PRELIMINARY NORMATIVE DATA FOR ADULT ENGLISH FIRST AND SECOND LANGUAGE SPEAKERS IN SOUTH AFRICA ON THE "RSA LOW LINGUISTICALLY LOADED CENTRAL AUDITORY PROCESSING TEST BATTERY".

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ABSTRACT

The lack of standardized test materials in the 11 official languages of South Africa led to the development of the "*RSA low linguistically loaded central auditory processing test battery*" as an interim measure until these tests can be developed. This study aimed at collecting and comparing preliminary normative data for English first and second language speakers in South Africa on this test battery and to compare the results with the available USA normative data. Thirty two participants were included in the study and were divided into two research groups depending on their proficiency in English. A between group research design was used to collate and compare the data. Results indicated that the two research groups performed equivalently on all tests apart from the *Dichotic Digits test* for the right ear and a qualitative comparison with the USA normative data showed lower scores for tests not involving speech stimuli. Accent and presentation levels affected the results but not significantly. Results point to the possibility of using the test battery reliably with population groups whose first language is not English but who have a good proficiency in the language and reiterates the need for development of specific test materials in all the official languages.

ABSTRAK

Die tekort aan gestandardiseerde toetsmateriaals in al 11 amptelike tale van Suid-Afrika het gelei tot die ontwikkeling van die "*RSA low linguistically loaded central auditory processing test battery"* as 'n tussentydse maatstaf totdat hierdie toetse ontwikkel kan word. Die studie het ten doel gehad om hierdie toetsbattery te gebruik om voorlopige normatiewe data te versamel en te vergelyk vir Engels eerste- en tweedetaal sprekers in Suid-Afrika en om die resultate met die beskikbare VSA normatiewe data te vergelyk. Twee en dertig deelnemers was ingesluit in die studie en is in twee groepe verdeel op grond van hul vaardigheid in Engels. `n Tussengroep navorsigsontwerp is gebruik om die data te versamel and vergeluik. Resultate het aangedui dat die twee navorsingsgroepe ewe goed presteer het op alle toetse behalwe die *Dichotic Digits test* vir die regte oor en 'n kwalitatiewe vergelyking met die VSA normatiewe data het laer punte vir toetse getoon wat nie spraak stimulie behels het nie. Resultate is deur aksent en aanbiedingsvlakke beinvloed, maar nie beduidend nie. Resultate dui op die moontlike betroubare gebruik van hierdie toets met populasiegroepe wat nie Engels eerstetaal sprekers is nie, op die voorwaarde dat hulle oor 'n goeie vaardigheid in die taal beskik en dit bevestig verder die behoefte vir die ontwikkeling van spesifieke toetsmateriaal in al die amptelike tale.

SUMMARY

TITLE: Preliminary Normative Data for Adult English First and Second Language Speakers in South Africa on the "RSA Low Linguistically Loaded Central Auditory Processing Test Battery".

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The challenges faced by South African audiologists working in the area of central auditory processing disorders resulted in the formulation of the RSA CAPD Taskforce in February 2000 (RSA CAPD Taskforce, 2000). One of the main aims of the Taskforce is to develop standardised central auditory processing screening and diagnostic procedures and protocols for the South African population. The Taskforce received permission to rerecord 16 tracks of the *Tonal and Speech Materials for Auditory Perceptual Assessment Disc 2.0* compact disc. The 16 tracks contain low linguistically loaded material such as digits and sound patterns that can be used with South Africans whose first language is not English but who have a fair competence in English as a second language. This is an interim measure until appropriate test materials can be developed for all population and age groups.

The present study forms part of a larger study undertaken by the RSA CAPD Taskforce in compiling normative data for different age and population groups in South Africa using the SA low linguistically loaded compact disc. The study aimed at collecting and comparing the preliminary normative data for adult English first and second language

speakers in South Africa on the low linguistically loaded test battery and comparing the results with the available USA normative data. This would indicate whether the test battery can be used as available interim measure in South Africa.

Thirty two participants were selected for the study and were divided into two groups, depending on their proficiency in English as a first or second language. The adult test protocol as recommended by the RSA CAPD Taskforce (2001) was administered to each participant after preliminary puretone audiometry, speech reception measures and immittance measures were administered. A between group research design was used to collate the data. Results were analysed using the Mann-Whitney *U* test and the SAS computer programme. A descriptive analysis with the USA normative data was made for each group.

The results of the study were as follows:

- The two research groups performed equivalently on all tests apart from the *Dichotic Digits test* for the right ear.

- Results for the *Frequency Patterns test* and *Duration Patterns test* were relatively low for both research groups when compared to the results of other tests in the test battery. As these tests do not use speech stimuli, further research is needed into these tests.

- The preliminary normative data obtained for both research groups was below the USA normative data for the *Frequency Patterns test* and the *Durations Patterns test.* The results of tests using speech stimuli were very similar to the USA normative data indicating that accent and presentation levels affected the results but not significantly.

The results point to the possibility of using the "RSA low linguistically loaded central auditory processing test battery" as an interim measure for South Africans whose first language is not English but who have a good proficiency in English. The need for

developing specific test materials in all the official languages and collecting clinic specific normative data is stressed.

Key words: Central auditory processing, central auditory processing disorder, RSA CAPD Taskforce, normative data, compact disc, low linguistically loaded test materials, language, interim measure, protocol, preliminary, standardised.

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CHAPTER 1: INTRODUCTION AND ORIENTATION

1.1. INTRODUCTION

"...as with all tests of central auditory function, clinicians are strongly urged to collect their own age appropriate normative data" (Bellis, 1996:149).

Audiologists working in the field of central auditory processing disorders face a multitude of challenges beginning with the lack of consensus as to a definition of the disorder. Other challenges include the variety of central auditory processing tests using different stimulus parameters and test protocols, the poor quality of test recordings and the susceptibility of audiotape recordings to deterioration with continuous use. This lack of standardisation has resulted in audiologists being unable to compare results across different clinics and investigations as no definitive normative data exists (Musiek and Rintelmann, 1999).

These problems led to the development of the *Tonal and Speech Materials for Auditory Perceptual Assessment, Disc 1.0* compact disc in the United States of America in 1992, with an updated version, *Disc 2.0* introduced in 1998 (Wilson and Strouse, 1998). The Department of Veterans Affairs in the United States of America developed these compact discs in order to standardise behavioural central auditory processing testing by providing a series of tests that assess different aspects of auditory processing and different levels of the central auditory nervous system. A standardised compact disc makes it easier to control factors such as stimulus parameters, differences in mechanical reproduction and signal to noise ratios. The collection and comparison of normative data is thus facilitated (Noffsinger, Wilson and Musiek, 1994).

South African audiologists face similar challenges, exacerbated by the lack of adequate test materials, the challenge of 11 official languages and the poor training in the

administration and interpretation of central auditory processing disorder tests and results as well as uncertainty as to intervention procedures (RSA CAPD Taskforce, 2000).

Against this background the development of appropriate and standardised test material for assessing central auditory processing disorders in South Africa has been highlighted and is currently being addressed by the RSA CAPD Taskforce. The field of central auditory processing is a complex one but clear guidelines for compiling a test battery are starting to emerge in the recent literature (Bellis and Ferre, 1999). The literature on central auditory processing disorders (CAPD) strongly recommends the use of both behavioural and electrophysiological measures in diagnosing CAPD (Bellis, 1996; Chermak and Musiek, 1997; Baran and Musiek, 1999; Bellis and Ferre, 1999). A behavioural central auditory processing test battery should consist of tests that assess different levels and processes of the central auditory nervous system. Electrophysiological measures should be included when the individual situation warrants such inclusion (Bellis, 1996).

One of the main aims of the RSA CAPD Taskforce is to develop standardised central auditory processing disorder screening and diagnostic procedures and protocols for the South African population. This is however a long term project and as an interim measure the RSA CAPD Taskforce received permission to rerecord 16 tracks consisting of low linguistically loaded speech materials and tonal stimuli from the *Tonal and Speech Materials for Auditory Perception Assessment Disc 2.0* compact disc from the Department of Veterans Affairs (Wilson, 2000). It is hypothesised that the use of speech stimuli with a light linguistic load such as digits and words would be easier for South Africans whose first language is not English but who have a good proficiency in the language thus diminishing the confounding effects of language.

Normative data for the "RSA low linguistically loaded central auditory processing test battery" needs to be collected on different cultural, language and age groups making up the South African population before the test material can be accountably used in the clinical setting. The RSA CAPD Taskforce is currently compiling this data with the

assistance of researchers and masters students at different universities and volunteers. The results of this project undertaken by the RSA CAPD Taskforce will determine whether the low linguistically loaded compact disc can be used as an interim measure by audiologists in South Africa until appropriate materials can be developed for the different language and cultural groups comprising the South African population.

This chapter will identify the complexities in the field of central auditory processing in its context, discuss the aims of the RSA CAPD Taskforce, the rationale behind the collection of normative data using the low linguistically loaded central auditory processing test battery and will define the concepts fundamental to this research project.

1.2. PROBLEM STATEMENT, RATIONALE AND OBJECTIVE OF THE STUDY

The focus of this section is to identify the problem and the rationale underlying the need for this research as well as defining the objectives of the study.

1.2.1. Problem Statement

The literature on auditory processing disorders stresses the importance of developing normative data within the context that the central auditory processing test battery will be utilised (Bellis, 1996). The development of normative data for the South African context thus needs to be collated to ensure that South African audiologists provide an accountable service to their clients.

One of the long term aims of the RSA CAPD Taskforce is to develop test materials for each cultural and language group that make up the South African population. As an interim measure, the use of low linguistically loaded test materials that should theoretically provide reasonably accurate results has been suggested (RSA CAPD Taskforce, 2000).

The majority of South Africans do not have English as a first language but are able to understand and use it as a second language. The low linguistically loaded test battery may thus provide an interim measure whereby South African audiologists could accountably work in the area of central auditory processing disorders until culturally and linguistically more appropriate test materials are developed. In order to test this hypothesis, preliminary normative data needs to be collected on different cultural and language groups and compared to each other and to the available normative data from the United States of America.

The results of this study together with other studies conducted as part of the larger RSA CAPD Taskforce's study will determine whether the SA CAPD low linguistically loaded compact disc can be used as an interim measure by audiologists in South Africa until appropriate central auditory processing test materials for the South African population can be developed.

1.2.2. Rationale and Objective of the Study

Central auditory processing is not a unitary disease entity but a description of functional deficits which is found in diverse clinical populations with and without neuropathology (Chermak and Musiek, 1997). The American Speech and Hearing Association Task Force (ASHA, 1996) on Central Auditory Processing defines this disorder as the inability to process the acoustic signal which cannot be attributed to impaired hearing sensitivity or intellectual impairment. Central auditory processing disorders are seen to involve a "deficit in one or more of the central auditory processes responsible for generating the auditory evoked potentials and the behaviours of sound localisation and lateralization, auditory discrimination, auditory pattern recognition, temporal processing, auditory performance with competing acoustic signals and auditory performance with degraded acoustic signals" (Chermak and Musiek, 1997:3).

People with central auditory processing disorder often complain of difficulty in understanding speech in competing noise, ask for frequent repetition, have difficulty following complex auditory directions, have difficulty in localising sound and are inattentive and distractible (Chermak, 1998; Keith, 1999). Central auditory processing disorders can severely affect the scholastic and later future work performance of both children and adults (RSA CAPD Taskforce, 2000).

The central auditory nervous system is a highly redundant and interdependent system. The importance and interrelatedness of each area of the central nervous system in the processing of auditory stimuli is stressed in the literature (Musiek and Baran, 1986; Bellis and Ferre, 1996). Failure of any one of the areas of the central auditory nervous system will result in a central auditory processing disorder and difficulty in one or more of the central auditory processes responsible for effective listening (ASHA, 1996; Bellis and Ferre, 1999). A central auditory processing test battery should consist of tests that assess different processes and different levels of the central auditory nervous system (Bellis, 1996; Chermak and Musiek, 1997; Bellis and Ferre, 1999).

It is strongly recommended in the literature (Bellis, 1996; Chermak and Musiek, 1997; Bellis and Ferre, 1999) that a behavioural central auditory processing test battery include at a minimum one test from each of four categories, namely dichotic speech tests (one linguistically loaded and one with a low linguistic load), monaural low-redundancy speech tests, temporal patterning tests and binaural fusion tests. This will ensure that the functional integrity of right and left hemisphere cortical regions, the corpus callosum and sub-cortical structures are assessed. The results of the test battery will assist in identifying individual strengths and weaknesses and developing subprofiles, thereby facilitating deficit specific individualised management plans (Bellis and Ferre, 1999).

In order to standardise behavioural central auditory processing testing in the United States of America the Department of Veterans Affairs in 1992 developed the *Tonal and Speech Materials for Auditory Perceptual Assessment Disc 1.0* (VA-CD). An upgraded version,

the *Tonal and Speech Materials for Auditory Perceptual Assessment Disc 2.0* was made available in 1998. The compact disc consists of a battery of tests that assess different aspects of auditory processing and different central auditory nervous system processes. A standardised compact disc would provide high quality recording and control factors such as stimulus parameters, differences in mechanical reproduction devices and signal to noise ratios. The use of various auditory perceptual tests that differ in quality, usefulness and complexity is thus eliminated and the collection of normative data and interclinic comparison is made easier (Noffsinger, Wilson and Musiek, 1994).

In the South African context, the difficulties of working in the field of central auditory processing disorders include the lack of standardised South African central auditory processing disorder test materials, the poor quality of available recordings, the presence of different versions of the same test, the challenge of 11 official languages and the poor training in the administration and interpretation of central auditory processing disorder tests and their results and the uncertainty of which intervention procedures to implement (RSA CAPD Taskforce, 2000). These challenges culminated in the formulation of the RSA CAPD Taskforce which was formally approved and affiliated to the Professional Board for Speech Therapy and Audiology on 8 February 2000.

The aims of the RSA CAPD Taskforce are to:

- compile guidelines for when central auditory processing disorder testing is indicated and what level of testing is required.
- develop and standardise recommended central auditory processing disorder screening and diagnostic procedures and protocols.
- compile recommended central auditory processing disorder intervention strategies and protocols for South Africa.
- disseminate central auditory processing disorder information to all audiologists and speech-language pathologists.
- promote collaboration with and between universities to ensure a high standard of training in central auditory processing disorders.

- promote research in the field of CAPD.
- promote communication and research between audiologists, speech-language pathologists and other professionals with an interest in central auditory processing disorders.
- promote communication with research teams currently developing RSA language specific word lists for audiometric testing in all 11 official languages. (RSA CAPD Taskforce, 2000).

The RSA CAPD Taskforce received permission from the Department of Veterans Affairs in the USA to rerecord 16 tracks of the *Tonal and Speech Materials for Auditory Perception Assessment Disc 2.0* compact disc (Wilson, 2000). This compact disc is widely used in the USA but clinicians are advised to compile their own clinic specific normative data (Bellis, 1996) The 16 tracks recorded for the RSA CAPD Taskforce compact disc contain low-linguistically loaded material, to ensure that it can be used for South Africans whose first language is not English but who have a fair level of competence in English (RSA CAPD Taskforce, 2000). Low linguistically loaded materials refers to sounds patterns, digits and words rather than sentences which place a increased linguistic load on the individual.

The RSA CAPD Taskforce is currently doing research using volunteer audiologists and masters degree research students at several universities in South Africa to compile this normative data on adults and children of different population groups. The project that is being reported on in this dissertation forms part of a broader study to collate the normative data.

Normative values for children and adults differ due to the effects of maturation on the results of all central auditory processing test procedures. Adult values are reached at approximately 12 years of age (Bellis, 1996). For this research project, aimed at establishing preliminary normative data for English first and second language speakers adult subjects will be used as they will provide more reliable results. It is thus important

to establish preliminary normative data for this population using low linguistically loaded test materials that theoretically will not negatively influence the results obtained and to compare the results to those obtained from English first language speakers using the same test materials.

English first language speakers in South Africa can be divided into several groups, including those of Indian and European descent. This study will concentrate on Indian first language English speakers with whom the researcher comes into contact in her work environment. This group is a minority in the South African population and needs to be included in establishing preliminary normative data for the South African population as a whole. As this study forms part of a group of studies undertaken under the auspices of the RSA CAPD Taskforce, data from other English first language speakers is being compiled and will be collated. It is hypothesised that there will not be differences between the different groups of English first language speakers but further research is necessary to confirm this hypothesis. This falls within the scope of the broader research project undertaken by the RSA CAPD Taskforce.

The second language English speakers will consist of people of African descent. This is also a group that the researcher comes into contact with in her work environment. People of African descent make up the bulk of the South African population and it is crucial that they be included in a study collecting preliminary normative data in order for the results to be accountable and reflective of the South African context.

The normative data obtained from each group in the study will be compared to each other and to the USA normative data. This will provide guidelines as to the feasibility of using low linguistically loaded materials as an interim measure in conducting central auditory processing disorder testing in South Africa for these two groups.

1.3. DISCUSSION OF TERMINOLOGY

In this section the different definitions and terminology which form the basis of this research will be discussed.

