SSW REPORTS ...

SENSITIVITY OF THE CENTRAL TEST BATTERY - CD

Vol. 23 No. 1 **February 2001**

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Sensitivity is one of the most important characteristics of a test. Sensitivity refers to the ability of a test to identify the target problem, in this case it is those with CAPD.

The Central Test Battery – CD (Katz, 1997) contains the basic tests that are used at many centers across the US and Canada, for evaluation of those suspected of having CAPD. At a minimum the battery consists of the SSW, Phonemic Synthesis (PS) and a speech-in-noise (SN) task. The CD contains a total of 7 tests and is distributed by Precision Acoustics (411 NE 87th Ave. Vancouver, WA 98664).

Readers of SSW Reports are well aware that this battery is useful not only for identifying those with CAPD, but importantly helps to categorize the problem and offers suggested approaches for remediation.

The primary focus of this study was to determine the sensitivity of this battery of tests in almost 100 individuals who were seen at clinics in the US and Canada.

Rules of Engagement

One of the major problems with this type of study is that there is no 'gold standard' for who has CAPD. Therefore we made the assumption that *everyone* who was referred for a CAP test actually had CAPD! This is a rather high standard and is likely not true in all cases. However it was best to err on the side of caution.

It is important to point out that this research is quite different from our jobs as clinicians.

1a) When someone comes to us as clinicians we do all in our power to help the individual even when some issues remain fuzzy. Every patient is different and we may come to different conclusions and recommendations based on the history, a gut feeling etc.

1b) In carrying out a research project we avoid individual considerations and concentrate on the aggregate. For consistency we treat everyone the same and rigidly employ stated criteria.

2a) In the clinic we ask extensive questions about the individual, their history (school, health etc.). We take into account the school system (some of them may be great, others terrible) and from all of this we make our decision based heavily on the norms but not completely. The most important thing is to get it right.

2b) In this research we have no knowledge about the individuals other than their scores, ages, and genders. Some children are especially smart, others may be slow, some advantaged others not. Some likely had extensive speech therapy or auditory training and others none. We hope that by selecting from a broad sample, that we have information that is broadly applicable to children and adults seen by audiologists for CAP evals.

We are grateful to the following audiologists who supplied the data for this study: Larry Medwetsky, Barbara Kurpita, Kevin Flannagan, Steven Guryan, Jerri Joyce, Susan Brandner, Teryl Delagrange, Mary Ann Littrell.

The Study

It was our purpose to obtain data for an unselected sample of individuals 6 years and older who were seen for CAP testing.

Subjects

Audiologists who used the CTB-CD *in the prescribed way*, were asked to submit their most recent 5 or 10 cases who were seen for CAP testing, who met the following criteria:

- 6-years-of-age or older (because the PS test is not a valid measure for children under 6)
- native English speakers
- no significant hearing loss (≤ 15dB HL)
- only initial evaluations were included (as retest scores are often influenced by a learning effect).

Eight audiologists submitted a total of 92 cases. There were 67% males and 33% females, an expected sex ratio. Their ages ranged from 6 to 52 years. The median age was 8.5 years. Table 1 shows the number of subjects and males in each age group.

Table 1

Age	6	7	8	9	10	11	Ad.
#	11	19	18	11	4	6	23
Male	8	13	12	8	3	4	14

Age/sex distribution for subjects 6yrs - adult.

It can be seen, the majority of Ss were 6-9 years of age (64% of the 92 subjects). Children younger than 6 were not submitted.

Procedures

Audiologists generally administer the SSW and PS tests in the standard fashion. However, SN is still the most variable procedure used for CAP testing. Therefore, before data were collected, it was determined that the contributing audiologists used the CTB-CD and employed the +5dB S/N that is called for in order to use the test norms.

Test order was not specified because typical conditions were needed. Only previously tested cases were requested, to insure that the person's standard procedures were used.

Results

Our first concern was the sensitivity of each of the 3 tests in the battery. We assumed that each person referred had significant CAPD. We believe that the vast majority of individuals referred for CAP do indeed have this problem, although not all of them.

SSW, PS and SN:

Table 2 shows the positive findings for the 3 tests. For this analysis a positive result on the SSW was a) ≥2 significant findings for Conditions/Total NOE or Response Bias, or b) 3 significant Qualifiers. For PS it was the a) significant Quantitative/Qualitative score or b) ≥ 2 significant Qualifiers. For SN a positive finding was a significant difference score for an ear or inter-aural comparison measure. All data were run through the SSW-Plus program to avoid errors (e.g., missing a Type A).

