CHAPTER 3: THE VALUE OF TESTS OF CONTINUOUS PERFORMANCE AND CAPD IN DIFFERENTIATING BETWEEN ADHD AND CAPD IN CHILDREN

3.1 INTRODUCTION

> *Differentiating Attention Deficit Disorder and Central Auditory Processing Disorder hinges on the accurate diagnosis of these conditions (Chermak et al, 1999).*

As discussed in Chapter 2, differentiating between ADHD and CAPD is a challenge for professionals as both groups of children are heterogeneous in nature and yet present with many similar characteristics (Keller, 1998). Children diagnosed with ADHD are frequently reported to present with difficulties on tasks that challenge the central auditory nervous system (Chermak et al, 1999, Copeland, 2002). It has even been proposed that CAPD and ADHD may reflect a singular disorder (Gason et al, 1986, Keller, 1998). As ADHD is a medical diagnosis, while CAPD is an audiological diagnosis (Chermak et al, 1998), some researchers have suggested that the diagnosis of these two disorders may be a function of the professional making the diagnosis (Riccio and Hynd, 1996). The observed comorbidity of CAPD and ADHD most likely also reflects a shortcoming in the diagnostic criteria as well as the procedures used in differentiating ADHD and CAPD, and is an area warranting further research (Riccio and Hynd, 1996).

In the literature there are three opposing theoretical schools of thought regarding the conceptualization of ADHD and CAPD as outlined in figure 3.1. In the first school of thought, CAPD is considered to be a specific disorder of the auditory modality while deficits in attention are suspected to be supramodal in nature. Included in this school of thought is the model of McFarland and Cacace (1995) who view auditory modality specificity as a criterion for diagnosing CAPD, and recommend using similar tasks in multiple (auditory and visual) sensory modalities to differentiate between auditory specific and supramodal disorders.

In the second school of thought, CAPD is viewed an auditory specific deficit (though the possible existence of co-existing multimodality symptoms based on shared neurophysiological site of dysfunction is recognized) while ADHD is seen to be supramodal in nature (Bellis, 2003b). Included in this school of thought there are three different models. In the first model, Chermak et al (1999) postulate that ADHD is a behavior regulation disorder or executive function disorder, and that the attention deficits associated with ADHD are supramodal in nature, whilst the attention deficits linked to CAPD are primarily associated with the auditory modality but may co-exist with more global dysfunction reflecting other modalities. The second model, namely the Bellis/Ferre Model (Bellis, 2003a), is similar to the model of Chermak et al (1999) with the primary difference between these models relating to the use of subprofiles of CAPD as seen in the Bellis/Ferre Model (Bellis, 2003a) model. In the third model, Barkley (1998) attributes the underlying cause of ADHD to deficiencies in executive dysfunction, most likely due to the underproduction of dopamine in the prefrontal cortex.

In the third school of thought, CAPD is not viewed as an auditory modality specific disorder but rather as a multimodal disorder. Included in this school of thought is the Buffalo model of Katz et al (1992).

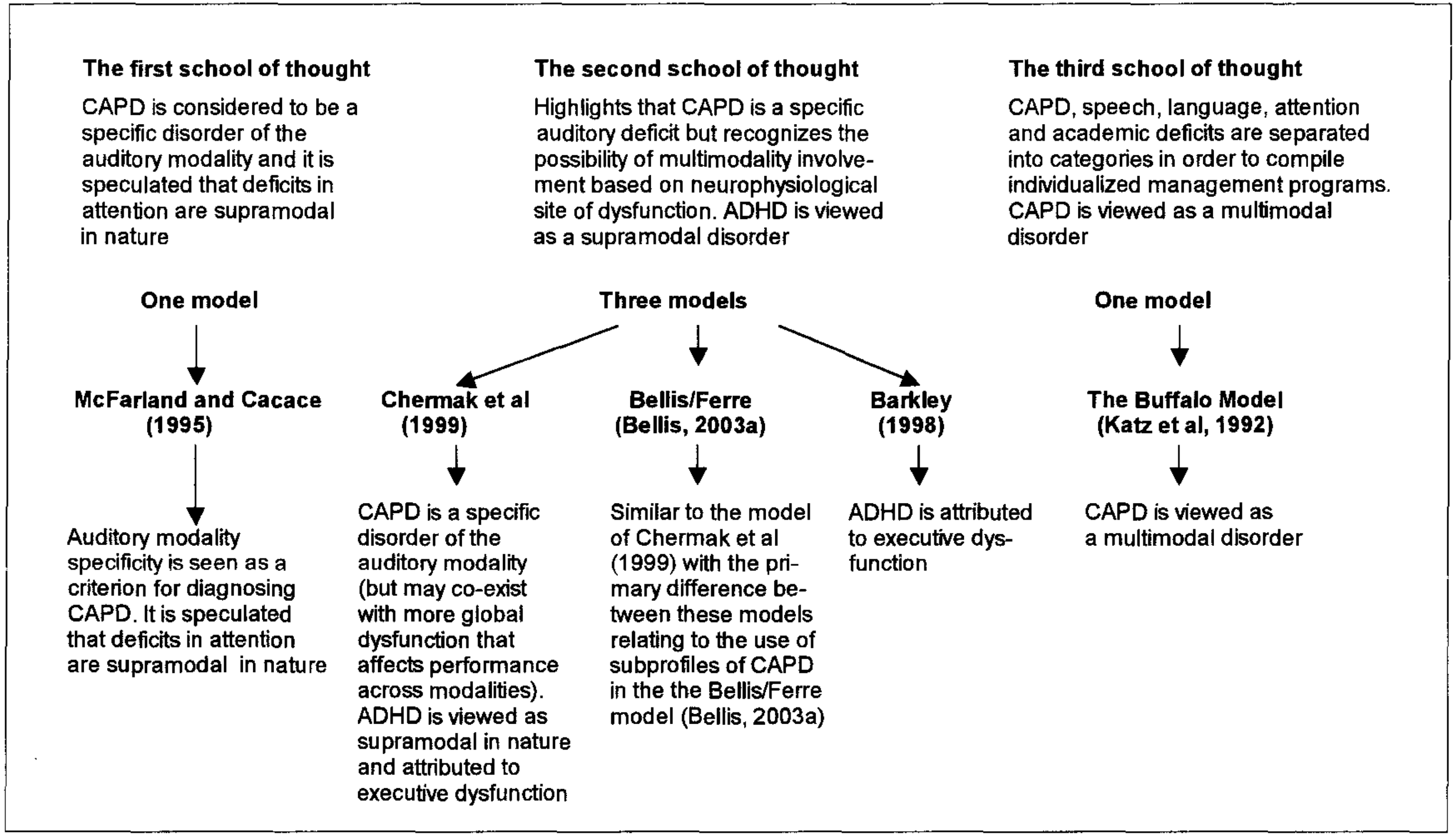

Figure 3.1: The three opposing theoretical schools of thought regarding the conceptualization of ADHD and CAPD.

