	edzinkra			
17	adwen			
18	afahyɛ			
19	afena			
20	efir			
21	afon			
22	afotu			
23	agor			

24	ehina			
25	ahoma			
26	ahotɔ			
27	ahwehwɛ			
28	akadze			
29	akate			
30	akokɔ			
31	akoma			
32	akyɛdze			
33	amambu			
34	anadwe			
35	anɔpa			
36	anyigye			
37	anodzi			
38	apɔnkye			
39	asafo			
40	asɔr			
41	aseda			
42	sikadzi			
43	esisi			
44	nsisi			
45	atɔɛ			
46	etsifi			
47	atsikɔ			
48	atweρ			
49	awar			
50	awoda			
51	awofo			
52	ayeyi			
53	bayer			
54	borEdze			
55	borɔfo			
56	bosom			
57	ɔhɔho			

58	ɔhene			
59	honam			
60	ɔkyena			
61	ɔsɔfo			
62	dwumadzi			
63	baasa			
64	eduaba			
65	edur			
66	edwuma			
67	eguafo			
68	egudze			
69	enufu			
70	enyidze			
71	enyiwa			
72	enyito			
73	fofor			
74	kakraba			
75	katakyi			
76	kɔtɔkɔ			
77	keteke			
78	ketsewa			
79	k□bena			
80	mbowa			
81	mfaso			
82	mfɛfo			
83	nhyira			
84	nkae			
85	nkate			
86	nkogu			
87	nkramo			
88	nsabow			
89	nsapan			
90	nson			
91	ntɛkyerɛ			

92	ntsin			
93	nyansanyi			
94	obiara			
95	obronyi			
96	odwira			
97	asotie			
98	owura			
99	pofonyi			
100	safowa			
101	samina			
102	srasrasra			
103	sumina			
104	tsitsir			
105	wɔfaase			
106	wukuada			
107	yafun			

APPENDIX F: 51 WORDS FOR FANTE TRISYLLABIC SRT WORDS

DEPARTMENT OF AUDIOLOGY
SCHOOL OF BIOMEDICAL AND ALLIED HEALTH SCIENCES
COLLEGE OF HEALTH SCIENCES, UNIVERSITY OF GHANA

Title of research: Development and evaluation of psychometrically equivalent trisyllabic words for speech audiometry in Fante

Spelling	Dictionary definition	Part of speech
abaa	rod	noun
abɔdwe	chin	noun
abɛbu	proverb	noun
abofra	child	noun
abrɔbɛ	pineapple	noun
abrewa	old woman/ grandmother	noun
adɔyɛ	charity/ gift	noun
adzekan	reading	noun
adzesua	studies	noun
adzetɔn	sales	noun
afena	matchet	noun
ahaban	farm	noun
ahoma	rope	noun
ahotɔ	comfort	noun
akoma	heart	noun
anadwe	evening	noun
anapa	morning	noun
anyigye	happiness	noun
apɔnkye	goat	noun
asɔfo	pastors	noun
aseda	thanksgiving	noun
atɔɛ	west	noun
atwer	ladder	noun
aware	marriage	noun
awoda	birthday	noun
awofo	parents	noun
bayer	yam	noun
borɔfo	English Language/ Whiteman	noun
borɛdze	plantain	noun
ɔsɔfo	pastor(singular)	noun
dwumadzi	project	noun
eduaba	Fruit	noun

edzinkra	traditional Akan symbols	noun
efir	trap	noun
eguafo	traders	noun
egudze	treasure (usually gold)	noun
ehina	pot	noun
ekutu	orange	noun
esisi	cheating	noun
katɛkyi	Brave or noble man	noun
mfaso	profit	noun
nhyira	blessings	noun
nkate	groundnut/ peanuts	noun
nkramo	muslim man or woman	noun
nsapan	empty handedness	noun
nsisi	events (plural)	noun
ntɛkyerɛ	feathers of a bird	noun
nyansanyi	wise man	noun
obronyi	white man (singular)	noun
odwira	traditional Akan festival	noun
pofonyi	fisherman/ seaman	noun
sikadzi	the state of being spendthrift/ profligate	noun

