Assessment of Central Auditory Processing Disorders (CAPD) Evaluation Protocol in a Clinical Setting

Hala Elsisy, Ph.D.
Purdue University, West Lafayette, IN

A review of forty clinical records of patients evaluated for central auditory processing disorders (CAPD) was conducted to investigate the utility of the screening and assessment protocol implemented in a university clinic setting. Results indicated that the clinic protocol has reduced the number of patients requiring CAPD assessments by more than half. It also showed that screening with the SCAN test positively identified patients with CAPD with a hit rate (sensitivity) of 50%. Overall, about 20% of the patients referred to the clinic were diagnosed with CAPD.

Introduction

The presence of central auditory processing disorders (CAPD) affects the central nervous system's ability to effectively and efficiently use auditory stimuli (American Speech Language Hearing Association, 2005), and therefore, could have a profound influence on the individual's ability to listen, learn, and navigate through social environments.

The complexity of the evaluation and the diagnosis of CAPD mandates the need for screening tools to identify individuals who are at risk for CAPD prior to the initial evaluation (Bellis, 2003). The purpose of the CAPD screening is to obtain preliminary information about an individual's auditory functional abilities and to determine the need for further comprehensive diagnostic testing (ASHA, 2005; American Academy of Audiology, 2010; Bellis, 2003). Another reason to screen for CAPD is to reduce the number of inappropriate referrals of individuals with higher order global deficits (attention, language, memory) who are mistakenly suspected of having CAPD. An effective screening protocol would also reduce overall cost, save time, and avoid unnecessary stress of individuals suspected of having CAPD and their families.

Several scholars have developed screening protocols, which may involve the administrations of standardized questionnaires or behavioral checklists, specific screening tools or audiometric procedures (Bellis, 2003; Jerger & Musiek, 2000; Musiek et al., 1990). Questionnaires or behavioral check lists can be used to sample the behaviors associated with CAPD. However, they do have limitations as being subjective measures that could be affected by respondent bias, or misinterpretation (Schow & Seikel, 2007).

One of the most widely used screening tests for CAPD is the SCAN test with its two versions; SCAN-A Test of Auditory Processing Disorders in Adolescents and Adults (Keith, 1994) and SCAN-C Test of Auditory Processing Disorders in Children- Revised (Keith, 2000b). The popularity of this test was demonstrated by survey data from Emanuel (2002), Chermak et al. (1998) and Emanuel et.al (2011).The reason for its popularity stems from the fact that it is easily administered and has well documented normative data for scoring and interpretation. The SCAN consists of four tests (Filtered Words, Auditory Figure Ground, Competing Words, and Competing Sentences). Therefore, it only examines two (binaural/dichotic and monaural low-redundancy test) of the seven test areas recommended by ASHA (2005). ASHA's seven test areas are: auditory pattern/temporal tests, monaural low-redundancy tests, binaural/dichotic speech tests, binaural interaction tests, auditory discrimination tests, electroacoustic tests, and electrophysiologic tests. Furthermore, some studies have shown that the SCAN has relatively unstable test-retest reliability (Amos & Humes, 1998), is highly dependent upon verbal knowledge (Chermak & Musiek, 1997), and its sensitivity did not ever reach 50% (Domitz & Schow, 2000).

Recently, the test has been largely modified and is known now as the SCAN-3:A/SCAN-3:C (Keith 2009 a, 2009 b). Some of the modifications in the SCAN-3 test included having separate sets of screening and diagnostic testing and adding Gap Detection as part of the screening tests. Specifically, the screening part of the SCAN-3 consists of three tests (Gap Detection, Auditory Figure Ground, and Competing Words- Free Recall), and therefore, tapping the area of auditory pattern/temporal tests, along with the other two areas included in the older version of the SCAN.

Clinical decision analysis procedures have been used to evaluate the effectiveness of audiological tests (Turner & Nielson, 1984) and CAPD tests (Hurley& Musiek, 1997).

Clinical decision analysis examines a sample by determining the relationship between presence or absence of a disorder and whether or not test results were positive or negative. These can be represented in a 2x2 decision matrix with 4 possible outcomes as shown in Table 1; the most commonly measured are the hit rate (sensitivity) and the false positive (false alarm) rate.

