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SSW Reports

The Spoken Language Processing Approach to Assessment: A Case Study by Larry Medwetsky

Processing with One Hemisphere

Jack Katz

The test battery I deploy is based on my conceptualization of the key processes engaged in spoken-language processing, which are summarized in Table 1. The Spoken-Language Processing (S-LP) approach is an extension of the Buffalo Model and departs from the Auditory Processing approach advocated by many in our profession. The S-LP approach does not seek to examine just auditory mechanisms but recognizes that successful spoken language processing involves the intertwining of cognitive (attention, memory, sequencing, etc.), language and auditory processes. The goal is to determine the specific nature / ex tent of the underlying deficits as it pertains to everyday settings, and, in turn, guide individualized management approaches. For more information on this approach, the reader is referred to Chapter 25 of the latest edition (Sixth) of the Handbook of Clinical Audiology (Lippincott, Williams & Wilkins, 2009, co-edited by Jack Katz, Larry Medwetsky, Robert Burkard and Linda Hood).

Background/Results of Testing

I saw NF when he was five and most recently when he was nine. Over the years I have evaluated NF on five different occasions but due to space limitations, results from alternate evaluations are reported. The findings are shown in Table 2.

June 2004: NF was initially referred to RHSC due to difficulty following/comprehending information presented verbally. In addition, NF was approximately 1-1½ years behind in his speech development and was exhibiting significant difficulty with both phonics and fine motor skills. At this initial evaluation, NF had no 504 Plan or IEP in place. Results of testing revealed difficulties in:

- tracking/representative phoneme/syllable changes on the Lindamood Auditory Conceptualization test. The LAC test assesses an individual's ability to segment and sequence syllables and discriminate/ sequence speech sounds in isolation or track changes within syllable context; in the most difficult subtest, the listener must track both syllabic/speech sound changes simultaneously. The individual's task is to indicate what has been heard via manipulation of different colored blocks (i.e. representing phonemes) and felt squares (i.e., representing syllables). The LAC is highly sensitive to predicting spelling ability and word attack skills (i.e. the ability to sound out words novel to the reader).
- selective auditory attention for (as assessed on the Speech-in-Noise test) as well as binaural separation (as assessed on the Competing Sentences Test). These two tests assess different aspects of selective auditory attention. The Speech-in-Noise test assesses an individual's ability to filter speech embedded in a shower-type noise, that is, involving two very disparate types of acoustic stimuli. As long as there are a sufficient number of critical bands with positive signal-to-noise ratios, the individual will be able to filter out the speech from the background noise as long as the individual is able to process the incoming stimuli with high fidelity. On the other hand, the Competing Sentences Test involves simultaneous presentation of competing sentences to both ears; recall that competing stimuli are best processed in the primary auditory region in the hemisphere contralateral to the stimulated ear. The listener internally directs attention (via the dorsolateral prefrontal cortex) to the auditory region of interest, while either ignoring or inhibiting the stimuli in the opposite hemisphere.
- some lexical (i.e., word) decoding speed difficulty (significant LNC finding on the SSW test).

In addition to various programmatic accommodations, I recommended that NF receive continued therapy in the area of phonological awareness/phonics and access to hearing assistive technology (HAT).

Please note that the Phonemic Synthesis Picture Test (PSPT) result was within age norms. The significant finding on the LAC test but within age norm finding on the PS(P)T is one I often find. This is likely due to the more complex mental operations involved for certain aspects of the LAC test. That is, for a number of tasks the listener must recognize differences between sequentially presented nonsense words – be it a change in a speech sound or syllable and in turn represent the phonemic changes (by colored blocks) and /or syllabic changes (by felt squares). To do these tasks successfully, the listener must process and retain the sequential items in short-term memory; problem-solve the difference present and indicate whether the presenter has added, deleted, or altered the sequence of the speech sounds or syllables. The LAC test contrasts with the more straightforward sequencing/blending of isolated speech sounds entailed on the PS(P)T. One exception – whereby the listener may exhibit more difficulty on the PS(P)T (i.e. a significant PS(P)T finding but within age norm LAC finding), is when fading-memory is present. In this case, the greater difficulty on the PS(P)T may be due to these individuals also not having learned to blend phonemes on the fly. By waiting to blend the phonemes, the individual may err on the earlier presented phonemes (i.e., a fading memory sign).

