CHAPTER 4: RESEARCH METHODOLOGY

4.1 INTRODUCTION

The review of the literature presented in Chapters 1, 2 and 3 highlights the lack of congruity in defining ADHD as a disorder. In many previous research studies the defining characteristics of children with ADHD have been subjective, poorly defined, frequently changing and disconnected from any theoretical construct or empirical base (Chermak and Musiek, 1997). This has lead to controversy concerning the etiology and prevalence of ADHD (and the different types of ADHD), as well as the value of different assessment methods and treatment options in the management of children with ADHD.

Against this background, the possible value of a specific multi-dimensional test battery (comprising tests of both continuous performance and CAPD) for investigating the nature of the deficits associated with the three different types of ADHD (in both the medicated and non-medicated state) is presented.

Chapter 4 presents the research methodology of the study, and entails a description and discussion of the aims, research design, participant selection criteria and procedures, as well as a description of the participants, apparatus and material, data collection procedures and, finally, the data analysis procedures used in the study.

4.2 AIMS

The main aim of the research is to determine the central auditory processing and continuous performance patterns of children with ADHD in the medicated and non-medicated state.

A specific multi-dimensional test battery was compiled for assessing the central auditory processing and auditory and visual continuous performance of the participants.

The sub-aims of the study are:

4.2.1 To assess the participants in 3 research groups (combined type, predominantly inattentive type, and the predominantly hyperactive-impulsive type of ADHD) in the medicated and non-medicated state using the specific multi-dimensional test battery.

4.2.2 To compare the inter- and intra-group tendencies of central auditory processing for the 3 research groups in the medicated and non-medicated state.

4.2.3 To compare the inter- and intra-group tendencies of auditory and visual continuous performance for the 3 research groups in the medicated and non-medicated state.

4.2.4 To analyze the specific multi-dimensional test battery results in relation to the different types of ADHD and subprofiles of CAPD.

4.3 RESEARCH DESIGN

A Between group (combined ADHD group, inattentive ADHD group and hyperactive-impulsive ADHD group) within-subjects design was used for two test conditions (with and without medication).

The test conditions were counterbalanced to control for order effect of the test conditions, as illustrated in Table 4.1. Half the participants in research groups 1 and 2, were tested, first in the medicated state and then the non-medicated state, while the remaining half of the participants in research groups 1 and 2 were

Table 4.1: The test conditions were counterbalanced to control for the order effect of the two test conditions (with and without medication).

	Research group 1: Combined group		Research group 2: Inattentive group		Research group 3: Hyperactive-impulsive group	
Test condition A: With medication	P1: 8yrs P2: 9yrs P3: 10yrs P4: 11 yrs P5: 12 yrs	P6: 8yrs P7: 9yrs P8: 10yrs P9: 11yrs P10: 12 yrs	P11: 8yrs P12: 9yrs P13: 10yrs P14: 11yrs P15: 12 yrs	P16: 8yrs P17: 9yrs P18: 10yrs P19: 11yrs P20: 12yrs	P21:11yrs	
Test condition B: Without medication	P6: 8yrs P7: 9yrs P8: 10yrs P9: 11yrs P10: 12yrs	P1: 8yrs P2: 9yrs P3: 10yrs P4: 11yrs P5: 12yrs	P16: 8yrs P17: 9yrs P18: 10yrs P19: 11yrs P20: 12yrs	P11: 8yrs P12: 9yrs P13: 10yrs P14: 11yrs P15: 12yrs		P21:11yrs

Key	
P	Participant
Yrs	Years (age of the participant)

first tested in the non-medicated state and then in the medicated state. Research group 3 consisted of only one participant and the test conditions could thus not be counterbalanced.

4.4 PARTICIPANTS

The participants, used in the study, were drawn from a school for children with learning disability. The decision to select participants from a school for children with learning disability was twofold. Firstly, children in schools for learning disability are reported to have a higher incidence of ADHD (Keller, 1998). Secondly, by using one school and doing the testing at the school the reliability and validity of the data collection procedures could be controlled in terms of

environmental noise, participants' fatigue and medication state and levels, as discussed later in this chapter under 4.4.2.

Three research groups were used in this study. Research group 1 consisted of 10 children with the combined type of ADHD, research group 2 consisted of 10 children with the predominantly inattentive type of ADHD, and research group 3 consisted of a child with the predominantly hyperactive-impulsive type of ADHD. The inclusion of only one participant in research group 3 was due to a lower incidence of the hyperactive-impulsive type of ADHD compared to the combined and inattentive types of ADHD, as discussed in greater depth under 4.4.2.

4.4.1 Participant criteria

The participants included in the study were required to meet the criteria discussed below. This information was obtained from the school files as well as the principal of the school.

4.4.1.1 Diagnosis of ADHD

Participants were required to have been diagnosed by a medical practitioner as having ADHD and were required to be taking medication for ADHD, as prescribed by their medical practitioner. As the type of ADHD was not consistently listed in the school files the researcher consulted the five medical practitioners (four pediatricians and a psychiatrist) primarily used by the school in the management of children with ADHD. The telephonic consultations yielded that there are differences in the diagnostic criteria and materials used by the different medical practitioners in the diagnosis of ADHD. The diagnostic criteria and materials used by these medical practitioners included the DSM-IV criteria (American Psychiatric Association, 1994), the ICD-10 criteria (World Health Organization, 1992), the Connors rating scales (Conners, 1972, 1989) as well as checklists compiled by the individual practitioners. This finding is consistent with literature (American Academy of Pediatrics, 2000) reporting the varied and

diverse measures currently used in the diagnosis of ADHD. The above measures, however, do not all allow for accurate differentiation between the different types of ADHD, and in the case of the DSM-IV (American Psychiatric Association, 1994) and the ICD-10 criteria (World Health Organization, 1992), different classifications of ADHD are provided.

A double criterion was thus set for potential participants. Participants were not only required to have been diagnosed with ADHD by a medical practitioner but were also required to meet the DSM-IV criteria (as outlined in Table 1.1) for a specific type of ADHD. This information was obtained from checklists completed by parents and teachers (Appendices I and II). The checklists were based on the criteria of the DSM-IV and each participant was required to meet the criteria for the specific type of ADHD by both the teacher and the parents in order to be placed in a particular research group. The DSM-IV criteria (American Psychiatric Association, 1994) for the diagnosis of the different types of ADHD require the presence of six or more symptoms of inattention and/or hyperactivity-impulsivity persisting 6 or more months. As discussed in Chapter 1, the combined type of ADHD meets criteria A and B (as listed in Table 1.1), the predominantly inattentive type of ADHD meets criteria A, but not B (as listed in Table 1.1), and the predominantly hyperactive-impulsive type of ADHD meets criterion B, but not all A (as listed in Table 1.1).

4.4.1.2 Age

Participants were required to be between 8 and 12 years of age. The motivation for this criterion is that the diagnostic CAPD test material available for children, younger than 8 years of age, is limited. Younger children can therefore not be assessed using a comprehensive diagnostic battery of CAPD tests (Chermak and Musiek, 1997, DeConde Johnson, Benson and Seaton, 1997).

4.4.1.3 Home language and medium of formal education

English, as home language and medium of formal education, was included as a criterion as the test materials currently available for assessing CAPD are only available in English. Individuals assessed in a language in which they have competence but which is not their home language have been documented to perform less favorably on CAPD and vigilance tests than when assessed in their home language (Bellis, 1996, Chermak and Musiek, 1997, DeConde Johnson et al 1997).

4.4.1.4 Cognitive abilities

Participants were required to have average to above-average intellectual abilities as documented in the school files. Average to above-average intellectual ability is a condition for acceptance into the school. A team comprising psychologists, speech-language pathologists and remedial teachers do the initial admission assessment at the school.

Below-average intellectual abilities have been shown to negatively influence CAPD test results (Bellis, 1996, Chermak and Musiek, 1997, DeConde Johnson et al, 1997) as well as tests of visual and auditory continuous performance. Children with below average intellectual abilities were thus excluded from the study.