In this study, clinical decision analysis was used to evaluate the sensitivity of the SCAN and the SCAN-3 tests, in identifying individuals with CAPD.

Guidelines for CAPD assessment by ASHA (2005) and AAA (2010) indicated that the CAPD test battery should be based on the individual's case history and other information provided to the audiologist, rather than a preset battery of tests for all patients. Both ASHA and AAA recommend a set of principles that should be applied when determining the composition of a test battery, which include: (a) CAPD assessment should be multidisciplinary; (b) diagnosis and management should be guided by case history and diagnostic findings; (c) diagnostic test batteries should include both verbal and nonverbal stimuli to assess different levels of the central auditory nervous system (CANS); (d) the test battery should examine different processes, regions, and levels of CANS; (e) behavioral tests and other screening tools (including questionnaires) should be well validated, have good test-retest reliability, and demonstrate high sensitivity and specificity; (f) testing should be completed within a reasonable period of time; (g) the audiologist needs to be sensitive to subject-related attributes that may influence the individual's test performance, such as chronological age and mental age, attention to task, fatigue, and native language; and (h) testing should not be test driven but rather motivated based on the referring complaint.

Despite these guidelines, there seems to be a lack of consensus among both researchers and clinicians regarding the tests that should be part of a basic CAPD test battery, as depicted in most studies that surveyed audiologists regarding their clinical practices in CAPD testing (Chermak et al., 2007; Chermak et al., 1998; Emanuel, 2002; Martin et al., 1998). Results from the most recent survey by Emanuel et al. (2011), indicated that the majority of audiologists, who described CAPD testing as an area of their expertise, reported using additional tests in their CAPD battery based on the individual case history and age, and therefore, were more inclined to follow these best practice guidelines. Furthermore, there appears to be some agreement among audiologists on the screening and assessment protocol being utilized (Emanuel et al., 2011).

Purpose

The purpose of this study was to evaluate a clinic protocol for CAPD screening and evaluation. The protocol was developed and implemented at a university clinic setting to streamline the screening and the assessment process and to reduce the number of inappropriate referrals. The goals of this study were to (a) examine the sensitivity of the SCAN-A/ SCAN-C, and SCAN-3:A/SCAN-3:C tests in identifying individuals with CAPD; and (b) compare the clinic's protocol to best practices reported in the literature .This has been accomplished through analysis of clinic records of individuals evaluated for CAPD.

Table 1. Decision Matrix Outcomes for Diagnostic Tests (Turner & Nielsen 1984)

		Confirmation Test (Diagnostic)	
		Positive	Negative
Screening Test	Positive	Hit	Miss
	Negative	False Alarm	Correct Rejection

Methods

A clinical protocol was developed and implemented to streamline the screening and assessment process for CAPD. Four years later, the records of patients who visited the clinic for CAPD testing were reviewed and analyzed to evaluate the protocol. Figure 1 presents the flow chart of the CAPD protocol. For school age children, the protocol included an initial screening by completing teachers' questionnaires: Children's Auditory Performance Scale (CHAPS; Smoski, Brunt, & Tannahill, 1992) and the Screening Instrument for Targeting Educational Risk (SIFTER; Anderson, 1989), along with a short CAPD questionnaire (see Appendix A).