The above three opposing theoretical schools of thought on the conceptualization of ADHD and CAPD will be critically reviewed in Chapter 3. Against this background, the value of tests of continuous performance and CAPD in assessing ADHD in children will be discussed.

3.2 THE FIRST SCHOOL OF THOUGHT: THE MODEL OF McFARLAND AND CACACE (1995)

In the model of McFarland and Cacace (1995) central "auditory" processing disorders are viewed as modality specific in nature. McFarland and Cacace (1995) reason that the concept of CAPD as a disorder has not been completely validated. They suggest that audiologists diagnose CAPD based on its auditory modality specificity nature. The deficit should thus occur primarily when the individual deals with acoustic information and not when similar information is presented in other sensory modalities (visual, tactile and olfactory). In contrast McFarland and Cacace (1995) view ADHD to be supramodal in nature.

In diagnosing CAPD, McFarland and Cacace (1995) suggest that similar tasks be compared in at least two separate modalities and recommend using the auditory and visual modalities, as these are the major channels of information exchange for the purposes of communication. A deficit in attention could thus be seen as a CAPD if it is established that it is auditory modality specific. If, however, an attention deficit is supramodal in nature (with both auditory and visual deficits) the diagnosis of ADHD is more appropriate. McFarland and Cacace (1995) conclude that further research is required to confirm the proposed auditory specific nature of CAPD and the supramodal nature of ADHD.

Stecker (1998) recommends that the Auditory Continuous Performance Test (Keith, 1984) be administered during CAPD assessment when ADHD is suspected. Stecker (1998) reasons that the Auditory Continuous Performance Test (Keith, 1984) screens for attention disorders and can be used as part of the CAPD test battery to aid in the differential diagnosis of ADHD and CAPD. Based on the model of McFarland and Cacace (1995) the inclusion of only an auditory continuous performance test is questionable practice, as the visual modality is not considered. To address the visual modality, the inclusion of a visual continuous performance test should, therefore, also be considered.

The Integrated Visual and Auditory Continuous Performance Test (IVA CPT) (Sandford and Turner, 2001) combines both auditory and visual stimuli in a counterbalanced design together with attention and vigilance. As discussed in Chapter 2, 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 continuous performance tests.

In some preliminary research using an earlier version of the IVA CPT, Sandford et al (1995) reported that children diagnosed with ADHD assessed using the IVA CPT made more errors for auditory than for visual stimuli and were more likely to present with auditory modality impulsivity than their peers. A weakness in the study of Sandford et al (1995) is that the ADHD diagnostic criteria and methods used in their study are not described and subjects are simply described as having the diagnosis of ADHD. There is, also, no acknowledgement of the different types of ADHD. Further research investigating the multi-dimensionality of the attention deficits associated with the different types of ADHD is thus warranted. The use of the IVA CPT (Sandford and Turner, 2001) that includes similar tasks using auditory and visual stimuli could thus provide valuable insights into the nature of the attention deficits associated with ADHD.

3.3 THE SECOND SCHOOL OF THOUGHT: THE MODEL OF CHERMAK ET AL (1999), THE BELLIS/FERRE MODEL (BELLIS, 2003a) AND THE MODEL OF BARKLEY (1998)

In the second school of thought, CAPD is viewed an auditory modality specific deficit (though the possible existence of co-existing multimodality symptoms based on shared neurophysiological site of dysfunction is recognized) while ADHD is seen to be supramodal in nature (Bellis, 2003b). There are three models within the second school of thought, namely the model of Chermak et al (1999), the Bellis/Ferre Model (Bellis, 2003a) and the model of Barkley (1998).

3.3.1 The model of Chermak et al (1999)

In the first model, Chermak et al (1999) view CAPD and ADHD as two distinct clinical disorders, not withstanding some overlap in their behavioral profiles as discussed in Chapter 2. The differences between CAPD and ADHD, as perceived by Chermak et al (1999), are summarized in Table 3.1.

According to Chermak et al (1999) there are distinctions that can be drawn regarding the modality of the inattention observed in CAPD and ADHD. The attention deficits seen in ADHD are pervasive and supramodal, impacting more than one sensory modality (American Psychiatric Association, 1994). In contrast, individuals with CAPD experience attention deficits that may be restricted to the auditory modality (Chermak and Musiek, 1997). As noted by Chermak and Musiek (1997), the commonly observed left-ear deficit on dichotic speech tasks in individuals with CAPD, as well as their depressed auditory performance under conditions of either contralateral or ipsilateral competition as a function of the level of brain dysfunction, argues against a pervasive attention deficit in CAPD and helps distinguish CAPD from ADHD. Although CAPD is seen to be the result of processes dedicated to audition, Chermak et al (1999) recognize that CAPD may also co-exist with more global dysfunction that affects performance across modalities.

Table 3.1: The differences between ADHD and CAPD (based on Chermak et al, 1999).

	ADHD combined and predominantly hyperactive-impulsive types	**ADHD predominantly inattentive type**	**Central auditory processing disorder**
Modality / modalities affected by the attention deficit	Attention deficits are supramodal (global)	Attention deficits are supramodal (global)	Attention deficits may be restricted to the *auditory modality*
Nature of the attention deficit, e.g.: sustained attention, selective attention, or divided attention deficit	Attention is restricted to sustained attention (multimodal)	Selective (multimodal) attention and speed of processing deficits	Selective (focussed) and divided auditory attention deficits
An output (behavior regulation) disorder or an input (processing) disorder	Output disorder	Input disorder	Input disorder
Executive dysfunction: primary or secondary feature of the disorder	Executive function is the primary source of dysfunction	Reduced rate of information processing is the primary source of dysfunction, with executive dysfunction as a secondary feature	Executive dysfunction is a secondary feature, not a primary cause, of listening difficulties

It is further argued that different types of attention deficit may be seen in ADHD and CAPD (Chermak et al, 1999). Although the neural mechanisms underlying the different behaviors associated with various attention tasks are unknown, research suggests that the attention deficits associated with the combined and predominantly hyperactive-impulsive ADHD types may be restricted to sustained attention, albeit in multiple modalities (Barkley, 1997a,b). Selective (multimodal) attention and speed of information processing deficits are thought to characterize the predominantly inattentive ADHD type (Barkley, 1997a). In contrast, both selective (focussed) and divided auditory attention deficits are thought to characterize CAPD (Chermak et al, 1999).

Chermak et al (1999) speculate that the inattentiveness seen in CAPD is a primary deficit resulting from an input or information processing deficit. In contrast, the hyperactive-impulsive and combined ADHD types are characterized as output or response programming and execution disorders (Barkley, 1997a,b). Differentiating the predominantly inattentive ADHD type from CAPD is more challenging since the inattention in both disorders is considered to be a primary input or information processing deficit.

