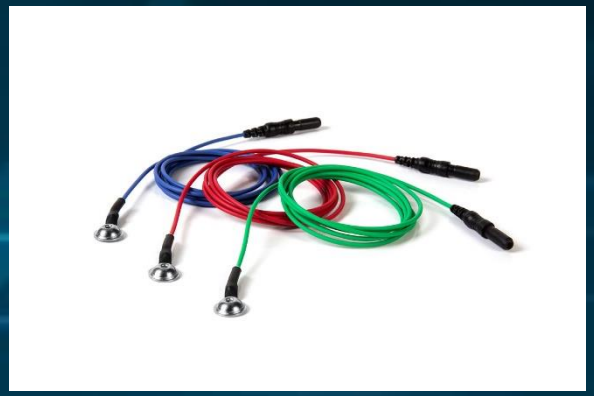
cABR/FFR Acquisition

SPECIFICS ON RECORDING AND NOTATING

Transducers

- Insert earphones are used to present stimuli.
- Shielded inserts are recommended.
- Personally, I have not had much luck with shielded, so I use unshielded.

Electrodes and Placement



- Silver/Silver Chloride are recommended.
- Gold is viable alternative.
  - I used cup electrodes only at first, but now prefer clip-ons for earlobes, and cup electrodes for Cz and Ground.
- Earlobe placement is preferred for inverting
- Cz is preferred for non-inverting
- Fp1 for Ground
  - Mastoid placement is dispreferred because of PAM artifacts.

Impedance

- Impedance should be less than 3 kOhms.
  - Best recordings when all electrodes are balanced. If necessary, accept slightly higher impedance with balance, over lower impedance on some electrodes and higher on one or two.
- I find that adherence improves with time. I may have borderline impedance while I do clicks, but it will have improved by time I am ready to measure cABR/FFR.
- For me, forehead is the hardest to keep on: tends to pull away, so I need to check it more often.

Patient State: typically, awake

- cABR/FFR assumes an awake testee. The stimuli are typically at 80 dB SPL which means that testees usually have difficulty sleeping.
- But responses can be recorded from sleeping testee.
  - If too much artifact from muscle tension, it helps to ask testee to close eyes and try to sleep.
- Most people become "entranced" when watching a video, so movement is minimal.
  - I use an Ikea Poang chair and Poang ottoman. Most people find it very comfortable. Upside is inexpensive with low maintenance. I cover it with towels that can easily be removed and washed. Downside is that it cannot be fully reclined.
- With a very active child, it may be more time-efficient to collect fewer samples, but collect more sweeps (6 sweeps of 1024 instead of 3 sweeps of 2048).

Settings

Montage: Cz, A1, with forehead as ground

	Click	40 msec DA	170 msec GA and BA
Gain	100,000	100,000	100,000
Filter: high pass	100,000 Hz	50 Hz	50 Hz
Filter: low pass	1,500K	3000 Hz	3000 Hz
Line Filter	on	on	on
Rejection	35.0 uV	35.0 uV	35.0 uV
Rate	31.1/second	10.9/sec	4.35/sec
Stimulus	100 us click	40 msec DA	170 msec GA or BA
Sweeps	1024 x 2	2048 x 3	2048 x 3
Phase	rarefaction	alternating	alternating
Intensity	70 dB HL	80 dB SPL	80 dB SPL
Ear	Right and left simultaneous	Right, then Left	Right only
Earphones	ER3 insert earphones (shielded)	ER3 insert earphones (shielded)	ER3 insert earphones (shielded)
Offline-filtering	none	100-1500 Hz	none

Worksheet: (made in WORD)

Easy to revise

Includes norms

cABR Worksheet

Name:	Birthdate/Age:	Evaluation Date:	IHS File Number

1. **Click ABR:** 2 runs, 1024 each at 31.1/sec at 80dB SPL, run R & L simultaneous

Click Latency	Latency V (under 6.26 ms)	**4-7** msec: CC 1st to 2nd (no less than 0.89)
Right		
Left		
CC: R to L (4 to 7 msec). Cutoff = 0.89		

2. **40 msec /DA/:** 3 runs of 2048 each, at 10.9/sec at 80 dB *SPL. Off-lined filtered 100-1500 Hz.*

Norms:	V	A	D	E	F	O
Expected						
Right						
Left						

3. Slope for Wave V/A of 40 msec /DA/

Ear	Wave V/A amplitude	Wave V/A latency	Wave V/A slope	(**6-42** ms): CC: 1st – 3rd
Expected: greater than	At least 0.30	Less than 1.40	At least 0.26	At least 0.70
Right				
Left				
		CC: R /DA/ to L /DA/		