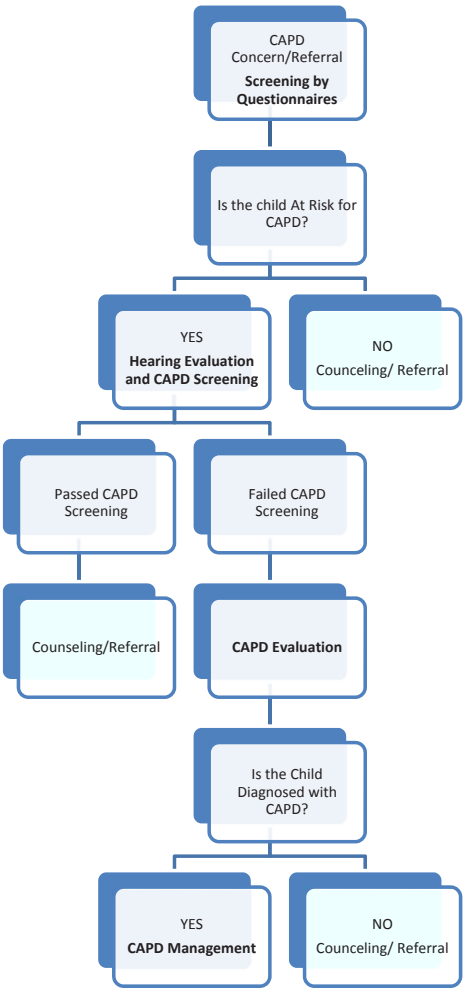

Figure 1. Flow chart of the CAPD clinic testing protocol

The audiological assessment included otoscopy, immittance measures (tympanometry and acoustic reflex measurements), pure tone audiometry and speech audiometry. Individuals with documented hearing loss were counseled and were not further evaluated for CAPD. The CAPD screening included the SCAN-A/ SCAN-C and SCAN-3:A/SCAN-3:C (screening) tests. The CAPD assessment consisted of a minimum test battery of four tests. More tests were added based on the case history and age of the patient. The battery was administered for those who did not pass the screening and their profile pointed to the presence of CAPD tendencies. Following the Bellis/Ferre model (Bellis & Ferre, 1999), four groups of tests were employed:

- Binaural speech tests including the Dichotic Digits Test (DDT; Musiek, 1983), the Staggered Spondaic Word test (SSW; Katz, 1962), and the Competing Sentences Test (CST; Willeford & Burleigh, 1994).
- Temporal processing tests including the Random Gap Detection Test (RGDT; Keith, 2000a), the Frequency Pattern Test (FPT; Pinheiro & Patcek, 1971), and the Duration Pattern Test (DPT; Pinheiro & Museik, 1985).
- Monaural low-redundancy tests including the QuickSIN test (Etymotic Research, 2001) and the NU-6 30% compressed speech (Beasley, Schwimmer, & Rintelmann, 1972).
- Binaural interaction tests including mainly the Masking Level Difference test (MLD) (Hirsh, 1948).

The patients' clinic records were reviewed and handled in accordance with the University IRB regulations/ committee on the use of human research subjects. Descriptive statistics were used to summarize the demographic data. Clinical decision analysis was applied to examine the sensitivity of the SCAN tests in identifying individuals with CAPD.

Results

Clinic records of 40 patients, 23 males (57.5%) and 17 females (42.5%), were reviewed. Patients were divided into two school age groups: 7-11years (n=17), 12-17 years (n=11), and one adult group: ≥18 years (n=12). Table 2 demonstrates the number of patients referred by different sources. It is clear that the schools were the most prevalent source of referral to the clinic (37.5%), followed by parental or self-referral (12.5% each), physicians, college counselors, vocational rehabilitation counselors (10% each), and (7.5%) from other health professionals.

Results of the audiological evaluation revealed hearing to be within normal limits (≤ 15 dB HL in children & ≤ 25 dB HL in adults at frequencies 250-8000Hz) in 35 of the 40 patients. Therefore, the CAPD screening was completed on 35 patients, and of those, 19 failed the screening as shown in Figure 2. Overall, 23 patients were screened with the SCAN, and of those, 13 patients failed the test: 11 of 13 patients failed the SCAN-A, and two of 10 failed the SCAN-C. The newer version of the test, the SCAN -3, was administered to 12 patients. Half of the patients failed the screening section, with one of four failing the SCAN-3:A, and five of eight failing the SCAN-3:C.

Figures 3 and 4 present the distribution of the SCAN and the SCAN-3 subtests failed respectively. It is notable that more patients failed the SCAN-A than the SCAN-C. The most commonly failed tests on the SCAN-A were Competing Words, Competing Sentences, and Auditory Figure Ground. Interestingly, more patients failed the SCAN-3:C than the SCAN-3:A, mainly on Auditory Figure Ground and Competing Words- Free Recall.

