Judith W. Paton, MA, FAAA
400 North San Mateo Drive, Suite 1
San Mateo, CA 94401 USA
(650) 340-1280/343-7225
judithpaton@me.com
California Audiology License #AU 133

Before-and-After Central Auditory Processing Test Results For AIT – a Clinical Retrospective Study

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Long-researched and commonly used central auditory processing tests offer a more objective way of confirming and quantifying the success of AIT than do observations and questionnaires. This presentation by an audiologist specializing in central auditory processing disorders (CAPD or APD) – or the "brain part of hearing" – shows the changes in central auditory processing test scores between pre-and post-AIT evaluation. Implications of these changes for daily life and as guides to other types of therapies will be discussed.

STUDY

Two-hundred-ten (210) patients receiving Berard AIT (Auditory Integration Training) seen over the last fourteen years were given a battery of central auditory processing tests as part of the determination of AIT candidacy. These tests are derived from the original audiologic site-of-lesion tests researched on clinically confirmed brain disorders and lesions, and later re-normed on "non-medical" populations. The cases chosen for the data collection were simply the consecutive patients seen, excluding only any with a gap between pre-and-post testing of more than a year (to reduce maturation influences)

This research group, the part of the entire clinical AIT population who returned for free post-AIT re-testing, consisted mostly of children and adults broadly grouped as having one or more of the following: learning disability (LD), dyslexia, speech/language disorders, and/or central auditory processing disorders (CAPD or APD).

This first group of 192 patients (termed LD) represented 99% of the study population. The remaining 18 (1%) fell in the autism spectrum of disorders (ASD). This small number represents partly the difficulty of obtaining valid CAP (central auditory processing) test scores on lower-functioning ASD children but mainly the fact that my specialty and referral base has allowed me to see the need for AIT among my much larger caseload, the LD/CAPD group. The age range was 5 to 55 years, all but ten being between ages 5 and 20.

Eleven CAP tests were used, the choice varying as suitable for the individual case, with only the abnormal tests being repeated at the recheck visit, usually six-to-nine months after the end of AIT. The large majority of CAP tests are scored as abnormal only if they fall more than 2 standard deviations below the age mean. Post-AIT scores were deemed improved if they went from abnormal to normal between visits, receiving 1 point each. If only one ear improved to normal, or if there was a marked improvement between an abnormal pre-test and a "borderline" post-test, the test was given ½ credit (.5 point).

Background on Central Auditory Processing Tests

Before the CT, MRI, and Evoked Response tests were developed, site-of-lesion or central auditory processing (CAP) tests offered the best non-invasive way of finding areas of dysfunction in the central auditory pathways of the brain. The alternative was to inject air or dye into the brain and compare a second set of X-rays with the first. To avoid these dangers, various listening tasks were designed that stressed different areas of sound processing. The accuracy of these tests was confirmed objectively through surgery reports and X-rays. These scientific studies were published in per-reviewed journals of Neurology, Audiology, Otolaryngology (Ear Nose and Throat), and others.

Over the years professionals had noticed that the types of hearing problems that first brought the medical patients into the clinic were similar to hearing problems reported by non-medical populations. Thus, for example, a multiple sclerosis patient complaining of trouble following a dinner table conversation if more than one person was talking sounded much like the student who couldn't follow the teacher's instruction in classroom noise.

These observations led to the re-norming of the old site-of-lesion tests for children without medical problems, for use in identifying CAPD. Finally, in the 1980s a study by Susan Jerger, Ph. D., et al. confirmed that the abnormal test profiles for children with CAPD were indistinguishable from a matched group of children with confirmed head injuries. The extensive body of scientific research behind the CAP/site-of-lesion tests now gives us some insight into how low-performing test subjects might function in daily life. These tests also show us some of the benefits of AIT.

Why Use CAP Tests to Measure Effects of AIT?

AIT is a little like aspirin: we knew it helped long before we discovered how it worked. With AIT, the best information we had in the 1970s was that the musical stimulation might be shaking loose tiny scars in the middle ears due to otitis media. When tympanometry and impedance audiometry came into common clinical use in the 1980s those measurements suggested that ossicular movement was an unlikely culprit.