1.3.1 Central Auditory Processing and Central Auditory Processing Disorders

In 1996 the American Speech-Language-Hearing Association (ASHA:41) Task Force on Consensus Development defined central auditory processing as "the auditory mechanisms and processes responsible for the following behavioural phenomena:

- sound localisation and lateralization
- auditory discrimination
- auditory pattern recognition
- temporal aspects of audition, including
    - temporal resolution
    - temporal masking
    - temporal integration
    - temporal ordering
- auditory performance decrements with competing acoustic signals
- auditory performance decrements with degraded acoustic signals".

The above definition refers specifically to the auditory system. Factors such as attention, memory, learning, long term phonological representation and higher level neurocognitive processes are considered only in their relation to the processing of the acoustic signal (ASHA, 1996).

The above consensus statement has been criticised at several levels. Bellis (1999) notes that the definition does not explore the underlying mechanisms responsible for the auditory behaviours listed and how deficits in these areas can lead to difficulties in higher level language, learning and communication. Jerger (1998) takes issue with the fact that the listed behaviours can apply to persons with peripheral hearing loss, the definition does

not emphasise the *uniqueness* of central auditory processing disorders which is crucial to intervention.

Furthermore, the consensus statement does not provide precise criteria to diagnose central auditory processing disorders . Without precise criteria the prevalence and impact of the disorder cannot be determined. The inherent heterogeneity of the disorder leads to different behavioural manifestations and makes precise criteria difficult to establish (Bellis, 1999; Friedl-Patti, 1999). The lack of precise defining criteria has also resulted in CAPD not being described in the Diagnostic and Statistical Manual of Mental Disorders as a diagnostic entity (DSM-IV-American Psychiatric Association, 1994).

ASHA's (1996:43) understanding of central auditory processing disorders as "an observed deficiency in one or more of a group of mechanisms and processes related to a variety of auditory behaviours" recognises the contribution of neurocognitive, attentional and auditory factors and applies to nonverbal and verbal signals (Keith, 1999). The ASHA (1996) definition is described as "vague and loosely defined" by Cacace and McFarland (1998: 36) who disagree with the inclusive view inherent in the definition and propose an exclusive definition concentrating on non-linguistic factors tested via one sensory modality only. This view is criticised by Keith (1999) as limiting the approach to assessment and remediation available to clinicians.

Chermak and Musiek (1997:3) state that "a central auditory processing disorder involves a deficit in one or more of the central auditory processes responsible for generating the auditory evoked potentials and the behaviours of sound localisation and lateralization, auditory discrimination, auditory pattern recognition, temporal processing, auditory performance with competing acoustic signals and auditory performance with degraded acoustic signals." This definition is broader than the ASHA (1996) definition and encompasses the area of electrophysiological measures that play a important role in diagnosing the disorder.

A recent development in the field is a disagreement as to the use of terminology. At the Bruton Conference on the Diagnosis of Auditory Processing Disorders in School-Age Children held in April 2000, it was deemed more appropriate to label the disorder as an 'auditory processing disorder' rather than 'central auditory processing disorder'. This was "in keeping with the goals of maintaining operational definitions, avoiding the imputation of anatomical loci, and emphasising the interactions of disorders at both peripheral and central site" (Jerger and Musiek, 2000:467). This definition emphasises the auditory specific nature of the disorder, however as stated by Medwetsksy (2002) it remains to be seen if audiologists will accept the term auditory processing disorder.

The term 'auditory processing disorder' does not clearly delineate the neuroanatomical site of this disorder as being from the level of the brainstem and higher cortical structures. An auditory disorder that can exhibit symptomatology similar to auditory processing disorders is 'auditory neuropathy'. Auditory neuropathy is characterised by normal cochlear function at the level of the outer hair cells but dysynchronous auditory brainstem responses. The definition places this functional disorder in the peripheral auditory system from the level of the inner hair cells of the cochlear and auditory nerve (Jerger and Musiek, 2000). The use of the term 'central auditory processing disorder' clearly distinguishes the characteristic of this disorder as originating in the central auditory nervous system.

From this discussion it can be noted that although there is general consensus that central auditory processing disorders exists there is no agreement as to the specifics of the definition or to terminology. For the purposes of this research the definition proposed by Chermak and Musiek (1997) will be utilized. This definition is broader than the ASHA (1996) definition while maintaining the crux of that definition. The term central auditory processing disorder (CAPD) will be used as it clearly delineates the disorder as originating at the level of the central auditory nervous system.

1.3.2. Low linguistically Loaded Test Battery

Low linguistically loaded materials refers to sound patterns such as frequency and duration patterns, digits and words as opposed to sentences that do not place a high linguistic load on the client (RSA CAPD Taskforce, 2000). Low linguistically loaded test materials are less likely to be affected by language and can possibly be used for South African people who do not have English as a first language but are competent second language English speakers as an interim measure until test materials for all the cultural and language groups in South Africa can be developed.

1.3.3. Preliminary Normative Data

Preliminary is defined by the Pocket Oxford English Dictionary (1992:703) as an "introductory , preparatory" action. The data collected in this study must be collated with data from other studies conducted under the auspices of the RSA CAPD Taskforce to establish normative data for the South African population using the low linguistically loaded central auditory processing test battery.

1.4 CHAPTERS OF THE RESEARCH PROJECT

This research project consists of five chapters namely Chapter 1- Introduction and Orientation , Chapter 2- Theoretical Perspectives on Central Auditory Processing Disorders , Chapter 3- Methodology , Chapter 4- Results and Discussion of Results and Chapter 5- Conclusions and Recommendations . The content and motivation for each chapter is presented in Table 1.1.

Table 1.1 Division of Chapters

CHAPTER	CONTENT	MOTIVATION
Chapter 1: **Introduction and Orientation**	• the rationale behind the research project. • the research question that needs to be answered. • definition of relevant terminology.	• to provide a overview of the research and the questions that need to be answered.
Chapter 2: **Theoretical Perspectives on Central Auditory Processing Disorders**	• central auditory processing test materials. • the neuroanatomy and neurophysiology of the central auditory nervous system. • the central auditory processing test battery and the RSA CAPD low linguistically loaded test battery.	• to develop a clearer understanding of what constitutes a central auditory processing test battery and the role of neuroanatomy and neurophysiology in selecting and interpreting CAPD tests. • the rationale underlying the study is developed and presented against the background of key and recent references.
Chapter 3: **Methodology**	• presentation of aims and subaims, participant selection criteria, apparatus and materials used, the research design used and the data collection procedures which were followed.	• the methodology provides detailed information to allow for exact duplication of the study.
Chapter 4: **Results and Discussion**	• present results according to the formulated subaims. • compare and discuss the test results against the background of the relevant and key references. • determine whether the questions posed at the onset of the study were answered.	• the details of the research and the research findings are discussed against the background of the literature and should be easily accessible.
Chapter 5: **Conclusions and recommendations**	• summarise the results of the study. • a critical evaluation of the study. • the contribution of this particular study to this area of research. • implications for future research and implications of the results for the profession and clinical situation will be discussed. • suggestions for future research.	• the reader should be able to evaluate the research, the implications of the research for the profession and the clinical setting and derive ideas for future research.

1.5. CONCLUSIONS

The development of culturally and linguistically appropriate central auditory processing test materials for the South African population has been highlighted and needs to be addressed. The "RSA low linguistically loaded central auditory processing test battery" is an interim measure that can fill this vacuum if the preliminary normative data collected from this study and other studies in South Africa on different cultural and age groups that make up the South African population prove viable.

1.6. SUMMARY

The literature on central auditory processing disorders stresses the need for collecting age appropriate normative data on central auditory processing tests within the particular setting to ensure reliability and validity. One of the main aims of the RSA CAPD Taskforce is to develop screening and diagnostic tests in all the official languages of South Africa. The "RSA low linguistically loaded central auditory processing test battery" is an interim measure in this long term process before appropriate test materials can be developed. The central auditory processing test battery should consists of tests that assess different levels and processes of the central auditory nervous system. The development of normative data using the low linguistically loaded test battery on different population groups with different competencies in English is thus a priority if the test battery is to be used accountably by audiologists.

CHAPTER 2. THEORETICAL PERSPECTIVES ON CENTRAL AUDITORY PROCESSING DISORDERS

2.1. INTRODUCTION

The phenomenon whereby children and adults present with difficulty in processing auditory stimuli despite normal peripheral hearing is called central auditory processing disorders (CAPD) (Jerger, 1998; Keith 1999). There is general consensus in the literature that central auditory processing disorders exist but controversy surrounds its definition, assessment and management (Chermak and Musiek, 1997; Sloan, 1998; Friedl-Patti, 1999 and Keith, 1999).

Consensus regarding a definition has remained elusive despite twenty years of effort by various researchers and clinicians and two ASHA subcommittees on central auditory processing disorders (Chermak and Musiek 1997). Controversy in defining this disorder results from the fact that central auditory processing disorder is a description of functional deficits which manifests in diverse clinical populations with or without neuropathology (Chermak and Musiek, 1997; Chermak, 1998). Central auditory processing disorders can be linked to central auditory nervous system pathology such as aphasia or traumatic head injury, functional disorders such as language or learning disorders as well as to maturation and aging (Willot 1991; Stach, Loiselle and Jerger, 1991; Stach and Loiselle, 1993; Gravel and Wallace, 1995; Stuart and Philips 1996; Chermak and Musiek, 1997). Central auditory processing disorder is also documented in people with a history of chronic otitis media (Friedl-Patti, 1990; Gravel and Wallace, 1995).

The controversy is reflected in the plethora of test materials available to assess the disorder. Various different test materials exist on tape recordings and recently compact disc, with varying degrees of quality. Different versions of tests using the same name but different stimuli and data collection procedures exist leading to a lack of uniformity and hindering efforts to set normative standards.

Efforts to standardise test materials has resulted in the production of the *Tonal and Speech Materials for Auditory Perceptual Assessment Disc, 1.0* and *2.0* by the Department of Veterans Affairs in the USA. This is a behavioural central auditory processing test battery comprising different tests to assess different processes and levels of the central auditory nervous system. The central auditory nervous system is a highly integrated system in which a breakdown in any one area can result in a central auditory processing disorder (Bellis and Ferre, 1996 and 1999). A sound knowledge of the anatomical and physiological structures of the central auditory nervous system is therefore crucial in the assessment and management of central auditory processing disorders.

In this chapter the development of central auditory processing test materials will be discussed and the neuroanatomy and neurophysiology of the central auditory nervous system and its importance in choosing a central auditory processing test battery will be highlighted. The central auditory processing test battery will be discussed and the importance of collecting relevant normative data for all population groups in South Africa will be emphasised in relation to the above.

2.2. CENTRAL AUDITORY PROCESSING DISORDER TEST MATERIALS

The insensitivity of traditional auditory tests in assessing central auditory nervous system disorders led researchers to develop behavioural test materials capable of assessing central auditory nervous system lesions. Over a period of thirty years test materials such as monaural speech tests, dichotic digits tests, binaural interaction tests and temporal ordering tests have been developed (Chermak and Musiek, 1997).

The development of the above test materials resulted in a variety of different test materials being available on audiotape. Taped versions of the same test using different stimulus parameters are available. Taped materials are often difficult to obtain, are of

inadequate quality and are susceptible to deterioration due to continuous use (Musiek and Rintelmann, 1999).

To address these issues the Department of Veterans Affairs in the USA produced the *Tonal and Speech Materials for Auditory Perceptual Assessment Disc 1.0* in 1992 with a updated version *Disc 2.0* in 1998 (Wilson and Strouse, 1998). Compact discs are of high quality and are resistant to deterioration due to wear and tear (Chermak and Musiek, 1997). The above compact discs consist of a variety of test materials with a high and low linguistic load designed to assess different levels and processes of the central auditory nervous system. Careful attention was paid to stimulus generation, test parameters, the development of test protocols and normative data in the compilation of the compact disc. (Noffsinger, Wilson and Musiek, 1994).

Normative data has been developed for many of the tests on the compact disc but is not provided with the compact disc. Clinicians are instead referred to a series of journal articles in the 1994 issue of the Journal of the American Academy of Audiology and to a paper by Humes, Coughlin and Talley (1996) to obtain the relevant normative data (Wilson and Strouse, 1998).

The continued use of both versions of the compact disc which do not contain the exact test materials, and the continued use of audiotaped test materials using different data collection parameters and procedures makes it difficult to compare studies and do interclinic comparisons. Despite the availability of a standardised behavioural CAPD compact disc in the USA the lack of definitive normative data further complicates any studies and comparisons.

These developments in the USA were monitored in countries such as South Africa, New Zealand and Australia which lacked adequate test materials (RSA CAPD Taskforce, 2000). The development of the Veterans Affairs compact disc provided clinicians with a possible means of using a high fidelity standardised behavioural test battery that was

readily available. The RSA CAPD Taskforce saw the possibility of using tests on the compact disc that contained low linguistically loaded materials such as digits and words as opposed to sentences as a interim measure that could be used by audiologists in South Africa on populations that had English as a second language until test materials in the 11 official languages can be developed.

The RSA CAPD Taskforce received permission to rerecord 16 tracks of the Veterans Affairs compact disc containing low linguistically loaded test materials (Wilson, 2000). This was recorded as the SA low linguistically loaded central auditory processing test battery. As with all tests of central auditory processing normative data needs to be collected for all cultural and age groups in South Africa before this test battery can be reliably used as an interim measure in South Africa. Various researchers and students at universities and clinics in South Africa are assisting in collecting this normative data (RSA CAPD Taskforce, 2000).

The tests on the low linguistically loaded compact disc, if proved to be efficient with clinical populations, will provide the audiologist with a starting point to standardising central auditory processing testing. Test results can then be verified over different situations and clinical settings in South Africa. Despite the availability of the compact disc in the USA, standardisation has still not been achieved as many audiologists still rely on different taped test materials and use different versions of the compact disc.

2.3. NEUROANATOMICAL AND NEUROPHYSIOLOGICAL ASPECTS OF THE CENTRAL AUDITORY NERVOUS SYSTEM

A sound knowledge of the central auditory nervous system is vital for compiling an individualised central auditory processing test battery that assesses the different levels and processes of the central auditory nervous system as ascertained by the clients case history. This also facilitates the interpretation of results and assists in devising a client specific management programme (Bellis, 1996; Chermak and Musiek, 1997).

The central auditory nervous system extends from the cochlear nucleus in the brainstem to the temporal lobes of each hemisphere in the brain (Kaplan, Gladstone and Katz, 1984). The *cochlear nuclei* is the initial point of entry of information into the central auditory nervous system (Musiek and Baran, 1986; Baran and Musiek, 1999). The cochlear nuclei are located on the posterolateral surface of the brainstem and are thus vulnerable to tumours such as acoustic neuromas (Bellis, 1996).

The *superior olivary complex* receives bilateral input from the cochlear nuclei. The first major crossover of ascending auditory fibres occurs at the level of the superior olivary complex (Baran and Musiek, 1999). This results in lesions above this level rarely causing significant losses in terms of threshold sensitivity or speech recognition abilities (Baran and Musiek, 1999). The arrival time of impulses from each ear to the superior olivary complex is critical for sound localisation, lateralization and binaural integration (Bellis and Ferre, 1996). The *lateral lemniscus* extends from the superior olivary complex to the *inferior colliculus* in the midbrain (Musiek and Baran, 1986). The lateral lemniscus is a major auditory fibre tract comprising both ascending and descending fibres (Musiek and Baran, 1986). It receives crossed and uncrossed projections from more caudal auditory structures and continues the bilateral representation of auditory stimuli (Bellis, 1996).

The *inferior colliculi* are located on the dorsal surface of the midbrain. It receives contralateral and ipsilateral acoustic information from all lower structures making it critical in binaural processing. Neurons in the inferior colliculi are sensitive to binaural stimulation, important for sound localisation (Musiek and Baran, 1986).

Through the brachium of the inferior colliculus information is sent to the ipsilateral *medial geniculate body.* This serves as a thalamic relay station for the transmission of auditory information to the auditory cortex via the internal capsule, external capsule and the insular in the cerebrum (Bellis and Ferre, 1996).

The *primary auditory cortex* or Heschl`s gyrus is located on the upper surface of the temporal lobe. It is the site of auditory sensation and perception. The primary auditory cortex is connected to the associated auditory cortex or Wernicke`s area on the surface of the temporal lobe by a extensive axonal bundle. The recognition of linguistic information, comprehension of spoken language and language formulation is associated with this area (Bellis and Ferre, 1996). Wernicke`s area projects to Broca`s area in the frontal lobe which is responsible for motor speech production and to the central associated auditory cortex via the corpus callosum (Bellis and Ferre, 1996).

The *corpus callosum* is the largest fibre tract in the central auditory nervous system. It is primarily responsible for communication and integration of information between the two cerebral hemispheres (Bellis and Ferre, 1996; Baran and Musiek, 1999). The *efferent or descending auditory system* extends from the cortex to the cochlear. Little is known of this system but it is thought to inhabit auditory stimuli for successful detection of signals in noise (Musiek and Baran, 1986).