The CAPD test battery was completed on 18 of the 19 individuals who failed the screening. The battery was completed

Table 2. CAPD Referral Sources

Referral Sources	Number of Patients
School	15
Parent	5
Self	5
Physician	4
College Counselor	4
Vocational Rehabilitation	4
Others	3

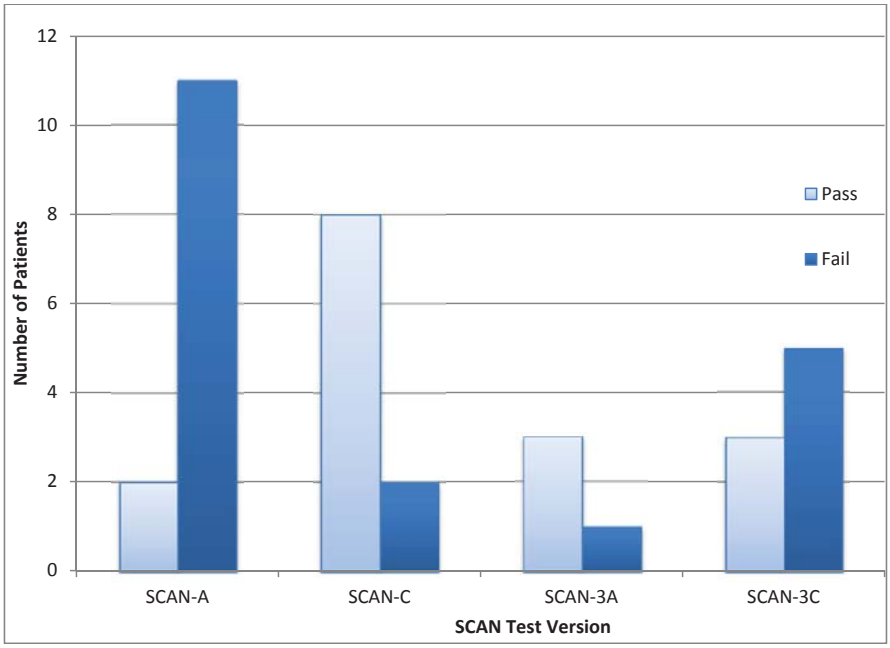

Figure 2. Number of patients who passed (light blue) and failed (dark blue) the SCAN and SCAN-3 tests

on 9 males and 9 females, with three age groups: 7-11 years (n =6), 12-17 years (n= 5), 18 years or older (n= 7). Fourteen of the patients were administered four or more tests, and the remaining four patients were only administered three tests due to test duration and attention. Figure 5 illustrates the number of patients within each age group that were evaluated in the four categories of the CAPD test battery. It should be noted that, across age groups, more patients were evaluated with the dichotic speech tests and the temporal processing tests than the monaural low-redundancy speech tests. The binaural interaction tests were administered only to the 18 years or older group. The most frequently administered tests were the Dichotic Digits (n=15), the Frequency Patterns (n=13), the Random Gap Detection (n=10), and the QuickSIN (n=8).

Results of the CAPD evaluation indicated that 8 of the 18 patients who completed the test battery were diagnosed with CAPD based on the criterion recommended by ASHA (2005) and AAA (2010). Table 3 compares the number of individuals screened, evaluated, and diagnosed with CAPD across the three age groups. Out of the 40 patients referred, 35 were screened, 18 of them were evaluated, and only 8 had the diagnosis of CAPD. Thus, only 45% of the patients screened needed a full assessment (18/35), and therefore reduced the number of unnecessary evaluation by 55%. It is clear that more children at the youngest age group of 7-11 years were referred compared to the other two groups, and only two of the 17 children screened within this age group were diagnosed with CAPD, indicating a large number of over-referral. Results also showed that one fifth (20%) of those referred to the clinic have the diagnosis of CAPD.