August 2006: NF now had an IEP with a classification of "Speech or Language Impairment." He was receiving speech and language therapy, occupational therapy, and indirect consultant teacher services through the school, as well as being seen privately for speech and language therapy. NF also had a number of program accommodations and modifications in place, including the use of an FM sound-field system, visual cues, preferential seating, etc. Parental perception of processing difficulties was less than in the past, though NF continued to reveal difficulty in phonics, reading, writing and math. Results of an S-LP testing revealed:

- on the Test of Auditory Perceptual Skills - Revised (TAPS-R), a reduced short-term memory span (STM) for digits/unrelated words (rote-memory span, that is, with minimal context present) but within age norms for sentence recall (i.e. with much linguistic/contextual redundancies).
- overall within age performance on the LAC test but some residual difficulty with higher order manipulations of phonemes/syllables.
- lexical decoding speed (significant RC and LNC findings on the SSW test) and auditory-linguistic integration (significantly more LC versus RC errors relative to normal limits on the SSW test) difficulties.
- selective auditory attention difficulties; results revealed significant Competing Sentence Test findings in both ears, while Speech-in-Noise scores in both ears were within age norms.
- an inability to perceive the largest gap (40 msecs) on the Random Gap Detection Test (RGDT). The RGCT seeks to determine the smallest gap – in milliseconds – that can be detected between two closely presented tonal stimuli of the same frequency.

The listener must perceive the gap between two successive tonal stimuli if they are to perceive two stimuli vs. one tonal stimulus. The gap thresholds for a number of different frequencies are obtained and then averaged to derive the average gap detection threshold. The RGDT is designed to identify a temporal processing disorder that may be related to a phonological processing deficit and/or problems of auditory discrimination, receptive language and /or reading. In comparing these results to those obtained in 2004, overall LAC performance had improved, though NF still exhibited some difficulty as it pertained to the manipulation of phonemes within syllabic context. Phonemic Synthesis Test (PST) performance was well within age norms. A gap threshold on the RGDT could not be obtained, suggesting that poor temporal resolution could be contributing to NF's phonics difficulties.

The total number of SSW errors had decreased, though NF had fallen further behind relative to SSW age norms. Lexical decoding speed difficulty was still present; in addition, auditory-linguistic integration difficulty was now apparent. Interestingly, at younger ages specific processing difficulties are sometimes masked but as the child ages these difficulties may become apparent. For example, if a child at age five exhibits 2 or more errors on most items of the SSW test, then sequencing difficulty may not be evident, however, this difficulty may be revealed as the number of errors decreases in later evaluations. In terms of its impact, lexical decoding speed and auditory-linguistic integration difficulties result in increased processing time/mental load and retrieval difficulty (accuracy and/or speed) within spoken language. These difficulties can also impact reading

(reading speed, degree of mental effort expended, possibly in the retention of information within working memory, and, in turn, comprehension); writing (ease of retrieval/integration of concepts/vocabulary, organization of thoughts/ language components, retention of information within working memory and task completion effectiveness/ efficiency); and math, such as word problems (which involves reading and the integration /retention of key concepts). These difficulties were consistent with those noted by NF's parents and school personnel.

Although speech-in-noise performance was now within age norms, NF's ability to selectively attend to target sentences in the face of competing sentences was still significantly below age norms, a finding that indicated continued difficulty listening in group settings. Last, the discrepancy between rote-memory span and sentence recall performance is a pattern I have noted for approximately 75% of the students I have evaluated. This pattern is likely due to the majority of students referred to RHSC having good basic language skills (i.e., no diagnosed speech-language deficit), and consequently, no difficulty recalling sentences per age norms (i.e. a basic language skill typically assessed as part of a speech-language test battery), but difficulty on the rote-memory span tasks since these are highly dependent on good underlying processing skills.