APPENDIX G: 25 SELECTED WORDS FOR FANTE TRISYLLABIC SRT WORDS

DEPARTMENT OF AUDIOLOGY
SCHOOL OF BIOMEDICAL AND ALLIED HEALTH SCIENCES
COLLEGE OF HEALTH SCIENCES, UNIVERSITY OF GHANA

Title of research: Development and evaluation of psychometrically equivalent trisyllabic words for speech audiometry in Fante

#	**Word**
1	abɛbu
2	abɔdwe
3	abaa
4	abrewa
5	adɔyɛ
6	adzekan
7	adzesua
8	ahaban
9	ahotɔ
10	akoma
11	anadwe
12	anapa
13	apɔnkye
14	aseda
15	abofra
16	borɛdze
17	borɔfo
18	eduaba
19	eguafo
20	ekutu
21	mfaso
22	nhyira
23	nkate
24	nsapan
25	ntɛkyerɛ

UNIVERSITY OF GHANA
SCHOOL OF BIOMEDICAL AND ALLIED HEALTH SCIENCES
DEPARTMENT OF AUDIOLOGY, SPEECH AND LANGUAGE THERAPY

October 7, 2014

Mr. Cyril M. Honu-Mensah
Dept. of Audiology, Speech and Language Therapy
SBAHS,
Korle Bu

Dear Mr. C.M. Honu-Mensah

ETHICS CLEARANCE

Following a technical and professional review of your research proposal by the Department Ethics and Protocol Review Committee and by your supervisors, I am pleased to inform you of the Committee's approval your research proposal entitled:

"Development and Evaluation of Psychometrically Equivalent Trisyllabic Words for Speech Audiometry in Fante"

This is an initial approval. You are therefore required to obtain a final approval from the School's Ethics and Protocol Review Committee per the Schools regulations.

You are required to work closely and in collaboration with your supervisors. Please report all serious adverse events related to this research to the supervisors and this Committee in writing.

Thank you.

Yours sincerely,

DR. S. ANIM-SAMPONG

For: Chairman DASL&T Ethics and Protocol Review Committee
DEPARTMENT OF AUDIOLOGY
SPEECH & LANGUAGE THERAPY
SCHOOL OF BIOMEDICAL AND ALLIED
HEALTH SCIENCES

UNIVERSITY OF GHANA
SCHOOL OF BIOMEDICAL AND ALLIED HEALTH SCIENCES
DEPARTMENT OF AUDIOLOGY, SPEECH AND LANGUAGE THERA

November 3, 2014

The Head
Hearing Assessment Centre
ENT Department
Korle Bu Teaching Hospital

Dear Sir/Madam,

PERMISSION TO CARRY MSc AUDIOLOGY RESEARCH PROJECT AT THE HEARING ASSESSMENT CENTRE, KBTH

The Department of Audiology, Speech & Language Therapy (DAS&LT) of the University of Ghana School of Biomedical and Allied Health Sciences (SBAHS) presents its compliments to you and has the pleasure requesting your kind consideration of the above subject.

Mr. Cyril Mawuli Honu-Mensah is a 2nd year MSc Audiology student of the Department of Audiology, Speech and Language Therapy of SBAHS, University of Ghana. He is conducting a research project in "Development and Evaluation of Psychometrically Equivalent Trisyllabic Words for Speech Audiometry in Fante" under the supervision of Dr. Y.N. Offei (Audiologist), and Ms. Nana Akua V. Owusu (Speech Language Therapist). His research study has been reviewed and passed by the Department's Ethics and Protocols Review Group of the School as meeting all ethical requirements.

The Department would be most grateful if you could kindly grant him permission to carry out this important research project for the common good of the University and your Centre. Thank you.

Yours faithfully,

Dr. S. ANIM-SAMPONG
For: (Head of Department)

cc: Dean (SBAHS)
Dr. Y.N. Offei
Ms. N.A.V. Owusu

HEARING ASSESSMENT CENTRE

In case of reply the number
And the date of this
Letter should be quoted

My Ref. No............................
Your Ref. No.........................