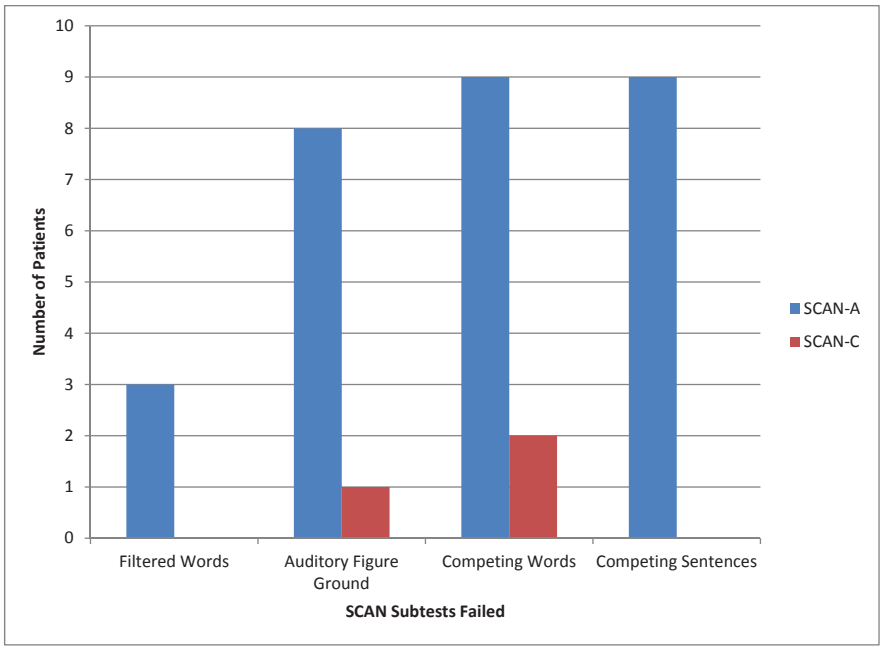

Figure 3. Distribution of the SCAN-A (Blue) and SCAN-C (Red) subtests failed

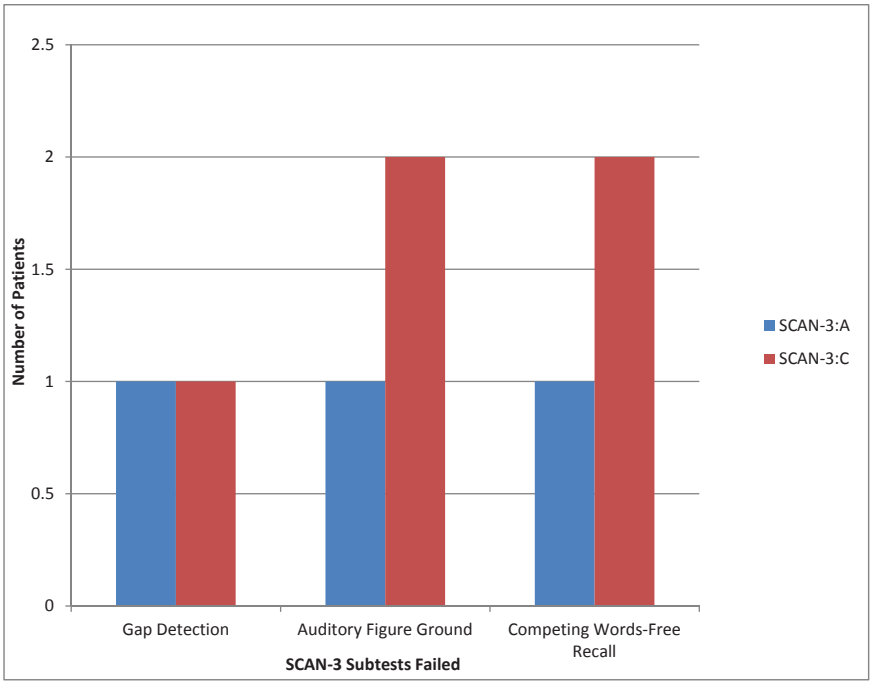

Figure 4. Distribution of the SCAN-3:A (blue) and SCAN-3:C (red) subtests failed

Applying the clinical decision analysis on those patients who failed the SCAN, and were diagnosed with CAPD, indicate that the SCAN positively identified patients with a hit rate (sensitivity) of 50% (six patients were diagnosed out of 12 failed), as seen in Figure 6. Results of the SCAN-3 showed a lower hit rate of 33% (two were diagnosed out of six failed). Figure 7 depicts the hit rate of individual tests, showing the SCAN-3:C to be the least sensitive, as it correctly identified only one of five patients (20%). It also showed a sensitivity of 45.5% for SCAN-A (5/11), 100% for SCAN-C (1/1), 100% for SCAN-3:A (1/1).

