Topics in Central Auditory Processing

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We can test central auditory processing (CAP) to explain a person's communicative, academic and other problems. This is most beneficial when these issues can be improved by therapy and accommodations/assistive technologies. Teaching the brain facts or the dangers of *a hot stove* can be fast, but changing how the brain works requires a gradual organized programing and takes a while to accomplish. Different professionals can bring a variety of approaches to help those with CAPD. We intend to bring you clinical, research and philosophical columns to inform and open up new avenues of insight into CAPD.

In This Issue

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[FoC provides more complete information for a deeper or broader understanding]

Frequency Modulation Devices and CAPD

Wayne J. Wilson Ph.D.

Many children with central auditory processing disorder (CAPD) have difficulty hearing in noise. This challenges their ability to succeed at school where classrooms are often noisy and reverberant. Frequency modulation (FM) devices (where the teacher wears a microphone and wireless transmitter and the student wears a wireless receiver and earphones) have long been thought to help children with CAPD by ensuring the teacher's voice arrives to the child's ears clearly and at a good signal-to-noise ratio. Recently, Reynolds et al. (2016) systematically reviewed the literature to determine if FM devices really are effective in improving academic outcomes in school-age with CAPD.

Reynolds et al. searched 4 databases to identify seven studies that met their inclusion criteria. To be included in the review, each study had to have investigated children with CAPD who had used an FM device in their classroom for at least 4 weeks. These children had to have been assessed on academic outcomes including (but not limited to) improved sound discrimination, reading scores, general academic performance, phonological awareness, speech perception, and attention.

The 7 studies included in the review involved a total of 211 participants. Of the participants 187 had CAPD and 24 acted as controls. Of the 187 with CAPD, 18 had a primary diagnosis of CAPD, 38 had dyslexia, 17 had Autism Spectrum Disorder, 10 had Friedreich's ataxia, and 4 had Attention Deficit Hyperactivity Disorder. The participants were aged between seven to 15 years (except in one study that included participants aged up to 42 years) and 68% were male. All seven studies used personal FM devices fitted binaurally (although one study included a subgroup fitted unilaterally). The use of the FM devices varied from 45 minutes to six hours every school day for 4 weeks to 8 months of a school year.

Reynolds et al. (2016) concluded that for children with CAPD, there is moderate evidence that using FM devices improves listening and attention in the classroom and mixed evidence that it improves specific academic performance areas. Perhaps the strongest evidence was seen in the widely reported improvements in speech perception and recognition in children with CAPD when using an FM device in the classroom. Limitations were noted in the reviewed studies including differences in measurement tools and diagnostic conditions, small sample sizes, poor participant randomization, and limited blinding.

Overall, Reynolds et al. (2016) concluded that educational teams should consider FM devices as an evidenced-based way of improving classroom functioning in children with CAPD.

[For Reynolds reference see page 6]

Neuroauditory Training in People with Aphasia

Alan Gertner, Mary Jo Santo Pietro,
Emma Carillo, Ariel Hausman,
and Hale Jaeger

This report summarizes initial findings of a pilot study. A more comprehensive manuscript is being developed for submission to a peer reviewed journal.

A group of researchers from the School of Communication Disorders and Deafness at Kean University, Union, NJ, initiated a pilot study on a sample of people with aphasia, investigating the effects of neuroauditory training. The training program followed the Dichotic Interaural Intensity Difference (DIID) training paradigm.   People with aphasia experience deficits in auditory comprehension due to structural damage of language processing areas, deficits in auditory processing, and/or compromised neural pathways. Those with aphasia display auditory processing deficits and several studies have linked aphasia with a reduced right ear performance on auditory tasks, resulting in a left ear dominance during dichotic listening (Gertner & Tomaino, 1982; Niccum & Rubens, 1983; Bamiou, et al, 2012).