This recent shift in conceptualizing ADHD as a behavioral or executive function disorder, as discussed in Chapter 2, may explain the self-control problems, social skills deficits, and language disorders (for example, difficulty in topic switching, turn taking and sustaining dialogue) so frequently observed in the combined and hyperactive-impulsive types of ADHD (Chermak and Musiek, 1997). Chermak et al (1999) speculate that executive dysfunction may be the source of the behavioral and inattention problems manifested in ADHD. Executive control is a component of metacognition that refers to a set of general control processes that ensure that an individual's behavior is adaptive, consistent with an appropriate goal and beneficial to the individual (Torgesen, 1996). Executive control is necessary for the execution of behavioral sequences, learning and problem solving, psychosocial function (including self-image, self-regulation of emotion and motivation), and goal-directed behaviors, including listening (Chermak et al, 1999).

In contrast with the combined and hyperactive-impulsive types of ADHD, the executive dysfunction observed individuals with the predominantly inattentive ADHD type and CAPD are considered a secondary feature, not a primary cause, of listening difficulties (Chermak et al, 1999).

The above reconceptualization of the predominantly hyperactive-impulsive and combined types of ADHD as an output and executive control disorder supports the use of pharmacological management in managing these types of ADHD (Chermak et al, 1999). Pharmacological management may however not be the most effective treatment in children with the inattentive type of ADHD (Chermak et al, 1999) and further research into the most effective management of the inattentive type of ADHD is thus indicated.

Assessing children with the three different types of ADHD with and without medication, using a continuous performance such as the IVA CPT (Sandford and Turner, 2001), will provide information about the value of using medication in the management of the different types of ADHD. These results could also yield information about the nature of the attention deficits associated with the three types of ADHD as the IVA CPT (Sandford and Turner, 2001) assesses similar tasks using both auditory and visual stimuli.

While Chermak et al (1999) recognize the heterogeneous nature of ADHD and the existence of different types of ADHD, they do not differentiate between different types or subprofiles of CAPD as seen in the discussion of the next model, namely the Bellis/Ferre Model (Bellis, 2003a).

3.3.2 The Bellis/Ferre Model (Bellis, 2003a)

In the second model, namely the Bellis/Ferre Model (Bellis, 2003a) CAPD is viewed as a specific auditory modality deficit, though the possible existence of co-existing multimodality symptoms, based on a shared neurophysiological site of dysfunction, is recognised.

The Bellis/Ferre Model (Bellis, 2003a) was developed, based on the need for a method of relating central auditory test findings to both their underlying neurophysiologic bases and their behavioral, cognitive, academic and communicative sequelae. The CAPD test battery is seen to provide a means of assessing the functional integrity of right- and left-hemisphere cortical regions, corpus callosum, and subcortical structures. Additionally the results of central auditory assessment allow the audiologist to determine the child's auditory strengths and weaknesses and relate these back to overall communication and learning difficulties, thereby identifying a possible subprofile/s of CAPD which, in turn, facilitates the development and implementation of individualized and specific management programs (Bellis, 1996, Bellis, 1999, Bellis and Ferre, 1999, Bellis, 2003a).

The choice of the specific test battery, used in central auditory assessment, varies among audiologists as reflected in the different test batteries that are available, for example, Katz et al (1992), the ASHA Task Force on Central Auditory Processing Consensus Development (1996), Bellis and Ferre (1999), Jerger and Musiek (2000) and Bellis (2003a). The question as to which test combinations are most effective in diagnosing CAPD remains an area of continuing debate (Bellis, 2003a).

Bellis and Ferre (1999), based on the guidelines of the ASHA Task Force on Central Auditory Processing Consensus Development (1996), recommend that a behavioral CAPD test battery include at least one test from each of the following categories: dichotic speech tasks (1 linguistically loaded and 1 linguistically non-loaded measure), monaural low redundancy speech tasks, tests of temporal patterning, and binaural fusion tasks.

More recently, in the report of the Bruton consensus conference (Jerger and Musiek, 2000), a minimum CAPD test battery comprising only three behavioral measures (a dichotic task, a temporal patterning task and a gap detection task) along with physiological measures such as immittance, oto-acoustic emissions and auditory evoked potential measurements was proposed. Bellis (2003a: 237) has challenged the above minimum CAPD test battery (Jerger and Musiek, 2000) arguing that this test battery is "too minimal" when reviewed against the background of the ASHA Task Force on Central Auditory Processing Consensus Development (1996) guidelines and the Schow, Seikel, Chermak and Berent (2000) update of the above ASHA Task Force guidelines.

Recently, Bellis (2003a) has recommended that the components of a comprehensive CAPD test battery be selected from the following general areas:

- A dichotic listening task that involves directed attention (Binaural separation)
- A dichotic listening task that involves report of both ears (Binaural integration)
- A temporal patterning test such as Frequency or Duration Patterns (Auditory Pattern Temporal Ordering)
- A test of monaural low-redundancy speech, such as the Low pass filtered speech test, Compressed speech with or without reverberation (Monaural separation or closure)
- A temporal gap detection test, such as the Random gap detection test (Other temporal processes)

- A binaural interaction test such as Binaural fusion or the more sensitive Masking level difference test (Binaural interaction)
- An auditory discrimination task such as the Northwestern parameter estimation by sequential tracking paradigm (requires additional equipment, not typically available in audiology clinics)
- Physiological measures of auditory function, such Auditory Brainstem Response, Middle Latency Response, and late event-related potentials.

Although the decision regarding how many and precisely which CAPD tests to utilize should be determined by each individual case, Bellis (2003a) suggests that it is prudent to include at least one test from each of the above categories with the exception of the electrophysiological measures that should be included when warranted for a particular case. In addition, Bellis (2003a) recommends including two dichotic tests, namely one with a low linguistic load and one with a high linguistic load.

As seen above, the Bellis/Ferre Model (Bellis, 2003a) is a dynamic and changing one that is continually revised as new insights are acquired and new assessment materials become available in the field of CAPD. The initial version of the Bellis/Ferre Model (Bellis, 1996) included four primary subprofiles and after many revisions (Bellis, 1999, Bellis and Ferre, 1999) now consists of three primary and two secondary subprofiles (Bellis, 2003a). The three primary subprofiles, representing primary auditory (left) cortex, nonprimary (right) cortex, and interhemispheric (corpus callosum) dysfunction are described in Table 3.2. The two secondary subprofiles, outlined in Table 3.3, describe dysfunction in associative (left) cortex and efferent and/or temporal-to-frontal cortex. Each CAPD subprofile, as described in Tables 3.2 and 3.3, is linked to its underlying neurophysiologic region of dysfunction in the brain as well as its higher-level

Table 3.2: Primary CAPD subprofiles of the Bellis/Ferre Model (Bellis, 1999, Bellis, 2003a). *The new additions to the central test findings as presented in the most recent version of the Bellis/Ferre Model (Bellis, 2003a) are presented in italics.*