Discussion

This study evaluated a protocol for screening and assessment of CAPD at a university clinic setting. The protocol consisted of initial screening, which included the use of teachers' checklists and questionnaires for the school age group of patients. The purpose of these questionnaires was to obtain teachers' input on the child's behavior as compared to others in the classroom. Although there has been some concerns regarding the use of these subjective checklists

Table 3. Number of Patients per Age Group at Different Stages in the CAPD Testing Protocol

Age Groups	Screened	Evaluated	Diagnosed
7-11 years	17	6	2
12-17 years	9	5	2
≥18 years	9	7	4
Total	**35**	**18**	**8**

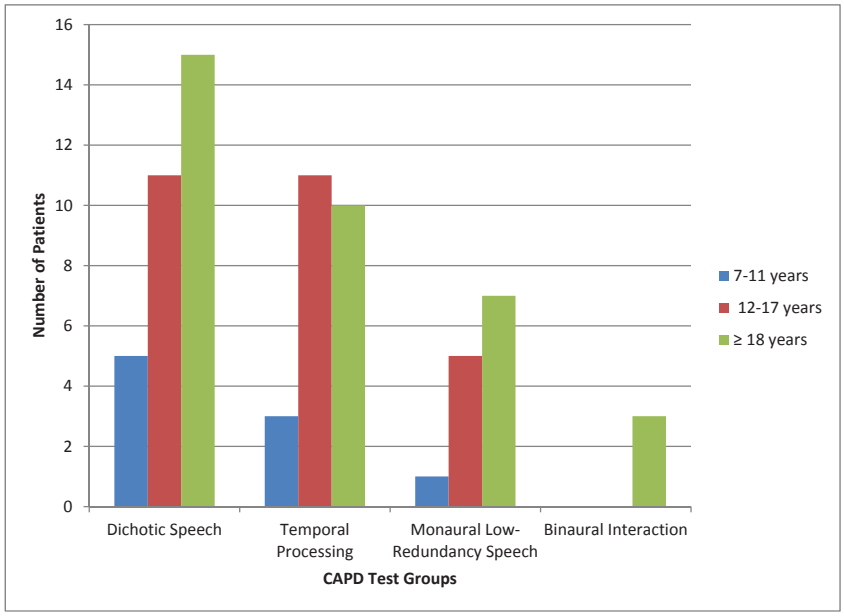

Figure 5. CAPD test battery categories administered to patients by age group: 7- 11years (blue), 12-17 years (red), and ≥ 18 years (green)

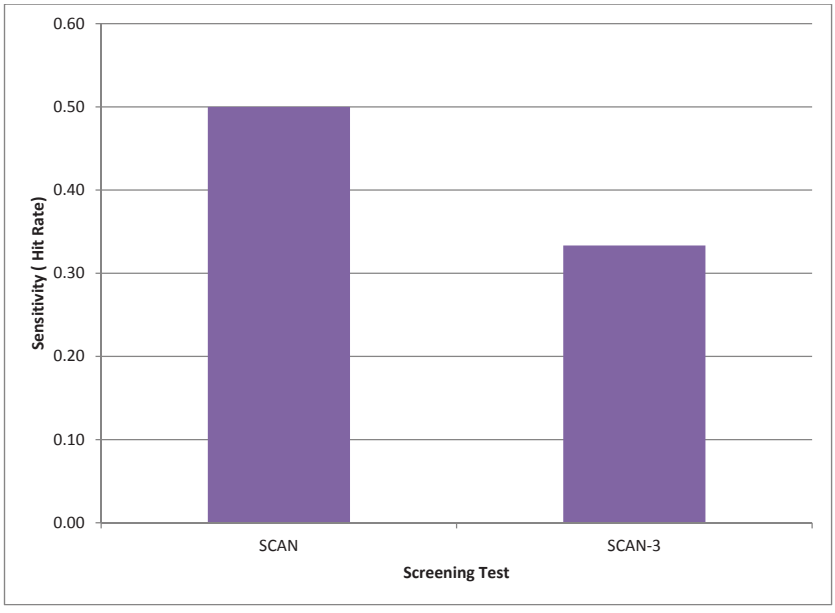

Figure 6. Sensitivity (hit rate) of the SCAN and the SCAN-3 tests

due to poor specificity and possible increase in over-referrals, they do provide valuable information about the auditory function in a variety of situations, such as listening in noisy backgrounds, following directions, and understanding rapid or distorted speech (Jerger & Musiek, 2000). Therefore, these checklists could be considered part of the case history, which guide the clinician in developing the appropriate test battery for each individual (AAA, 2010). They could be also used to supplement and contextualize the behavioral test findings after a diagnostic battery confirms CAPD (Schow & Seikel, 2007).