4.4.1.5 Medical history

Participants were required to have no history of neurological dysfunction due to medical conditions such as epilepsy and cerebral palsy or head trauma. Neurological dysfunction of this nature may influence the individual's ability to respond appropriately in the test situation and may impact negatively on CAPD test scores (Bellis, 1996, Chermak and Musiek, 1997) and tests of visual and auditory vigilance (Tillery, 1998).

Children with medical conditions and syndromes such as visual disorders, Tourette Syndrome and Asperger's Syndrome as well as other conditions such as Oppositional defiant disorder, Conduct disorder, and Obsessive compulsive disorder were also excluded as possible participants for the study in order to control for additional variables that could influence the results of the study. This information was obtained from the school files.

4.4.1.6 Medication

Each participant included in the study was assessed using the specific multi-dimensional test battery under two test conditions, namely the medicated and non-medicated state. The participants were children diagnosed by medical practitioners as having ADHD and had been prescribed medication for ADHD. Each child was assessed in the medicated state at the optimal levels of the medication following the onset of action period, and in the non-medicated state after a period of withdrawal, when the medication was no longer present in the participant's system. The onset of action for Ritalin and Ritaphen (a generic of Ritalin) is 10-20 minutes after ingestion with a clinical effect lasting 3-5 hours (Copps, 2002). The onset of action for slow release Ritalin (Ritalin SR) is 1 hour with a clinical effect lasting 4-6 hours and occasionally as long as 8 hours (Copps, 2002). When testing in the non-medicated state, an extended withdrawal period of at least 12 hours was required for children taking Ritalin/Ritaphen, and a 24 hour period for children using slow release Ritalin.

4.4.1.7 Peripheral hearing and middle ear functioning

Normal peripheral hearing and middle ear functioning at the time of the data collection were included as criteria as both elevated hearing thresholds and abnormal middle ear functioning impact negatively on a participant's ability to understand test instructions correctly. Furthermore, abnormal peripheral hearing and middle ear functioning impacts negatively on CAPD test scores as well as

measures of auditory continuous performance (Bellis, 1996, Chermak and Musiek, 1997, DeConde Johnson et al, 1997).

Normal peripheral hearing is defined as normal puretone thresholds between 0 and 15dBHL (for the frequency range 125-8000Hz) and normal middle ear functioning as a type A tympanogram with a middle ear pressure of between –100 and +50dB, and a static compliance between 0,3 and 1,75cm³. The normative data used is based on the recommendations of Musiek and Rintelmann (1999).

Ipsi- and contra-lateral stapedial reflex measurements were included as part of the immittance measurements but formed part of and are discussed under the data collection procedures.

4.4.1.8 Motivation

The participants included in the study were required to be motivated to participate in the study. The researcher explained what the testing would entail to the participants, namely "a computer game and some listening games". The children were also given a sticker of a cartoon character at the end of each session. Only those children who wished to partake in the study were included. Motivation or the willingness to partake and cooperate during behavioral CAPD assessments (Jerger and Musiek, 2000) and tests of continuous performance (Sandford and Turner, 2001) are important variables to consider as a lack of motivation may impact on the validity of the test results.

4.4.2 Participant selection procedures

An appointment was made with the principal of a school for children with learning disabilities to discuss the proposed study and to obtain permission to use children from the school in the study.

The principal agreed to participate in the study but asked that arrangements be made for the data collection to be done at the school rather than at the Department of Communication Pathology at the University of Pretoria, as originally proposed by the researcher. This request was made by the principal for the following reasons:

- Firstly, the testing needed to be done in the morning to control for participants' fatigue and this had implications for the school program. The principal felt that by doing the data collection at the school, the amount of time that each child missed would be reduced by eliminating traveling time.

- Secondly, the principal was concerned that the parents would not be able or willing to take time off work to bring children for the testing.

- Thirdly, although willing to arrange for the school to bring the children for the testing, the principal for safety reasons was concerned about transporting the children for safety reasons.

- Fourthly, the principal felt that the children would respond more appropriately within a familiar environment.

- Fifthly and finally, it was noted that the teachers usually administer the medication at the school (with the permission of the parents). The principal felt that the medication could be better controlled if the testing took place at the school.

Possible participants for the study, namely children diagnosed with ADHD by a medical practitioner and meeting the participant criteria stipulated above, were identified by the researcher and the principal using the school files. There were 157 children enrolled at the school with 64 (40,76%) children diagnosed with ADHD by a medical practitioner. Of the 64 children diagnosed with ADHD by a medical practitioner, 41 (64,06%) of the children also met the participant

selection criteria stipulated for age, home language and medium of formal education, cognitive abilities, motivation, medical history, medication as well as peripheral hearing and middle ear functioning.

A letter outlining the study, and requesting permission for their child to participate in the study (included as part of Appendix I) was sent to the parents of the 41 children that met the criteria for the study. Thirty five (85,37%) of the 41 letters were returned providing written permission for their children to participate in the study.

A checklist of the child's behavior based on the DSM-IV (as discussed under 4.4.1) was sent, together with above letter of permission (as part of Appendix I), for the parents to complete. A similar checklist (Appendix II) was adapted for the teachers and given by the principal to each child's teacher to complete. The information obtained from the checklists was used to allocate the participants to the three research groups (the combined type, the hyperactive-impulsive type and the inattentive type of ADHD) as discussed under 4.4.1. Each participant was required to meet the specific ADHD type criteria by both the teacher and the parents in order to be placed in a particular research group.

The number of potential participants meeting the specific ADHD criteria, as assessed by both the parents and the teachers for each age interval (8, 9, 10, 11 and 12 years), is presented in Table 4.2. The Frequency Procedure of the SAS Program (SAS Institute Inc., 1999) was used to determine the number of children meeting the specific ADHD criteria, as assessed by both the teachers and parents. In the selection of the participants, it was hoped to identify two participants at each age interval for each research group. Only one participant who met the criteria for the hyperactive-impulsive type of ADHD was identified. This finding is supported by the literature (Wilens et al, 2002) that reports a lower incidence of the hyperactive-impulsive type of ADHD than the combined or inattentive types of ADHD.

Table 4.2: The number of potential participants meeting the specific ADHD criteria as assessed by both the parents and the teachers for each age interval.

Age interval	Combined type of ADHD	Inattentive type of ADHD	Hyperactive-impulsive type of ADHD	Did not meet the criteria	TOTAL
8 years	3	2	0	2	**7**
9 years	2	3	0	1	**6**
10 years	2	2	0	2	**6**
11 years	3	3	1	3	**10**
12 years	2	2	0	2	**6**
TOTAL	**12**	**12**	**1**	**10**	**35**

4.4.3 Description of the participants

Ten participants (2 participants representing each age interval) were randomly selected for the research group 1 (combined type of ADHD) and research group 2 (inattentive type of ADHD). Only one participant who met the criteria for the hyperactive-impulsive type of ADHD, as discussed under 4.4.2 was identified. Table 4.3 provides a summary of the participants included in the study.

4.5 APPARATUS AND MATERIAL

The apparatus and material used in the selection of the participants and during data collection will be discussed separately.

4.5.1 Material and apparatus used to identify possible participants for the study

The following material and apparatus was used to identify possible participants for the study:

Table 4.3: Description of the participants included in the study

Research group	Participant number	Age (in years)	Gender	Hand dominance	Medication
Research group 1: Combined type	1	8	Male	Left	Ritaphen
	2	9	Male	Right	Ritalin
	3	10	Female	Right	Ritalin
	4	11	Male	Right	Ritalin
	5	12	Male	Right	Ritaphen
	6	8	Male	Right	Ritalin
	7	9	Male	Right	Ritalin
	8	10	Male	Right	Ritalin
	9	11	Male	Right	Ritalin SR
	10	12	Female	Right	Ritalin SR
Research group 2: Inattentive type	11	8	Male	Right	Ritalin
	12	9	Male	Right	Ritalin SR
	13	10	Male	Right	Ritalin
	14	11	Female	Left	Ritalin
	15	12	Male	Right	Ritalin
	16	8	Male	Right	Ritalin
	17	9	Male	Right	Ritalin
	18	10	Male	Left	Ritalin SR
	19	11	Male	Right	Ritalin
	20	12	Female	Left	Ritalin
Research group 3: Hyperactive-impulsive type	21	11	Female	Right	Ritalin

4.5.1.1 School files

Permission was obtained from the school principal to use the school files to identify possible candidates for the study.