From this overview the interrelatedness of auditory nervous system structures in tasks required for effective central processing and thus effective listening is emphasised. Any breakdown in any area may result in a central auditory processing disorder. A central auditory processing test battery should thus consists of tests that assess different processes and different levels of the central auditory nervous system (Bellis, 1996; Chermak and Musiek, 1997; Bellis and Ferre, 1999). The test procedures that can be used in assessing the different levels of the central auditory nervous system are discussed in the following section.

2.4. THE CENTRAL AUDITORY PROCESSING TEST BATTERY

The ASHA (1996) Task Force recommends that the components of the central auditory processing assessment should include a case history, observation of auditory behaviours, audiologic test procedures such as puretone audiometry, speech recognition, immittance

measures, temporal processes, localisation and lateralization, low redundancy monaural speech, dichotic stimuli, binaural interaction procedures and administration of speech-language measures. The ASHA (1996) Task Force also recognised that middle, late and event related evoked potentials are tools that can be used in CAPD assessment but which need further research and development.

It is strongly recommended in the literature that a behavioural central auditory processing test battery include at the minimum one test from the four categories; namely dichotic speech tests (one linguistically loaded and one with a low linguistic load), monaural low-redundancy speech tests, tests of temporal patterning and binaural interaction tests (Bellis, 1996; Chermak and Musiek, 1997; Bellis and Ferre, 1999). By assessing different levels and processes of the central auditory nervous system, auditory profiles that highlight the individual's auditory strengths and weaknesses can be developed and recommendations related to deficit specific management made (Bellis, 1996; Bellis and Ferre, 1999).

In keeping with the above criteria and taking the South African context into account, in which the majority of the population are not English first language speakers, the RSA CAPD Taskforce recommended the use of low linguistically loaded test battery comprising of tests from each of the four categories (RSA CAPD Taskforce, 2001). This would allow audiologists to work in the field of central auditory processing using standardised material. Normative data could then be compiled to ensure accountability (RSA CAPD Taskforce, 2001). As discussed previously this is an interim measure until SA specific central auditory processing disorder tests and test materials with a higher linguistic load can be developed for all the eleven official languages.

The behavioural central auditory processing disorder test battery should include tests from the following four categories.

2.4.1. Dichotic Speech tests

These tests involve the presentation of stimuli to both ears simultaneously, with the information presented to one ear being different from that presented to the other ear. The listener is requested to repeat all stimuli (binaural integration) or to attend to one ear only (binaural separation) (Bellis, 1996; Bellis and Ferre, 1999). Stimuli can vary from low linguistically loaded stimuli such as digits and nonsense syllables to linguistically loaded stimuli such as competing sentences. In the South African context a low linguistically loaded test provides a method of testing in the interim until appropriate test materials are developed.

In a comparative study reported by Baran and Musiek (1999) in which the relative sensitivity of three Dichotic Speech tests (Dichotic Digits, Competing Sentences and Staggered Spondaic Words) in the assessment of central auditory nervous system disorders of 12 people with brainstem involvement and 18 with cortical lesions showed that the dichotic digits test yielded slightly more abnormal finding for both groups than the other tests. The results suggest that the use of Dichotic Digits test may be more sensitive in identifying brainstem and cortical lesions than the Competing Sentences test and the Staggered Spondaic Word test. These results thus add weight to the inclusion of the dichotic digits test in the RSA CAPD low linguistically loaded central auditory processing test battery.

Dichotic Speech tests are sensitive to disruption of interhemispheric transfer of information via the corpus callosum and to cortical and brainstem lesions (Bellis, 1996; Bellis and Ferre, 1999). Normal listeners exhibit a slight right ear advantage in dichotic speech tasks due to the cerebral dominance of the left hemisphere for speech (Bellis, 1996) Research by Noffsinger, Wilson and Musiek (1994) shows a 100% pass rate for young adults using dichotic single digits. The effects of aging on recognising a set of hierarchical dichotic digits ranging in complexity from easy (1-paired digits) to difficult (4-paired digits) showed a decrease in performance as the complexity of the task

increased for both the under 30 age group and the over 60 age group with the performance of the latter group significantly poorer in all test conditions.

2.4.2. Monaural Low-Redundancy Speech tests

Normal listeners use the intrinsic and extrinsic redundancy of the normal auditory system in order to perceive speech in the presence of a distorted signal. This ability is compromised in a listener with central auditory dysfunction (Bellis, 1996). These tests involve the presentation of monosyllabic words that have been distorted in some way to reduce to the extrinsic redundancy of the signal. Methods used to reduce the redundancy of the speech signal include low-pass filtering, time compression and the addition of reverberation (Bellis, 1996; Baran and Musiek, 1999; Bellis and Ferre, 1999). The listener's ability to achieve closure and discriminate speech is the presence of a less than clear speech signal is evaluated.

In terms of the South African context the use of monosyllabic words with a lighter linguistic load than stimuli such as sentences may make it appropriate to use with a population who has English as a second language. Normative data however needs to be established for local English first and second language speakers before the tests can be reliably used.

These tests are sensitive to brainstem and cortical pathologies and in pathology involving the primary auditory cortex (Bellis, 1996; Bellis and Ferre, 1999). Site of lesion however cannot be determined by filtered speech tests (Musiek and Baran, 1984; Bellis, 1996).

2.4.3. Temporal Patterning tests

These tests assess the listener's ability to perceive a pattern of auditory events occurring over time (Bellis and Ferre, 1999). The listener is asked to make discriminations based on the temporal order of auditory stimuli. Non speech items such as pitch and duration

stimuli are used in the testing procedure (Bellis and Ferre, 1999). This makes its use in the RSA low linguistically loaded CAPD test battery appropriate as the linguistic load on the listener is lessened.

Tests included in this paradigm are the Pitch Patterns sequence test or Frequency Patterns test the Duration Patterns test and the Psychoacoustic Pattern Discrimination test. Two tests conditions apply, each testing a different area of the central auditory nervous system. In the first the listener labels the pattern heard verbally thus assessing the interhemispheric transfer of acoustic information from the right to the left hemisphere. In the second test condition the listener is requested to hum the pattern, thus removing the linguistic component (Bellis and Ferre, 1999). Patients with disruptions in the interhemispheric transfer of auditory information perform better when the linguistic component of the test is removed. The test is thus also sensitive to corpus callosum dysfunction (Bellis, 1996).

The Frequency Patterns test is sensitive to disorders of the cerebral hemispheres and to corpus callosum dysfunction (Musiek and Baran, 1984; Baran and Musiek, 1999). The Duration Patterns test is sensitive to cerebral lesions and is not affected by peripheral hearing loss as long as the stimuli is perceived by the listener (Bellis, 1996). The test assesses the process of duration, discrimination, temporal ordering and linguistic labelling (Bellis, 1996). This test proved to be the most effective in identifying cerebral lesions in a study conducted by Hurley and Musiek (1997).

Neuromaturation affects the performance on temporal patterning tests with skills improving with age and adult values reached by approximately 12 years of age (Bellis, 1996).

2.4.4. Binaural Interaction tests

These tests assess the ability of the central auditory nervous system to process disparate but complementary information presented to the two ears (Baran and Musiek, 1999). It differs from dichotic listening tasks in that stimuli presented is either sequential or the information presented to each ear is composed of a portion of the entire message. Interaction between the two ears is necessary to perceive the entire message (Bellis, 1996; Bellis and Ferre, 1999).

Tests included in this paradigm are the Rapidly Alternating Speech Perception test, Consonant -Vowel-Consonant (CVC) Binaural Fusion test and High-pass/Low-pass Binaural Fusion test, Interaural Difference Limen tests and the Masking Level Difference test (Bellis, 1996; Bellis and Ferre, 1999).

The clinical utility of all Binaural Interaction tests except the Masking Level Difference test has been questioned as they are not sensitive to anything other than gross brainstem pathology (Bellis, 1996). Brainstem pathology can be more effectively demonstrated using electrophysiological measures such as auditory brainstem response (ABR) or middle latency response (MLR). The RSA CAPD Task Force low linguistically loaded compact disc contains the Speech Masking Level Difference test and CVC Binaural Fusion test. It is important to include this test in developing normative data for the South African population as electrophysiological measures may not always be available to audiologists and audiologists may not have access to audiometric equipment to carry out the speech masking level test. A test from this category is also necessary to ensure that the recommended criteria in assessing central auditory processing is met.

2.5. THE RSA CAPD TASK FORCE AND THE LOW LINGUISTICALLY LOADED CENTRAL AUDITORY PROCESSING TEST BATTERY

South African audiologists are faced with the challenge of working in a culturally diverse country with eleven official languages. Audiologists working in the field of central auditory processing face the additional task of having access to very limited test materials, many being inadequate copies of outdated original test materials. Recognising the need for the development of CAPD test material the RSA CAPD Taskforce was mandated by the Professional Board for Speech- Language Pathology and Audiology affiliated to the Health Professionals Council of South Africa, to oversee research and development in the field of central auditory processing in South Africa (RSA CAPD Taskforce, 2000).

The RSA CAPD Taskforce recognises the importance of developing CAPD test materials specifically for the South African population in all the official languages. As a interim measure before these tests are developed, the Taskforce received permission to rerecord 16 tracks of the *Tonal and Speech Material for Auditory Perception Assessment Disc 2.0* compact disc from the Department of Veterans Affairs (Wilson, 2000).

The 16 tracks recorded for the RSA CAPD Taskforce compact disc contain low-linguistically loaded material, to ensure that it can be used for South Africans whose first language is not English but who have a fair level of competence in English (RSA CAPD Taskforce, 2000). Low linguistically loaded material refers to the use of sound patterns, digits and words rather than sentences which place an increased linguistic load on the individual (RSA CAPD Taskforce, 2000). It is hypothesised that low linguistically loaded tests are less likely to be affected by language and can be used as an interim measure for South African people who may not have English as a first language but are competent second language English speakers.

The literature (Bellis, 1996; Keith, 1999) stresses the importance of developing normative data within the context that the central auditory test processing battery will be utilised to ensure reliability of test results and thus accountability. Normative data for the South African context needs to be developed to assess whether the test battery can be used accountably as an interim measure for the South African population.

The aim of this research project is thus to collect preliminary normative data for first and second language adult English speakers on selected tests from the SA CAPD low linguistically loaded compact disc. Adult subjects are being used as maturation which affects the results of central auditory processing tests is reached by approximately 12 years of age. Results will thus be constant and more reliable (Bellis, 1996). Adults can also give immediate consent to participate in the study, and being volunteers will be more co-operative, thus improving the reliability of the research. It is also sound research to derive normative data for adults first as results will be of greater consistency and reliability . As the study aims to assess the performance of English second language speakers it is envisaged that adult second language English speakers will provide more reliable results.

This research project forms part of a larger study undertaken by the RSA CAPD Taskforce in collecting normative data from various population groups and age groups in South Africa. The compilation of preliminary normative data is essential to enable audiologists to use the test materials in the clinical setting in an accountable manner. Preliminary results will provide guidelines whether it is feasible to use low linguistically loaded materials as an interim measure in conducting CAPD testing in South Africa.

The RSA CAPD Taskforce has recommended an adult test protocol from the low linguistically loaded compact disc to be followed by audiologists collecting the preliminary data throughout South Africa. The protocol follows international guidelines that state that a comprehensive CAPD test battery should include at a minimum a test

from each of the four categories discussed in the previous section (RSA CAPD Taskforce, 2001).

The adult test protocol used in the study included the:

- Two pair Dichotic Digit test
- Frequency Patterns test and the Duration Patterns test
- Low-Pass Filtered Speech test and 45% Time Compressed Speech test
- Masking Level Difference test and the CVC Binaural Fusion test

Apart from the Dichotic Speech test category, two tests were included for the other categories as adults would be able to co-operate for an increased length of time and the inclusion of more normative data would enhance the accountability of using different tests of central auditory processing in the test battery.

2.6. CONCLUSIONS

The progress in the development of central auditory processing disorder test materials and the need for standardisation of test materials led to the development of the *Tonal and Speech Materials for Auditory Perceptual Assessment Disc 1.0 and Disc 2.0* in the USA. Although not providing all the answers to standardisation and not providing conclusive normative data, the compact disc is seen as a way forward by audiologists in South Africa. The RSA CAPD Taskforce have developed a low linguistically loaded version of this compact disc to be used as an interim measure until culturally specific test materials can be developed in all 11 official languages. Preliminary normative data needs to be developed for the South African context as Bellis (1996) stresses the importance of developing normative data for each clinic and setting where the CAPD test battery will be utilized.

2.7. SUMMARY

Significant developments in the understanding of the neuroanatomy and neurophysiology of the central auditory nervous system and the development of a standardised CAPD compact disc in the USA has given audiologists greater confidence in working with CAPD. In South Africa the formulation of the RSA CAPD Taskforce is a significant step meeting the challenges faced by audiologists and speech-language pathologists working or interested in working in this complex area. The RSA CAPD Taskforce's undertaking of the development of normative data using the SA CAPD low linguistically loaded compact disc for different population and age groupings in South Africa as an interim step in the eventual development of CAPD test materials in all 11 official languages is encouraging and helpful to audiologists and speech-language pathologists working in this country.

CHAPTER 3: METHODOLOGY

3.1. INTRODUCTION

One of the aims of the RSA CAPD Taskforce (2000) is to develop and standardise recommended CAPD screening and diagnostic procedures and protocols to be used by audiologists working in South Africa. In accordance with this aim permission was obtained from the Department of Veterans Affairs in the United States of America to rerecord 16 tracks of the *Tonal and Speech Materials for Auditory Perception Assessment Disc 2.0* compact disc (Wilson, 2000).

The material chosen for the RSA CAPD Taskforce compact disc contain low linguistically loaded material. It is hypothesised that speech stimuli with a light linguistic load will be easier for South Africans whose first language is not English but who have a fair level of competence in English (RSA CAPD Taskforce, 2000). Due to the complexity of the South African situation with 11 official languages and the lack of test materials in languages other than English the low linguistically loaded compact disc provides the audiologist in South Africa with a standardised test battery that controls for factors such as stimulus parameters, differences in mechanical reproduction devices and signal to noise ratios (Noffsinger, Wilson and Musiek, 1994). This will facilitate the collection of normative data and validate interclinic comparison. The low linguistically loaded test battery is an interim measure until materials in all the 11 languages can be developed.

To ensure that the test materials can be reliably and accountably used by audiologists normative data needs to be collected in the settings where the tests will be used (Bellis, 1996). In accordance with one of the aims of the RSA CAPD Taskforce, namely promoting research in the area of auditory processing disorders, the Taskforce is using volunteer audiologists and masters students at several South African universities to

collect normative data on adults and children on behavioural test batteries selected from the low linguistically loaded compact disc.

3.2. AIMS

The main aim of the study was to obtain preliminary normative data for South African adult English first and second language speakers on the "RSA low linguistically loaded central auditory processing test battery" and to compare the preliminary normative data obtained to the USA normative data.

The sub-aims of the study were:

- To determine and compare the performance of English first language (Research group 1) and English second language (Research group 2) speakers on the low linguistically loaded SA central auditory processing test battery.
- To compare the preliminary normative data obtained for the two research groups with the USA normative data.

3.3. RESEARCH DESIGN

A *between group research design*, was used (Leedy and Ormrod, 2001). This design allows the researcher to examines how performance on an independent variable (the SA CAPD low linguistically loaded compact disc) is affected by the depended variable (the listeners proficiency in English). The *between group research design* involves looking at existing conditions and comparing groups along a dependent variable with the intention of identifying possible cause-effect relationships (Leedy and Ormrod, 2001).

Participants were assigned to one of the two groups on the basis of their proficiency in English. Data collection entailed administering a uniform set of predetermined tests from each of the four categories on the SA low linguistically loaded compact disc to each of

the research groups and comparing the results obtained to each other and to the USA normative data..

3.4. PARTICIPANTS

Thirty two participants were included in the study. They were divided into two groups of sixteen participants. This included a group of English first language speakers and a group of English second language speakers. The two participants used for the pilot study were included in the main study on the advise of the statistician as no significant changes were necessary to the data collection procedures after the completion of the pilot study. The participant numbers was thus increased which is important for statistical purposes. This effectively meant that 64 ears were included in establishing the preliminary normative data.

3.4.1. Criteria for Selection

A questionnaire (Appendix 1) and audiometric evaluation consisting of puretone audiometry and test of middle ear function were used to ensure that participants met the following criteria:

3.4.1.1. Age

Participants were required to be between 18 and 40 years of age. The maturation of the central auditory nervous system affects all central auditory processing tests except the binaural fusion tests up to approximately 12 years of age (Bellis, 1996). Maturation for the binaural fusion tests is reached by approximately 6 years of age (Bellis, 1996). From the pre-teen to the middle adult years performance on central auditory processing tests is constant (Katz and Wilde, 1994). Performance begins to decline above this age limit due to physiological changes in the brain (Katz and Wilde, 1994). Eighteen years also marks the beginning of independence for young adults where parental consent is not necessary

and was advantageous for the researcher as permission to participate in the study could be obtained directly from the participant.