Evidence from treatment of people with weak auditory processing skills has demonstrated improved neuro-physiological and behavioral responses following neuroauditory training (Tremblay & Kraus, 2002; Song, et al, 2012; Russo et al, 2012).   Auditory improvements following training have been related to more efficient neuroauditory signal processing (Tremblay, et al, 2001). Further, Musiek, Weihing, and Lau (2008) reported DIID training resulted in improved weak ear scores in children with auditory processing disorders.

This pilot study population was composed of ten participants, seven males and three females with an average age of 62 years. Treatment sessions had durations of 30 minutes, twice weekly, over a six week period. Pre and post language and auditory processing testing were performed. The study procedure included administration of Dichotic Digits (single pairs) and the Staggered Spondaic Word Test (SSW). For training purposes, split halves of the tests were presented during the first three and last three weeks of the study to reduce training effects.

Dichotic performance on first and last session test scores for numbers and words (Dichotic Digits and the SSW), analyzed with related t-tests, demonstrated improved performance following training (DD improvement resulted in p .023; SSW split half error reduction resulted in a p .045). Findings support that dichotic training, specifically using the DIID protocol, improves dichotic listening skills in people with aphasia.

DIGIT PRE	**DIGIT POST**	**SSW PRE**	**SSW POST**
25	39	31	27
42	48	23	14
19.5	27	46	37
39	46	35	26
32.9	37.5	24	18
16.5	43	25	29
Digits p 0.023		**SSW p 0.045**	

First/last training session scores, t-tests for Dichotic Digits & total SSW split-half error scores of six participants who completed all phases of the study.

[Continued in Free of Charge – page 7]

BMQ-R vs. Speech-in-Noise Testing and WINT Therapy Results

Jack Katz

I believe that the Buffalo Model Questionnaire-Revised (BMQ-R, Katz and Zalewski, 2011) is a wonderful independent source of information. The 4 simple noise questions can give not only independent but also unexpected information. This is before you press a button or turn a dial. It gives much more noise information than I thought.

Fifty folders of children 6 to 18 years of age were studied. After 45 files were randomly selected I noticed that so few children had 2 or fewer indicators of noise difficulty on the BMQ-R. Therefore, 5 folders with 2 or fewer noise indicators were included.

1. What each of the 4 BMQ-R noise questions tells us and what they say when combined.
   a. The 4 BMQ-R Speech-in-Noise (S-N) questions: 1. Hypersensitive to Noise, 2. Distracted by Noise, 3. Understands in Noise and 4. Noisy Child.
   b. Distracted (Dist) = highest # of hits 33; Understand (Und) = 31, Hypersensitive (Hyp) = 28 and Noisy Child (N Ch) was indicated only 12 times.
   c. It's counterintuitive but higher #s suggest <u>weaker</u> S-N issues.
   d. Table 1 shows the percent of subjects for each noise question.
   e. Note that Dis had the most signs 3 positive (+) to 1+ and the highest percentage overall.

	4 +	3 +	2 +	1 +	0 +
Dist	74%	91%	75%	33%	1 for 1
Hyp	67%	64%	12%	33%	1 for 1
Und	78%	64%	50%	0%	0 for 1
N Ch	37%	18%	0%	0%	0 for 1
Mdn	**70%**	**64%**	**31%**	**16%**	--

Table 1. % of cases with 4 to 0 positive noise questions. Very few Ss below 2+.

   f. N Ch had only scores of 4+ and 3+.
   g. Logic would also suggest that the least significant issue for a child would be just distracted by noise. Understanding/hypersensitive would be next. Children who are so annoyed/ threatened by noise that they have to block it out with their own voices. It's likely the most challenging sign.
   h. 74% of parents-teachers rated the children with 4 or 3 noise issues and 25% with 0 to 2 issues (even with 5 stuffed ballots).
   i. It seems we can look at which items and how many are positive to suggest the severity of S-N. Let's see if that holds up.
2. BMQ-R is completely independent of actual S-N data. So let's see how close the number of positive BMQ-R findings predicts S-N scores.
   a. Figure 1 shows how the number of positive BMQ-R signs relate to the % correct on the S-N (noise) test.
   b. Initially for 4+ cases the mean S-N score was 57% correct (3 SD poorer than 9-yr-old mean). For 1+ and 0 pos-itive, the median was about 75%, just about normal limits (for this very small sample).