4.5.1.2 Letter of consent (Appendix I)

A letter of consent (Appendix I) to gain written permission for their children to participate in the study was compiled by the researcher and completed by the parents. This letter of consent outlined the study, guaranteed confidentiality, and provided practical information such as the nature of testing, venue and the period of time that would be necessary for completing the testing.

4.5.1.3 Behavioral checklists (included as part of Appendix I and Appendix II)

A checklist of behaviors based on the criteria of the DSM-IV (included as part of Appendix I) was given to the parents to complete and a similar checklist (Appendix II) was given to the teacher of each child to complete. The information obtained from the checklists was used to allocate participants to the three research groups. Each participant was required to meet the specific ADHD type criteria by both the teacher and the parents in order to be placed in a particular research group.

4.5.1.4 Audiometric equipment and audiogram (Appendix III)

A GSI 68 Diagnostic Audiometer with Telephonic TDH-39P earphones and a GSI 28A Middle Ear Analyzer was used to assess the peripheral hearing and middle ear functioning of the participants prior to administering the specific multi-dimensional test battery. The audiometer and middle ear analyzer had been calibrated according to the requirements of the South African Bureau of Standards (SABS). The results were recorded on the audiograms (Appendix III) of the Department of Communication Pathology, University of Pretoria.

4.5.2 Material and apparatus to be used during data collection

A specific multi-dimensional test battery was compiled to assess the central auditory processing as well as auditory and visual continuous performance of the participants. The administration of the specific multi-dimensional test battery necessitated the use of an audiometer, a compact disc player and a laptop computer. A sound level meter was used to monitor the noise levels in the room used for the testing.

4.5.2.1 The specific multi-dimensional test battery

The specific multi-dimensional test battery consisting of a comprehensive CAPD test battery as well as The Integrated Visual and Auditory Continuous Performance Test (IVA CPT) and IVA STAR (narrative report writer for the IVA CPT) (Sandford and Turner, 2001) as presented visually in figure 4.1. The term "specific multi-dimensional test battery" is used to refer to the above test battery as it includes "specific" measures of both central auditory processing and continuous performance. The concept "multi-dimensional" as used in this term refers to the complexity and diversity of factors being considered; namely the central auditory processing, and auditory and visual performance of the participants in both the medicated and non-medicated state. The rationale for the test material included in the specific multi-dimensional test battery, as discussed in Chapter 3, is summarized in Table 4.4.

4.5.2.1.1 <u>The CAPD test battery</u>

In the Bruton conference consensus report, Jerger and Musiek (2000) identify three possible approaches to the construction of a CAPD test battery, namely behavioral tests, electrophysiological and electroacoustic tests, and finally, neuroimaging studies. Behavioral measures are seen to hold the greatest promise in routinely used test batteries as electrophysiological and electroacoustic tests, as well as neuroimaging are more expensive and time consuming with limited availability (Jerger and Musiek, 2000).

As discussed in Chapter 3, the choice of specific tests used in the behavioral assessment of central auditory processing, varies among audiologists (Katz et al, 1992, Bellis and Ferre, 1999, Jerger and Musiek, 2000).

In a relevant article differentiating between ADHD and CAPD, Bellis and Ferre (1999) propose that tests of CAPD may be useful in differentiating between ADHD and CAPD in children. The CAPD test battery used in the study is thus

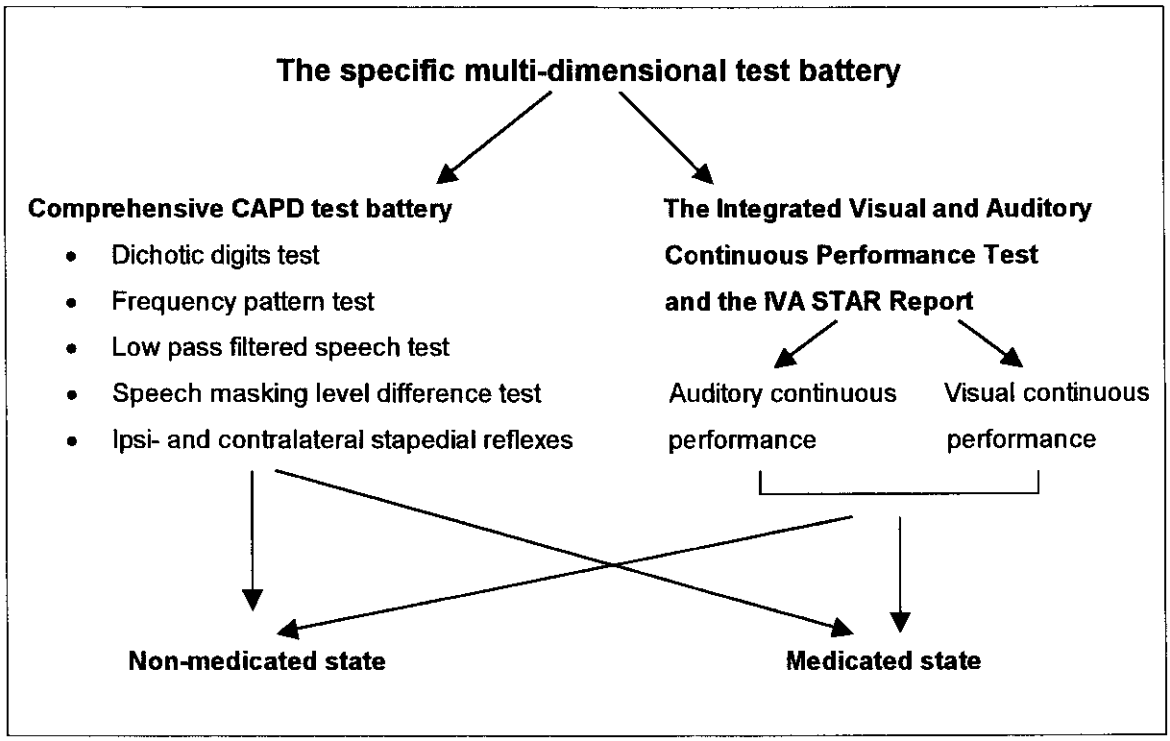

Figure 4.1: The specific multi-dimensional test battery

based on the recommendations of Bellis and Ferre (1999). Bellis and Ferre (1999) recommend that a behavioral CAPD test battery includes at least one test from each of the following categories:

- Dichotic tests (one linguistically loaded test and one test with a lighter linguistic load)
- Temporal ordering
- Monaural low redundancy tests
- Binaural fusion tests

As discussed in Chapter 3, Bellis (2003a) recently provided an update on recommendations for the components of a comprehensive CAPD test battery. The value of this updated comprehensive CAPD test battery in differentiating between ADHD and CAPD warrants further investigation but is beyond the scope

Table 4.4: The rationale behind the components of the specific multi-dimensional test battery.