KORLE BU TEACHING HOSPITAL
EXCELLENCE IN HEALTHCARE
KBTH
1923

KORLE BU TEACHING HOSP.
P. O. BOX 77
KORLE BU, ACCRA

Tel: 233-21- 673033-6
Fax: 233-21- 667759
Email: korlebu@ghana.com
Web Site: www.korlebu.com

17th November, 2014

The Head
Dept. of Audiology, Speech and Language Therapy
School of Biomedical and Allied Health Sciences
College of Health Sciences
University of Ghana

Dear Sir,

RE:PERMISSION TO CARRY MSc AUDIOLOGY RESEARCH PROJECT AT THE HEARING ASSESSMENT CENTRE, KORLE BU TEACHING HOSPITAL

Mr. Cyril Mawuli Honu-Mensah has been granted permission to conduct his research project in "Development and Evaluation of Psychometrically Equivalent Trisyllabic Words for Speech Audiometry in Fante".

He is expected to work closely with Audiologists at the Centre to ensure that protocols are observed and equipment well handled.

Yours Sincerely,

E. N. T. CLINIC
KORLE BU TEACHING HOSPITAL

JEMIMA A. FYNN (MRS.) FWACN
MSc AUDIOLOGICAL SCIENCE

Cc: Head, ENT UNIT

UNIVERSITY OF GHANA
SCHOOL OF BIOMEDICAL AND ALLIED HEALTH SCIENCES
DEPARTMENT OF AUDIOLOGY, SPEECH AND LANGUAGE THERAPY

November 3, 2014

The Coordinator
Centre for Hearing and Speech Services
University of Education, Winneba

Dear Sir/Madam,

PERMISSION TO CARRY MSc AUDIOLOGY RESEARCH PROJECT AT CENTRE FOR HEARING AND SPEECH SERVICES, UEW

The Department of Audiology, Speech & Language Therapy (DAS&LT) of the University of Ghana School of Biomedical and Allied Health Sciences (SBAHS) presents its compliments to you and has the pleasure requesting your kind consideration of the above subject.

Mr. Cyril Mawuli Honu-Mensah is a 2nd year MSc Audiology student of the Department of Audiology, Speech and Language Therapy of SBAHS, University of Ghana. He is conducting a research project in "Development and Evaluation of Psychometrically Equivalent Trisyllabic Words for Speech Audiometry in Fante" under the supervision of Dr. Y.N. Offei (Audiologist), and Ms. Nana Akua V. Owusu (Speech Language Therapist). His research study has been reviewed and passed by the Department's Ethics and Protocols Review Group of the School as meeting all ethical requirements.

The Department would be most grateful if you could kindly grant him permission to carry out this important research project for the common good of the University and your Centre. Thank you.

Yours faithfully,

Dr. S. ANIM-SAMPONG
For: (Head of Department)
cc: Dean (SBAHS)

CENTRE FOR HEARING AND SPEECH SERVICES
UNIVERSITY OF EDUCATION, WINNEBA

E-mail:chss@uew.edu.gh
Tel: 020 686 4023

Our Ref. No.:......................

Your Ref. No.:....................

In case of reply the number and Date of this letter should be quoted

November 12, 2014

The Head
Dept. of Audiology, Speech and Language Therapy
School of Biomedical and Allied Health Sciences
College of Health Sciences
University of Ghana

Dear Sir/Madam,

RE: PERMISSION TO CARRY OUT MSc AUDIOLOGY RESEARCH PROJECT AT THE CENTRE FOR HEARING AND SPEECH SERVICES (CHSS), UNIVERSITY OF EDUCATION, WINNEBA

I write to grant permission to Mr. Cyril Mawuli Honu-Mensah to carry out a research on "Development and evaluation of psychometrically equivalent trisyllabic words for speech audiometry in Fante".

He is expected to work closely with the Audiologist in charge whiles adhering strictly to the standards and protocols of the Centre.

Yours faithfully,

CO-ORDINATOR
HEARING & SPEECH SERVICES
UNIV. OF EDUC.
WINNEBA

YAW NYADU OFFEI (PhD)

(Audiologist/ Coordinator, CHSS)