[More figures, data etc. see page 8]

Speech-Language Therapy through an Information Processing Lens

LaVae Hoffman, Ph.D.

This article provides a brief overview of how information processing is integral to the speech-language intervention process. A clear understanding of how the multiple components of information processing operate in therapy can effectively inform clinical decisions to support client success.

Information processing (IP) is an approach to cognitive psychology to explain how humans make sense out of incoming sensory stimuli and learn. Fundamental concepts across common IP models include the assertion that mental processing can be interpreted as occurring through a *series of steps or stages*, such as perception, attention, memory encoding, storage, and retrieval. Another fundamental preset is that individuals may differ in their IP *capacity* (i.e., how much information can be processed at a given time). In general, through sensory experiences, over time, neural synapses are modified, which leads to consciousness and learning.

The initial stages of IP include **sensory processing** during which all incoming sensations (auditory, visual, tactile, kinesthetic, olfactory, and gustatory) are available to be acted on by the IP system. However, not all sensory stimuli receive conscious attention or are assigned meaning. From this perspective, the *initial sensory register* is not the same as sensory perception, which occur later in the IP chain. Thus, auditory or visual stimuli may be received neurologically, but not cognitively recognized or correctly interpreted.

Although various IP models differ in their descriptions of sensory processing and mnemonic activity in each stage, the **long-term memory** store (enduring knowledge) can be thought of as having both declarative memory and procedural memory. *Declarative memory* includes recollections of word meanings, experiences, understandings of the world, and our sense of personal identity and history. These constitute the content of our interpersonal verbalizations.

Procedural memory, on the other hand, allows us to operate behaviorally without conscience awareness of each action or response. Procedural memories are not reflexes, such as blinking after a puff of air. Rather, they are performance sequences that have been mastered. These memories were often learned initially via conscience attention, but with successful completion and frequent repetition, they no longer require focused and conscience attention. Tying a shoe or riding a bicycle are examples of procedural memory. When newly acquired skills are integrated into procedural memory, these activities can be completed without attention, thereby reducing the cognitive load and allowing

[Explanation of IP stages see – page 10]

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Frequency Modulation Devices and CAPD – Wilson

Reference

Reynolds, S., Kuhaneck, H.M., & Pfeiffer, B. (2016). Systematic review of the effectiveness of frequency modulation devices in improving academic outcomes in children with auditory processing difficulties. The American Journal of Occupational Therapy, 70(1), 1-11.

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Neuroauditory Training in People with Aphasia - Gertner (cont.)

Both dichotic digits and SSW responses revealed considerable auditory processing deficits as well as poorer right ear than left ear findings. Following training, improvement in auditory processing was evidenced, however the left ear dominance persisted. In addition to significant deficits in auditory processing, the study results demonstrated that right ear responses to dichotic stimuli continued to be poorer than those of the left ear. These results are in agreement with previously reported findings of an ear dominance shift in people with aphasia.

	RNC	RC	LC	LNC
Pre Test	24	27	12	7
Post Test	15	25	15	8

Mean SSW RNC, RC, LC, LNC pre/post error scores

	Right Ear	Left Ear
Pre Test	52	81
Post Test	66	88

Mean dichotic digits pre/post right and left ear scores

The intent of Kean University's research team is to follow this pilot study with a larger, more comprehensive investigation to assess effects of neuroauditory training on ear dominance shift, central auditory processing, and language comprehension in people with aphasia.

This project would not have been possible without the help of several undergraduate and graduate students from the School of Communication Disorders and Deafness:

Marissa Falzone, Lawrence McDonald, Sadia Akhtar, Kyle Smith, Yael Gabbay, Lynn Phillipe, Beth Bilinski, Siobhan McLaughlin, Sabrina Berg.