Auditory Decoding Deficit	Prosodic Deficit	Integration Deficit
Region of dysfunction Primary auditory cortex in the language-dominant (usually left) hemisphere **Auditory processes likely to be impacted** • Auditory closure • Temporal processing • Auditory discrimination • Binaural separation and/or integration **Central auditory test findings** • Bilateral deficit on dichotic speech tests, right ear often worse than left • Bilateral deficit on monaural low redundancy speech tasks, right ear often worse than left and errors phonemically similar to target • *Elevated temporal gap detection thresholds and other temporal processing deficits* • *Elevated just noticeable differences for speech sound discrimination* • *Electrophysiology may show decreased responses over left hemisphere and/or absent Mismatch negativity* • *Performance on tests of temporal patterning, binaural interaction, and discrimination for slowly changing speech sounds (vowels, glides, liquids) is typically normal*	**Region of dysfunction** Nonprimary (usually right) hemisphere **Auditory processes likely to be impacted** • Temporal patterning • Auditory discrimination of nonspeech stimuli (e.g., frequency, intensity or duration discrimination); vowel discrimination difficulties are possible • Binaural separation and/or integration **Central auditory test findings** • Left ear deficit on dichotic speech tasks • Deficit in both temporal patterning tasks in both labeling and humming conditions, indicating difficulty with perception of acoustic contour itself • *Electrophysiology may show decreased responses over right hemisphere. Mismatch negativity (MMN) are typically present to consonant-vowel contrasts, but may be absent to tonal stimuli* • *Performance on tests of binaural interaction, temporal processing, monaural low-redundancy speech, and speech sound (especially consonant) discrimination is typically normal; however some difficulty with vowel discrimination may be present*	**Region of dysfunction** Corpus Callosum **Auditory processes likely to be impacted** • Temporal patterning • Binaural separation and/or integration **Central auditory test findings** • Left ear deficit on dichotic speech tasks, which may be more pronounced with linguistically loaded material • Deficit on temporal patterning tasks in linguistic labeling condition only, indicating intact perception of the acoustic contour itself but inefficient transfer to the left hemisphere for verbal output • *Electrophysiology may show a lack of typical hemispheric asymmetry patterns to speech stimuli* • *Performance on tests of binaural interaction, temporal processing, monaural low-redundancy speech, and auditory discrimination is typically normal*

Table 3.2 continued

Auditory Decoding Deficit	Prosodic Deficit	Integration Deficit
Primary auditory complaints • Difficulty hearing in noise or if speaker does not enunciate clearly • Frequent mishearing and misunderstanding • Feeling as if hearing loss is present even if hearing is normal • Auditory fatigue or overload • Fares better in quieter listening environments or when visual or multimodality cues are added	**Primary auditory complaints** • Difficulty comprehending the intent (rather than the content) of communications • Frequent misunderstandings, complaints of hurt feelings, and perceptions of others' communications as abrupt, rude, sarcastic, or negative in some or other way • Difficulty perceiving jokes, sarcasm, and other messages that rely on subtle prosodic cues • Possible difficulty understanding messages in which subtle changes in stress alter the meaning • Difficulty in comprehending overly abstract communicative exchanges or topics • Auditory complaints are typically not dependent on acoustic environment	**Primary auditory complaints** • Significant difficulty hearing in noise • Difficulty linking linguistic content with prosodic intent, leading to possible misunderstandings • Difficulty with localizing and tracking a moving sound source, especially if it crosses the midline • Feeling as if the right ear is "better", or preference for monaural (right ear amplification) over binaural hearing aids
Related sequelae • Poor phonological awareness abilities • Possible phonological production errors • Vocabulary and syntax may be affected • Good pragmatic communication skills • Poor word attack abilities during reading and spelling, combined with good sight word abilities • Verbal IQ lower than performance IQ • Good performance in nonverbal tasks such as mathematics, art and music	**Related sequelae** • Poor pragmatic and social communication abilities • Poor sight-word reading and spelling abilities, combined with good word-attack or phonological decoding skills • Performance IQ often lower than verbal IQ • Significant difficulty with nonverbal tasks such as mathematics, art and music • Poor visual-spatial abilities • Poor gestalt patterning abilities • May be at risk for depressive disorder secondary to right-hemisphere dysfunction • May meet diagnostic criteria for nonverbal learning disabilities; alternatively, presentation may be very subtle and	**Related sequelae** • Difficulty with any task in which interaction between the two hemispheres of the brain is required • Difficulty associating the visual symbol on the page with the sound, affecting both sight-word and word-attack skills, reading speed, and reading fluency • Performance IQ and Verbal IQ usually relatively evenly developed, with scatter within scales depending on the task demands • Poor bimanual or bipedal coordination abilities • Musical difficulties such as playing an instrument that requires significant

Table 3.2 continued

Auditory Decoding Deficit	Prosodic Deficit	Integration Deficit
	performance across academic areas may be loosely within the normal range • Performs better with concrete than abstract information • May have difficulty with topic maintenance • Phonological awareness abilities, vocabulary, and syntax are usually intact	bimanual coordination (e.g., piano), hearing the lyrics of sounds, or singing in time to melody • Greater difficulty when multimodality cues are added • Significant difficulty in taking dictation or notes • Difficulty drawing a picture from verbal or written descriptions or instructions • Auditory and related symptoms vary widely
Management and intervention strategies • Improvement acoustic access to information • Preteach new vocabulary and concepts • Augment with visual and/or multimodality cues • Repeat, rather than rephrase, messages • Phoneme training, focusing on discrimination of minimal contrast pairs and speech-to-print skills • Compensatory strategies training to include principles of active listening, auditory closure skills, and vocabulary enhancement activities • Speech and language therapy may be indicated to address phonological and language deficits	**Management and intervention strategies** • Placement with an "animated" teacher who makes generous use of prosodic cues and multimodality augmentation • Avoid hints; spell out precisely what is meant • Temporal patterning and prosody training • Reading aloud with exaggerated prosodic features • Compensatory strategies training to include social communication and judgment, role-playing, comprehension of underlying intent, topic maintenance, and communication repair strategies • Psychological counseling often critical in addressing social concerns and depressive symptoms • Intervention by other professionals (e.g., vision therapy, mathematics tutoring, pragmatic therapy) may be indicated	**Management strategies** • Improve acoustic access to information in the classroom • Avoid multimodality cues; present information via one modality at a time • Some aspects of prosody training may be indicated to assist in integrating content with intent, including reading of body language cues • Directed therapy to target interhemispheric activities and binaural separation/integration training • Compensatory training to include principles of active listening, and recruitment of stronger, top-down language and cognitive functions • Occupational therapy and tutoring in specific academic areas as indicated

Table 3.3: Secondary CAPD profiles of the Bellis and Ferre Model (Bellis, 1999, Bellis, 2003a). *The new additions to the central test findings as presented in the most recent version of the Bellis/Ferre Model (Bellis, 2003a) are presented in italics.*