4. Pitch Tracking: 3 runs (2048) /GA/ and 3 runs (2048) each /BA/]

Syllable	Waveform #	Pitch Error	Pitch Strength	S-R Highest Correlation	At (Latency)	CC: 1st to 3rd (**15-60** msec)	CC: 1st to 3rd (**60-150**)
Cutoff		Less than 1.73	At least 0.43	At least 0.43		At least 0.66	At least 0.55
/GA/							
/BA/							

5. Cross-phaseogram: Compare /GA/ to /BA/. Save as .jpg

   10-50 msec: (bright red splotch) _____

   60-170 msec: (green) _____

6. Save copy of waveforms as .pdf

Revised 1/2/2015

Demographics

Important to have the file Number because it is encrypted in the "IHS Data File".

cABR Worksheet

Name:	Birthdate/Age:	Evaluation Date:	IHS File Number

Age is important because DA norms based on age.

Data Collection

- Approximately 1 hour
- Collected in sound booth, but since it is a supra-threshold signal, environment can be modified: i.e. door open
- I administer behavioral tests first, then electrophysiological.
- When AEPs collected, send client home.
- Analysis done off-line, usually after client is gone.

Click ABR

I like to include instructions on the worksheet.

Cross-correlations have to be done uniformly.

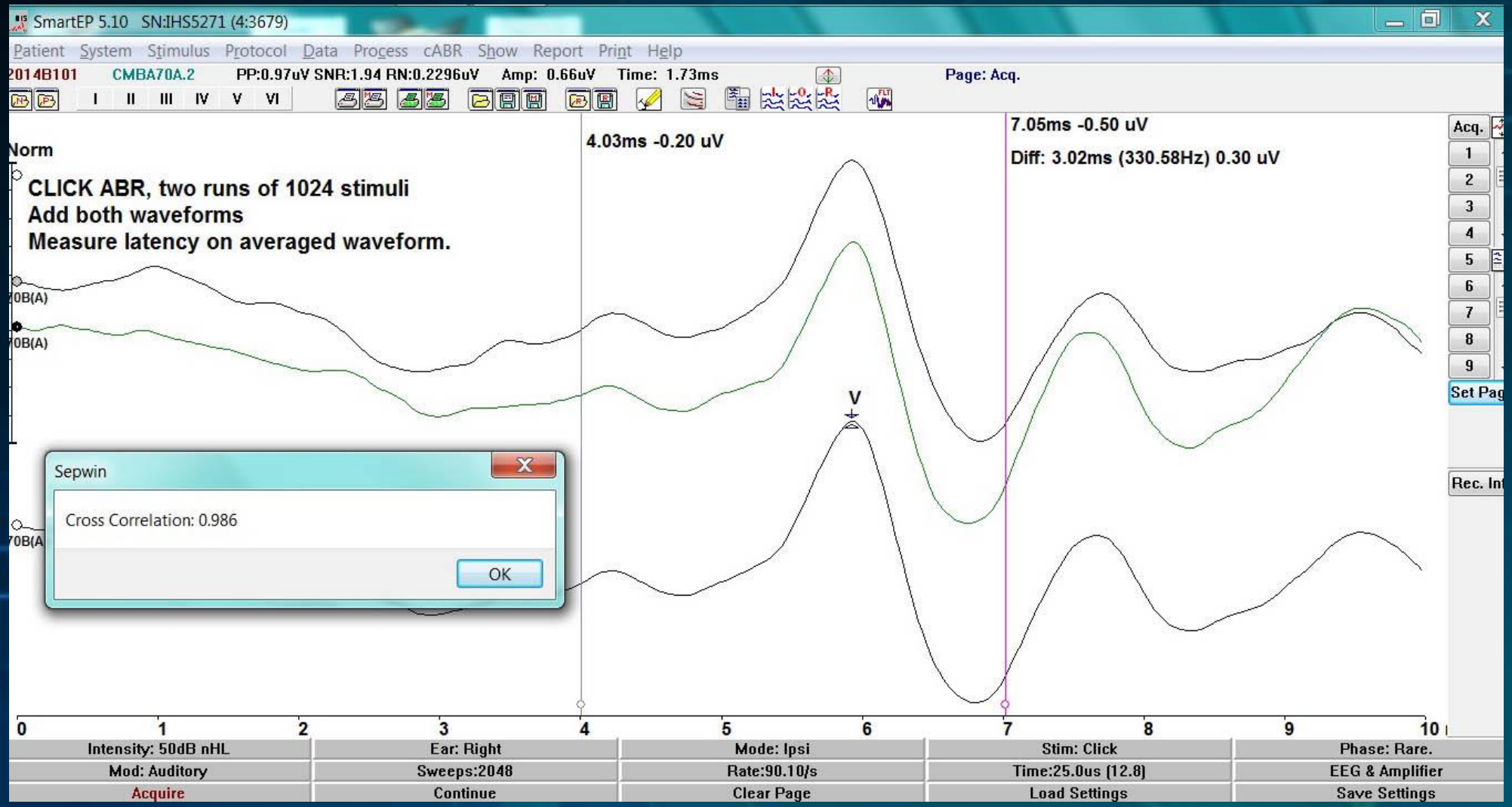
1. **Click ABR:** 2 runs, 1024 each at 31.1/sec at 80dB SPL, run R & L simultaneous