In addition to many of the same recommendations suggested in 2004, I also recommended an evaluation of NF's lexical organization with the goal of improving lexical decoding speed. Note that lexical decoding speed is contingent on how well phonemes/ vocabulary are organized/represented in long-term memory (LTM). At the time of this evaluation, the lexical decoding speed difficulty was possibly due to disorganized phonemic representations and/or how well the lexicon was organized in LTM.

September 2008:
NF still had an IEP in place with many of the same services/accommodations, although OT services had been discontinued. The parents and the school personnel noted continued improvement, though NF still exhibited some difficulty reading, writing and completing tasks in a timely manner. The results revealed;

- STM span results (as evidenced on the TAP-R) were now all within age norms, a finding consistent with the decrease in the underlying processing difficulties.
- Phonological awareness/phonics was now an area of strength (as evidenced by NF's performance on the LAC and PST tests).
- Lexical decoding speed (significant RC and significant Order Lo/Hi and Ear Hi/Lo on the SSW test) and auditory-linguistic integration difficulties (significant right/left ear discrepancy on the CST) were still evident, but the magnitude of the decoding speed and integration difficulties were less than they were two years earlier. It appears that the remaining lexical decoding speed difficulty was due to issues related to how well the lexicon was organized in LTM, since phonemic representation/organization no longer appeared to be an issue.
- Temporal resolution difficulty was still present but NF was now able to perceive the larger tonal gaps. Interestingly, the gap thresholds were greatest for the higher frequency tones – suggesting perceptual difficulties were greatest for short-duration, fast changing high frequency speech sounds (such as plosives).
- Speech-in-noise performance had improved immensely since NF's first evaluation four years earlier, while CST performance, though improved, still revealed deficits in both ears – indicating continued difficulty listening in the presence of multiple talkers.

These findings resulted in my recommending a discontinuation of phonics-based training but a shift to auditory-perceptual training (specifically for speech sounds of short durations/fast formant transitions) as well as continued work on lexical organization. In addition, I recommended continued access to a HAT system as well as various programmatic accomodtions.

Summary: I hope this case study illustrates how a comprehensive test battery can not only guide professionals in devising an individualized management plan, but also allows one to assess changes in performance of various processes over time, thus allowing for appropriate adjustments in management.

Table 1. Summary of the processes examined using the Spoken Language Processing Approach.

- **Temporal resolution:** the ability to detect rapid changes in the speech signal.

- **Lexical decoding speed:** the ability to process the words of speech quickly and accurately.
- **Short-term/working memory:** the maintenance of information in conscious memory; fading-memory is a deficit in attentional allocation/maintenance resulting in earlier presented information fading rapidly from short-term memory.
- **Short-term/working memory span:** the amount of information (number units) that can be retained in short-term/working memory.
- **Sequencing:** the ability to maintain speech sounds, words, or directions in the correct order.
- **Auditory-linguistic integration:** the ability to integrate information across different aud-itory/language processing regions. On com-peting stimuli tasks (such as the SSW or Competing Sentences Test), an integration deficit is manifested by significantly more errors in the left versus right ear relative to normal limits, while on the Pitch Pattern

blocking out competing stimuli. This can be evaluated by (a) figure-ground tests (i.e., speech embedded in a shower type noise) and (b) binaural separation (whereby comp-eting stimuli are presented dichotically).
- **Divided auditory attention:** the ability to recall both of the competing stimuli that are presented.
- **Sustained auditory attention:** the ability to maintain attention to verbally presented information over an extended period of time.

I also examine higher order phonological skills including:
- **Phonemic Synthesis:** the ability to blend individually presented speech sounds and derive the target whole word.
- **Sound-symbol associations** (i.e. phonics): the ability to discriminate, sequence and represent speech sounds through the use of symbols.
- Sequence Test it is manifested by signif-icantly poorer verbal versus non-verbal (humming) results.