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Bamiou, D., Werring, D., Cox, K., Stevens, J, Musiek, F., Brown, N., & Luxon, L. (2012). Patient-reported auditory functions after stoke of the central auditory pathway. *Stroke*, 43: 1285-1290.

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Tremblay, K. & Kraus, N. (2002). Auditory training induces asymmetrical changes in cortical neural activity. *Journal of Speech Language and Hearing Research*, 45: 564-572.

Tremblay, K., Kraus, N., McGee, T., Ponton, C., & Otis, B. (2001). Central auditory plasticity: Changes in the N1 – P2 Complex after speech-sound training. Ear & Hearing

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BMQ-R, S-N and WINT- Katz (cont.)

c. So there was a gradual increase in correct S-N scores as there were fewer positive signs on BMW-R.

d. Of course, the S-N score is not corrected for WRS. So the next question was if the score was more purely the effect of noise would that change the results.

e. Figure 2 shows the same analysis for the Quiet-Noise Difference score for each ear. Larger #s are poorer scores.

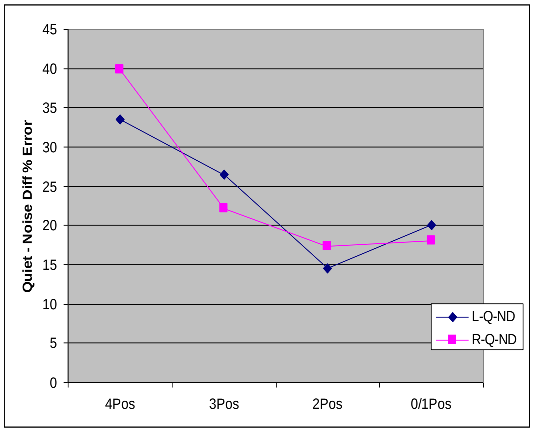

Figure 2 shows the same analysis for the S-N error scores corrected for WRS.

f. Figure 2 shows the Quiet minus Noise Difference scores for each ear. For 4+ the score was 37 and for 0 or 1+ was 19.

g. The S-N Difference for 4 + was 3 SDs poorer than the mean and for 0/1 + upper end of normal limits.

h. As in the case of S-N the S-N Difference score shows the same inclination for those with more S-N concerns on the BMQ-R having poorer scores and S-N Difference scores.

i. This would suggest that the 4 noise questions on BMQ-R have credence in predicting severity of noise difficulty as measured by the Buffalo Model S-N test and for the S-N Difference score.

j. I decided to push my luck by looking at both the initial score for WINT (given via loud-speaker to both ears) and again at the end of Round-1.

k. Seeing a relationship between the 4 questions and the initial WINT scores would add another independent variable. Therapy was begun about 5 or 6 months after the initial evaluation. WINT relies on 2 ears working together, and the presentation level is usually about 5 or 10 dB above the S-N test. The signal-to-noise ratios varied from +12 to 0dB with 10 words at each of the 6 or 7 levels.

l. Was on a roll so I took a *look at WINT test-retest scores about 5 or 6 months later, after* about 12 S-N sessions.

m. Figure 3 shows the results. Interestingly first we saw just a slight trend and not the impressive difference from 4+ to 0/1+ that we saw on the test scores. It is difficult to say what the difference might be. However, all of the previous test

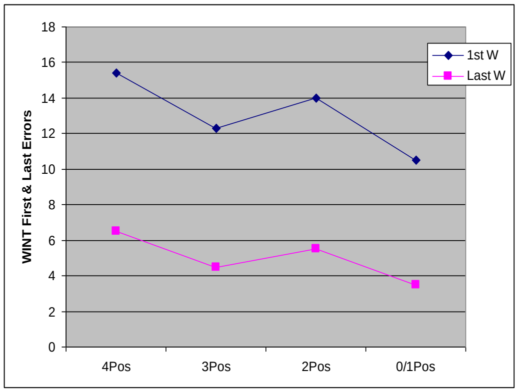

Figure 3 WINT results for the initial and final sessions in R-1.