Table 2

Age	SSW	PS	SN
< 10 yr	83%	54%	76%
> 10 yr	61%	55%	64%
All Ss	77%	54%	72%

Percent of subjects failing each test.

The SSW was the most sensitive test of the battery. It was more effective in identifying those under 10 years than over 10. The SN task was almost as sensitive as the SSW, the PS was the least sensitive of the 3. This will be discussed in the discussion section.

Number of Significant Tests:

Table 3

Age	None	Fail-1	Fail-2	Fail-3
< 10	2%	19%	46%	34%
≥ 10	9%	33%	21%	36%
All Ss	4%	24%	38%	35%

Percent passing or failing the tests of the 3-test battery.

Although a high percentage of those ≥10 years failed all 3 tests, overall they were identified less often than those less than 10. This is consistent with previous findings. Overall the battery was quite sensitive with

96% failing 1 or more tests and 73% failing 2 or all 3 of them.

Number of Significant Signs:

If you give the 3-test battery (that has roughly 35 indicators of different CAP problems) how many positive signs would you expect for the average person who has CAPD? Based on this sample we would expect 8 significant signs! The mean was 7.8 and the standard deviation (SD) 3.94. So the average person with CAPD would have between 4 and 12 significant findings.

Significant Test Finding Combinations:

The next question was which tests were most likely to identify the problems and in what combinations. Four percent passed each of the tests so 96% failed

Table 4

	SSW	PS	SN
1 SigTst	10%	4%	10%
	SSW+SN	SSW-PS	PS-SN
2 SigTsts	24%	11%	3%
	SSW+PS+SN		
3 SigTsts	35%		

Percent of subjects failing 1, 2 or all 3 tests.

When only one test was failed it was equally likely to be the SSW or SN (see Table 4). It was less likely that PS was the only positive test. 35% of the time *all 3 tests were failed*!

Signs on the SSW Test:

Table 5

Cond	RNC	RC	LC	LNC		TOT
%	30	50	64	39		64
R.B.	OHL	OLH	ELH	EHL	Rev	TpA
%	12	20	20	14	11	18
Qual	TTW	X	Q	P	QR	SM
%	6	34	18	24	1	32
	Y	AYR	XX	BTB	SM2	
%	8	8	13	2	9	

Percent of times Conditions, Total NOE, Response Bias and Qualifiers were significant on the SSW test.

For this study the LC Condition was equal in sensitivity to Total NOE score (see Table 5). In a prior study the latter was a bit more sensitive. It is likely that they are very similar, although in some cases one may be positive and not the other. It is impressive that 64% of cases were identified by each of 2 signs. The RC was next with a 50% hit rate. It is interesting to see that (as expected with the statistical norms) the tendency toward TFM (anterior) bias is evened out. You can see that the TFM (anterior) indicators ORD HL and EAR LH we significant 32% of the time, while the DEC (posterior) signs ORD LH & EAR HL were significant a very similar 34% of the time.

Using the NOE criteria, we expected an increase in the significant Type A patterns. Previously we had Type A in 10-15% of cases. The 18% in this study appears to be the expected, though slight, increase in the percent of significant Type A's.

Qualifiers are shown in their order of likelihood among normal subjects. Interestingly these individuals with CAP follow a different pattern. This is good as it suggests that those with CAP have different patterns according to their type of difficulty. This makes it easier to identify those with CAPD. Perseverations (P), smushes (SM) and extreme delays (XX) seem to be especially sensitive to large numbers of those with CAPD. More about this found in the discussion.

A few words are a appropriate here for 2 Qualifiers with which you may not be familiar. Back-to-back (BTB) refers to a response such as "up stairs stairs town". Smush-2 (SM2) refers to combining two words of a single spondee (as opposed to one competing word from each ear). For example, "coy" for *cowboy*. See the discussion.

For the average patient seen for CAP testing the number of significant signs ranged from 0 to 11 with a mean of 4.9 and a SD of 2.8. So 68% of cases can be expected to have between 2 and 8 significant signs on the SSW assuming that you tally SSW Qualifiers.