3.4.1.2. Language

Participants were required to have English as a first language for inclusion in Research group 1 and English as a second language for inclusion in Research group 2. This was necessary in order to establish appropriate normative data. Bellis (1996) states that individuals tested on central auditory processing tests in a language that is not their first language may be disadvantaged. Central auditory processing tests available in South Africa at present are only in English and this may impact on results obtained in the South African context where the majority of the population do not have English as a first language. Normative data for this population on the currently available low linguistically loaded CAPD test battery is thus crucial to determine whether the low linguistically loaded CAPD test battery is a viable interim measure until culturally and linguistically appropriate CAPD test materials can be developed in South Africa.

3.4.1.3. Educational level

Participants were required to have an educational level of Grade 10 or higher to ensure average or above average intellectual abilities and competence in English as a second language for the second research group. As English is the medium of instruction for children of African descent an educational level of Grade 10 ensured a basic competence in English.

3.4.1.4. Medical history

Participants were required to have no history of neurological disabilities due to medical conditions such as epilepsy or traumatic brain injury. Neurological dysfunction can

influence adequate performance in the test situation and affect the CAPD test scores adversely (Bellis, 1996).

3.4.1.5. Peripheral hearing and middle ear functioning

Participants were required to have normal peripheral hearing and middle ear function as decreased peripheral hearing and abnormal middle ear functioning affects most CAPD results negatively (ASHA, 1996; Bellis, 1996). Puretone thresholds between 0 and 20dBHL for the frequency ranges 125-8000Hz is defined as normal peripheral hearing for adults (Hall and Mueller, 1997). Normal middle ear functioning implies a type A tympanogram, with middle ear pressure between +50 and -150daPa and a static compliance between 0,3 and 1,75cm (Martin and Clark, 2000).

A peripheral hearing test and test of middle ear function was done on the day of CAPD testing as this was expedient for the participants. A speech reception threshold was established on participants before administering the low linguistically loaded CAPD test battery as many of the audiometer settings for the CAPD tests are based on this value.

3.5. SELECTION PROCEDURES

Participants were selected from the student and staff population of a university and teaching hospital where the researcher works. Interested people were asked to contact the researcher at the Speech and Hearing Department via notices placed at different places on the campus and hospital. Once identified, a questionnaire (Appendix 1) based on the selection criteria was completed by the researcher for each prospective participant. Information regarding name, age, sex first and second language, medical history and educational level was obtained.

An otoscopic examination, immittance measurements, puretone audiometry and speech reception threshold test was performed on each participant to ensure that the selection

criteria was met. A speech reception threshold was obtained for each participant as the audiometer settings during many of the central auditory processing test procedures are based on this information.

3.5.1. Description of the Participants

Participants were between 18 and 40 years of age. Research group 1 consisted of 16 participants who spoke English as a first language and Research group 2 consisted of 16 participants with English as a second language. The two participants used for the pilot study were included in the main study on the advise of the statistician as no significant changes were necessary to the data collection procedures after the completion of the pilot study. This served to increase the participant numbers which are important for statistical purposes. Further description of the participants is provided in Table 3.1

The English first language speakers were of Indian descent. The South African Indian cultural group forms a small percentage of the total population and needs to be included in establishing normative data to ensure that the normative data represents all of South Africas culturally diverse population groups. Access to this population group was also easy for the researcher in her work environment. It is hypothesised that the results of the South African Indian English first language speakers would not differ from those of other South African English first language speakers although further research is needed to confirm this hypothesis. It should be noted that there are different dialectical differences in the English spoken by South African English first language speakers that is linked to the different geographical regions of the country.

Table 3.1 Description of participants

Participant Information	Research group 1: English First Language Speakers	Research group 2: English Second Language Speakers
Age:	Range: 21-39 years Mean: 25.8; SD:4.99	Range: 18-36 years Mean: 25.3; SD; 5.68
Gender	5 males; 11 females	8 males; 8 females
Educational level	2 grade 12 level; 14 university level	2 grade 10 level; 5 grade 12 level; 9 university level
Medical history:	No medical contra-indications	No medical contra-indications
Childhood otitis media	1 participant	3 participants
Difficulty in hearing	0 participants	0 participants
Trauma to head	0 participants	0 participants
Epileptic fits	0 participants	0 participants
Motor vehicle accidents	0 participants	0 participants
Medication at present	0 participants	2 participants-(1 hypertension; 1 migraine)

The home languages of the English second language speakers (Research group 2) is outlined in Table 3.2

Table 3.2. Home languages of English second language speakers

Home Language	Number of participants: (n=16)
Tswana	7
Zulu	5
Northern Sotho	3
Ndebele	1

Four of the ten indigenous South African languages are represented in this sample. They represent the demographics of the staff and student population of this university and hospital.

3.6. MATERIAL AND APPARATUS

The discussion on material and apparatus used in the study is divided into two sections, namely materials and apparatus used for participant selection and those required for data collection.

3.6.1. Material and Apparatus used for selection of participants

This included a letter of consent, a questionnaire and audiometric testing apparatus.

3.6.1.1. Letter of Consent (Appendix 2)

A letter (Appendix 2) was addressed to each participant to obtain written consent for voluntary participation in the study. The letter outlined the objectives of the study, guaranteed confidentiality and gave practical information such as the nature of the testing, the time needed to complete the testing and the venue of the testing.

3.6.1.2. Questionnaire (Appendix 1)

A questionnaire (Appendix 1) focusing on the selection criteria listed above was devised and completed by the researcher for each prospective participant. Questions pertaining to English language proficiency, age, level of education and medical history formed part of the questionnaire. The researcher completed the questionnaire with each participant to develop rapport with the participant and to ensure that all relevant information was

satisfactorily completed. The information obtained was used to determine whether participants met the criteria for participation in the study and to assign the participant to a research group depending on their proficiency in English as a first or second language.

3.6.1.3. Audiometric Equipment

An Interacoustic AC30 clinical audiometer and a GSI 28A middle ear analyser were used to assess the peripheral hearing, speech reception threshold and middle ear functioning of all participants prior to administering the central auditory processing test battery. Both machines were calibrated in August 2001 and complied with SABS requirements. Otoscopic examination was done using a Welch-Allyn 3,5V HAL Otoset otoscope. Testing was conducted in a soundproof testing booth and Telephonic TDH-50 earphones were used.

3.6.2. Material and Apparatus used for data collection

An audiometer, compact disc player, the low linguistically loaded compact disc and the RSA CAPD Taskforce test recording forms (Appendices 3-10) were the apparatus and material used for data collection purposes.

3.6.2.1. Audiometer and Compact disc player

The low linguistically loaded central auditory processing test battery selected for the study was presented via a single disc Philips portable AX1000 compact disc player coupled to the Interacoustic AC30 audiometer which had been calibrated to comply with SABS requirements. Testing was conducted in soundproof booth using Telephonic TDH-50 earphones.

3.6.2.2. RSA CAPD Taskforce test recording forms

The results were recorded on test forms (Appendixes 3-10) devised by the RSA CAPD Taskforce in accordance with the test material on the central auditory processing compact disc.

3.6.2.3. RSA low linguistically loaded central auditory processing test battery and compact disc

The SA CAPD low linguistically loaded compact disc consists of 16 tracks which are listed in Table 3.3.

Table 3.3. The tracks on the SA CAPD low linguistically loaded compact disc

Left Channel	Right Channel
1. 1000Hz Calibration Tone	1000Hz Calibration Tone
2. 25, 1-pair Dichotic Digit	25, 1-pair Dichotic Digit
3. 25, 2-pair Dichotic Digit, List 1	25, 2-pair Dichotic Digit, List 1
4. 25, 2-pair Dichotic Digit, List 2	25, 2-pair Dichotic Digit, List 2
5. 25, 3-pair Dichotic Digit, List 1	25, 3-pair Dichotic Digit, List 1
6. 25, 3-pair Dichotic Digit, List 2	25, 3-pair Dichotic Digit, List 2
7. 54, 1,2&3 pair Dichotic Digits	54, 1,2&3 pair Dichotic Digits
8. 54, 1,2&3 pair Dichotic Digits	54, 1,2&3 pair Dichotic Digits
9. 30, Dichotic CV'simultaneous onset	30, Dichotic CV'simultaneous onset
10. 30, Dichotic CV's, 90ms lag	30, Dichotic CV's, 90ms lag
11. 30 frequency patterns 880Hz &1122Hz	30 duration patterns 250ms & 500ms
12. Spondaic Words SπNo MLD	Spondaic Words SπNo MLD
13. NU No.6,45%comp+0,3-s reverb	NU No.6 45% compressed
14. NU No.6,45%comp+0,3-s reverb	NU No.6 45% compressed
15. List 3, NU No.6 words high-pass	List 3, NU No.6 low-pass filter
16. List 4, NU No.6 words high-pass	List 4, NU No.6 low-pass filter

A comprehensive central auditory processing test battery provides information about the integrity of right and left cortical regions, corpus callosum and subcortical structures. Results also highlight the individual's auditory strengths and weaknesses, leading to the development of auditory subprofiles and deficit specific management plans (Bellis and Ferre, 1999).

There is general agreement in the literature that a behavioural CAPD test battery should include one test from four different categories designed to assess the different levels of the central auditory nervous system (Bellis, 1996; Chermak and Musiek, 1997; Hall and Mueller, 1997; Bellis and Ferre, 1999). The categories are *Dichotic Speech tests (one linguistically loaded and one with a low linguistic load), Temporal Patterning tests, Monaural Low-Redundancy Speech tests and Binaural Fusion tests.* For the purposes of this study the adult test protocol recommended by the RSA CAPD Taskforce (2001) was used. As the research project is part of a larger project to establish preliminary normative data the use of a standardised test battery recommended by the Taskforce is necessary to ensure constancy of the data collected.

The tracks on the SA CAPD low linguistically loaded compact disc will be discussed in detail and thereafter the adult test protocol as recommended by the Taskforce will be presented.

- *Dichotic Speech tests (Tracks 2 to 10)*

These tests involve the presentation of stimuli to both ears simultaneously, with the information presented to both ears being different (Bellis, 1996). *Dichotic Speech tests* are sensitive to disruption of interhemispheric transfer of information via the corpus callosum and to cortical and brainstem lesions (Bellis, 1996; Bellis and Ferre, 1999). Reduced performance for the ear contralateral to the lesion is expected, with a slight right ear advantage for normal listeners (Bellis, 1996).

Dichotic Digits have a low linguistic load and it is postulated will be easier for second language speakers compared to syllables. Track 3 List 1 on the CD consisting of *2-pair Dichotic Digits* were used in this study as it is more challenging than single digits while being easy for adults (Bellis, 1996). Research by Noffsinger et al. (1994) showed a 100% pass rate for young adults using dichotic single digit pairs. Wilson and Jaffe (1996) studied the effects of aging on the recognition of a hierarchical set of dichotic digits ranging in complexity form ear (1-paired digits) to difficult (4-paired digits). Results indicated a decrease in performance as the difficulty of the task increased from 1 to 4 digits for both the under 30 age group and the over 60 age group with performance in the older age group significantly poorer in all test conditions. Decrease in performance was greater in the left ear than the right ear in both age groups. Two digit pairs are thus challenging but easier for normal young adults than three or four digit pairs (Bellis, 1996).

- *Temporal Patterning tests (Track 11 left and right channels)*

The aim of these tests is to assess the listeners ability to perceive a pattern of auditory events occurring over time (Bellis and Ferre, 1999). Tests consist of the *Frequency Patterns test* and the *Duration Patterns test*. For the purpose of this study both the *Frequency Patterns* test *and the Duration Patterns* test will be used. The two tests are sensitive to different levels of the central auditory nervous system. The *Duration Patterns test* is sensitive to cerebral lesions while being unaffected by peripheral hearing loss if stimuli is presented at a frequency and intensity that can be perceived by the listener (Bellis, 1996; Hurley and Musiek, 1997). The *Duration Patterns test* assesses duration discrimination, temporal ordering and linguistic labelling (Bellis, 1996). The frequency of the tones presented is held constant while the listener is asked to discriminate the duration the three tones presented in sequence. Short (250msec) and long (500msec) tone burst are presented in sequences such as short-long-short and the listener is required to label the sequences (Bellis, 1996).

The *Frequency Patterns test* assesses the pattern perception and temporal sequencing abilities of the listener (Bellis, 1996). As with the *Duration Patterns test* the listener is required to label the frequency of three tone bursts, two of one frequency and one of another. Frequencies of 1,122Hz and 800Hz are utilised and the listener is required to discriminate whether the sequences are high or low tone with six patterns possible (Bellis, 1996). This test can be used to detect disorders of the cerebral hemispheres, although laterality information cannot be obtained (Musiek and Pienhiero, 1997 as cited by Bellis, 1996). If the listener is unable to verbally name the sequences the option of humming the sequence is available on both the duration and frequency patterns tests. The linguistic component is removed and research by Musiek et al. as cited by Bellis (1996) has shown that patients with disruptions in the interhemispheric transfer of information perform better on this version of the test. The tests are thus sensitive to corpus callosum dysfunction.

- *Monaural Low Redundancy Speech tests (Tracks 13-16)*

These tests assess the listeners ability to achieve closure and discriminate speech in the presence of a distorted speech signal. Monosyllabic words that have been distorted by either time compression, low or high pass filtering or time compression and reverberation, to reduce the extrinsic redundancy of the speech signal are used (Bellis, 1996). *Low-Pass Filtered Speech tests* are sensitive to brainstem and cortical lesions, while *Time Compressed Speech tests* can be used to assess diffuse pathology involving the primary auditory cortex. (Bellis, 1996; Bellis and Ferre, 1999).

Two tests from this category will be used in this study, namely, Track 13 -Right channel *(NU No. 6 45% Time Compressed)* and Track 15-Right channel *(List 3, NU No. 6 Low-Pass Filter)* will be used. Research by Wilson, Zizz and Sperry (1994) shows that the 65% compressed paradigm is difficult even for normal listeners. The *45% Time Compression* has a success rate of 90% for normal hearing adults with performance decreasing as compression levels increase, making it a clinically useful test. *Low Pass*

Filtering has been shown by researchers to be sensitive to various central disorders including brainstem and cortical dysfunction (Bellis, 1996). Research by Borstein et al. (1994) for normative data on the VA-CD indicates that optimal results (73,5%) are obtained at 1500Hz cut off for the low-pass condition and 2100Hz cut off for the high pass condition (73,5%). As the low linguistically loaded compact disc is derived from the VA-CD the same low-pass filtering condition applies to tests on the compact disc.

- *Binaural Fusion tests (Tracks 12, 15 and 16)*

These tests assess the ability of the central auditory nervous system to process disparate but complementary information presented to the two ears sequentially (Bellis, 1996; Bellis and Ferre, 1999). Interaction between the two ears is necessary to perceive the entire message. Apart from the *Masking Level Difference test* all other tests in this paradigm are only sensitive to gross brainstem pathology. Their clinical utility is thus limited (Bellis, 1996).

Track 12 (Spondaic Words SπNo MLD) will be used in this study as the *Masking Level Difference test* is highly sensitive to brainstem dysfunction (Bellis, 1996). The *Masking Level Difference test* is done by comparing the listeners signal threshold for different masking conditions (Bellis, 1996). A homophasic condition with the signal and noise in phase is compared to a antiphasic condition in which either the signal or noise in the two channels are 180 degrees out of phase (Wilson, Zizz and Sperry, 1994). Spondaic words were used in this study instead of pure tones as the masking level difference for speech is more sensitive than for pure tones (Bellis, 1996).

The Consonant-Vowel-Consonant (*CVC) Binaural Fusion test* (Track 16, left and right channels) was included in this test battery to establish preliminary normative data on a test that is easier to administer than the *Masking Level Difference test.*

The adult test protocol based on the recommendations of the RSA CAPD Taskforce thus included the:

- Two pair Dichotic Digit test (Track 3 and 4. left and right channel)
- Frequency Patterns test (Track 11, left channel) and the Duration Patterns test (Track 11, right channel)
- Low-Pass Filtered Speech test (Track 15 and 16, right channel) and 45% Time Compressed speech test (Track 13 and 14, right channel)
- CVC Binaural Fusion test (Track 15 and 16, left and right channels) and the Speech Masking Level Difference test (Track 12, left and right channels)

These tests were selected by the RSA CAPD Taskforce as they met the recommendations that tests from four categories need to be included in a central auditory processing test battery to ensure that all levels and processes of the central auditory nervous system are assessed (Bellis, 1996). More than one test per category was included as adults, who can concentrate for a longer timespan, were being assessed. The use of more test materials facilitates the collection of normative data on different test materials on the test battery.

3.7. DATA COLLECTION PROCEDURES

Procedures followed in conducting the study included a pilot study to familiarise the researcher with the testing procedures and to allow for any changes needed and the data collection procedures used for the main study.

3.7.1. Pilot Study

A pilot study performed using two participants. Each participant represented a research group namely English first language speakers (Research group 1) and English second language speakers (Research group 2) who met the required participants criteria discussed under section 3.4. The aims of the pilot study were:

- to ascertain the time required to complete the peripheral audiometric and central auditory processing battery protocol listed above.
- to ascertain whether testing should be done in one or two stages to account for possible factors such as fatigue in accordance with the participant feedback.
- to ensure that the researcher became aware of possible unfamiliar words that could affect test results. Participants in the actual study could then be familiarised with these words prior to testing if necessary.
- to familiarise the researcher with the data collection procedures such as instructions to the participants, audiometer settings and scoring to be used for each test in the protocol.