Click Latency	Latency V (under 6.26 ms)	**4-7** msec: CC 1st to 2nd (no less than 0.89)
Right		
Left		
CC: R to L (4 to 7 msec). Cutoff = 0.89		

Click ABR

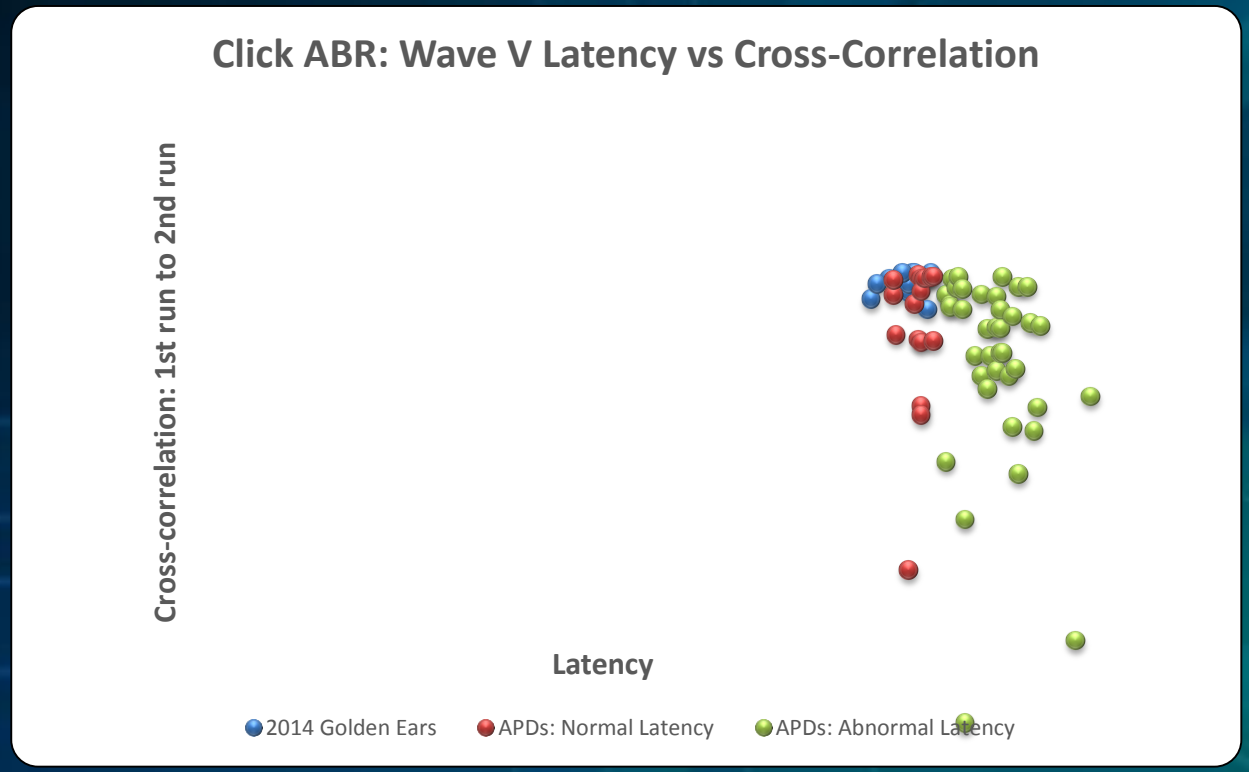
- Place right ear sweeps on screen
- Calculate Response Consistency (4-7 ms)
  - Correlation under 0.89 is outside of normal limits.
- Add right ear sweeps
- Mark Wave V of the summed waveform
- In over 500 clients, I have never had one without Wave V on click ABR
- Click Wave V latency and consistency is typically excellent, but there are clients with delayed responses or poor consistency.
- Repeat above steps for left ear

Verify click ABR



Clicks: variation

(Note: some APDs had negative correlations between first and second runs)



1. Golden Ears (blue) cluster tightly.

2. APDs scatter:
Most cluster for latency, but scatter for correlation.

Still, abnormal latency is seen too.