Associative Deficit	Output-organizational Deficit
Region of dysfunction Auditory association cortical areas (in the dominant hemisphere – usually left hemisphere) **Central test findings** • Bilateral deficit on dichotic speech tests, often with the right ear worse than the left • *Performance on tests of monaural low redundancy speech (using appropriate vocabulary), temporal processing, temporal patterning, and binaural interaction is often good, indicating intact function of the primary auditory cortex, corpus callosum and right hemisphere* • *Speech sound discrimination is typically good; however word recognition may be poor depending on the child's receptive language* • *Electrophysiology may show decreased amplitudes over the left hemisphere* **Primary auditory complaints** Difficulty in applying the rules of language to incoming acoustic information, for example: experiences difficulty with sentences presented in passive voice, compound sentences, and other linguistically complex messages **Related sequelae** • Receptive language deficits in vocabulary, semantics and syntax • Early academic achievement appropriate but, as the	**Region of dysfunction** Temporal-to-frontal and/or efferent system **Central test findings** • Deficit on any task requiring report of more than 2 elements (Frequency and duration patterns, Dichotic digits, Competing sentences, Staggered spondaic word test) • May have elevated or absent contralateral acoustic reflexes • *Performance on low-pass filtered or time compressed speech tasks usually within normal range (child is only required to repeat one word at a time)* • *Performance on speech in noise tests may be impacted due to auditory figure/ground difficulties* • *Absence of contralateral suppression during otoacoustic emission testing* **Primary auditory complaints** Inability to sequence, plan, and organize appropriate responses to novel auditory information and instructions. **Related sequelae** • Difficulty hearing in noise • Poor organizational skills • Difficulty following directions

Table 3.3 continued

Associative Deficit	Output-organizational Deficit
linguistic demands in the class start to increase(3rd grade), general academic difficulties may start to become apparent	• Reversals • Poor recall and word retrieval abilities • Expressive speech errors (consisting of perseverative responses in which the target is substituted by a previously heard word) • Sequencing errors and sound blending difficulties are not uncommon • Generally good reading comprehension though spelling and writing skills may be poor
Management and intevention strategies • Language intervention for receptive language • Metacognitive techniques (verbal rehearsal, chunking, tag words, and organizational aids • Classroom management strategies (pre-teaching new information and imposition of external organization within the classroom) • Instructions and information should be rephrased rather than simply repeated	**Management and intervention strategies** • Imposition of external organization (written reminders and checklists) • Metacognitive techniques • Speech-language therapy • Repetition and rephrasing (with the message or response broken down into smaller linguistic units of no more than 2 critical elements

language and learning implications and sequelae. The new additions to the central auditory test findings, as represented in the most recent version of the Bellis/Ferre Model (Bellis, 2003a), are presented in italics in Tables 3.2 and 3.3. This distinction is made as the data collection for the study took place prior to the publication of the most recent version of Bellis/Ferre Model (Bellis, 2003a). The discussion of the results of the study takes place against the backdrop of the penultimate version of the Bellis/Ferre Model (Bellis, 1999) but the recommendations of the most recent version (Bellis, 2003a) are considered and discussed in Chapter 6.

In the past, the two secondary subprofiles were seen to represent the gray area between audition, language and executive function, but included in Bellis/Ferre model (Bellis, 1999) as they yield definitive findings on central auditory assessment. Recently, Bellis (2003a: 289) again questioned the inclusion of the secondary subprofiles in the latest version of the Bellis/Ferre model describing the secondary subprofiles as "riding the fine, gray line between audition and higher-order abilities such as receptive language and executive function". It is possible that future revisions of the Bellis/Ferre Model (Bellis, 2003a) may not include one or possibly both of the current secondary subprofiles (Bellis, 2003b). Bellis (2003b) has suggested for example that the Output-organization subprofile more likely reflects an attention disorder than a CAPD. Further research examining the nature of the relationships between the secondary subprofiles, language, executive function and attention is thus warranted.

In an interesting article differentiating between ADHD and CAPD, Bellis and Ferre (1999) have suggested that tests of CAPD may be helpful in differentiating between CAPD and ADHD in children. Four case studies are presented in their article, namely; case 1: a child with an auditory decoding deficit CAPD subprofile, case 2: a child with an integration deficit CAPD subprofile, case 3: a child with a prosodic CAPD subprofile, and case 4: a child with ADHD. A CAPD test battery comprising dichotic speech tasks, monaural low-redundancy speech tasks, tests of temporal patterning and binaural interaction tasks, was used to assess the children. The CAPD results of the first three children yielded patterns that can be linked to specific CAPD subprofiles. In case 4, the child with ADHD, the CAPD test results were found to be within the normal range despite, initially presenting with both behavioral and academic difficulties suggestive of auditory dysfunction. Bellis and Ferre (1999) and Bellis (2003a) report (based on clinical experience) that children with ADHD are either expected to perform normally or poorly across all measures of CAPD, with no clear error pattern emerging in the test results. Further research examining the central auditory processing of children with the three different types of ADHD, namely the combined type, the inattentive type and the hyperactive-impulsive type, is indicated. Additionally, the issue of whether CAPD testing in these children should be done in the medicated or non-medicated state warrants further investigation and will be discussed under 3.6.

3.3.3 The model of Barkley (1998)

Although the model of Barkley (1998) does not refer directly to CAPD, the similarities between the models of Barkley (1998) and Chermak et al (1999) regarding the conceptualization of ADHD as an executive disorder necessitate their inclusion as part of the second school of thought. Much of the pioneering work in conceptualizing ADHD, as an executive dysfunction, can be attributed to the work of Barkley (Barkley, 1990, Barkley, 1996, Barkley 1997a, Barkley, 1997b). It is noted that Chermak et al (1999) refer to Barkley's work in their model. Additionally, the uncertainty over the inattentive type of ADHD, reflected in both the models of Barkley (1998) and Chermak et al (1999), and the possible links between the inattentive type of ADHD and CAPD, support the ensuing discussion of the model of Barkley (1998) and its inclusion as part the second school of thought.

As seen in figure 3.2, Barkley (1997b, 1998) proposes that behavioral inhibition is the fundamental attribute linked to the performance of the other executive functions in children with ADHD, namely prolongation, separation and regulation of affect, internalization of language, reconstitution and motor control and fluency.