Signs on the PS Test:

Table 6

Quant	Qual		X	Q	XX
42%	38%		5%	9%	5%
Rev	**NF**	**QR**	**O/L**	**1st**	**P**
7%	11%	11%	11%	12%	10%

Percent of subjects with significant findings on various aspects of PS test

Overall PS was failed in 54% of the evaluations. Some passed the Quantitative score but when 4 types of Qualifiers were taken into account, some of the 'correct' responses we downgraded to errors. This increased the hit rate by 4%. As in the case of SSW test, the least common Qualifiers were the ones that the CAP cases had most frequently (see Table 6). This group of subjects had considerable difficulty with 1st phoneme omissions (1st), and non-fused (NF) responses, perseverations (P) and quiet rehearsals (QR). These Qualifiers add to the success rate of the PS test in identifying CAP problems, but more importantly they help to determine the CAP category and what can be done to assist the individual.

The PS test has fewer signs and was less sensitive than the SSW test. Therefore the average number of significant findings is much smaller than the SSW. The mean was 1.5 and SD 1.65. Thus, the average person with CAPD would have zero to 3 significant signs.

Signs on the SN Test:

Table 7

	R-Diff	L-Diff	IA-Diff
Significant	41%	51%	39%

Percent of cases with significant right ear-, left ear- and inter-aural-difference scores.

Most audiologists who use a speech in noise test subtract the noise score from the word recognition (WR) in quiet score. In this way a person who has a poor WR score in quiet will not be assumed to have poor speech in noise ability if they also have a comparably reduced SN score. The difference scores are shown in Table 7.

The left ear had about 10% more failures than the right. A third score was considered in this study, the inter-aural (IA) difference, that is the right-ear-difference minus the left ear difference score. We know that when the two ears have different sensitivities, this creates additional difficulty under noisy conditions. We have seen the same type of binaural inequality lead to speech in noise problems for WR and for SN scores. An impressive 39% of the time it appears that in addition to any right or left channel problem, that there was also a significant difference between the functioning of the two ears, suggesting a reduction in the binaural advantage.

From the standpoint of sensitivity, the IA difference score added 4% (when neither ear was significant). While this is not a large increase, it may help to explain stated SN problems of a patient when the ear performances are normal.

As stated earlier, the convention used by audiologists is not to consider the WR noise score by itself, but rather to subtract it from the WRS in quiet. However, we noticed a somewhat consistent pattern of non-significant SN results in the ear with significantly depressed WRS while in the other ear with normal WRS the SN score was significant.

Table 8

	WRS-Sig	WRS-NSig
SN-Sig	17%	54%
SN-NSig	83%	46%

Percent of subjects who had abnormally poor (sig.) WRS and normal WRS vs. performance on SN task.

We see from Table 8 that when WRS is significant (depressed) then there is a very low probability of a positive SN score in that ear. On the other hand when WRS is normal (for age) there is an equal (or slightly better than

equal chance) of a significant SN score. Several explanations are possible. Among them is the thought that depressed WRS could mask the presence of a SN problem in that ear. It would behoove us to keep track of this possibility to see if cases that are likely to have TFM problems are passed because of the reduced WRS.

There were only 3 possible significant signs on the SN test. The average number of signs for the 92 subjects was 1.4 (SD=1.0). Therefore, the average person with CAPD had zero to 2 significant findings on this test.

Discussion

Overall Test Results

The 3 CAP tests on the CTB-CD had a sensitivity of 96% when using one or more significant test as the criterion. When using 2 or all 3 failures as the criterion, the hit rate was 73%. This shows the battery, even using research rather than clinical criteria, had excellent to good sensitivity

Under clinical conditions the hit rate would be even higher. We would take into account that a child received auditory training and therefore discount the great score on the PS test. We would be strengthened in our concern for TFM when we see these characteristics on 2 or 3 of the tests (in this study we considered each test by itself and did not look across tests, as one would clinically).

Related to this same question is the influence of age (i.e., maturity, test-wise etc.). Consistent with previous studies we see that those ≥10 years are less likely to fail this (and other CAP) battery of tests. It is likely that those who are older can use their intellect to beat the tests. The problem is a complex one, but we wonder if there might be some simple suggestions that will aid the process.

One advantage an older child/adult has is that they can take advantage of the redundancy in the test items and given loose time constraints they are able to come up with the correct answer. It is for this reason that we must be especially alert when testing older individuals that we mark down every Qualifier. Quick and delayed responses, quiet rehearsals and non-fused responses all show us the underlying struggle and the effort to compensate. They also tell us the type of difficulty the person is compensating for. So Qualifiers take on even great significance when a person does well on the tests.