The pilot study was conducted using the same conditions and equipment used for the actual study.

3.7.1.1. Description of pilot study participants

Two participants, one aged 21 and representing Research group 1, and the other aged 36 representing Research group 2, were used in the pilot study. The educational level of the participants differed with one being a university student and the other having a grade 12 qualification. No medical contra-indications were reported by either participant.

3.7.1.2. Procedures of the pilot study

The participant selection procedures presented under section 3.4 and 3.5 were followed. The data collection procedures recommended by the RSA CAPD Taskforce and described under section 3.7.2. were followed. This was to ensure that the recommended procedures were viable and to make any changes if needed.

3.7.1.3. Results of the Pilot Study

The results of the pilot study discussed in terms of the above aims indicated that the time needed to complete the peripheral and central auditory testing protocol was approximately one hour. Feedback from the participants was for testing to be done in one stage as fatigue was not a factor and time constraints would not allow for students and staff to come back for further testing in a two stage procedure. No unfamiliar words were noted in the pilot study. The pilot study indicated that both participants experienced particular difficulty with the *Frequency Patterns test*. Both participants required additional familiarisation and the use of the 1000Hz and 750Hz tones on the audiometer as approximates for the high and low tones on the test before testing could proceed. This was done as both participants found the presentation of the test sequences very rapid and could not adequately distinguish the differences in the tones. The researcher presented a puretone at 1000Hz and 750Hz on the audiometer which approximated the 1,122Hz and 880Hz tones used in the test in sequence, this helped the participant in distinguishing the differences. This was incorporated into the researchers familiarisation and instructions to the participants in the data collection phase. Apart from this no changes in terms of instructions, audiometer settings and scoring were needed.

3.7.2. The Main Study

The following data collection procedures were utilised. These are based on recommendations of the RSA CAPD Taskforce (2001) and reinforced by the results of the pilot study. As the pilot study did not result in any changes to the test procedure and due to the small number of participants in each group the Statistics Department at the University of Pretoria recommended that the participants in the pilot study be included in the data analysis process of the main study.

3.7.2.1. Audiometer settings

The following audiometer settings were used:
'Tape 1' was set for the left ear and 'Tape 2' was set for the right ear on the AC 30 Interacoustic audiometer for all the tests in the protocol. Channel 1 on the compact disc corresponded to the left ear and Channel 2 to the right ear.

3.7.2.2. The test protocol and test administration procedures

The test protocol for adults and the test administration procedures recommended by the RSA CAPD Taskforce and followed in this study were:

- Dichotic Speech tests

Two pair Dichotic Digits test (Track 3, left and right channels)
Track 3 consists of 25, 2 pair dichotic digits stimuli, known as List 1. The audiometer was set so that the left channel information was routed to the left ear and the right channel information routed to the right ear of the participant. The test material was presented at 50dBSL (50dB above the participants speech reception threshold of the best ear). The participant was asked to repeat all four of the digits heard in both ears regardless of order. The first five test items were used as practice items with the test starting at test item 6. The participants responses for the right ear and left ear were recorded on the test scoring sheet (Appendix 3). The test was scored in terms of percentage correct with each item worth 2.5%.

- Temporal Patterning tests

Frequency Patterns test (Track 11, left channel)
Thirty frequency patterns sequences of the low frequency 880Hz and high frequency 1122Hz were presented to the participant in three sequence triads. The audiometer was

set at an intensity level of 50dBSL relative to the 1000Hz threshold of the particular test ear. Thirty sequences were presented first to the one ear and than to the other ear. The left channel was used, with the presentation set first for the left ear and then the right ear. The participant was asked to label the sequences heard in terms of frequencies i.e. high low, high etc. The second test condition in which the participant is asked to hum the sequence was done when the participant was unable to label the sequences. The first five items were used as practice items with the test beginning at test item 6. The test was scored in terms of percent correct per ear with each item worth 4%. The responses were recorded on the test result sheet (Appendix 4).

Duration Patterns test (Track 11, right channel)

Thirty duration patterns sequences comprising short (250msec) and long (500msec) tones were presented to the participant in triad sequences. The audiometer was set to 50dBSL relative to the 1000Hz threshold of the particular ear. The right channel was activated with the stimuli presented first to the left ear and then to the right ear. The participant was asked to label the duration response of each sequence, for example "short, short, long". The second test condition in which the participant is asked to hum the duration sequence was only to be used if the subject was unable to label. The first five test items were used for practice in order to familiarise the participant and testing began at test item 6. The test was scored in terms of percent correct per ear with each test item worth 4%. The participant responses will be recorded on the test result sheet (Appendix 5).

- Monaural Low Redundancy Speech tests

Low-Pass Filtered Speech test (Track 15, right channel)

Fifty monosyllabic words from List 3 of the North Western University Test number 6 were used for this test procedure. The audiometer was set at a 50dBSL intensity level relative to the spondee threshold of the particular ear. The right channel of the audiometer was activated with the presentation first to the left ear and then the right ear. The first five items of list 3 were used for training purposes for the left ear with the

testing beginning at test item six. Test items six to twenty five were recorded for the left ear. Practice items for the right ear were test items twenty six to thirty with testing beginning at test item thirty one to fifty. The participant was asked to repeat the words heard and to guess if they were unsure of any of the words. The test was scored in terms of percentage correct per ear with each test item worth 5%. Participant responses were recorded on the test result sheet (Appendix 6).

Forty five percent (45%) Time Compressed Speech test (Track, 13, right channel)
Fifty monosyllabic words from the North Western University list number 6 were used for this test. The audiometer was set at 50dBSL relative to the spondee threshold of the particular ear. The right channel was used with the stimuli presented first to the left ear and then to the right ear. The participant was requested to repeat the words heard and to guess the word if unsure. The first five items of the test were used as practice items for the left ear and items twenty six to thirty were used to train the right ear. The test was scored in terms of percent correct per ear with each item worth 5%. The participant responses were recorded on the test result sheet (Appendix 7).

- Binaural Fusion tests

Speech Masking Level Difference test (Track 12, left and right channels)
Testing was done in two conditions. Firstly a homophasic condition and then an antiphasic condition. Results were obtained by subtracting the scores from condition two from condition one. The participant was given a printed list of 10 spondee words (Appendix 8). Testing in the homophasic (SoNo) condition was done by routing the left channel of the compact disc to the left channel of the audiometer at 50dBSL relative to the speech reception threshold in the best ear, but set for both ears i.e. LR/LR. Only the left channel is activated. The participant was asked to repeat the words. Four words were automatically presented for each of the 16 signal-to-noise ratios, beginning at 0dBS/N. Testing continued until the participant failed to respond correctly to all words at two consecutive signal-to-noise ratios. Testing in the antiphasic (SπNo) condition was then

done by routing each channel of the compact disc to the corresponding channel of the audiometer at the same sensation level. Both channels were activated and testing continued until the participant failed to respond to all words at two consecutive signal-to-noise ratios. The final masking level difference was calculated by subtracting the SπNo threshold from the SoNo threshold. Results were recorded on the test result sheet (Appendix 9).

CVC Binaural Fusion test (Track 16, left and right channels)

Words containing consonant-vowel-consonant combinations from list 4 of the North Western University Test number six were used for this test. The audiometer was set at 50dBSL relative to the speech reception threshold of the best ear. The test consist of fifty items of which five items were use for training, the test therefore consists of 45 words. The words were presented simultaneously to both ears with the words of the left channel of the compact disc which are high pass, filtered to the left ear and words of the right channel of the compact disc which are low pass, filtered to the right ear. The participant was requested to repeat the words and to guess the word if unsure. The test was scored in terms of percentage correct per ear with each test item worth 2.2%. Responses were recorded on the test result sheet (Appendix 10).

3.8. DATA ANALYSIS PROCEDURES

Data was derived from the 64 ears that were tested using the selected central auditory processing protocol. The results of the two groups were compared to each other and to the USA normative data. As the data was collected from a small sample of subjects the Mann-Whitney *U* test and the SAS program, a computer based program was used to analyse and compare the data between the two research groups. The Mann-Whitney *U* test is used to compare two groups on a variable that is measured at ordinal level. The test focuses on differences in central location and makes the assumption that any difference in the distribution of the two populations are due to differences in locations rather than variability (Diamantopoulos and Schlegelmitch, 2000). The null hypothesis tested by the

Mann-Whitney *U* test is that there is no difference between the two groups in terms of location, focusing on the median as a measure of central tendency (Diamantopoulos and Schlegelmitch, 2000). The test can also be used to draw conclusions about means in the case of symmetrical distributions and given interval data as is the case with this research. Using the Mann-Whitney *U* test a significant difference between two groups is indicated by a score of <0,05% (Diamantopoulos and Schlegelmitch, 2000).

Data was analysed using the SAS computer program. The data was presented in terms of mean scores and standard deviations for each test. To derive a preliminary normative value the formula of two standard deviations below the mean was used (Bellis, 1996). Two standard deviations was selected as there was large variability in the samples for each of the tests (Bellis, 1996).

Descriptive analysis was be used to compare the data to the USA normative data. A direct comparison could not be made as there were differences in test materials used, data collection procedures and subject criteria.

3.9. VALIDITY AND RELIABILITY OF THE STUDY

Validity refers to the accuracy, meaningfulness and credibility of a study. It can be divided into internal and external validity (Leedy and Ormrod, 2001). The internal validity of a study refers to the extent to which its research design eliminates other possible explanations for the results that are obtained (Leedy and Ormrod, 2001). The internal validity of this research project was increased by controlling variables such as age, language, educational level, medical history and normal peripheral hearing for all participants. All participants had to fit these selection criteria to ensure that the internal validity of the study was not compromised. The participant criteria also enhances the reliability of the study as the study can be replicated using this criteria.

External validity refers to the extent to which the results of a study can be generalised to other contexts (Leedy and Ormrod, 2001). A way of ensuring external validity is to have a representative sample of participants. The participants selected for this research represented a representative sample of the two groups that formed the basis of the research. If the results of this study can be replicated by other researchers using the same methodology and different participant groups and arrive at the same conclusions the external validity of this research as well as its reliability will be enhanced (Leedy and Ormrod, 2001).

3.10. ETHICAL ISSUES IN THE STUDY

Ethical issues were initially addressed by submitting the Ethics form (Appendix 11) together with the research proposal to the Ethics Committee of the Department of Communication Pathology and the Faculty of Humanities before the commencement of the research.

Ethical considerations relating to issues of informed consent and right to privacy were addressed by means of a letter explaining the research, the strictly voluntary basis of participation and their right to withdraw at anytime as well as a guarantee of confidentiality (Appendix 2) (Leedy and Ormrod, 2001). The right to privacy was also adhered to by ensuring that none of the participants were named in the study, each was assigned a number for data analysis purposes (Leedy and Ormrod, 2001). Participants were not subjected to any harm during the testing procedure and were informed of the length of the procedure prior to testing to ensure that they were aware and comfortable with the testing process, and honesty with professional colleagues was addressed in this research by means of honest representation of all test procedures and data collected during the research (Leedy and Ormrod, 2001).

3.11 SUMMARY

The methodology used to conduct this research was presented in this section. The aims of the research project, the research design used, the participants and the criteria used to select them as well as the central auditory processing test battery that was used for data collection purposes is discussed in detail. This will facilitate any future attempt to replicate this study and will thus enhance its validity and reliability. Ethical considerations relating to the study are discussed.

CHAPTER 4: RESULTS AND DISCUSSION

4.1. INTRODUCTION

One of the primary aims of the RSA CAPD Taskforce is to develop central auditory processing test materials for all language and cultural groups in South Africa. This however is a long term project due to the complexities of the South African situation. As an interim measure before this can be developed it is hypothesised that the use of English low linguistically loaded test materials that decreases the linguistic load on second language English speakers will not adversely affect the results of different cultural and language groups and thus provide reliable data that could be used by audiologists working is South Africa in a accountable manner (RSA CAPD Taskforce, 2000).

In accordance with this hypothesis the RSA CAPD Taskforce received permission to rerecord 16 tracks from the Department of Veterans Affairs compact disc (Wilson, 2000). Volunteers and masters degree students from different areas and universities in South Africa are involved in collecting preliminary normative data on people of different language, cultural and age groups throughout South Africa. The results of this project will provide preliminary normative data for the "RSA low linguistically loaded central auditory test battery" that can be used as an interim measure for different language and cultural groups in South Africa. This research project forms part of this larger project to collect preliminary normative data on different cultural and language groups in South Africa.

The results of the study will be presented according to the formulated sub-aims, which are to determine and compare the performance of English first language (Research group 1) and second language (Research group 2) speakers on the "RSA low linguistically loaded central auditory processing test battery" and to compare the preliminary normative data obtained for the two groups with the USA normative data.

4.2. To determine and compare the performance of English first language (Research group 1) and English second language (Research group 2) speakers on the "RSA low linguistically loaded central auditory processing test battery".

The performance of English first language speakers (Research group 1) and English second language speakers (Research group 2) are presented in Tables 4.1 and 4.2. Tables 4.1 and 4.2 provide a overview of the test results for each of the CAPD tests for Research group 1 and Research group 2 in terms of the mean, standard deviation, score range, 2 standard deviation below the mean scores and the Mann-Whitney *U* test value that indicate whether significant differences between the groups exist. Table 4.1 focuses on the CAPD tests that test each ear separately and for which a score is obtained for each ear whereas Table 4.2 focuses on the CAPD tests that integrate the ears and for which one score is obtained.

The performance of the two research groups will be discussed in relation to each of the tests administered.

4.2.1. Dichotic Digits test

The mean scores obtained for the English first language speakers (Research group 1) was higher than the mean scores obtained for the English second language speakers (Research group 2). Right ear values were higher for both research groups, confirming the slight right ear advantage cited in the literature (Bellis, 1996). As seen in Table 4.1, a Mann-Whitney *U* score of 0,0333 for the right ear indicates a significant difference between the two research groups for this ear only. A *p*-value of less than 0,05 is indicative of a significant difference between groups.

Table 4.1. Results of CAPD tests that test each ear separately.

CAPD TEST	English first language speakers (Research group 1)	Right ear	Left ear	English second language speakers (research group 2)	Right ear	Left ear	Mann-Whitney *U* test-Right ear	Mann-Whitney *U* test-Left ear
Dichotic Digits test	Mean	91,56	85,00	Mean	86,67	80,31	***0,0333**	**0,0708**
	Standard Deviation	4,36	7,74	Standard Deviation	6,29	5,90		
	Score Range	85%- 100%	70%- 100%	Score Range	75%- 95%	70%- 90%		
	2 SD below the mean	82,84	69,52	2 SD below the mean	74,09	68,51		
Frequency Patterns test	Mean	68,50	69,25	Mean	68,25	64,75	**0.939**	**0,338**
	Standard Deviation	8,86	11,00	Standard Deviation	11,07	10,95		
	Score Range	56%- 92%	56%- 96%	Score Range	52%- 82%	48%- 88%		
	2 SD below the mean	50,78	47,25	2 SD below the mean	46,11	42,85		
Duration Patterns test	Mean	83,75	84,25	Mean	78,25	77,25	**0,1657**	**0,0811**
	Standard Deviation	10,47	9,73	Standard Deviation	12,47	13,20		
	Score Range	64%- 100%	64%- 100%	Score Range	60%- 100%	56%- 100%		
	2 SD below the mean	62,81	64,79	2 SD below the mean	53,31	50,85		
Low-Pass Filtered Speech test	Mean	77,50	75,31	Mean	76,87	77,18	**0,6978**	**0,3859**
	Standard Deviation	6,83	7,40	Standard Deviation	6,80	7,95		
	Score Range	60%- 90%	60%- 90%	Score Range	65%- 90%	60%- 90%		
	2 SD below the mean	63,84	60,51	2 SD below the mean	63,27	61,28		
Monaural Low Redundancy test	Mean	98,75	96,87	Mean	96,87	95,68	**0,1771**	**0,4747**
	Standard Deviation	2,23	4,42	Standard Deviation	4,03	4,78		
	Score Range	95%-100%	85%- 100%	Score Range	90%- 100%	85%- 100%		
	2 SD below the mean	94,29	88,03	2 SD below the mean	88,81	86,12		

*** = significant difference of less than 0,05**

Table 4.2. Results of CAPD tests that integrate both ears.

CAPD TEST	Test Scores	English first language speakers (Research group 1)	English second language speakers (Research group 2)	Mann-Whitney *U* Test
CVC Binaural Fusion test	Mean	99,43	98,25	**0,1525**
	Standard Deviation	1,20	2,48	
	Score Range	97%- 100%	93%-100%	
	2 SD below the mean	97,03	93,29	
SMLD- SoNo	Mean	52,81	53,67	**0,3630**
	Standard Deviation	4,18	5,46	
	Score Range	46-61	41-62	
	2 SD below the mean	44,45	42,75	
SLMD- SπNo	Mean	45,75	46,06	**0,9698**
	Standard Deviation	3,80	5,42	
	Score Range	41-52	36-57	
	2 SD below the mean	38,15	35,22	
SLMD	Mean	7,06	7,62	**0,4659**
	Standard Deviation	1,34	2.12	
	Score Range	5-9	5-12	
	2 SD below the mean	4,38	3,38	

As seen in Table 4.1, a analysis of the standard deviation indicates greater variability existed in Research group 1 for the left ear as compared to Research group 2 whereas greater variability existed for Research group 2 for the right ear. Two standard deviations below the mean was used to establish a normal cut-off point for the tests as the variability of the sample was large for most of the tests administered.