Table 2: Summary of NF's spoken language processing findings

TEST SCORES	June 2004 (5 yrs old)	August 2006 (7 yrs old)	September 2008 (9 yrs old)
1. Test of Auditory Perceptual Skills-Revised			
Numbers:	25%ile (wnl)	14%ile (sig)	28%ile (wnl)
Unrelated words:	50%ile (wnl)	12%ile (sig)	75%ile (wnl)
Sentence Recall:	53%ile (wnl)	53%ile (wnl)	53%ile (wnl)
2. Lindamood Auditory Conceptualization Test #3	<1%ile (sig)	45%ile (wnl- some difficulty with higher order phonics)	77%ile (high-average)
3. Phonemic Synthesis (Picture) Test	12/15 (wnl) 8/15 (normal limit)	22/25 (wnl) 17/25 (normal limit)	24/25 (wnl) 17/25 (normal limit)

4. SSW Test	RNC	RC	LC	LNC	Total	RNC	RC	LC	LNC	Total	RNC	RC	LC	LNC	Total
- NOE	4	16	22	10	52	1	10	26	3	40	0	7	7	1	15
- Normal Limit	4	20	22	6	46	2	7	12	2	22	2	4	6	1	10
** (2004 results x2 bec: 20 items)	wnl	wnl	wnl	sig	sig	wnl	sig	sig	sig	sig	wnl	sig	sig	wnl	sig
											** Sig Order LH & Ear HL				

5. Speech-in-Noise Test	R ear	L ear	R ear	L ear	R ear	L ear
- Quiet:	92%	92%	92%	96%	96%	100%
- Noise:	56%	52%	72%	72%	76%	80%
- Difference:	36%	40%	20%	20%	20%	20%
- Result:	sig	sig	wnl	wnl	wnl	wnl

Table 2 continued…

- **Selective auditory attention:** the ability to focus and recall target stimuli, while

Prosodic perception: the ability to perceive/replicate rhythmic patterns.

Table 2 continued…

TEST SCORES	June 2004 (5 yrs old)	August 2006 (7 yrs old)	September 2008 (9 yrs old
6. Competing Sentence Test:			
Selective Attention			
Right ear:	0% (significant)	45% (sig)	72.5% (sig)
Left ear:	0% (significant)	0% (sig)	37.5% (sig)
7. Pitch Pattern Sequence			
- non-verbal:	DNT	100% (wnl)	100% (wnl)
- verbal:	DNT	69.2% (wnl)	83.3% (wnl)
8. Random Gap Detection Test	DNT	Unable to obtain reliable responses	28.3 msecs average (sig) 15 msecs (.5 KHz) 30 msecs (1 KHz) 40 msecs (2 & 4 KHz)

Processing with One Hemisphere
Jack Katz

I remember before APD came on the scene that Bill Hodgson wrote an article about a patient (or three) who had a hemispherectomy. Central testing was in its infancy and Bill used the Rush Hughs word recognition test (a somewhat difficult listening task) to see the effect of the absent hemisphere. To us it is not surprising that the ear opposite the lesion was very poor compared to the ipsilateral ear.

Two years ago Mike, now age 7, had the right hemisphere of his brain removed to relieve intractable seizures. Although his speech was pretty good (6 yrs of Speech Therapy), there was no way of getting a % correct score. Mike was pleasant and cooperative, but his speech required significant effort and was very slow.When he had a long delay the item was repeated. Sometimes it was necessary to teach him the answer to get any response at all. In such cases, on the next item he often perseverated, but eventually with further repetition he did respond to the new item. Because of the effort that he put in it was necessary to give him several breaks.

Basic Tests

Hearing was tested from 500-4000 Hz the previous month. In the right ear 500 Hz was at 20dB but the other frequencies were within normal limits. The left ear at 500 Hz and 1k were at 25dB, 10dB at 2k and 20dB at 4k. The 2-best frequency speech averages were 8dB and 17dB in his right and left ears respectively. His SRTs were 10dB and 15dB which supported the puretones. When he was seen at my office for central testing the results were briefly re-checked. They were the same or slightly better.

Tympanometry showed normal compliance but negative pressure (RE= -30daPa and LE=-225) in the left ear. When rechecked here both were normal. The audiologist who evaluated hearing function was not able to assess acoustic reflexes because of equipment limitations. The same was true when retested by me prior to the APD evaluation.