A second consideration is presentation level (PL). We know that SSW-Max (the level needed to achieve a maximum score on the SSW test) is 25 to 50dB SL. We have used 50dB SL as the PL (±5dB) to be consistent and to be sure that the person has every opportunity to get a good score despite high frequency loss etc. For fun with normal listeners we often go down to 15dB SL and still see fine results, but this may not be the case with those who are hard pressed to puzzle out the correct response. By presenting at 45dB SL we may add a level of difficulty for the CAP cases that normals would not have. It would be a reasonable and defensible procedure to use 45dB SL for cases ≥10 years. This should have no influence on normals, at least on the SSW and PS tests and probably (@35dB SL) on the SN test.

If the PL challenge at 45dB SL proves to be a successful approach then it would be helpful to see if even lower PLs could maintain maximum scores by normals but not those who have (are thought to have) CAPD.

SSW Results

The importance of using Qualifiers (on SSW & PS) have been mentioned previously in *SSW Reports* and above. They are especially important when testing older children or adults because of their ability to compensate for their limitations on the test (but not hour after hour at school).

There are 3 Qualifiers that are used in the *SSW-Plus* program, although they have not been studied previously with LD or CAPD cases. Back-to-Back (BTB), Smush-2 (SM2) and Intrusive Word (IW) are signs that have

been noted in the studies we have carried out with mentally retarded adults (both in the past and more recently). Therefore it was of interest to see that 2 of the 3 signs were noted in the present study. Because we have not done research on these 3 signs we did not know what categories, if any, they represent. Because of the limited information that we have about our subjects, we cannot add much about their contribution. Katz (*SSW Reports*, 1999; *SSW-Plus*, 1997) speculated that they were DEC signs. Because these 2 signs were noted in the more traditional CAP population, it would be appropriate to determine whether these are useful DEC signs or possibly signs of other categories.

We were surprised to see a rather large number of extreme delays (XX) especially because they were not seen in cases with Type A patterns. This could suggest that we have erred in making this an indicator of the INT category, *or* that the different criteria were used for XX. There are 3 criteria for XX.

- an extremely long delay (e.g., 30 sec)
- the item is correct when finally given
- there is no evidence of struggle to determine the words - most often the response is given in a matter-of-fact fashion, despite the extended time it took for the person to respond.

PS Results

Previous experience with the PS test suggested a higher hit rate than the 54% that was noted in this study. While 54% is respectable it is less than expected because of the large percentage of cases with DEC problems in the LD population. Thus a significant number of poor decoders may have passed the test.

Some possible reasons for this finding may lie in the greater emphasis on phonics in the schools, the more common use of auditory training, and the stimulation of phonemic awareness than in the 1980s when the original norms were obtained. The more recent norms (1997) did indeed show that higher standards were needed and perhaps the 3 years since then may have had an additional influence.

If these are the reasons for the lower hit rate for the PS test, it is at least a positive reason. Control children of previous years had less stimulation in phonics and less emphasis on the phoneme in school and home stimulation programs. Because we assume a child being tested is naïve, in the same way as the control group, we may be missing some of the kids with DEC problems.

The previous suggestion that reduced PLs be used (45dB SL instead of 50dB SL) would hold for PS as well as for SSW (see previous discussion).

Phonemic awareness appears to have impacted negatively on our test/s. We're not displeased becasue phonemic awareness has made *professionals* aware of the phoneme.

SN Results

David Eddins, at UB, found that the speech noise used on the CTB-CD is more heavily represented in the low frequencies than the speech noise from the GSI-10. This would help to explain why it is likely that those with TFM problems were identified and not pure decoders. TFM folks are distractible and can't block out competing noises, so even a low frequency speech noise interferes with word recognition. On the other hand those who have pure DEC problems are less likely to break down with this noise because it does not interfere with their fuzzy perception of speech. Only if there is a heavy emphasis in the critical frequencies (e.g., 1500-3K) would we expect them to have greatly reduced scores.

Summary

This study has shown the CTB-CD battery to be an effective group of tests to identify the presence of CAPD in the vast majority of cases in our sample. Suggestions have been made for increasing test sensitivity and productive areas for further study.

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