Components of the specific multi-dimensional test battery	Motivation
The Integrated Visual and Auditory Continuous Performance Test (IVA CPT) and the IVA STAR (Narrative report writer for the IVA CPT) (Sandford and Turner, 2001)	• The inclusion of the IVA CPTand IVA STAR (Sandford and Turner, 2001) consisting of similar tasks in multiple (auditory and visual) sensory modalities assists in determining the modality of attention deficits associated with ADHD. Chermak et al (1999) describe the attention deficits associated with ADHD to be supramodal in nature. McFarland and Cacace (1995) postu late that CAPD are auditory specific in nature and that the use of similar tasks in multiple sensory modalities are thus of value in differentiating between ADHD and CAPD. By including the IVA CPTand IVA STAR (Sandford and Turner, 2001) in the specific mu lti-dimensional test battery the modality or modalities affected by the attention deficit associated with ADHD could be determined for the three different types of ADHD. • The IVA CPT and IVA STAR, were selected in preference to other available tests of co ntinuous performance, as these measures combine *both* auditory and visual stimuli in a counterbalanced design, together with attention and vigilance, thus incorporating two continuous performance tests into one measure (Kane and Whiston, 2001).
Comprehensive CAPD test battery (based on the recommendations of Bellis and Ferre, 1999)	• The comprehensive CAPD test battery (based on the recommendations of Bellis and Ferre, 1999) was included in order to determine whether patterns occur in the CAPD test results for both the medicated and non-medicated conditions. Specific patterns in CAPD test results have been linked to CAPD subprofiles (Bellis and Ferre, 1999). Bellis and Ferre (1999) speculate that children with ADHD should present with intact central auditory processing abilities, or in the case of abnormal CAPD test results, that no clear patterns that can be linked to CAPD subprofiles will be observed. • Bellis (2003a) recently provided an update of their recommendations for the components of a comprehensive CAPD test battery. The value of this updated comprehensive CAPD test battery in differentiating between ADHD and CAPD warrants further investigation but is beyond the scope of this study as the data collection phase of the study had been completed prior to the publication of these recommendations.

of this study as the data collection for the study was completed prior the publication of these recommendations.

The specific behavioral tests used in compiling the CAPD test battery for the study were drawn from the "Tonal & Speech Materials for Auditory Perceptual Assessment Disc 2.0" (Department of Veterans Affairs, 1998). This compact disc has twenty-two recorded tracks that can be used in assessing central auditory processing. The compact disc was compiled and recorded in the USA and the speakers used to record the test stimuli thus have American accents. Normative data is not provided with the compact disc and the audiologist is referred to a series of papers in the July 1994 issue of the Journal of the American Academy of Audiology in which preliminary normative data are provided for some of the test materials (Department of Veterans Affairs, 1998). As with all tests of central auditory processing, it is strongly recommended that clinicians develop appropriate normative data for their own clinics (Bellis, 1996, Department of Veterans Affairs, 1998). As no equivalent tests of CAPD are available in South Africa, phase I of the pilot study was used to compile normative data that could be used during data analysis.

The CAPD test battery used in this study, namely that of Bellis and Ferre (1999) consists of four behavioral measures and one electrophysiological/ electroacoustic measure. The specific tests included in the test battery are presented below, followed by the motivation for the inclusion of the specific test in each test category:

- The Dichotic digits test (Double digits)
- The Frequency pattern test (both the labeling and humming conditions)
- Low pass filtered speech test
- Speech masking level difference test
- Ipsi- and contra-lateral acoustic reflexes (measured during the immittance testing)

The Dichotic digits test (double digits) from the "Tonal & Speech Materials for Auditory Perceptual Assessment Disc 2.0" (Department of Veterans Affairs, 1998) was selected to represent the dichotic test category. This test has a lighter linguistic load than some of the other dichotic tests such as the Dichotic sentence identification test that is also available on the above compact disc. The Dichotic digits test is available in two versions, namely single and double digits. The double digits version was selected as the task is more challenging, yet simple enough even for young children (Bellis, 1996, Bellis, 2001, Bellis, 2003a). Track 3 on the compact disc was used and consists of 25 test items each consisting of 4 different digits where 2 digits are presented with the other 2 digits being simultaneously presented to the other ear. The first 5 items were used as practice items and the remaining 20 items were used as the test items. The scoring sheet used is presented in Appendix IV.

Although it is recommended in the literature (Bellis, 1996; Bellis and Ferre, 1999, Bellis, 2003a) that a dichotic test with a higher linguistic load also be included in the test battery, this was not done for the following reasons. Firstly, the participants included in the study were drawn from a school for children with learning disability. As discussed above, children with learning disability are reported to have a higher incidence of language disorders (Medwetsky, 2002). The inclusion of measures with a lighter linguistic load thus reduces the effects that possible language impairment may have on CAPD results. Secondly, the Dichotic sentence identification test on the above compact disc requires a level of reading ability that could negatively have affected the results of the younger participants. Finally, time constraints were also taken into account. The complete specific multi-dimensional test battery needed to be administered in a single test session in the medicated and non-medicated state.

The Frequency pattern test from the "Tonal & Speech Materials for Auditory Perceptual Assessment Disc 2.0" (Department of Veterans Affairs, 1998) was

selected to represent the temporal ordering test category. This test consists of frequency tone patterns and the participant is requested to repeat the frequency pattern heard, for example: "low, low, high" or "high, low, high". Track 16 on the above compact disc was used and the stimuli were presented first to one ear and then to the other. There are 30 test items. The first 5 items were again used as practice items while the remaining 25 items were used for the actually testing. This test was also administered under two conditions. In the first condition, the participant was asked to label the frequency pattern and in the second test condition, the participant was asked to hum the frequency pattern (thus removing the linguistic labeling component). The comparison of the results obtained under the two conditions provide information about the interhemispheric transfer of information (Bellis, 1996, Bellis, 2003a). The Frequency pattern test rather than the Duration pattern test on the compact disc was selected, as age norms for the test are better defined, and the test is more appropriate for young children (Bellis, 1996, Bellis, 2001, Bellis, 2003a). The scoring sheets used are included in Appendices V (labeling condition) and VI (humming condition).

The Low pass filtered speech test from the "Tonal & Speech Materials for Auditory Perceptual Assessment Disc 2.0" (Department of Veterans Affairs, 1998) was selected to represent the monaural low redundancy test category. This test consists of monosyllabic words from list 3 of the Northwestern University Auditory Test no. 6, spoken by a female. The words are low pass filtered (1500Hz cutoff; 115dB/octave). Track 14 on the above compact disc was used. There are 50 test items. The first 5 items were used as practice items after which test items 6-25 were presented to the left ear. The next 5 items (items 26-30) were again used for training, after which items 31-50 were presented to the right ear. The Filtered speech test rather than other tests such as the 45% or 65% Time compressed speech was selected for inclusion in the CAPD test battery as the validity of the Filtered speech test in both children and adults is better documented. Furthermore the normative data available for the filtered speech test are more comprehensive than for other measures of

monaural low redundancy (Bellis, 1996, Bellis, 2003a). The scoring sheet used is presented in Appendix VII.

The Speech masking level difference (MLD) test from the "Tonal & Speech Materials for Auditory Perceptual Assessment Disc 2.0" (Department of Veterans Affairs, 1998) was selected to represent the binaural fusion test category. This test consists of spondaic words embedded in bursts of broadband noise that are presented in the S_0N_0 and $S_\pi N_0$ paradigm. The MLD threshold is calculated by determining the difference between the thresholds obtained for the above two conditions. The Binaural fusion test using monosyllabic words (with low frequency information presented to the one ear and the high frequency information simultaneously presented to the other ear), was originally considered but rejected based on literature (Bellis, 1996) that questions the utility of the Binaural fusion test, as most children obtain high scores for the test. The Tonal MLD test was then considered but could not be used as the GSI 68 Diagnostic Audiometer that had been loaned to the researcher for the data collection did not have this function. The decision was thus made to use the Speech MLD test from the "Tonal & Speech Materials for Auditory Perceptual Assessment Disc 2.0" (Department of Veterans Affairs, 1998). The scoring sheet used is presented in Appendix VIII.

The ipsi- and contra-lateral stapedial reflex measurements (obtained during the Immittance measurements) were included as the final component of the CAPD test battery. These measurements are routinely used by the researcher during CAPD testing and there is evidence in the literature to suggest that the contra-lateral reflexes may be elevated or absent for some children with CAPD (Bellis, 1996; Bellis, 1999, Bellis, 2003a).