Buffalo Model Questionnaire (BMQ)

	DEC	Noise	Memory	Various
# Items	5	4	5	4
Mike	3	2	3	2
Signif	+	+	+	+
	INT	ORG	APD	Gen
# Items	3	3	5	11
Mike	2	2	4	4
Signif	+	+	+	

Table 1. Results of Mike's BMQ showing all 4 categories of APD. TFM total = 10/13.

Based on the BMQ it looks like all four categories may be affected. This was fairly consistent with the information on the Case History form.

Word Recognition in Quiet Test

Before the WR test I practiced with live voice speech to show Mike the task and get him in the swing of things. Then speech was presented at 55dB first to the right ear. I recorded 6 correct responses (no known errors). In the left ear he had more trouble (3 correct responses, no known errors). More items had been presented but there was no resonse. That was as much time as I could afford on speech in quiet. He appeared to be roughly okay in the right ear and not quite as good in the left, but both might be roughly in normal limits I suspect.

Word Recognition in Noise Test
I felt that the standard +5dB SNR would be too frustrating for Mike so I gave him a +10 SNR. He had 4 correct on the small group of words to the right ear, although intially one was perseverated on. In the left ear "start" was "stone" and "add" was "up" and he had no idea what "we" was. It seemed clear that the left ear was much poorer than the right but I am quite sure the right was not wonderful.

Phonemic Synthesis (PS) Test
He responded with only the last sound of the easy words that I gave him live voice (generally a short-term memory sign). I told him the word was "she" and then said the sounds and he got it but then I gave him "go" but he said "she". I gave him the next word and then he got it correct.

Interpretation & Recommendations
By this time the Mike was tired. I felt from a rehab standpoint that I had enough information to form a *working hypothesis* (not a diagnosis). That was not difficult even though I was not able to get a single score.

Yes, he sure did have a major APD, but was there enough information to suggest what categories? There was good evidence of DEC (e.g., PS) and TFM with SN and signs of STAM problems. Both were supported by the BMQ. We would love to have a lot more, but it is most critical to get started and not have him fall even further behind. DEC and TFM are also the most important categories because they are the most basic skills and first therapies. In therapy we would want to see DEC, memory and speech-in-noise improve before considering the more advanced processing skills of ORG and INT.

DEC is most important because everything we want to hear has to be decoded first, so I would start with the Phonemic Training Program (PTP) with cards with the letters on them and in his case after some progress I'd start Phonemic Synthesis (PS), but it might require a letter chart to make it multiple choice. Once he can point to two letters (g-o) then we point out that, that is a word "go" and thereby start PS. For much more information you know that it is in the "*Therapy for APD: Simple, Effective Procedures*" book from the Educational Audiology Association.

Next I would work on memory. First to get baseline information as formal tests may not be possible for Mike at this time. See where he stands in digits and words (working memory is likely too difficult right now). When DEC and memory are better I'd start SN therapy with no noise and then gradually work up.

One Hemisphere
So how much of all of this is the usual APD and how much is the fact that Mike has no active brain tissue on one side? I don't know but I am reasonably sure that the severity of his problem is related, in part, to the lack of support from the R-hemisphere and his setback because of years dealing with paralysis, brain surgery etc.

An ALD?
One of my recommendations was for an ALD in class. The parents understood that it would be binaural but when the school records showed no benefit and actually a slight loss in every one of the observations! So they inquired and found out that the ALD was in one-ear-only and that was the LEFT ear (that is supposed to talk to the RIGHT hemisphere that he does not have)!

In a case like this; surely no one knows the best way to handle an ALD or if one will help him. Angela Loucks and I have proposed to evaluate Mike with an ALD in the right ear, (I suspect it will be good) the left ear (I think it won't be good) and bilateral which could be weaker/the same or better than the right.

We learned some things that might relate to hemispherectomy, but we expect to learn a lot more each time we see Mike. One thing is for sure. Unless you have tested the ALD in advance; don't put it in the ear opposite the absent hemisphere. * * * * *