Audiological assessment was performed on all patients, as part of the initial screening, to rule out peripheral hearing as a factor in their possible CAP difficulties. This important step is recommended by ASHA (2005), and it has resulted in the exclusion of five patients from the poll due to the presence of hearing loss, which in itself could cause auditory processing difficulties.

The screening for CAPD was completed using the SCAN test, as it is cited to be the most widely used test for CAPD screening (Emanuel, 2002; Chermak et al., 1998; Emanuel et al., 2011). The reason for its popularity was described by Emanuel (2002) as being easily administered and having well documented normative data for easy scoring and interpretation. Some studies, however, have shown that the SCAN has relatively unstable test-retest reliability (Amos & Humes, 1998) and is highly dependent upon verbal knowledge (Chermak & Musiek, 1997). Two versions of the SCAN were used by the clinic, the SCAN-A/ SCAN-C, and with most recent cases, the SCAN- 3:A/ SCAN- 3:C were employed. As described in the results section, 19 of 35 patients failed the screening, and of those, 18 were evaluated with the CAPD test battery. This finding indicates that the screening protocol used by the clinic reduced the number of unnecessary assessments by more than half. This resulted in saving clinic resources, reducing patients/ family stress, and saving resources of the referring agencies, such as the schools.

The CAPD test battery was completed on 18 patients who failed the screening. On average, four tests were given to each patient. The battery included the four main groups of tests in the Bellis- Ferre Model: dichotic speech tests, temporal processing tests, monaural low-redundancy speech tests, and binaural interaction tests. This is fairly consistent with the results from a recent

survey of audiologists who reported CAPD as a specialty area by Emanuel et al. (2011). The most popular tests administered in the battery were dichotic, monaural low-redundancy speech, and temporal processing tests (Emanuel et al., 2011).

The screening protocol used in this study is also consistent with the above mentioned survey findings. The majority of audiologists completed a screening for CAPD (69%), and they used mainly the SCAN-A and SCAN-C. More than half of the audiologists surveyed (56%) used questionnaires instead of, or in addition to, the screening.

CAPD test battery diagnosed eight patients with CAPD based on the criterion recommended by ASHA (2005) and AAA (2010) of having poor performance of two standard deviations (or more) below the mean on two or more tests in at least one ear. Computing the sensitivity of the SCAN tests revealed that the sensitivity (hit rate) of the SCAN is 50%, as six of 12 patients who failed this version were positively identified with CAPD. This result is comparable with the 45% SCAN sensitivity reported by Domitz & Schow, (2000). A lower hit rate of 33% was computed for the SCAN-3, only two of the six patients who failed the screening with the SCAN-3 version were diagnosed with CAPD. This small hit rate for the SCAN-3 could be attributed to the sensitivity of 20% for SCAN-3:C observed in this study. Looking at the results of individual SCAN-3 subtests, it appears that more children failed the Auditory Figure Ground and the Competing Words- Free Recall, than the Gap Detection test. Overall, the number of patients screened with the SCAN-3 is much lower than those screened with the SCAN due to the relatively recent availability of the SCAN-3 in the clinic.