4.5.2.1.2 The Integrated Visual and Auditory Continuous Performance Test IVA CPT (Sandford and Turner, 2001)

As discussed in Chapter 2, there are a number of commercially available tests of continuous performance. For this study, The Integrated Visual and Auditory Continuous Performance Test (IVA CPT) and IVA STAR (narrative report writer for the IV CPT) (Sandford and Turner, 2001) were selected. The Integrated Visual and Auditory Continuous Performance Test (Sandford and Turner, 2001) combines both auditory and visual stimuli in a counterbalanced design, together with attention and vigilance. As discussed in Chapters 2 and 3, Kane and Whiston (2001) suggest that the inclusion of both visual and auditory attention measures in a single administration, provides the IVA CPT (Sandford and Turner, 2001) with an advantage over other tests of continuous performance. The IVA STAR is an additional feature of the IVA CPT (Sandford and Turner, 2001) that can be purchased. The IVA STAR does not require any additional testing and is an automated report that provides a comparison of the auditory and visual modalities.

The IVA CPT (Sandford and Turner, 2001) is a 20 minute computerized continuous performance test that combines both auditory and visual stimuli. As stated above, by combining the auditory and visual modes in a counterbalanced design together with attention and vigilance, the IVA CPT (Sandford and Turner, 2001) incorporates two continuous tests of performance into one. The main testing segment takes 13 minutes, with the remaining time being used for instructions, the practice period and "warming up" and "cooling down".

As for other tests of continuous performance the IVA CPT (Sandford and Turner, 2001) is designed to be mildly boring and starts with a five-minute warm-up and training session after which the thirteen minute test commences. The test task is simple and requires the individual to click on the mouse only when s/he hears or sees the target (the number "1") and not to click when s/he hears or sees the non-target or foil item (the number "2"). Since the "1's" and "2's" are presented in

a pseudo-random combination of visual and auditory stimuli, it is more demanding than other tests of continuous auditory performance as it challenges the individual's ability to change cognitive sets. The administration of the test is automated to standardize the presentation of auditory and visual stimuli. The computer "speaks" all test instructions in order to minimize test variability. The test contains two conditions in two modalities for a total of 200 trials. The first block of 100 trials consists of 50 trials in the auditory modality and 50 trials in the visual modality. This is a measure of impulsivity using a ratio of targets to non-targets of 5,25:1. The second block of 100 trials consists of 50 trials in the auditory modality and 50 trials in the visual modality. This assesses inattention where the number of targets to foils is reduced but the ratio stays the same. This counterbalanced design allows the individual to rest to some degree and controls for practice and fatigue effects during the course of the test. By using a mouse click as a means of response, the IVA CPT (Sandford and Turner, 2001) provides an objective means of determining fine motor hyperactivity by measuring inappropriate mouse clicking activity.

The scores are presented as both raw scores and quotient scores. All quotient scores have a mean of 100 and a standard deviation of 15, the same as those used for most Intelligence Quotient (IQ) tests. The automated normative database (n=1700 normal individuals, aged 5-90+) takes gender and age into account. An example of the scoring sheet is presented in Appendix IX.

The IVA CPT (Sandford and Turner, 2001) consists of 6 composite scores and 22 other scores divided into 5 groups, namely the Fine motor regulation/hyperactivity score, the Response control scores, the Attention scores, the Attribute scores, and the Validity scores. The 2 main global composite quotient scores of the IVA CPT (Sandford and Turner, 2001) (defined in Table 4.5) are the Full scale response control quotient and the Full scale attention quotient scores. The Full scale response quotient is based on 2 composite

Table 4.5: A description of the IVA CPT scores (Sandford and Turner, 2001)

IVA scores	Description of the IVA scores
Full Response Control Quotient - Auditory Response Control Quotient (ARCQ) - Visual Response Control Quotient (VRCQ)	(Based in equal weights on the ARCQ and VRCQ) (Based in equal weights on auditory prudence, consistency and stamina) (Based in equal weights on visual prudence, consistency and stamina)
Full Attention Quotient - Auditory Attention Control Quotient (AACQ) - Visual Attention Control Quotient (VACQ)	(Based in equal weights on the AACQ and VRCQ) (Based in equal weights on auditory vigilance, focus and speed) (Based in equal weights on visual vigilance, focus and speed)
Fine motor regulation / hyperactivity	Off-task behaviors with the mouse (including multiple clicks, spontaneous clicks, anticipatory clicks and trials when the mouse is held down)
Response control - Auditory prudence - Visual prudence - Auditory consistency - Visual consistency - Auditory stamina - Visual stamina	Prudence is a measure of impulsivity and response inhibition Consistency is a measure of general reliability of response times (ability to stay on task) Stamina used to identify problems related to sustaining attention over time
Attention - Auditory vigilance - Visual vigilance - Auditory focus - Visual focus - Auditory speed - Visual speed	Vigilance is a measure of inattention and is determined by the ability to maintain preparedness to an intermittent signal Focus is sensitive to an unusual number of occurrences of slow reaction times Speed refers to the reaction time of all the correct responses
Attribute - Balance - Auditory readiness - Visual readiness	Balance refers to whether the person processes information more quickly visually, aurally or equally Readiness is a subtle measure of attention problems by measuring test performance when demands to respond are less frequent
Validity - Auditory comprehension - Visual comprehension - Auditory persistence - Visual persistence - Auditory sensory motor - Visual sensory motor	Comprehension identifies random responding and help reduce false positives Persistence may reflect a lack of motivation, or in some cases, mental or motor fatigue Sensory/motor provides a measure of reaction times to simple singular test stimuli to screen for slow reaction times

scores, namely the Auditory response control quotient and the Visual response control quotient. These response control quotients are derived from the primary scores of Auditory and Visual prudence, Consistency and Stamina scales as defined in Table 4.5. The Full scale attention quotient is based on 2 composite scores, namely the Auditory attention control quotient and the Visual attention control quotient. These attention control quotients are derived from the primary scores of Auditory and Visual vigilance, Focus and Speed scales as defined in Table 4.5. The Fine motor regulation scale provides additional information by recording off-task behaviors with the mouse, including multiple clicks, spontaneous clicks during the instruction period, anticipatory clicks and holding the mouse button down. The Attribute scores provide information about the individual's learning style. The Attribute scores, namely Balance, Auditory readiness and Visual readiness, are defined in Table 4.5. The Validity scores provide information about the individual's random responses, lack of motivation or fatigue and reaction times. The Validity scores, namely Auditory and Visual comprehension, Persistence and Sensory motor, are defined in Table 4.5.

The IVA STAR (normative report writer for the IVA CPT) consists of primary and combined scales (defined in Table 4.6) and provides additional information about attention. These scales also make use of standard scores (Q scores) to facilitate comparisons between them. An average score is 100, with 15 points representing one standard deviation, similar to IQ scores. An example of the scoring sheet is presented in Appendix X. The four primary scores determined for both the auditory and visual modalities are alertness, steadiness, promptness and constancy. The combined scales integrate the four primary scales and provide an overall impression of the performance of the auditory and visual modalities. The Combined attention quotient score further combines the visual and auditory quotients into one global score in order to provide a measure of overall attention.

Table 4.6: A description of the IVA STAR scores (Sandford and Turner, 2001)

IVA scores	Description of the IVA STAR scores
Primary Scales	
- Auditory alertness - Visual alertness	Alertness measures the percentage of correct responses when the demand to respond is infrequent (reflects problems with inattention)
- Auditory steadiness - Visual steadiness	Steadiness is defined as the percentage of correct responses when targets are frequent (reflects problems in sustaining attention)
- Auditory promptness - Visual promptness	Promptness is defined as the discriminatory reaction time to the targets during sections when the targets are rare (reflects mental processing speed
- Auditory constancy - Visual constancy	Constancy is defined as the variability of an individual's discriminatory reaction time when targets are infrequent (reflects fatigue and distractions by internal or external conditions)
Combined Scales	
- Auditory specific	General attention for the auditory modality
- Visual specific	General attention for the visual modality
- Global (Auditory and Visual)	Overall attention combining the auditory and visual modality

4.5.2.2 Audiometric equipment, compact disc player, notebook computer and sound level meter

A GSI 68 Diagnostic Audiometer with Telephonic TDH-39P earphones was used to administer the CAPD test battery. The CAPD test materials from the compact disc were routed via the Sony CD player through the audiometer to the headphones worn by the participant. The GSI 68 Audiometer had been calibrated according to the SABS Standards.