Scientific advancements in the 1990s pointed towards a different reason for the mild sensorineural depressions in the audiogram that could be reduced by the tenth day of AIT: a damping of cochlear hair cell movement through the action between brain stem and inner ear via the efferent **olivo-cochlear bundle** that could be turned on or off. This inhibitory mechanism can depress pure tone thresholds as much as 20dB. This discovery led our attention to the central auditory nervous system.

Brain cell re-allocation is the other scientific discovery that clarifies how AIT works. It was shown through animal nerve cell studies that, when one group of cells was depleted or not working adequately, the brain could recruit cells from nearby areas to take over the function. One of the best known applications of that principle lies behind Fast ForWord computer-based training, based on the collaborative work of Paula Tallal and Michael Merzenich, Ph. D.s.

The abrupt volume changes seemed to help **synchronize the firing** of all the nerve cells, producing a sharper, clearer brain wave – and therefore a clearer rendering of the auditory message. A small study in the articles from the Autism Research Institute confirmed this improved speed and synchrony in normalized auditory evoked response (an EEG technique) wave forms.

Thus, the focus has moved from the middle ear to include the brain itself in our understanding of AIT – hence the usefulness of central auditory processing tests as a non-invasive way of measuring some auditory nervous system functions.

CAP Tests and Functions in This Study

What are the CAP tests, and how do they expand our knowledge of what AIT can do?

1) Brain stem

a) Tests: Speech Discrimination in Ipsilateral Noise @ 0dB S/N (signal-to-noise ratio), Binaural Fusion, and Masking Level Difference. The first test reflects "stream separation" or our ability to mentally separate out meaningful speech from other, equally loud, non-speech background noise.

The latter two assess ability to deal with timing of wave peaks arriving to the brain from each ear, which allows us to locate a sound in the environment or the speaker on whom we want to focus. Inhibiting sound from the surrounding "points on the compass" makes the target sound or voice comparatively louder so that it stands out.

b) Functions of the regions assessed: ability to follow what is said in the presence of other noise. Can also signal problems with anatomically adjoining systems for short term auditory memory, rote memory or habituation, and nearby visual and vestibular/balance system functions.

2) Cerebral (includes cortex, as well as long connecting tracts like the corpus callosum and angular gyrus, and shorter white matter fibers that communicate between and retrieve from the cortex.

a) Tests: Dichotic Competing Sentences, Competing Words, TCST (Time-Compressed Sentences at 60% compression), Duration Pattern Sequencing (measuring slower processing speed from 250 to 500 msec), Filtered Speech (low-pass), and PPS (Pitch Pattern Sequencing).

The Sound Blending from the Woodcock-Johnson Test of Cognitive Abilities (not a site-of-lesion test) was also used for the dyslexic children in the group.

b) Functions of the regions assessed include: temporal lobe language; ability to cross the midline to make mind's eye images of what is heard or read, or to express one's one ideas and needs fully and adroitly (e.g. complete narrative and language pragmatics); quick auditory-visual integration (connection) of sounds and letters for full and fluent writing and reading; processing speed for analysis of speech phonemes (for clear articulation, mastery of phonics, and sustained listening); and pattern recognition for grammar and lexicon.

The information that can be gained from the test scores at the AIT check not only reassures us of how AIT changed the auditory processing of these patients, but also helps with further planning. The types of test still yielding low scores can guide people to other needed therapies for the remaining weaknesses.

At the end of the re-check visit patients or parents were given suggestions of therapies that often help the problems that AIT did not solve.

Findings

Preliminary test data tabulations have shown the following:

1) The mean test improvement for LD and ASD groups together across tests was 67%. (The small number of ASD patients showed 61% improvement, with the even smaller number of adults at 78%.)

2) The lowest 3 improvement scores were 12, 15, and 17%.

3) The total amount of improvement after AIT for all subjects on all repeated tests was:

a) 80 to 100% improved -- 49%
b) 50 to 79% improved -- 50%
c) 12 to 49% improved -- 1%

(See Table 1)

4) Different tests showed different amounts of improvement in all subjects, which has implications for candidate selection and advice to inquiring parents and professionals. The four tests showing the most improvement (70-90%) were:

a) Speech Discrimination in Ipsilateral Noise at 0dB S/N (signal-to-noise ratio) (90%)
b) Filtered (low-pass) Speech at (81%)
c) Time Compressed Sentences (at 60% compression) (73%)
d) Pitch Pattern Sequencing (70%)

5) Second-most improved by AIT (50-69%) were:

a) Sound Blending (68%)
b) Duration Pattern Sequencing (56%)
c) Dichotic Competing Sentences (56%)
d) Binaural Fusion (55%)
e) SSW (Staggered Spondaic Word) test (54%).
f) Competing Words (47%).