Table 4.1 shows that scores for Research group 1 ranged from 70% to 100% whereas scores ranged from 70% to 95% for Research group 2. Research group 1 performed slightly better on the *Dichotic Digits test*, however there was only a significant difference between the groups for the right ear as indicated by the Mann-Whitney *U* test which states that a p-value of less than 0.05 is indicative of a significant difference between groups (Table 4.1) (Diamantopoulos and Schlegelmilch, 2000).

A specific reason for the differences in the right ear values cannot be made as all participant criteria for the two groups was equivalent. Further research into this test with a greater sample of participants is necessary to establish conclusive normative data. Comparisons with other research being conducted under the RSA CAPD Taskforce auspices will also help in clarifying the results.

4.2.2 Frequency Patterns test

A analysis of the mean scores of both research groups indicate very little difference between the groups as seen in Table 4.1. The mean scores range from 64.75 to 69.25 for both research groups. These scores are relatively low compared to the scores obtained by the two research groups on the other tests presented as part of the test battery. The results confirm the difficulty that both research groups experienced with this test as discussed in Chapter 3 under section 3.7.1.3.

As seen in Table 4.1, the variability in the sample is reflected in the standard deviation scores for both research groups. Research group 1 scored slightly higher in terms of range of scores as compared to Research group 2. Maximum scores were higher for the left ear for both research groups. This could be attributed to the fact that the right hemisphere is attuned to music and art whereas the left hemisphere is largely responsible for speech. The Mann-Whitney *U* test scores are above 0.05 and indicate no significant difference between groups.

4.2.3. Duration Patterns test

As seen in Table 4.1, both research groups performed better on the *Duration Patterns test* than the *Frequency Patterns test* with mean scores for the *Duration Patterns test* better than for the *Frequency Patterns test.* The test was comparatively easier for both groups of subjects than the *Frequency Patterns test*. The Mann-Whitney *U* test shows no significant difference between the two research groups for the *Duration Patterns test.*

Standard deviation scores indicated greater variability for Research group 2. This however did not result in a significant difference between the groups as indicated by the Mann-Whitney *U* score which was greater than 0.05. Scores ranged from 64% to 100% for Research group 1 and 56% to 100% for Research group 2. These scores are better than that achieved for the *Frequency Patterns test* again showing that this test was easier for both research groups.

4.2.4 Low Pass Filtered Speech test

As seen in Table 4.1, the mean scores for the two research groups were very similar confirming the Mann-Whitney *U* test which showed no significant difference between the two research groups. The standard deviation scores were also very similar with the minimum and maximum scores ranging form 60% to 90% for both research groups.

The results indicate that proficiency in English is not a significant factor when low linguistically loaded speech materials are used. The results further indicate that the low linguistically loaded central auditory processing test battery can be used as an interim measure for second language English speakers in South Africa who have a good proficiency of the language.

4.2.5 Monaural Low Redundancy Speech test

Table 4.1 shows that mean scores for this test ranged above 90% for both research groups. The results indicate that this test was easy for both English first and second language speakers. The Mann-Whitney *U* test score indicated no significant differences between the groups.

Standard deviation for both groups was low, indicating very little variability in the research sample. Scores ranged from 85% to 100% for both research groups once again reflecting that both groups found the test easy. English as a second language does not appear to affect the results of Research group 2, indicating that this test can be used as part of a low linguistically loaded central auditory processing test battery in South Africa.

4.2.6. CVC Binaural Fusion test

As seen in Table 4.1, the mean scores ranged close to 100% for both research groups indicating that this test was very easy for both research groups. Standard deviation scores were very low reflecting the low variability in the samples. Scores ranged form 93% to 100% again reflecting the easy nature of this test. The Mann-Whitney *U* test scores showed no significant differences between the groups thus confirming the above results.

4.2.7. Speech Masking Level Difference test

Mean scores for this test were very similar for both research groups as shown in Table 4.2. Standard deviations were low indicating the low variability in the samples. Scores ranged from 5-12dB. The Mann-Whitney *U* test showed no significant difference between the groups, reflecting that both groups performed equally well on this test. Proficiency in English as a first language was again not a significant factor.

The preliminary normative data indicates no significant differences in any of the CAPD tests between the two groups except for the *Dichotic Digits test* for the right ear. The low linguistically loaded test battery appears to be a viable interim measure that can be used for second language English speakers, especially in view of the results of the low linguistically loaded speech tests which showed very comparable preliminary normative data.

4.3 To compare the normative data obtained for the two research groups with the USA normative data.

A direct comparison between the normative data collected in the USA and the preliminary normative data obtained for this study cannot be made due to factors such as the differences in data collection parameters used, the fact that not all normative data collected in the USA was collected using the Veterans Affairs compact disc and that the sample size on which the data was collected was not identical. The Veterans Affairs central auditory processing test battery is available in two editions *'Disc 1.0'* and *'Disc 2.0'* which do not contain exactly the same test materials. Taped versions of various tests on the Veterans Affairs compact disc, such as the NU-6 word lists are also available. The taped version of the NU-6 word list uses a male speaker whereas the compact disc version uses a female speaker. This difference can also affect the results and excludes a direct comparison.

The level of presentation used for establishing normative data on the compact disc version also differs. The USA normative data was collected at various intensity levels for the low-pass filtered speech tests, the monaural low redundancy tests and the speech masking level difference test (Bornstein et al. 1994; Wilson 1994; Wilson, et al. 1994). The presentation levels used for this study for the above tests was 50dBSL relative to the spondee threshold of the particular ear being tested or in the case of the speech masking level difference test relative to the spondee threshold of the better ear as recommended by the RSA CAPD Taskforce (2000). This difference excludes a direct comparison.

The normative data established for the various tests on the Veterans Affairs compact disc (VA-CD) *Disc 1.0* called the "compact disc trails" was collected on a total of 120 young normal hearing adults with a mean age of 23 years who were naive listeners (no audiology students) (Noffsinger, et al. 1994). A total of 120 listeners participated in all the "compact disc trails" however the participants were divided into smaller groups of varying sizes to establish normative data for the varying intensity levels at which most of the tests could be administered. This was done to control for familiarity with test materials (Noffsinger, et al. 1994). This study had a smaller sample of 32 young normal hearing adults with a mean age of 25 years. Participants were divided into two research groups of 16 participants each, and one of the research groups did not have English as a first language.

These factors as well as the American accent used on the low linguistically loaded compact disc also precludes a direct comparison. A qualitative comparison between the preliminary data obtained from the two research groups used in this study and the USA normative data will thus be made.

Normal cut-off values are usually determined to be 2 standard deviations below the mean (Bellis, 1996). The variability of the sample usually influences the choice of using a 1 or 2 standard deviation as a cut-off value. The choice of 2 standard deviations is influenced

by larger variability within the sample (Bellis, 1996). As most of the results obtained from the test battery used to collect the preliminary normative data in this study had a large variability within the sample, a cut-off of 2 standard deviations below the mean was used to establish the preliminary normative data for the two research groups (see Tables 4.1 and 4.2).

Normative data established by Bellis (1996) also uses a cut-off value of two standard deviations below the mean. The normative data established for the tests on the Veterans Affairs compact disc and presented in a series of articles for the Journal of the American Academy of Audiology (Volume 5, 1994) focuses on the mean and standard deviation scores and does not establish a cut-off value. Bellis (1996) in an analysis of the central auditory processing test battery establishes the cut-off value for these tests presented on the compact disc by using the formula of two standard deviations below the mean.

The preliminary normative data for the two research groups will be compared to the USA normative data in accordance with the presentation of tests on the central auditory processing test battery.

4.3.1 Dichotic Digits test

Preliminary normative data for the two research groups and the USA normative data is presented in Table 4.3. A discussion of the data follows:

Results indicate that the preliminary normative data for the two research groups were lower than the USA normative data. Research group 1 had slightly higher normative data as compared to research group 2 as shown in Table 4.3. Values for the right ear were better for both groups as compared to the left ear. Results for the left ear were closer for the two groups than the right ear. This confirms the Mann-Whitney *U* test cited in the

Table 4.3. Dichotic Digits test normative data

	Data Collection Parameters: Intensity Levels	**Normative Data-Right ear**	**Normative Data-Left ear**
English first language speakers (Research group 1)	50dBSL-relative to spondee threshold	mean:91,56%, SD:4,36% mean-2SD= **82,84%** **(2 SD below mean)**	mean:85,0%, SD:7,74% mean-2SD= **69,52%** **(2 SD below mean)**
English second language speakers (Research group 2)	50dBSL relative to spondee threshold	mean:86,67%, SD:6,29% mean-2SD= **74,09%** **(2SD below mean)**	mean:80,31%, SD:5,90% mean-2SD= **68,51%** **(2 SD below mean)**
USA normative data - Bellis (1996)	50dBSL relative to spondee threshold	**90%** **(2 SD below mean**	**90%** **(2 SD below mean)**
USA normative data- Noffsinger et.al. (1994)	Single dichotic digits at 50,60 and 70dBHL	94% **(1 SD below mean)**	94% **(1 SD below mean)**

preceding section 4.2.1 which indicates a significant difference between the groups for the right ear only. The results also confirm the slight right ear advantage as recorded in the literature. The lower scores could be a result of the accent as South Africans may not be as attuned to a foreign accent presented at a quick pace as on the test. The results need to be collated with other studies which form part of the broader study undertaken by the RSA CAPD Taskforce before normative data can be formulated. The results also confirm that normative data should be collected at individual clinics to ensure that the tests are reliable and valid (Bellis, 1996).

Normative values for adults as cited by Bellis (1996) using 2 standard deviations below the mean is 90% for both ears. Bellis (1996) however does not state if one or two digits were used in establishing this normative data or whether the taped or compact disc

version of the dichotic digits test was used. This makes a direct comparison with the preliminary normative data obtained from the two research groups difficult.

In the study by Noffsinger, Martinez and Wilson (1994) using the VA -CD *Tonal and Speech Materials for Auditory Perceptual Assessment, Disc 1.0,* to establish preliminary data for digits, sentences and nonsense syllables, the researchers used young adults who were asked to repeat single dichotic digit pairs presented at 50, 60 and 70dBHL. Results indicated that at all intensity levels all subjects scored 94% or better as shown in Table 4.3. A standard deviation of 1 below the mean was used. This result cannot be directly compared to the present study as single dichotic digits were used at different intensity levels. Further research could be done using similar parameters in the South African context in the future to establish normative data.

4.3.2. Frequency Patterns test

Table 4.4 provides a overview of the preliminary normative data for the two research groups and the USA normative data for the *Frequency Patterns test*.

Results show large differences between the preliminary normative data obtained for the two research groups as compared to the USA normative data. Apart from the right ear results for research group one all the values are below 50%. The data collection parameters were equivalent and cannot account for this difference. Results cannot be attributed to language as frequency patterns needed to be identified. The small participant base of 32 participants divided into two groups as used for the present study as compared to the 150 participants used for establishing the USA normative data established by Bellis (1996) and 120 participants used for establishing the normative data for the Veterans Affairs compact disc can account for the differences. Further research using a greater participant base and comparison with data collected from other studies in South Africa needs to be made to determine whether this test can be used reliably.

Table 4.4. Frequency Patterns test normative data

	Data Collection Parameters: Intensity Levels	**Normative Data- Right ear**	**Normative Data- Left ear**
English first language speakers (Research group 1)	50dBSL relative to 1000Hz pure tone threshold	mean:68,5%, SD:8,86% mean-2SD= **50,78%** **(2 SD below mean)**	mean:69,25%, SD:11,00% mean-2SD= **47,25%** **(2 SD below mean)**
English second language speakers (Research group 2)	50dBSL relative to 1000Hz pure tone threshold	mean:68,25%, SD:11,07% mean-2SD= **46,11%** **(2 SD below mean)**	mean:64,75%, SD:10,95% mean-2SD= **42,85%** **(2 SD below mean)**
USA normative data - Bellis (1996)	50dBSL relative to 1000Hz pure tone threshold	**80%** **(2 SD below mean)**	**80%** **(2 SD below mean)**
USA normative data- Musiek (1994)	40dBSPL 70dBSPL	**78%** **(1 SD below mean)** **78%** **(1 SD below mean)**	**78%** **(1 SD below mean)** **78%** **(1 SD below mean)**

Normative data for the VA-CD version of the *Frequency Patterns test* is 78% for young normal hearing adults (Musiek, 1994). Normative data collected by Bellis (1996) is in agreement with this with values of 80% for people of 12 years and older. Stimuli was presented at 50dBSL relative to the 1000Hz puretone threshold, which conformed to the criteria recommended by the RSA CAPD Taskforce and followed in the present study. Stimuli for the normative data collated for the VA-CD was presented via the speech channel of the audiometer at 40dBSPL and 70dBSPL to two groups consisting of 60 participants each at one of the intensity levels respectively. The level of presentation did not affect the test results with both groups performing equally well.

4.3.3. Duration Patterns test

Normative data is presented in Table 4.5. and will be discussed accordingly.

Table 4.5. Duration Patterns test normative data

	Data Collection Parameters: Intensity Levels	**Normative Data-Right ear**	**Normative Data-Left ear**
English first language speakers (Research group 1)	50dBSL relative to 1000Hz pure tone threshold	mean:83,75%, SD:10,47% mean-2SD= **62,81%** **(2 SD below mean)**	mean:84,25%, SD:9,73% mean-2SD= **64,79%** **(2 SD below mean)**
English second language speakers (Research group 2)	50dBSL relative to 1000Hz pure tone threshold	mean: 78,25%, SD:12,47% mean-2SD= **53,51%** **(2 SD below mean)**	mean:77,25%, SD;13,20% mean-2SD= **50,85%** **(2 SD below mean)**
USA normative data-Musiek (1994)	40dBSPL 70dBSPL	**73%** **(1 SD below mean)** **73%** **(1 SD below mean)**	**73%** **(1 SD below mean)** **73%** **(1 SD below mean)**

Results for the two South African research groups show values that are better than those for the *Frequency Patterns test* as discussed in the previous section, confirming that participants found this test easier. Results are however still below those obtained for the USA normative data, although different data collection parameters were utilised. As with the *Frequency Patterns test*, the normative data for the VA-CD was collected using two groups consisting of 60 participants each at intensity levels of 40dBSPL and 70dBSPL respectively. The level of presentation did not affect performance as the results were same for both groups(Table 4.5).

One of the factors that could have affected the results is the small number of participants used in the present study. The USA study by Musiek (1994) was conducted on 120 normal hearing adults whereas this study used 32 participants. Further research using a greater participant base is necessary before normative data is formulated.

4.3.4. Low -Pass Filtered Speech test

Table 4.6 provides a overview of the preliminary normative data for the two South African research groups used in this study and the USA normative data.

Table 4.6. Low-Pass Filtered Speech test normative data

	Data Collection Parameters: Intensity Levels	**Normative Data- Right ear**	**Normative Data- Left ear**
English first language speakers (Research group 1)	50dBSL relative to spondee threshold, 1500Hz cut-off	mean: 77,5%, SD:6,83% mean-2SD= **63,84%** **(2 SD below mean)**	mean:75,31%, SD:7,40% mean-2SD= **60,51%** **(2 SD below mean)**
English second language speakers (Research group 2)	50dBSL relative to spondee threshold, 1500Hz cut-off	mean:76,87%, SD:6,8% mean-2SD= **63,27%** **(2 SD below mean)**	mean:77,18%, SD;7,95% mean-2SD= **61,28%** **(2 SD below mean)**
USA normative data - Bellis (1996)	50dBHL, 1000Hz cut-off, tape version	**78%** **(2 SD below mean)**	**78%** **(2 SD below mean)**
USA normative data- Bornstein et al. (1994)	65dBHL, 1500Hz cut-off	mean: 66,5%, SD of 8,5%	mean: 66,5%, SD of 8,5%

Results of this study on the *Low-Pass Filtered Speech test* show preliminary normative data of 60% and greater for both research groups. In comparing the mean scores of the two research groups and the normative data established by Bornstein et al. (1994) the results are better than those obtained by Bornstein et al. (1994) using the VA-CD at a presentation level of 65dBHL as seen in Table 4.6. The study by Bornstein et al. (1994)

did not convert the results using a one or two standard deviation cut-off value and together with the differences in presentation levels the results cannot be compared directly. The results indicate that accent and language did not affect the results of the two research groups adversely indicating that the test could be used as a part of a low linguistically loaded central auditory processing battery if results collated by the RSA CAPD Taskforce from other researchers prove comparable.