A Mecer Pentium III Notebook (Series A450) was used to load the IVA CPT software (Sandford and Turner, 2001) purchased from Braintrain. The test stimuli were presented through Digitech CD-3000 stereo headphones to the participants.

The testing was done at the school in the teachers' computer room, where the noise levels were monitored using a Rion Sound Level Meter NA-24 set on function A. The room is situated away from the central noise areas of the school, has a dimension of 3x2m² and is fitted with a carpet and curtains. The noise levels were monitored in the room and noise levels were kept below the 40-45dBSPL marker on the sound level meter. The sound level meter had been calibrated according to SABS standards. Ideally, the testing should have been done in a soundproof booth but for reasons discussed under 4.4.2 this was not possible as the data collection needed to be done at the school. By using a sound level meter and controlling the environmental noise, the researcher was able to assess all the subjects under the same controlled and quiet conditions.

4.6 THE PILOT STUDY

The pilot study consisted of three phases as outlined in Table 4.7.

Table 4.7: The aim, motivation, procedure, results and conclusions/adaptations relating to the three phases of the pilot study.

Phase	Aim	Motivation	Procedure	Results	Conclusions/ adaptations
I	The collection of normative data for the CAPD test battery.	The normative data available have been obtained in the USA and may thus not necessarily be reflective of the SA population. Furthermore, it is strongly recommended that clinicians develop appropriate normative data for their own clinics (Department of Veterans Affairs, 1998, Bellis, 1996).	The researcher and two final year Communication Pathology students at the University of Pretoria assessed 50 children (ten children aged 8, 9, 10, 11, and 12 years) using the training and test procedures presented in Table 4.8 and discussed under 4.7 (Data collection procedures). The children were required to have no history of developmental and/or learning disability or ADHD and were attending mainstream schools.	The results (means and standard deviations) are included in Appendix XI. The results obtained were similar to those reported by Bellis (1996, 2003a) with the exception of the Filtered speech test where the children in this study performed more poorly. This is possibly attributable to the different versions in the test material used by Bellis (1996, 2003a). Bellis (1996, 2003a) obtained normative data for the Ivey filtered word test (male speaker) on tape with a 1000Hz cut-off. The Filtered speech test on the Tonal and Speech Materials for Auditory Perceptual Assessment Disc 2.0. uses the voice of a female speaker and a 1500 low pass cut-off. Scores obtained using the compact disc version have been reported to be lower than for the tape version (Bellis, 1996, 2003a)	Based on the recommendation that clinicians develop appropriate normative data for their own clinics (Bellis,1996, Department of Veterans Affairs, 1998), the normative data collected by the researcher will be used in the study.

Table 4.7 continued

Phase	Aim	Motivation	Procedure	Results	Conclusions/ adaptations
II	To gain experience in administering and interpreting the IVA CPT and IVA STAR.	The IVA CPT and IVA STAR were new assessment measures to the researcher and it was thus necessary for the researcher to gain experience in administering and interpreting the IVA CPT and IVA STAR.	Three adults (aged 36,38 and 57) and thereafter five mainstream children (two of whom were aged 8, two aged 9 and one aged 10) were assessed using the IVA CPT and IVA STAR. Thereafter the researcher interpreted the results according to IVA CPT test manual (Sandford and Turner, 2001).	No difficulties were experienced in administering and interpreting the test results. It was, however, noted that the one child was left-handed but had been taught to use his right hand when working with the computer mouse. The researcher allowed the child to use his right hand as his ability to work with the computer mouse was far superior to that of his left hand. His results using his right hand were within the normal range and similar to those of the other children. The other children and adults were all right handed.	The researcher gained experience in administering and interpreting the IVA CPT and IVA STAR. It was decided to allow left-handed participants in the study to use the hand that they were accustomed to using when manipulating the computer mouse.
III	To determine the length of time required in administering the immittance, puretone (air-conduction) audiometry (part of the selection procedures) and the specific multi-dimensional test battery (the data collection phase).	Information about the length of time required to complete the testing was necessary in order to compile a testing roster than could be accommodated into the school program.	Two children (aged 8) were assessed using the immittance, puretone (air-conduction) audiometry and the specific multi - dimensional test battery. Both children were in the mainstream educational setting. The first child had no history of learning disability while the second child had a history of learning disability. The second child was included to determine whether children with a history of learning disability would require more time to complete the testing	The time required for administering the different tests to the children was similar and as follows: Immittance and puretone testing (10 minutes), IVA CPT / IVA STAR (20 minutes) and the CAPD test battery (30 minutes: 5 minutes for instructions and 25 minutes for the testing). The total testing time was thus approximately 1 hour.	It was decided to use a 1 hour 15 minute test session to allow for any additional time required and to create a relaxed and unrushed atmosphere during the testing.

The first phase consisted of the collection of normative data for the behavioral CAPD test battery using children within the mainstream setting and experiencing no developmental or learning disabilities. The behavioral CAPD test battery comprised of the Dichotic digits test (double digits), the Frequency pattern test, the Low pass filtered speech test and the Speech masking level difference test. The CAPD tests were all administered at an intensity of 50dBSL (re: average puretone threshold at 500, 1000 and 2000Hz). The normative data for CAPD tests provided in the literature were compiled using varying intensity settings (Bellis, 1996). A fixed intensity of 50dBSL (re: average puretone threshold at 500, 1000 and 2000Hz) was used and puretone thresholds rather than speech reception thresholds were used as the data collection was to be done in one room at the participants' school and live voice speech audiometry was thus not possible. The use of recorded USA speech audiometry materials (no equivalent measures are available in South Africa) was considered but decided against, as no normative data are available for the South African population for these measures.

In compiling the normative data, fifty children were assessed (ten children aged 8, 9, 10, 11 and 12 years) respectively. Prior to commencing with the CAPD testing, the children were familiarized with the test material, as outlined and motivated in Table 4.8. The children's attention was also drawn to the fact that the recorded material had been compiled in the USA and that due to the American accent, some words might be pronounced slightly differently. Children in South Africa receive exposure to the American accent through television programs, films and teaching materials and it was thus felt that differences in accent would not be unfamiliar to the children participating in the study.

The results of the fifty children were processed using the Means Procedure of the SAS program (SAS Institute Inc., 1999). The mean, standard deviation, mean – 1 standard deviation and mean - 2 standard deviations were determined