(See Table 2)

To help answer the question of whether anyone seemed to be worse after AIT, parents were given a chance to re-answer the CAPD Screening Questionnaire at the re-check visit as "same, better, or worse." No improvement ("same") was rated as zero (0 total points), each "better" as +1 and each "worse" as -1.

6) In answer to the question of whether AIT seemed to make someone worse, on a 25-item parent questionnaire 2 patients scored as "worse", at -1.5 and -2 points, respectively.

Three more scored 0 (no improvement), for a total percentage of 1% for the five patients.

7) In contrast, the objective overall test improvement scores for these same patients were 40% and 64% for the minus pair and 50%, 80%, and 80% respectively for the three 0 ("no improvement") cases.

(See CAPD by Region questionnaire)
(See Table 3)

CONCLUSIONS

1) Results of this study show that AIT can be reasonably quick and effective way of improving functioning of the central auditory nervous system.

2) If you want to design a quick central auditory screening for AIT candidacy and likely success, consider the tests showing the greatest post-AIT change in most patients:

- a) Speech discrimination in ipsilateral noise at 0dB S/N
- b) Filtered (low-pass) Speech
- c) Time Compressed Sentences (at 60% compression)
- d) Pitch Pattern Sequencing

3) Does AIT also help with adult central nervous systems?

Probably yes – 78% test improvement average in 10 patients ages 27 – 56

4) Do ASD patients differ from LD/CAPD group?

- a) Brain stem comparable (same or slightly better for ASD)
- b) ASD people start to look somewhat worse at cerebral level on some tests (SSW, TCST, PPS), though similar for Filtered Speech/Words, Competing Words, and Dichotic Competing Sentences.

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TABLE 1

<u>% of CAP Test Scores Improved from Abnormal to Normal</u>
6-12 months after AIT in 210 Subjects
(**ASD** = ASD only, n 18)
A – adult non-ASD, ages 27-55, n 10)

Test %	Bin. Fus-ion	Noise @ 0dB S/N	MLD Mask. Level Diff.	SSW Stag. Spon. Word	FS/W Filt. Sp./ Wds.	DCS Dich. Comp. Sent.	CW Com. Wds.	TCST Time Comp Sent.	PPS Pitch Patt. Seq.	SND. BL. GE 3 +	DPS Dur. Patt. Seq.
90 - 100%		90% *A*, **ASD**				*A*					
80-89				*A*	81% *A*, **ASD**						
70-79	**ASD**							73% *A*	70% *A*		
60-69										68%	
50-59	55%			54%		56%	**ASD**	**ASD**			56%
40-49						**ASD**	41%				
30-39			**ASD**	**ASD**							
20-29			20%						**ASD**		
0-19											
Number	60	193	5	167	88	79	16	109	95	17	24

Average improvement all Ss over all tests done – 67%
ASD – 61%   Adult – 78%
(range of improvement 12% – 100%)

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TABLE 2

<u>% of Subjects by Degree of Total Test Score Improvement from Abnormal to Normal</u>

6-12 months after AIT in 210 Subjects

Improvement %	1-49% Ss (13%)	50-79% Ss (50%)	80-100% Ss (34%)
90 -100%			34 16%
80-89			34 16%
70-79		33 16%	
60-69		40 19%	
50-59		33 16%	
40-49	12 .06%		
30-39	12 .06%		
20-29			
10-19	3 .01%		
1-9			

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TABLE 3

Perceived Improvement on **CAPD by Region** parent questionnaires

6-12 months after AIT in 167 Subjects (not all parents completed the form)

Worse by -1 to -2 points (2 patients) Zero improvement (3 patients)

Improvement %	1-49% Ss (13%)	50-79% Ss (50%)	80-100% Ss (34%)
90 -100%			34 16%
80-89			34 16%
70-79		33 16%	
60-69		40 19%	
50-59		33 16%	
40-49	12 .06%		
30-39	12 .06%		
20-29			
0-19	3 .01%		
-1 to -2	2		