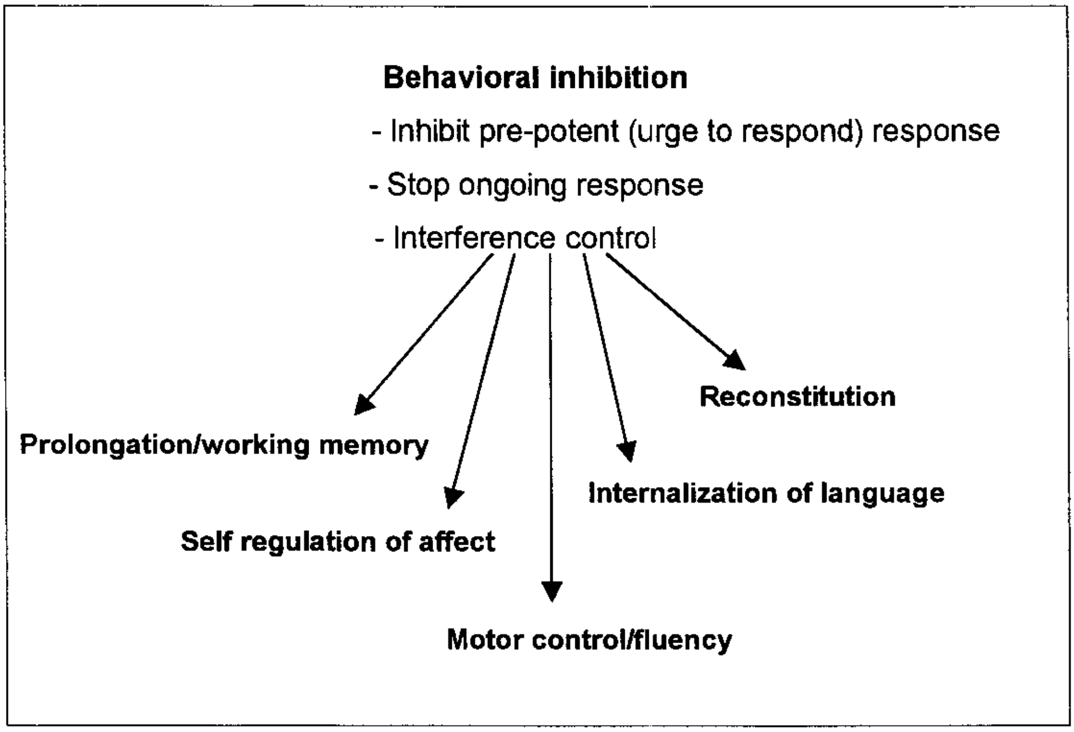

Figure 3.2: Barkley's (1997b, 1998) conceptualization of ADHD

There are three types of behavioral inhibition: firstly, the ability to inhibit a pre-potent response (urge to act) before it happens; secondly, the ability to stop an ongoing response that is ineffective, maladaptive or detrimental and change it to another response; and thirdly, the ability to protect the delay in response from outside interference. Acts of self-control occur in the brain between the time the event occurs and the time it takes to respond. During this time interval the brain regulates action. Behavioral inhibition is thus the key to these executive dysfunctions. Barkley (1997b, 1998) describes the attention deficits associated with ADHD as a mismatch between demands and resources and ascribes the disorder to behavioral inhibition which creates secondary impairments in the executive functions which lead to deficient self-regulation as well as impairment in the organization of behavior over time which, in turn, results in deficits in social/adaptive behavior.

Barkley (1998) has proposed that individuals with the *inattentive type of ADHD* differ from the combined and hyperactive-impulsive types of ADHD and suggests that individuals with the inattentive type of ADHD will receive no greater benefit from stimulants (such as Ritalin) than do normally functioning children. Similarly to Chermak et al (1999), Barkley (1998) suggests that the inattentive type of ADHD is a processing disorder rather than a dysfunction of executive dysfunction. The relationship between the inattentive type of ADHD and CAPD and the effects of medication thus warrants further investigation.

Executive functions can be assessed using a variety of neuropsychological assessments such as the Wisconsin Card Sort, the Cambridge Neuropsychological Tests Automated Battery, Category test, and Trailmaking (Packer, 2002). There is currently no agreed on test battery for assessing executive dysfunction in children (Packer, 2002). Computerized tests of continuous performance have also been reported to tap into executive function (Packer, 2002). Welsh (1994) reasons that although tests of continuous performance were originally designed to measure the global construct of attention, it is evident that sub-processes, including effortful information processing over time and inhibition of irrelevant and impulsive responding, are also tapped. Thus the performance measures observed in these attention tasks may also reflect executive function deficits (Welsh, 1994, Packer, 2002). In selecting a test such as the IVA CPT, not only the nature of the attention deficits associated with the three types of ADHD can be determined, but executive functions can also possibly be tapped.

3.4 THE THIRD SCHOOL OF THOUGHT: THE BUFFALO MODEL (KATZ ET AL, 1992)

In the third school of thought, CAPD is not viewed as an auditory modality specific disorder but rather as a multimodal disorder. The Buffalo Model (Katz et al, 1992) describes four categories of CAPD, namely Decoding, Tolerance-fading memory, Integration and Organization. A summary of the CAPD categories is provided in Table 3.4.

The different types or categories were initially based solely on the results of the Staggered spondaic word test (Katz, 1992). The Staggered spondaic word test was originally employed to study site-of-lesion in adults with tumors and strokes and later "...when interest turned to CAPD in learning-disabled children, the test was pressed into service to identify auditory processing disorder" (Katz, 1992: 81). Subsequently, even though a CAPD test battery (comprising the Staggered spondaic word test (Katz, 1986), the Phonemic synthesis test (Katz, 1983), a speech-in-noise test (Stecker, 1992), and the Masking level difference test at 500Hz) has been recommended (Stecker, 1998), the categorization of CAPD continues to be based primarily on the Staggered spondaic word test results.

Additionally, the Buffalo Model (Katz et al, 1992) describes not only clusters in Staggered spondaic word test results but also the behavioral characteristic of the children during CAPD evaluation (Stecker, 1998). These behaviors include aspects such as "impulsive responses", "long response delays" and "confused responses" (Stecker, 1998). Clear distinctions are not made in the Buffalo Model (Katz et al, 1992) between aspects such as memory, attention and CAPD, thus suggesting that CAPD is a multimodal disorder.

Table 3.4: The CAPD categories of the Buffalo Model (based on Katz et al, 1992)