Table 4.8: Training that occurred prior to the CAPD Testing

CAPD Test	Training	Motivation for training
Dichotic digits test	Each child was asked to repeat a sequence with 4 digits.	The Dichotic digits test consists of 4 digits, with 2 digits being presented simultaneously in the different ears. A pre-requisite for this test is that a child is able to repeat a sequence of 4 digits. Each child was required to be able to repeat a sequence of 4 digits.
Frequency pattern test	A low puretone was presented on the audiometer at 500Hz and a high puretone at 4000Hz was used to illustrate the concept of "high" and "low", whereafter the child was asked to say whether the puretone presented was "low" or "high".	The Frequency pattern test consists of patterns that the child must label and later hum, for example "low low high". This requires an underlying understanding of the concepts "low" and 'high". Each child was required to be able to correctly identify the "low" and "high" puretones.
Low pass filtered speech test	The words included as test items were read to each child and the meaning of each word was discussed.	Although the Low pass filtered speech test was compiled for the USA population, an examination of the words included in the test revealed that these words should also be familiar to children in SA. Some of the words included in the test do, however, require a fairly advanced level of vocabulary, for example words such as "seize", "dodge" and "void". The children included in both the pilot and actual study ranged in age from 8 to 12 years of age and thus had different levels of linguistic ability. The children in the actual study also attend a school for children with learning disability. Children with learning disability are reported to have a higher incidence of language impairment (Medwetsky, 2002). It was thus decided to read the list of words to each child and discuss the meaning of the words prior to commencing with the testing. By familiarizing the children with the words the effects of language ability could be reduced in order to obtain a more accurate reflection of each child's central auditory processing.
Speech masking level difference test	The words included as test items were read to each child and the meaning of each word was discussed. The researcher also read through the list of printed words given to each child together with the child to ensure that the child was able to read the words that s/he was required to repeat.	Similarly (as for the Low pass filtered speech test) although the Speech masking level difference test was compiled for the USA population the words included in the test should also be familiar to children in SA. Some of the words included in the test do, however, require a fairly advanced level of vocabulary, for example "inkwell", "oatmeal" and "northwest". The children included in both the pilot and actual study ranged in age from 8 to 12 years of age and thus had different levels of linguistic ability. Additionally, the Speech masking level difference test requires the child to identify and repeat the words they hear (while ignoring competing noise) from a printed list of 10 spondaic words. It was thus decided to read the printed list of words with each child and discuss the meaning of the words prior to commencing with the testing. By familiarizing the children with the printed words (and the meaning of the words) the effects of verbal and written language ability could be reduced in order to obtain a more accurate reflection of each child's central auditory processing.

for each age interval, namely 8, 9, 10, 11, and 12 years of age, for each CAPD test. The average mean, standard deviation, mean – 1 standard deviation and mean - 2 standard deviations for the combined age intervals were also determined. The normative data for the CAPD test battery are included as Appendix XI.

The second phase involved administering the IVA CPT and IVA STAR (Sandford and Turner, 2001) to a group of individuals with no reported history of learning disorder in order for the researcher to gain experience in administering and interpreting the tests. Three adults and 5 mainstream children were assessed. The findings of the second phase did not require statistical analysis and are presented in Table 4.7.

The third phase was to administer the complete test battery to two children; one child with and one child without a history of developmental or learning disability, in order to determine the length of time required to administer the immittance, puretone (air-conduction) audiometry (part of the selection procedures) and the specific multi-dimensional test battery (the data collection phase). The immittance and puretone audiometry required as part of the participant selection procedures was done prior to but during the same session as the data collection, as discussed under 4.7. The findings of the third phase did not require statistical analysis and are presented in Table 4.7.

4.7 DATA COLLECTION PROCEDURES

The researcher assessed the twenty-one subjects at their school. As discussed under 4.5.2.2 the testing was done in the teachers' computer room, where the noise levels were monitored using a Rion Sound Level Meter NA-24 set on function A. The room is situated away from the central noise areas of the school, has a dimension of 3x2m² and is fitted with a carpet and curtains. The noise levels were monitored in the room and noise levels were kept below 40-45dBSPL. Ideally, the testing should have been done in a soundproof booth but

for the reasons discussed under 4.4.2 this was not possible as the data collection needed to be done at the school. By using a sound level meter and controlling the environmental noise, the researcher was able to assess all the subjects under the same controlled and quiet conditions.

The test procedure was administered twice to each participant under the two test conditions, namely with and without medication. As discussed under 4.3, the test conditions were counterbalanced to control for the order effect of the two conditions. A minimum period of at least one week (7 days) was required between the two test conditions of each participant. The order of the test conditions for each participant is presented in Table 4.1. The testing time per participant with and without medication was 1 hour to 1 hour 15 minutes.

The immittance (including acoustic reflex measurements) and puretone (air conduction) audiometry that formed part of the participant selection procedures were administered in the first session. The reasons for doing this testing at the same time as the data collection were twofold. Firstly, the middle ear functioning and peripheral hearing of each participant was required to be within the normal range at the time of the data collection and secondly, the puretone thresholds obtained were used to set in the stimulus intensity levels for the CAPD tests. As hearing thresholds had already been established during the first session, only the tympanometry part of the immittance (not the acoustic reflex measurements) was repeated at the beginning of the second session in order to monitor middle ear functioning of the participants. All participants were required to have normal middle ear functioning and peripheral hearing as discussed under 4.4.1.7. The ipsi- and contralateral reflexes measurements were done at 500, 1000 and 2000Hz but were seen to form part of the data collection procedures as discussed under 4.4.1.7. The participants were given the following instructions prior to the immittance testing: "Sit as still as you can, just like a statue. This is a quick test for your ears. Your ears may feel a bit blocked and you will hear some loud sounds". The immittance meter is automated and immediately prints the

results after each test. During the puretone audiometry the participants were instructed, "to push the button even if the beep-beep sound is very soft".

The complete specific multi-dimensional test battery was administered after the immittance and puretone audiometry. The IVA CPT (Sandford and Turner, 2001) was administered following the standardized instructions and procedures stipulated in the IVA CPT Test manual (Sandford and Turner, 2001). The participants were told that the IVA CPT was a "fun computer game" and that they had to click on the mouse every time they heard or saw the number "1" and ignore any number "2's" that they heard or saw. They were told the computer would repeat the instructions and that there would be a practice session first before the actual "game" started. The IVA CPT (Sandford and Turner, 2001) is an automated test that generates an automated test summary with scores presented as both raw scores and quotient scores. All quotient scores have a mean of 100 and a standard deviation of 15, the same as that used for most Intelligence Quotient (IQ) tests.

The hand preference of each child was noted prior to commencing with the IVA CPT. The IVA CPT Test Manual (Sandford and Turner, 2001) recommends that the person's dominant hand be positioned over the mouse, with the index finger over the leftmost button. The left-handed children at the school had, however, been taught to use their right hand when working with a computer mouse and all preferred to use their right hands. The left-handed child included in Phase II of the pilot study (Table 4.7) also showed a right hand preference when using a computer mouse. The left-handed children were thus permitted to use their right hand for manipulating the computer mouse during the administration of the IVA CPT.

The IVA STAR (narrative report writer for the IVA CPT of Sandford and Turner, 2001) does not require any additional testing and is an automated report that

provides a comparison of the auditory and visual modalities based on the results of the IVA CPT (Sandford and Turner, 2001) results.

The CAPD test battery comprising the Dichotic digits test (double digits), the Frequency pattern test, the Low pass filtered speech test, the Speech masking level difference test and the acoustic reflex measurements was administered after the IVA CPT, with the exception of the acoustic reflex measurements (as already discussed earlier in this section). Scores were obtained for both ears for each CAPD test, with the exception of the Speech masking level difference test, where only one score was obtained, as this is a binaural interaction task.

As for the pilot study (discussed under 4.6), the behavioral CAPD tests were administered at an intensity of 50dBSL (re: average puretone threshold at 500, 1000 and 2000Hz). Puretone thresholds, rather than speech reception thresholds, were used as the testing was done in one room at the participants' school and live voice speech audiometry was thus not possible. The use of recorded USA speech audiometry materials (no equivalent measures are available in South Africa) was considered but decided against, as no normative data are available for the South African population for these measures. Prior to commencing with the CAPD testing, the participants were familiarized with the test material as outlined and motivated in Table 4.8. The participants' attention was also drawn to the fact that the accent of the recorded material was American and that the pronunciation of some of the words might differ a bit from the South African pronunciation. Children in South Africa are frequently exposed to American accents through the media in the form of television programs, films and training materials.

The Dichotic digits test consists of 25 items (5 practice items and twenty test items). The dichotic digit test was administered at an intensity of 50dBSL (re: average puretone threshold for 500, 1000 and 2000Hz). The participants were instructed as follows: "You will hear numbers in both your ears. Say / repeat the

numbers that you hear". The scoring sheet used to record the responses is presented in Appendix IV.