Normative data collected by Bellis (1996) using the Auditec magnetic tape version of the 1000Hz cut-off, low pass filtered NU-6 words at a presentation level of 50dBHL showed values of 78% for participants of 12 years to adult as seen in Table 4.6. If a score using two standard deviation from the mean is calculated for the Bornstein et al. (1994) data a score of 49,5% is obtained. These scores are thus better than those obtained from the Borstein et al. (1994) study which uses the compact disc version of the test s with a presentation level of 65dBHL with Bellis (1996) indicating that a primary difference between the two versions of the NU-6 lists is that the compact disc version uses a female speaker whereas the taped version uses a male speaker. The importance of collecting clinic specific normative data is also highlighted.

Results of the two research groups are thus closer to the Bellis (1996) normative data although different versions of the test were used. This once again highlights the importance of developing appropriate normative data.

4.3.5. Monaural Low-Redundancy test

Preliminary normative data for English first and second language speakers and the USA normative data is presented in Table 4.7

Results for Research group 1 is better than the USA normative data for the right ear only with all the other preliminary normative data for the two research groups very similar to the USA normative data as seen in Table 4.7. Presentation levels of 50dBSL relative to

the spondee thresholds were used as recommended by the RSA CAPD Taskforce for this study whereas a steady presentation at 55dBHL was used in the USA normative study. Presentation by a female speaker with a foreign accent did not thus affect the results. Results need to be compared to other studies but preliminary it would appear that this test could be used as a interim measure in South Africa.

Table 4.7. Monaural Low-Redundancy test-45% Time Compressed test normative data

	Data Collection Parameters: Intensity Levels	**Normative Data-Right ear**	**Normative Data-Left ear**
English first language speakers (Research group 1)	50dBSL relative to spondee threshold	mean:98,75%, SD:2,23% mean-2SD= **94,29%** **(2 SD below mean)**	mean:96,87%, SD:4,42% mean-2SD= **88,03%** **(2 SD below mean)**
English second language speakers (Research group 2)	50dBSL relative to spondee threshold	mean:96,87%, SD:4,03% mean-2SD= **88,81%** **(2 SD below mean)**	mean:95,68%, SD:4,78% mean-2SD= **86,12%** **(2 SD below mean)**
USA normative data - Wilson et al. (1994)	55dBHL	mean:94,9%, SD:4,2% mean-2SD= **86,5%** **(2 SD below mean)**	mean:94,9%, SD:4,2% mean-2SD= **86,5%** **(2 SD below mean)**

4.3.6. CVC Binaural Fusion test

Table 4.8 highlights the preliminary normative data for the two South African research groups and the normative data collected in the USA for this test.

Table 4.8. CVC Binaural Fusion test normative data

	Data Collection Parameters: Intensity Levels	**Normative Data**
English first language speakers: (Research group 1)	50dBSL relative to spondee threshold	mean: 99,43% SD: 1,20% mean-2SD= **97,03%** **(2 SD below mean)**
English second language speakers: (Research group 2)	50dBSL relative to spondee threshold	mean: 98,25% SD: 2,48% mean-2SD= 93,29% **(2 SD below mean)**
USA normative data-Wilson (1994)	30dBHL	mean: 95,2% SD; 3,9% mean-2SD= **87,4%** **(2 SD below mean)**

Data collected from this study at a presentation level of 50dBSL relative to the spondee threshold shows preliminary normative data for both Research groups 1 and 2 to be above 90%. The results highlight that language does not play a significant part in the performance by second language speakers with good proficiency in English on the low linguistically loaded central auditory processing test battery. Results also confirm that this test is generally very simple for most people.

Normative data collected by Wilson (1994) using 20 participants at 30dBHL indicates a mean score of 95,2% with a standard deviation of 3,9% as seen in Table 4.8. Bellis (1996) using this data and the formula of 2SD below the mean derives a cut-off of 87.4% at a presentation level of 30dBHL for young normal hearing adults. The difference in the levels of presentation could account for the differences in the normative values as presentation at a comfortable level would make the test easier for the participants in this study.

4.3.7. Speech Masking Level Difference test

Preliminary normative data for this test is presented in Table 4.9

Table 4.9. Speech Masking Level Difference test normative data

	Data Collection Parameters: Intensity Levels	Normative Data
English first language speakers (Research group 1)	50dBSL relative to spondee threshold	7,06dB with a standard deviation of 1,3dB
English second language speakers (Research group 2)	50dBSL relative to spondee threshold	7,62dB with a standard deviation of 2,1dB
USA normative data- Wilson et al. (1994)	65dBSPL=45dBHL 85dBSPL=65dBHL	7,8dB with a standard deviation of 2,1dB 8,8dB with a standard deviation of2,7dB

This study using presentation levels of 50dBSL above spondee thresholds showed mean a score of 7.06dB with minimum scores of 5dB and maximum scores of 9dB for research group 1 with a standard deviation of 1,3dB. Result of research group 2 were very similar with a mean score of 7.62dB and minimum and maximum scores of 5dB and 12dB respectively (Tables 4.1 and 4.2).

Normative data collected by Wilson, Zizz and Sperry (1994) using the Veterans Affairs compact disc showed mean masking level difference values of 7.8dB and 8.8dB for presentation levels of 65dBSPL and 85dBSPL respectively. They found that 90% of listeners had MLDs of 5.5dB or better and suggested that MLDs smaller than 5.5dB be considered as abnormal for normal hearing listeners. The minimum MLD`s obtained for this study were thus slightly lower than those obtained by Wilson et al. (1994) but, as more than 90% of participants had scores greater than 5dB, results are comparable. Presentation levels for the two studies were different but results obtained were comparable indicating that this test is a viable option that can be used in a low linguistically loaded CAPD test battery.

A comparison of the normative data obtained using the *Tonal and Speech Materials for Auditory Perceptual Assessment* compact disc and the preliminary normative data obtained for the two research groups used in this study using the SA low linguistically loaded compact disc show very comparable data for all tests excluding the *Frequency Patterns test*. Further data collection is needed to see of this test can be used reliably in South Africa.

The preliminary results obtained from this study and the comparison with the USA normative data highlights the importance of developing normative data for each clinic and setting where the central auditory processing test battery will be administered. The effects of data collection parameters, audiometer settings, the quality and type of CAPD test materials used all affect the data obtained at a particular clinic. The use of a standardised test battery helps in controlling these parameters but the need for clinic specific normative data is not eliminated.

4.4. CONCLUSIONS

A analysis of the performance of the English first and second language speakers on the low linguistically loaded central auditory processing test battery using the Mann-Whitney *U* test indicated no significant difference between the two research groups on any of the tests utilised apart from the results of the right ear for the *Dichotic Digits test*. Language did not pose a insurmountable obstacle in the performance of the second language group on any of the tests using low linguistically loaded stimuli with the results of both research groups being very similar. The use of a foreign accent may have affected the results slightly but performance was generally equal for both research groups. Both groups performed poorly on the *Frequency Patterns test* which does not rely on speech stimuli. Further research is necessary using this test before it can be included in a CAPD test battery for South African populations.

A qualitative comparison between the preliminary normative data obtained for the two research groups and the USA normative data indicates higher USA normative values for the *Dichotic Digits test*, the *Frequency Patterns test* and the *Duration Patterns test*, with normative values very similar for the other tests in the CAPD test battery. The USA data was collected on a much greater number of participants and with different collection parameters and a direct comparison cannot be made. However the fact that the South African research groups did well on tests with speech stimuli is encouraging and points to language not being a significant factor with second language speakers who are proficient in English. The need for collecting clinic specific normative data is also highlighted by the research.

4.5. SUMMARY

This chapter analysed the performance of adult English first and second language speakers on the "RSA CAPD low linguistically loaded test battery" in terms of developing preliminary normative data and noted any significant differences between the two research groups. Encouragingly, apart from the results of the right ear for the *Dichotic Digits test,* no significant differences were noted between the two groups. The results were especially encouraging in that performance on tests with low linguistically loaded speech stimuli such as the *Monaural Low Redundancy test* results of the two groups were very similar. These results point to low linguistically loaded test battery being a viable option as an interim measure for South Africans with a good proficiency in English until tests in all 11 languages can be developed.

A qualitative comparison with the USA normative data also shows very favourable results for tests with a low linguistically loaded speech content. Performance was generally poorer for the South African research groups on tests involving tonal stimuli such as the *Frequency and Duration patterns tests*. Further research is necessary using a greater number of participants to get conclusive normative data for these tests.

The results of this comparison highlight the need to develop clinic specific normative data as a standardised test battery while controlling for parameters such audiometer settings and the quality of the test material in the case of the compact disc, cannot control for all variables, especially the human variable. This includes both procedural variables such as equipment calibration and participant variables such as age, attention span, intelligence and linguistic ability.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.1. INTRODUCTION

Central auditory processing plays a crucial role in the academic development of children and adults. The lack of training of South African audiologists in identifying, diagnosing and treating central auditory processing disorders as well as the difficulties involved in working in the area of central auditory processing disorders in South Africa led to the formulation of the RSA CAPD Taskforce. One of the main aims of the Taskforce is to develop and standardise CAPD screening and diagnostic procedures and protocols for South Africa (RSA CAPD Taskforce, 2000). Due to the complexities and long term nature of developing CAPD test materials in all 11 official languages the Taskforce received permission from the 'Veterans Affairs' in the USA to rerecord 16 tracks of the *Tonal and Speech Materials for Auditory Perception Assessment Disc 2.0* compact disc (Wilson, 2000). The 16 tracks form the "RSA low linguistically loaded central auditory processing test battery". This test material is seen as an interim measure until test materials for the South African context can be developed.

Normative data needs to be collected for this central auditory processing test battery to ascertain whether it can be used reliably on all ages and population groups in South Africa. It is hypothesised that the use of stimuli with a light linguistic load such as digits and words will not detrimentally affect the results of South Africans whose first language is not English but who are competent second language English speakers.

This study aimed to ascertain the performance of adult English first and second language speakers on the low linguistically loaded test battery and to develop preliminary normative data for the research groups being tested. This was then compared to the USA normative data collected for the VA-CD and other available USA normative data to determine whether the low linguistically loaded test battery is a viable option that can be

used by audiologists in South Africa in a reliable manner. The collection of normative data will assist audiologists in using the test battery accountably.

5.2 CONCLUSIONS DERIVED FROM THE STUDY

The conclusions derived from the study will be discussed in relation to the formulated sub-aims, namely to determine and compare the performance of English first language (Research group 1) and second language (Research group 2) speakers on the low linguistically loaded RSA central auditory processing test battery and to compare the normative data obtained for the two groups with the USA normative data.

5.2.1. Conclusions relating to the performance of English first language (Research group 1) and second language (Research group 2) speakers on the "RSA low linguistically loaded central auditory processing test battery".

The results of the study indicated that language thus did not play an insurmountable part in the performance of English second language speakers on the low linguistically loaded central auditory processing test battery. The results of English first language speakers were slightly better on all of the tests but analysis using the Mann-Whitney *U* test which notes a significant difference between groups indicated a significant difference between the performance of the groups on the results of the right ear of the *Dichotic Digits test* only.

Both research groups found the *Frequency Patterns test* especially difficult. This test does not involve speech stimuli and requires the participant to differentiate between tones. Both groups performed better on the *Duration Patterns test*. On tests involving speech stimuli such as the *Monaural Low Redundancy tests*, the *Low-Pass Filtered Speech test*, the *CVC Binaural Fusion test* and the *Masking Level Difference test* both groups scored well. These results point to the possibility that stimuli with a low linguistic load can be used for English adult second language speakers who have a good

competence in English. The results indicate that factors such as a foreign accent may have affected the results but did not hamper the performance of either research group significantly in relation to one another.

5.2.2. Conclusions regarding the comparison of the normative data obtained from the two groups to the USA normative data.

A qualitative comparison between the normative data obtained from the South African research groups and the USA normative data showed higher normative values were obtained in the USA for tests such as the *Dichotic Digits test*, the *Frequency Patterns test* and the *Duration Patterns test*. Performance on the other tests involving speech stimuli were very similar and better in the case of the *Monaural Low Redundancy test*. These results also point to the low linguistic central auditory processing test battery being a possible interim measure that can be used by audiologists in South Africa until appropriate test materials are developed for the country.

The USA normative data was collected on a larger participant base and at different collection parameters for some tests. This can affect the results obtained in the study. However the results of the comparison encouragingly points to language or accent not being a major factor affecting the performance of South African English first or second language speakers as the results of the two research groups were very similar.

5.3. IMPLICATIONS OF THE FINDINGS

The preliminary normative data obtained from this research indicates that the "RSA low linguistically loaded central auditory processing test battery" can be used as an interim measure by audiologists in South Africa on adult English first and second language speakers until appropriate CAPD test materials are developed in all 11 official languages. The results indicate that further research is necessary into the *Frequency Patterns tests*

and the *Duration Patterns test* as the performance of both research groups on these tests was below the USA normative standard.

The preliminary normative data collected needs to be collated with other research aimed at collecting normative data using this test battery, this can then be used by audiologists in South Africa when testing patients using the test battery. The collection of clinic specific normative data is stressed by the findings and as results can depend on different variables that cannot all be controlled by the standardised test battery.

5.4 CRITICAL EVALUATION OF THE RESEARCH

It is important to note that English second language speakers needed a good comprehension of English as a criteria for participation in this study. The vast majority of the South African population do not have this degree of proficiency in English and this will preclude using the test battery. This makes the compilation of test material in the official languages a necessity.

The results of this research indicate that the participants did not do well on the *Frequency Patterns test*. Only one condition of this test was applied due to test time constraint. The performance of the participants using the humming condition that excludes the verbal component was not assessed. This would remove the linguistic component and provide information on the interhemispheric transfer of information. This can be a area of further research.

Participants performed well on all tests using speech stimuli. The compilation of data followed the RSA CAPD Taskforce protocol and indicates that participants were comfortable with the recommended data collection parameters. This is important as it will lead to uniformity in data collection across clinics in the country if the test battery is used by audiologists. This will make interclinic data comparison possible and facilitate the setting up of normative data using larger groups of participants.

This research project used a small number of participants. Results may have been improved if a larger participant base was used. This can be a area of further research. A larger participant base will improve the validity and reliability of normative data collected.

5.5 RECOMMENDATIONS FOR FURTHER RESEARCH

Areas of further research that can be addressed from this research project are:

- further research into the *Frequency and Duration Patterns tests*. Results of both these tests were poor when compared to the results obtained from participants on other tests in the test battery. Further research could include having a greater number of participants and focusing on these tests using both the labelling and humming options.

- the effect of dialect and regional differences on the performance of English first language speakers on the SA low linguistically loaded central auditory processing test battery.

- The performance of people with a common first language such as Tswana, Afrikaans on the low linguistically loaded central auditory processing test battery

5.6. CONCLUSION

This study provided valuable data on the performance of adult South Africans on the "RSA CAPD low linguistically loaded test battery". The similarity in the results of the two research groups indicate that test materials with a low linguistic load would be appropriate to use as an interim measure for South Africans whose first language is not English but who are competent second language speakers. Apart from certain tests both the English first and second language research groups scored well on the test battery. Further research is necessary into the *Frequency and Duration Patterns tests* as

participants did not score as well on these tests when compared to their scores on the other tests in the test battery.

The results of this study need to be integrated with other studies being conducted in South Africa using the SA CAPD low linguistically loaded test battery in order to establish normative data for different age, cultural and language groups in South Africa. The need for audiologists to establish their own clinic specific normative data on the SA CAPD low linguistically loaded test battery is recommended as these results are an interim measure that can be used until appropriate test materials are developed for the South African population.

The field of central auditory processing disorders in South Africa is still in its infancy. With the formation of the RSA CAPD Taskforce (RSA CAPD Taskforce, 2000) impetus was given to further research in this field as well as assist audiologists who previously had no guidelines as the assessment and management of central auditory processing disorders. The compilation of the "RSA CAPD low linguistically loaded test battery" and the normative data that is currently being compiled on children and adults will provide audiologists in South Africa with an interim assessment tool until appropriate CAPD test materials can be developed in South Africa. For this to happen commitment is required from the Professional Board of Speech Therapy and Audiology in South Africa as ultimately they are the driving force for the profession as a whole.

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Appendix 1

NAME: _____

AGE: _____ **SEX:** **M** **F**

HIGHEST LEVEL OF EDUCATION: (Please tick)

Grade 10
Grade 12
College
University

ENGLISH LANGUAGE PROFICIENCY: (Please tick)

First language _____

Second language _____

What is your home languae? _____

MEDICAL HISTORY:

Do you have a history of:	**Yes**	**No**
ear infections when young?		
ear infections now?		
difficulty in hearing? if yes, where? in background noise		
trauma to the head?		
epileptic seizures?		
motor vehicle accident?		
Are you on any medication?		

Appendix 2

University of Pretoria
Pretoria 0002 Republic of South Africa Tel (012) 4202357/4202816
Fax (012) 420-3517 http://www.up.ac.za

Department of Communication Pathology
Speech, Voice and Hearing Clinic

To: The Participant

I am a Masters student at the Department of Communication Pathology at the University of Pretoria. I am also working at the Speech Therapy Department at Ga-Rankuwa Hospital. As part of my degree requirements I am conducting research with the aim of establishing normative data for English first and second language speakers on a low linguistically loaded central auditory processing test battery.