scores were at a +5 SNR, whereas more than half of the noise items of WINT had milder SNRs. Also for therapeutic purposes we generally used 60dB SL instead of 5 to 10 dB less .

n. The initial pretest scores differed by less than 5 errors from 4+ to 0/1+. So the relationship was clearly a weak one, but what it tells us is so much more important.
o. The curve of the final S-N data from those with 4+ to 0/1+ was similar to the initial with about a 5 point improvement at retest for each group in R-1.
p. On retest each group was near the ‘theoretical completion level’ of 5 errors!
q. The take-away is that every group made good progress in therapy, even those who had performed pretty well on the S-N testing.
r. Only one child out of 50 had no signs of S-N issues on the BMQ-R and the best initial score on WINT of 6 with several delays. WINT improvement was minimal.
s. I believe that the project should be done again including delays. We always indicate delays but we have no norms at this point. I think it is important to consider delays when testing or doing WINT.
t. Finally, in therapy when a person has significant S-N scores and/or one or more noise items of the BMQ-R it would be well to try WINT in order to see if there may be value in doing additional S-N training.

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Speech-Language Therapy through Information Processing - Hoffman (cont.)

attentional focus to be available for processing other aspects of experience or learning.

Another common axiom in IP is the idea that **downstream filters upstream**. In other words, the quality and completeness of information that passes through an earlier stage will set the foundation for processing at the next stage.

Therefore, higher levels of processing, such as memory storage and retrieval, will be constrained by any inadequacy in the information signal that has been encountered or generated at an earlier stage of processing, such as the sensory register, attentional system, or working memory. Consequently, a student who does not adequately sense or register auditory signals will have difficulty assigning meaning to the degraded auditory information as it passes through their IP system.

Therapy: From an information processing perspective, SLPs strive to correctly *identify the specific stage(s)* of information processing that are troublesome for each client. This insight provides a foundation for determining treatment objective(s) and intervention techniques.

With this information in mind, an SLP will teach improved communication skills by:

- Identifying the upper limits of a client's current communicative ability that can be achieved with support ("*zone of proximal development*")
- Identifying *sources of communication breakdowns* during moment by moment interactions
- Provide *systematic supports* (such as cues, reminders, alternative information, models, feedback, etc.) to promote successful communicative interactions.

Through frequent repetitions of this supported experience, the client learns how to talk, sign, or use an augmentative or alternative communication system. Ideally, this improved ability will be learned to the level of *automaticity*, whereby the communicative skill is integrated into procedural memory and can be enacted whenever needed without the client's conscious awareness.

Compensatory Strategies: Unfortunately, the goal of automaticity is not always achievable. For some individuals, some communication skills will always require conscious effort. In these circumstances, SLPs can **explicitly teach executive function skills** to assist the individual to recognize a breakdown of communication. Then to choose communication options that will repair the unsuccessful attempt. Explicitly teaching these skills promotes the acquisition of **flexible response sets** (communication choices) and helps the client become increasingly **self-regulated** to function effectively in the world beyond the therapist.

Conclusion: In order to fully integrate improved communicative abilities from an IP perspective, a successful practitioner is one who can identify a client’s information processing abilities and difficulties, including basic sensory processes. Then, modify and improve a client’s communicative abilities, hopefully to the level of automaticity. Finally, explicitly teach executive function skills that will allow attentional focus to be available for processing other aspects of experience or learning.

Another common axiom in IP is the idea that **downstream filters upstream**. In other words, the quality and completeness of information that passes through an earlier stage will set the foundation for processing at the next stage. Therefore, higher levels of processing, such as memory storage and retrieval, will be constrained by any inadequacy in the information signal that has been encountered or generated at an earlier stage of processing, such as the sensory register, attentional system, or working memory. Consequently, a student who does not adequately sense or register auditory signals will have difficulty assigning meaning to the degraded auditory information as it passes through their IP system.