The Frequency pattern test consists of 30 items (5 test practice items and 25 test items). The test was administered at an intensity of 50dBSL (re: average puretone threshold for 500, 1000 and 2000Hz). The test was administered separately to both ears under the two test conditions, namely labeling and humming. The comparison of the results under the two test conditions provides information about the inter-hemispheric transfer of information. The instructions for the labeling condition provided to the subjects were as follows: "You will be hearing short tunes. You must say what you are hearing, for example "low low high" or "high low high". For the humming condition the participants were instructed as follows: "You will be hearing short tunes. You must hum what you hear, for example (demonstrated by humming) "low low high" or "high low high". The scoring sheets used are included in Appendix V and Appendix VI.

The Low pass filtered speech test consists of 50 items. The Low-pass filtered speech test was administered at an intensity of 50dBSL (re: average puretone threshold for 500, 1000 and 2000Hz). The first 5 items were used as practice items for the left ear and the next 20 items were included as test items for the left ear. The remaining 25 items were used for the right ear (5 practice items and 20 test items). The instructions provided were as follows: "The words that you will hear sound funny. They do not sound very clear. Say/repeat the words that you hear. You can guess the word if you are not sure of it". The researcher read the list of words to each participant and discussed the meaning of the words prior to commencing with the testing. This was done to familiarize the participants with the words and thereby reduce the possible confounding influences of language ability. The scoring sheet used is included in Appendix VII.

For the Speech masking level difference test the participant was given a printed list of the 10 spondaic words and asked to "ignore the noise that you hear and

just say/repeat the word that you hear". The researcher read through the printed list of words with each participant and discussed the meaning of the words prior to commencing with the testing. This was done to familiarize the participants with the words and thereby reduce the possible confounding influences of language and reading abilities. The Speech masking level difference test was administered at an intensity of 50dBSL (re: average puretone threshold for 500, 1000 and 2000Hz). The scoring sheet used is included in Appendix VIII.

4.8 DATA ANALYSIS

The correct responses for each test in the behavioral CAPD test battery (with the exception of the Speech masking level difference test) were totaled and converted to percentages for each participant. The ipsi- and contra-lateral stapedial acoustic reflexes of each participant for each ear were analyzed in terms of the following categories:

- Two or more of the acoustic reflexes at 500, 1000 and 2000Hz within the normal range (70-90dBSL)
- Two or more of the acoustic reflexes at 500, 1000 and 2000Hz elevated (> 90dBSL) or absent at maximum intensity settings.

The percentage ipsi- and contra-lateral stapedial reflexes occurring in each of the above categories was then determined for each research group.

The IVA CPT and IVA STAR both provide automated scoring. The scores in these automated result sheets include both raw scores and quotient scores. All quotient scores have a mean of 100 and a standard deviation of 15, the same as that used for most Intelligence Quotient (IQ) tests. The automated normative database (n=1700 normal individuals, ages 5-90+) takes gender and age into account. The results of research groups 1, 2 and 3 were compared with the above mean quotient score of 100 and standard deviation of 15 and results below 85 and above 115 were seen to reflect significant differences in relation to

the normative data. A validity check is built into the interpretation of the IVA CPT and IVA STAR scores as discussed under 4.5.2.1.2. In cases where the comprehension scales for both modalities are identified as very low (as shown in the automated report of the results) further interpretation of the remaining scales is not possible. In cases where the comprehension score is identified as very low for one modality only, for example the auditory modality, further interpretation of the remaining auditory scales is not possible. Further interpretation of the visual scales in this case is, however, possible as the visual comprehension scale was valid (Sandford and Turner, 2001). Low comprehension scales, despite cooperation from the individual being tested, can be ascribed to severe ADHD and/or difficulty in shifting mental sets between the different modalities (Sandford and Turner, 2001).

The results of each participant in research groups 1 and 2 for each of the tests in the behavioral CAPD test battery, the IVA CPT and the IVA STAR were then transferred by the researcher to Microsoft Excel Spreadsheets for statistical analysis. Only those scores that were valid for the IVA CPT and IVA STAR as discussed in the preceding paragraph were used. The SAS Program (SAS Institute Inc., 1999) was used for the statistical analysis of the results of research groups 1 and 2. The specific procedures employed in achieving each sub aim are presented in Table 4.9. Research group 3 consisted of one participant and the results could thus not be analyzed statistically. The results of the participant in research group 3 are discussed qualitatively against the results of research group 1 and 2 in Chapter 5.

4.9 SUMMARY OF CHAPTER 4

"The method that was used to collect data-including the sample, measurement instruments, and procedures – should be described with the utmost precision" (Leedy and Ormrod, 2001: 289).

Table 4.9: The procedures used to achieve the sub-aims of the study

Sub-aim	Procedures
To compare the inter- and intra-group tendencies of *central auditory processing* of research groups 1 and 2 in the medicated and non-medicated state.	- The Kruskal-Wallis test (Non-parametric one-way ANOVA) was used to compare the behavioral CAPD test results of research groups 1 and 2 (in the medicated and non-medicated state) with the CAPD normative data (Appendix XI) and to determine whether significant differences occurred at the 5% level of significance, by using the BMDP3S procedure of the BMDP. The null hypothesis (namely no significant difference at the 5% level of significance) was rejected if the Z value (observed value from standard normal distribution) was larger than the critical value ZC, where 1-PHI (ZC)=ALPHA/(K(K- 1)). PHI refers to the cumulative standard normal distribution function, ALPHA the desired overall significance level, and K the number of groups compared
	- ANOVA (cross-over design) was applied by using the General Linear Means procedure of the SAS (SAS Institute Inc., 1999) to: - determine the overall effect of medication on the behavioral CAPD test results - compare the overall behavioral CAPD test results of research groups 1 and 2 Probability factor values (p)<0,05 (5% level of significance) were seen to be significant.
	- ANOVA (cross-over design), the General Linear Means procedure and Scheffe's multiple comparisons test were used (at the 5% level of significance) in the analysis of the inter - and intra-group tendencies of the behavioral CAPD test results of research groups 1 and 2 in the medicated and non-medicated state
To compare the inter- and intra-group tendencies of *auditory and visual continuous performance* of research groups 1 and 2 in the medicated and non-medicated state.	- The results of research groups 1, 2 and 3 were compared with the mean quotient score of 100 and standard deviation of 15 (as stipulated in the IVA CPT test manual, Sandford and Turner, 2001) and results below 85 and above 115 were seen to reflect significant differences in relation to the IVA CPTand IVA STAR normative data.
	- ANOVA (cross-over design) was applied by using the General Linear Means procedure of SAS (SAS Institute Inc., 1999) to: - determine the overall effect of medication on the IVA and IVA STAR test results - compare the overall IVA and IVA STAR test results of research groups 1 and 2 Probability factor values (p) <0,05 (5% level of significance) were seen to be significant.
	- ANOVA (cross-over design), the General Linear Means procedure and the Scheffe's multiple comparisons test were used (at the 5% level of significance) in the analysis of the inter- and intra-group tendencies of the IVA CPT and IVA STAR test results of research groups 1 and 2 in the medicated and non-medicated state

Table 4.9 continued

Sub-aim	Procedures
To analyze the central auditory processing and continuous performance results in relation to the different types of ADHD and subprofiles of CAPD	- The results of each participant in the medicated state on the behavioral CAPD test battery were qualitatively analyzed in terms of the audiometric results outlined in the subprofiles of the Bellis/Ferre model (Bellis, 1999) as summarized in Chapter 3 and where appropriate assigned to a specific CAPD subprofile.
	- The IVA CPT procedural guidelines, presented in the test manual (Sandford and Turner, 2001), and included as Appendix XII were followed in allocating participants (based on scores obtained in the non-medicated state) to the different types of ADHD. The results of the above procedural guidelines were then compared with the DSM IV diagnosis originally used to allocate the participants to the 3 research groups.

The research methodology presented in Chapter 4 entails a description and discussion of the aims, research design, participant selection criteria and procedures as well as a description of the participants, apparatus and material, data collection procedures and finally the data analysis procedures used in the study. A detailed discussion of the above aspects is provided to allow for replication of the research method.