Central auditory processing disorders can have detrimental effects on the individuals academic and future work prospects. It involves the ability to localise, discriminate and process acoustic stimuli. In South Africa we need to establish normative data on a representative normal young adult population of English first and second language speakers before the test material can be used effectively.

Your participation in this study will assist in collecting this data. All tests results will be strictly confidential. The testing will take approximately forty five minutes and will include a hearing test as well as the battery of central auditory processing tests in which you will be asked to listen and repeat speech and tonal stimuli (tones, digits and words) that you will hear through the earphones. Participation is entirely voluntary and you can to withdraw from the study at any time so you wish.

Testing will take place at the Speech Therapy Department situated on the third floor of the Health Sciences Building, Medunsa, at a time suitable to you. If you would like to be informed of the results you are welcome to contact me.

Your participation is highly appreciated.

Thank you

Safia Saleh
(Student)

Mrs N.G. Campbell
(Tutor)

I, ---------- hereby provide written and informed consent to partake in the above study.

Signature

Date

Appendix 3

Two pair dichotic digit test

(Tracks 3 and 4, left and right channel)

Attention: CAPD Taskforce

Fax: 012-3481511

Name of Audiologist:_____

Initials of subject (e.g.: R.S.):_____

Date of birth:_____

Gender of subject:_____

Comments:_____

Test item	Left channel	Right channel
1.	4___ 3___ Practice item	1___ 6___ Practice item
2.	3___ 1___ Practice item	9___ 10___ Practice item
3.	9___ 6___ Practice item	1___ 5___ Practice item
4.	2___ 10___ Practice item	4___ 8___ Practice item
5.	4___ 8___ Practice item	6___ 9___ Practice item
6.	9___ 1___	10___ 2___
7.	2___ 4___	9___ 10___
8.	1___ 9___	8___ 6___
9.	2___ 4___	3___ 9___
10.	1___ 4___	10___ 5___
11.	2___ 5___	1___ 3___
12.	4___ 5___	2___ 6___
13.	3___ 10___	5___ 6___
14.	4___ 1___	9___ 5___
15.	4___ 5___	3___ 8___
16.	9___ 5___	4___ 1___
17.	4___ 5___	10___ 2___
18.	9___ 8___	3___ 4___
19.	9___ 10___	8___ 5___
20.	8___ 6___	4___ 1___
21.	6___ 8___	10___ 2___
22.	9___ 1___	2___ 8___
23.	6___ 9___	3___ 1___
24.	1___ 2___	3___ 9___
25.	5___ 3___	2___ 1___
Total:	___/20 _____%	___/20 _____%

Appendix 4

Frequency pattern test
(Track 11, left channel)
Test condition 1: Labelling

Attention: CAPD Taskforce
Fax: 012-3481511

Name of Audiologist: _____
Initials of subject (e.g.: R.S): _____
Date of birth: _____
Gender of subject: _____
Comments: _____

Test item	Left ear	Right ear	Any comments
1.	LLH (Low Low High) Practice item	LLH (Low Low High) Practice item	
2.	LHH Practice item	LHH Practice item	
3.	HLL Practice item	HLL Practice item	
4.	HHL Practice item	HHL Practice item	
5.	HLH Practice item	HLH Practice item	
6.	LHL	LHL	
7.	LHH	LHH	
8.	LLH	HHL	
9.	HHL	HLH	
10.	HLH	LHL	
11.	LHL	HLL	
12.	HLL	HHL	
13.	HHL	HHL	
14.	LHL	LHL	
15.	HLH	HLH	
16.	LHH	LHH	
17.	HLL	HLL	
18.	LLH	LLH	
19.	HHL	HHL	
20.	LLH	LLH	
21.	LHL	LHL	
22.	HLH	HLH	
23.	LHH	LHH	
24.	HLL	HLL	
25.	LLH	LLH	
26.	HLL	HLL	
27.	LHL	LHL	
28.	LHH	LHH	
29.	HHL	HHL	
30.	HLH	HLH	
Total:	___/25 _____%	___/25 _____%	

Appendix 5

Duration pattern test
(Track 11, right channel)
Test condition 1: Labelling

Attention: CAPD Taskforce
Fax: 012-3481511

Name of Audiologist: _____
Initials of subject (e.g.: R.S): _____
Date of birth: _____
Gender of subject: _____
Comments: _____

Test item	Left ear	Right ear	Comments
1.	LLS (Long Long,Short) Practice item	LLS (Long Long,Short) Practice item	
2.	LSS Practice item	LSS Practice item	
3.	SLL Practice item	SLL Practice item	
4.	SSL Practice item	SSL Practice item	
5.	SLS Practice item	SLS Practice item	
6.	LSL	LSL	
7.	LSS	LSS	
8.	LLS	LLS	
9.	SSL	SSL	
10.	SLS	SLS	
11.	LSL	LSL	
12.	SLL	SLL	
13.	SSL	SSL	
14.	LSL	LSL	
15.	SLS	SLS	
16.	LSS	LSS	
17.	SLL	SLL	
18.	LLS	LLS	
19.	SSL	SSL	
20.	LLS	LLS	
21.	LSL	LSL	
22.	SLS	SLS	
23.	LSS	LSS	
24.	SLL	SLL	
25.	LLS	LLS	
26.	SLL	SLL	
27.	LHL	LHL	
28.	LSS	LSS	
29.	SSL	SSL	
30.	SLS	SLS	
Total:	___/25 _____%	___/25 _____%	

Appendix 6

Low pass filtered speech test
(Track 15, right channel)

Attention: CAPD Taskforce
Fax: 012-3481511

Name of Audiologist: _____
Initials of subject (e.g.: R.S) : _____
Date of birth: _____
Gender of subject: _____
Comments: _____

Test item	Left ear	Test item	Right ear	Any comments
1.	Youth Practice item	26.	Wine Practice item	
2.	Mouse Practice item	27.	Cool Practice item	
3.	Lid Practice item	28.	Ditch Practice item	
4.	Pole Practice item	29.	Bar Practice item	
5.	Beg Practice item	30.	Mess Practice item	
6.	Hire	31.	Dodge	
7.	Pearl	32.	Cheek	
8.	When	33.	Five	
9.	Soup	34.	Team	
10.	Pain	35.	Search	
11.	Shell	36.	Seize	
12.	Cab	37.	Gun	
13.	Tell	38.	Cause	
14.	Note	39.	Good	
15.	Germ	40.	Void	
16.	Base	41.	Phone	
17.	Talk	42.	Half	
18.	Walk	43.	Date	
19.	Luck	44.	Mop	
20.	Road	45.	Jug	
21.	Name	46.	Late	
22.	Sheep	47.	Ring	
23.	Rush	48.	Life	
24.	Chat	49.	Rat	
25.	Thin	50.	Hit	
Total:	___/20 _____%		___/20 _____%	

Appendix 7

45% Time-compressed speech
(Track 13 , right channel)

Attention: CAPD Taskforce
Fax: 012-3481511

Name of Audiologist: _____
Initials of subject (e.g.: R.S) : _____
Date of birth: _____
Gender of subject: _____
Comments: _____

Test item	Left ear	Test item	Right ear	Any comments
1.	Hall Practice item	26.	Match Practice item	
2.	Shirt Practice item	27.	Chair Practice item	
3.	Rough Practice item	28.	Bought Practice item	
4.	Vote Practice item	29.	Thought Practice item	
5.	Dip Practice item	30.	Gaze Practice item	
6.	Join	31.	Voice	
7.	Peg	32.	Rot	
8.	Neat	33.	Shack	
9.	Wheat	34.	Pike	
10.	Get	35.	Merge	
11.	Doll	36.	Numb	
12.	Chat	37.	Keep	
13.	Hire	38.	White	
14.	Bar	39.	Said	
15.	When	40.	Room	
16.	Rat	41.	Which	
17.	Five	42.	Moon	
18.	Team	43.	Hurl	
19.	Germ	44.	Raid	
20.	Ring	45.	Jar	
21.	Talk	46.	Met	
22.	Date	47.	Take	
23.	Youth	48.	Shout	
24.	Far	49.	Pool	
25.	Deep	50.	Boat	
Total:	___/20 _____%		___/20 _____%	

Appendix 8

Word list for the Speech Masking Level Difference Test:

1. Mushroom
2. Armchair
3. Northwest
4. Oatmeal
5. Toothbrush
6. Sidewalk
7. Headlight
8. Hotdog
9. Inkwell
10. Horseshoe

Speech Masking Level Difference Test (Track 12)

Attention: CAPD TF
Fax: 012-3481511

Name of Audiologist: _____
Initials of subject (e.g.: R.S): _____
Date of birth: _____
Gender of subject: _____
Comments: _____

0dB S/N Ratio	**-8dB S/N Ratio**	**-16dB S/N Ratio**	**-24dB S/N Ratio**
1. Horseshoe	17. Headlight	33. Armchair	49. Horseshoe
2. Mushroom	18. Sidewalk	34. Hotdog	50. Hotdog
3. Northwest	19. Hotdog	35. Oatmeal	51. Oatmeal
4. Toothbrush	20. Inkwell	36. Armchair	52. Armchair
-2dB S/N Ratio	**-10dB S/N Ratio**	**-18dB S/N Ratio**	**-26dB S/N Ratio**
5. Sidewalk	21. Sidewalk	37. Sidewalk	53. Mushroom
6. Inkwell	22. Hotdog	38. Inkwell	54. Horseshoe
7. Oatmeal	23. Mushroom	39. Headlight	55. Hotdog
8. Hotdog	24. Oatmeal	40. Northwest	56. Toothbrush
-4dB S/N Ratio	**-12dB S/N Ratio**	**-20dB S/N Ratio**	**-28dB S/N Ratio**
9. Headlight	25. Armchair	41. Headlight	57. Sidewalk
10. Armchair	26. Northwest	42. Mushroom	58. Headlight
11. Oatmeal	27. Inkwell	43. Sidewalk	59. Inkwell
12. Toothbrush	28. Horseshoe	44. Inkwell	60. Northwest
-6dB S/N Ratio	**-14dB S/N Ratio**	**-22dB S/N Ratio**	**-30dB S/N Ratio**
13. Horseshoe	29. Headlight	45. Toothbrush	61. Oatmeal
14. Armchair	30. Armchair	46. Armchair	62. Armchair
15. Mushroom	31. Oatmeal	47. Oatmeal	63. Sidewalk
16. Northwest	32. Horseshoe	48. Northwest	64. Mushroom

The thresholds in both conditions and final MLD are computed as follows:

S_0N_0 Threshold = (dBHL of audiometer) + 1 – (total number of words repeated correctly/2) _____dB

$S_\pi N_0$ Threshold = (dBHL of audiometer) + 1 – (total number of words repeated correctly/2) _____dB

The **final MLD Threshold** is calculated as follows:

Final MLD threshold = S_0N_0 Threshold - $S_\pi N_0$ Threshold _____dB

CVC Binaural Fusion Test
(Track 16)

Attention: CAPD Taskforce
Fax: 012-3481511

Name of Audiologist:_____
Initials of subject (e.g.: R.S):_____
Date of birth: _____
Gender of subject: _____
Comments: _____

Test item	Stimulus word	Test item	Stimulus word	Any comments
1.	Vote Practice item	26.	Lease	
2.	Long Practice item	27.	Dog	
3.	Hole Practice item	28.	Rose	
4.	Get Practice item	29.	Bone	
5.	Make Practice item	30.	Should	
6.	Food	31.	Perch	
7.	Tape	32.	Gas	
8.	Kick	33.	Mob	
9.	Dip	34.	Sale	
10.	Tire	35.	Kill	
11.	Wife	36.	Near	
12.	Wash	37.	Bath	
13.	Hall	38.	Came	
14.	Join	39.	Sour	
15.	Neat	40.	Chain	
16.	Have	41.	Doll	
17.	Red	42.	Wheat	
18.	Ripe	43.	Thumb	
19.	Such	44.	Fit	
20.	Back	45.	Shirt	
21.	Check	46.	Lean	
22.	Lose	47.	Rough	
23.	Peg	48.	Yearn	
24.	Judge	49.	Pass	
25.	Time	50.	Mood	
Total:	Children: ___/20 _____%		Adults: ___/45 _____%	

Appendix 11

UNIVERSITY OF PRETORIA

FACULTIES OF HUMANITIES, EDUCATION, LAW, THEOLOGY, ECONOMIC & MANAGEMENT SCIENCES

*APPLICATION FOR APPROVAL OF RESEARCH INVOLVING HUMAN SUBJECTS AND / OR WITH ETHICAL IMPLICATIONS

PLEASE NOTE:

1. **No applications will be considered without the necessary documentation. See 3.5, 3.7, 3.8 and 4.1 below.**
2. **No applications will be considered unless they have been approved by the Departmental Research Committee.**

Please type or print legibly with black pen.

Name: Address: University Department: Professional status (if student: student number, degree and year of study): Telephone: Cell phone: Fax: E-mail:	TITLE OF RESEARCH PROJECT: PURPOSE OF THE RESEARCH: Undergraduate Graduate Not for degree purposes
ANTICIPATED FUNDING SOURCE (if any):	ESTIMATED DURATION OF THE PROJECT : From…….. to……..
FIRST APPROVAL REQUESTED: Yes No RESUBMISSION Yes No	

1. OBJECTIVES OF THE RESEARCH
Please list:

2. SUMMARY OF THE RESEARCH

Please provide a brief summary of the research (maximum 250 - 300 words)

3. SUBJECTS' PARTICIPATION

3.1 Where and how are subjects to be selected?

3.2 If subjects are asked to volunteer. who is to be asked to volunteer and how are they to be selected?

3.3 If subjects are to be recruited, what inducement is to be offered?

3.4 If subjects' records are to be used, specify the nature of these records and indicate how they will be selected.

3.5 Has permission been obtained to study and report on these records?

Yes No Not applicable

If Yes, attach letters.

3.6 Salient characteristics of subjects:

Number :

Gender : Female Male

Age :.....

3.7 Describe if permission of relevant authorities (e.g. school, hospital, clinic) has been obtained?

Yes No Not applicable

*If **Yes**, attach letters.*

3.8 List proposed procedures to be carried out with subjects to obtain data required by marking the applicable box(es):

Record review

Interview (*Attach)*

Questionnaire (*Attach, if available. If not, submit at a later stage, together with initial approval of Ethics Committee.*)

Clinical assessment

Procedures (e.g. therapy). Please describe.

Other. Please describe.

3.9 If specific evaluation/assessment and treatment procedures are to be used, is the researcher registered to carry out such procedures?

3.10 If the researcher will not personally carry out the procedure, state name and position of person who will.

4. INFORMED CONSENT

4.1 *Attach copy* of consent form

4.2 If subjects are
- under 18, mentally incompetent, legally incompetent to consent to participation, how is their assent obtained and from whom is proxy consent obtained?

Please describe.

If subjects are
under 18, mentally incompetent, legally incompetent, how will it be made clear to the subjects that they may withdraw from the study at any time?

Please describe.

4.3 If the researcher is not competent in the mother tongue of the subjects, how will he/she ensure that subjects fully understand the content of the consent form?

Please describe.

5. RISKS AND DISADVANTAGES TO THE SUBJECTS

5.1 Do subjects risk any potential harm (e.g: physical, psychological, legal, social) by participating in the research? No Yes

*If **Yes**, answer 5.2:*

5.2 What safeguards will be taken to minimize the risks?

Please describe.

5.3 Will participation or non-participation disadvantage the subjects in any way?
No Yes If Yes, explain in which way.

6. DECEPTION OF SUBJECTS

6.1 Are there any aspects of the research about which the subjects are not to be informed?

No Yes

If *Yes*, describe the nature thereof.

7. BENEFITS TO THE SUBJECTS:

7.1 Will participation benefit the subjects? No Yes

If *Yes*, please describe.

8. CONFIDENTIALITY

8.1 How is confidentiality and/or anonymity to be assured?

Please describe.

9. DISSEMINATION OF RESEARCH

9.1 To whom will results be made available?

9.2 In which format do you expect results to be made available?

Please mark those applicable:

book scientific article lay article TV radio

conference papers other, please describe.

10. STORAGE OF RESEARCH DATA

10.1 Will research data be destroyed at the end of the study? Yes No

10.2 If **No**, where, in what format and for how long will the data be stored? Please describe.

10.3 For what uses will data be stored?
Please mark those applicable:

research
demonstration –
public performance
archiving

10.4 How will subjects' permission for further use of their data be obtained?
Informed consent form
Other. Please describe.

11. OTHER INFORMATION

Any other information which may be of value to the committee should be provided here:

APPLICANT'S SIGNATURE : **DATE:**

SUPERVISOR'S SIGNATURE: **DATE:**

CHAIR : DEPARTMENTAL RESCOM: SIGNATURE: **DATE:**

Are you of the opinion that the proposed research project has ethical implications? **Yes** **No**

HEAD OF DEPARTMENT: SIGNATURE **DATE**

Are you of the opinion that the proposed research project has ethical implications? **Yes** **No**

CHAIR: FACULTY ETHICS COMMITTEE **DATE:**

ATTACHMENTS:

Other authorities' approval
Questionnaires, interviews, assessment
Other
Informed consent
Subject instructions

With acknowledgement to Harvard University 1999-2000, and the University of the Witwatersrand 1992