	CAPD categories			
	Decoding	**Tolerance-fading memory**	**Integration**	**Organization**
Description of the category	Difficulty in accurately and quickly processing what is heard	Difficulty in understanding speech under adverse circumstances and/or short-term memory weaknesses	Difficulty in integrating auditory information with other functions, such as visual and non-verbal aspects of speech. There are two types, namely Type 1, which is similar to the decoding deficit and Type 2, which is similar to the tolerance-fading memory deficit	Characterized by reversals, sequencing errors and disorganization. This category is usually secondary to another CAPD category and rarely occurs in isolation *Category seldom occurs in isolation – seems to be some overlap with Tolerance-fading memory and Decoding categories*
Site-of-lesion	Posterior temporal region	Anterior temporal region and frontal lobes	Type 1: Corpus callosum and the angular gyrus Type 2: Anterior region of the brain and anterior portion of the corpus callosum	Frontal lobe and adjacent to posterior temporal region
Behavioral characteristics	Difficulty in keeping up with the flow of conversation, poor phonemic skills, slow responders, often have articulation errors, difficulty following directions, weak oral reading and spelling skills	Impulsive responders, easily overstimulated, may be hyperacusic, poor reading comprehension and handwriting due to poor motor planning, have short attention spans, easily distracted	Learning disabled, poor readers, often labeled as dyslexic. The type 1 profile also included poor spelling skills, poor sound-symbol relationships, excessively slow rate and poor handwriting	Characterized by reversals, sequencing errors and disorganization.
CAPD test results	History of conductive hearing loss, Staggered spondaic word test – weakness in right competing and/or left non-competing conditions, long response delays, more errors on items presented to the right ear first, more errors	Staggered spondaic word test – peak in left competing condition, more errors on the first spondee, tend to err on items presented to the left ear first, Phonemic synthesis test – omission of initial sounds and quick impulsive	Type 1 and 2: Type A pattern on the Staggered spondaic word test. Phonemic synthesis test – Type 1 has scores below grade level with long delays and confused responses and quiet rehearsals.	Staggered spondaic word test – reversals, Phonemic synthesis test - reversals

Table 3.4 continued

	CAPD categories			
	Decoding	**Tolerance-fading memory**	**Integration**	**Organization**
	on second than on first spondee, Phonemic synthesis test – scores outside normal limits, a Speech-in-noise deficit is sometimes present	responses, Speech-in-noise tests – poor scores	Speech-in-noise tests – poor score for Type 2, sometimes with a large discrepancy between the two ears	
Speech-language findings	Difficulties with receptive language (morphology), word-finding, prosody, oral and written discourse and articulation errors	Expressive language weakness: cluttering, inconsistent articulation, receptive language weakness: elaborated syntax, discourse errors: oral and written	Word finding problems, receptive language errors (morphology and syntax), expressive language errors (oral and written)	Discourse errors (oral and written sequencing), disorganized in work
Academic implications	Slow responder, phonics problems, poor understanding of directions, weak on written tests, minimal, oral discussions, difficulty with group listening	Poor attention span, distractible, reading weakness, weak short term memory, difficulty following directions, poor handwriting, impulsive behavior, poor motor planning	Slow responders, poor phonetic skills, poor-sound symbol relationships, severe spelling and reading problems, poor handwriting, difficulty with multi-modal tasks	Sequencing errors, disorganized in work
Management strategies	Improve phonemic and metaphonological skills, use phonic approach in reading, use clear and concise directions, allow for testing modifications, provide outlines, rephrase and restate, pretutor, provide written instructions	Improve signal to noise ratio, noise desensitization practice, compensatory strategies for auditory memory, preferential seating, earplugs, strategies to gain attention, take notes and outline in class, tape record classes, quiet study area	Improve phonemic and metaphonological skills, improve signal-to-noise ratios, use note-takers, tape record classes, reader-writer for tests, texts on tape, word processor with audio spell-check	Discourse therapy (sequence, information), consistent routines, checklists, calender

Interestingly, Stecker (1998) has reported that children with the Tolerance-fading memory deficit often exhibit similar characteristics to those with ADHD. Stecker (1998) recommends that the Auditory Continuous Performance Test (ACPT) (Keith, 1994) be administered if ADHD is suspected as this test screens for attention disorders. Stecker (1998) reasons that the inclusion of the Auditory Continuous Performance Test (Keith, 1984) in the CAPD test battery will aid in the differential diagnosis of ADHD and CAPD and thus facilitate appropriate intervention. Overlooked, however, in the reasoning of Stecker (1998) is the importance of considering not only auditory but also visual continuous performance. In selecting a test such as the IVA CPT, which combines both the auditory and visual continuous performance, the nature of the attention deficits associated with ADHD can possibly be determined.

Medwetsky (2002) also speculates that the Tolerance-fading memory deficit is the consequence of an attention deficit. Individuals with the Tolerance-Fading Memory deficit experience difficulty in retaining information presented and have difficulties in the presence of background noise. Medwetsky (2002) reasons that the latter is likely due to two causes. Firstly, if the underlying cause is related to attention, the individual is less capable of focusing on target stimuli while blocking out competing stimuli. Secondly, since individuals with this deficit are less capable of retaining information in their short term memory then any factor that increases the amount of time that stimuli will need to be processed will, in turn, affect the amount of information that can be retained. Should the Tolerance-fading memory deficit prove to be the consequence of an attention deficit, then management strategies should include metacognitive strategies to improve the individual's attention, and stimulant medication warrants consideration (Medwetsky, 2002).

3.5 THE VALUE OF TESTS OF CONTINUOUS PERFORMANCE AND CAPD IN DIFFERENTIATING BETWEEN ADHD AND CAPD IN CHILDREN

In summarizing the above discussion of the three opposing schools of thought regarding the conceptualization of ADHD and CAPD the following insights are developed:

The first school of thought:

- McFarland and Cacace (1995) propose that CAPD is an auditory modality specific disorder whereas the attention deficits associated with ADHD are suspected to be supramodal in nature, i.e. associated with both the auditory and visual modalities. Research examining the nature of the attention deficits associated with ADHD is thus warranted. McFarland and Cacace (1995) recommend using similar tasks in assessing the auditory and visual modalities. The IVA CPT that combines both auditory and visual stimuli with tasks of attention and vigilance in a counterbalanced design may be a useful tool in determining the nature of the attention deficits associated with ADHD.

The second school of thought:

- Chermak et al (1999) support McFarland and Cacace's (1995) view of the supramodal nature of the attention deficits associated with ADHD, and additionally ascribe the combined and hyperactive-impulsive types of ADHD to an executive dysfunction. The inattentive type of ADHD is seen as a processing disorder with executive dysfunction as a secondary disorder. Differentiating between the inattentive type of ADHD and CAPD thus becomes a challenge as CAPD is also considered to be a processing disorder though the attention deficits associated with CAPD are primarily considered to be auditory modality specific in nature. Although CAPD is seen to result from dysfunction of the processes dedicated to audition, it is recognized that CAPD may co-exist with more global dysfunction that affects performance across modalities (Chermak et al, 1999).

Chermak et al (1999) report that children with the inattentive type of ADHD appear to receive limited if any benefit from stimulants, in contrast to the combined and hyperactive-impulsive types of ADHD that are linked to executive dysfunction. Further research investigating the nature of the attention deficits associated with ADHD and the effects of stimulants on the functioning of children with the three different types of ADHD is thus indicated. Tests of auditory and visual continuous performance and tests of CAPD may be useful in determining the nature of these attention deficits and the effects of medication.