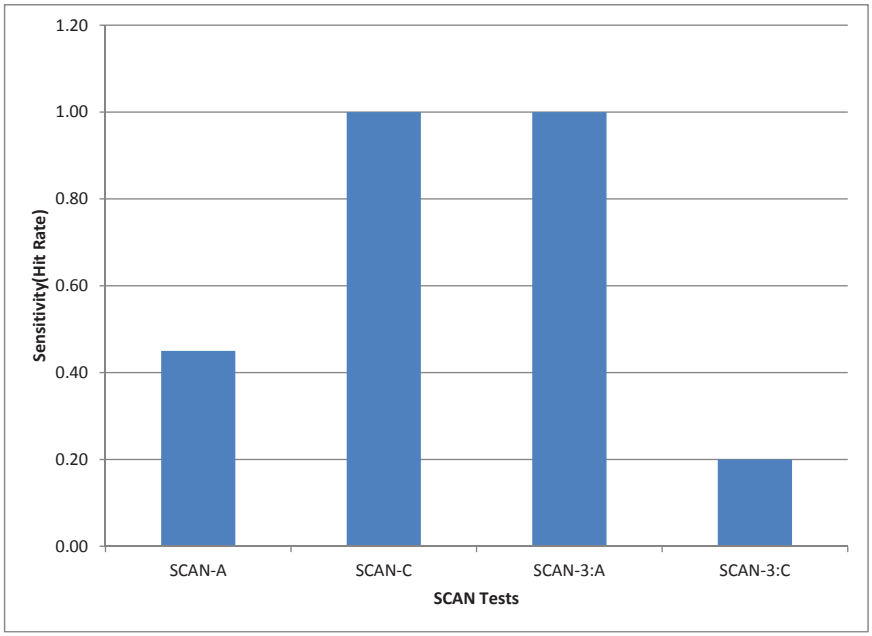

Figure 7. Sensitivity (hit rate) of individual SCAN tests

Comparing the initial number of patients referred for CAPD by age group and the number of those diagnosed with CAPD showed that out of 17 children who were initially referred, only two children in the 7-11 age group was diagnosed with CAPD. This high rate of over-referral is more pronounced in the youngest age group and could be explained by the difficulty in the differential diagnosis of CAPD, as symptoms and behaviors of other disorders, such as attention deficit disorders and language disorders, are closely similar to those of auditory processing disorders.

Conclusions and Future Directions

In summary, the clinic protocol evaluated in this study was consistent to what has been recently reported by other practicing audiologists. According to the latest survey by Emanuel et al., (2011) there seems to be a relatively consistent approach among audiologists towards the assessment and diagnosis of CAPD. This study showed that the protocol reduced the number of unnecessary CAPD assessments by 55%, and consequently helped save clinic and referring agencies' resources as well as reducing patients' anxiety and testing time. Screening with the SCAN test positively identified patients with a sensitivity of 50%, which is comparable to what has been reported in other studies.

The study also depicts a large number of over-referrals, especially for the age group of 7-11 years old. This finding could be explained by the inherent difficulty in the differential diagnosis of CAPD, as symptoms and behaviors of other disorders, such as attention deficit disorders and language disorders are closely similar to those of auditory processing disorders. This problem could be minimized by continuing to implement and advocate for the use of a multidisciplinary approach to the CAPD evaluation. The number of patients who were screened with the new SCAN-3 was limited because the test was recently administered in the clinic. More research is needed to investigate the effectiveness of the screening portion of the SCAN-3 in identifying individuals with CAPD.

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Appendix A. Central Auditory Processing Disorders Referral / Questionnaire

Please consider the following criteria when requesting or referring for CAPD evaluation:

- Age is 7 years or older
- Normal hearing in both ears
- IQ is 85 or better (normal overall cognitive status)
- Good speech intelligibility
- Adequate English language skills
- No severe emotional and /or behavioral disorders
- Copy of a recent psycho-educational evaluation (if available)
- Copy of a recent speech and language evaluation (if available)

Please take a few minutes to answer the following questions about your child:

1- How well is your child doing in school?

	Doing Fine	Having Difficulty	Comment
Academically	_____	_____	_____
Socially	_____	_____	_____
Behaviorally	_____	_____	_____

2- Please describe any academic problems in:

Spelling _____

Reading _____

Phonics _____

Others _____

3- How are your child's organizational skills?

What does his/her room look like?

_____Organized _____Somewhat organized _____Messy

What does his/her desk at school look like compared to other students?

_____Organized _____Somewhat organized _____Messy

4- Does your child have trouble getting class assignments done on time?

_____In class assignments _____Homework assignments ____No trouble

5- Is your child diagnosed with attention deficit disorders (ADHD, ADD)?
_____Yes _____No

If yes, is he/ she on medication? _____Yes _____No

Does medication seem to help? _____Yes _____No

Please make sure that your child continues taking his/her medication on the day of the appointment.

6- Please use the space below (or use extra sheets) to provide any additional information that you think might be useful.