- In the Bellis/Ferre Model (Bellis, 2003a), CAPD is viewed as a specific auditory deficit, but the existence of co-existing multimodality symptoms based on shared neurophysiological site of dysfunction is acknowledged. This model is a dynamic and changing one. The initial version of the Bellis/Ferre Model (Bellis, 1996) included four primary subprofiles and now, after many revisions, consists of three primary and two secondary subprofiles. The most recent Bellis/Ferre Model (Bellis, 2003a) includes three primary and two secondary subprofiles. Bellis (2003b) currently questions the inclusion of the secondary subprofiles in their most recent model, arguing that these subprofiles appear to represent language, executive function and attention rather than central auditory processing. Bellis (2003b) has suggested, for example, that the Output-organization subprofile more likely reflects an attention disorder than a CAPD. Further research examining the relationships between the secondary subprofiles, language, executive dysfunction and attention is thus warranted.

  Bellis and Ferre (1999) propose that tests of CAPD may be helpful in differentiating between ADHD and CAPD in children and use four case studies in their article to illustrate this. Based on clinical experience, Bellis and Ferre (1999) and Bellis (2003a) suggest that children with ADHD are expected to perform normally or poorly across all measures of CAPD, with no clear pattern emerging on the test results. Further research examining the central auditory processing of children diagnosed with the three different types of CAPD is thus warranted.

The choice of the specific tests used in a behavioral test battery for assessing central auditory processing varies amongst audiologists. Bellis and Ferre (1999) have recommended that a behavioral CAPD test battery should include at least the following: dichotic speech tasks (1 linguistically loaded and 1 linguistically non-loaded measure), monaural low redundancy speech tasks, tests of temporal patterning, and binaural fusion tasks. Recently, in the Bruton conference consensus report, Jerger and Musiek (2000) have recommended a minimum behavioral CAPD test battery including puretone audiometry, performance-intensity functions for word recognition, a dichotic task, a frequency or duration pattern sequence test and a temporal gap detection test. Jerger and Musiek (2000) have, however, not as yet reported on the possible value of their test battery in differentiating between ADHD and CAPD. The CAPD test battery recommended by Bellis and Ferre (1999) in examining the value of behavioral tests of CAPD in differentiating between ADHD and CAPD in children warrants further research after which the value of other test batteries such as the one proposed by Jerger and Musiek (2000) could be investigated.

Finally, it is recognized that Bellis (2003a) recently published an update for recommendations regarding 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 had been completed prior to the publication of these recommendations.

- Barkley (1998) also contributes the combined and hyperactive-impulsive types of ADHD to an executive dysfunction and furthermore suggests the inattentive type of ADHD is likely a processing disorder. Barkley (1998) supports Chermak et al's (1999) view that children with the inattentive type of ADHD will receive no greater benefit from stimulants such as Ritalin than do normally functioning children. The relationship between the different types of ADHD and the effects of medication thus warrants further investigation. Again, tests of auditory and visual continuous performance and tests of CAPD may be useful in determining the nature of these attention deficits and the effects of medication.

The third school of thought:

- Based on the Buffalo Model of Katz et al (1992), both Stecker (1998) and Medwetsky (2002) have reported that children with the Tolerance-fading memory deficit often exhibit similar characteristics as those with ADHD and thus recommends including the Auditory Continuous Performance Test (Keith, 1994) during CAPD testing, when ADHD is suspected. The inclusion of a visual continuous performance test, in addition to the above test of auditory continuous performance, is likely to yield more information on the nature of the attention deficit associated with ADHD. The IVA CPT (Sandford and Turner, 2001) that combines both auditory and visual stimuli with tasks of attention and vigilance in a counterbalanced design may be a useful tool in determining the nature of the attention deficits associated with ADHD. The inclusion of a CAPD test battery would be useful in determining whether patterns exist in the test results that can be linked to the different categories of CAPD.

3.6 CONCLUSIONS

The value of assessing the auditory and visual continuous performance and central auditory processing of children with the three different types of ADHD (combined, inattentive and hyperactive-impulsive) is thus as follows:

- Tests of auditory and visual performance will yield information on the nature of the attention deficits associated with each type of ADHD, i.e. supramodal (visual and auditory modalities) or modality specific.

- A CAPD test battery will yield information about whether patterns exist in the results of children with the three different types of ADHD, and whether these results can be matched with specific categories or subprofiles of CAPD.

By incorporating the above measures of auditory and visual continuous performance, and central auditory processing a "specific multi-dimensional test battery" can be created. The term "specific multi-dimensional test battery" as used here encompasses two concepts (as discussed in Chapter 1), namely "specific" and "multi-dimensional". The term "specific" refers to specific measures of both central auditory processing and continuous performance. The concept "multi-dimensional" refers to the diversity and complexity of the factors being considered; namely the central auditory processing, and (auditory and visual) continuous performance of the participants in both the medicated and non-medicated state.

An important consideration in administering the above procedures to children with ADHD is whether these children should be assessed in the medicated and non-medicated state.

Chermak et al (1999) and Bellis (2001, 2003a) suggest that tests of CAPD be administered to children with ADHD in the medicated state as this will control attention deficits and enable the audiologist to obtain a more accurate representation of the child's actual central auditory processing abilities. Others may argue that audiological assessment should be conducted in the child's natural state (without medication) and/or express concerns about the possible confounding effects of medication on the test performance (Chermak et al, 1999). Tests of auditory and visual continuous performance provide information about the child's attention and vigilance and the purpose of the testing should dictate whether the child is tested in the medicated or not-medicated state. For example, if the purpose of the testing is to determine the attention and vigilance of the child, it would probably be best to test the child in the non-medicated state. If, however, the purpose of the testing is to determine the effect of the medication on the child's functioning, then testing in the medicated state or at least a comparison of functioning in both the medicated and non-medicated state would be more appropriate.

Based on the suggestions made by both Chermak et al (1999) and Barkley (1998) that children with the inattentive type of ADHD are unlikely to benefit from medication, it may be of interest to assess the continuous performance and central auditory processing of children with the three different types of ADHD in both the medicated and non-medicated state.

3.7 SUMMARY OF CHAPTER 3

The three opposing theoretical schools of thought regarding the conceptualization of ADHD and CAPD in children are discussed. In the first school of thought, CAPD is considered to be a disorder of the auditory modality while ADHD is suspected to be supramodal in nature. In the second school of thought, the auditory specific nature of CAPD is highlighted (while simultaneously recognizing that multimodality involvement may co-exist with CAPD due to the interconnectedness of the central nervous system) and ADHD is seen to be supramodal in nature. The value of tests of CAPD in differentiating between CAPD and ADHD, as suggested by Bellis and Ferre (1999), is highlighted in the discussion. In the third school of thought, the Buffalo Model (Katz et al, 1992) and the multimodal nature of CAPD is discussed. The possible link between Tolerance-fading memory deficit (one of the CAPD categories of the Buffalo Model (Katz et al (1992)) and ADHD, as reported by Stecker (1998) and Medwetsky (2002), is highlighted. Thereafter, the value of tests of auditory and visual continuous performance in investigating the nature of the attention deficits associated with the three different types of ADHD is discussed. Finally, the issues surrounding the administration of the above measures in the medicated and/or non-medicated state are addressed.