40 msec DA

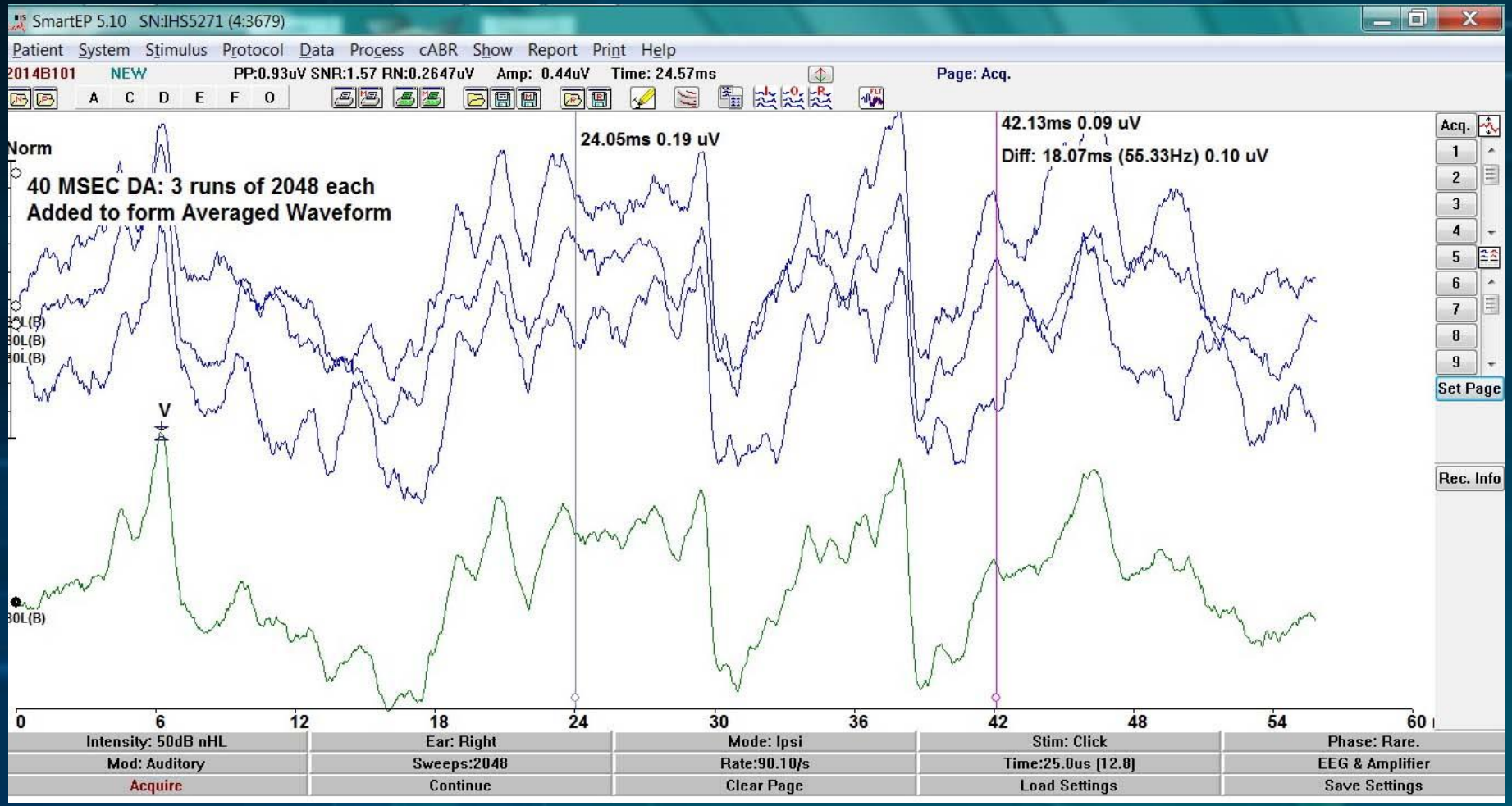
2. **40 msec /DA/:** 3 runs of 2048 each, at 10.9/sec at 80 dB *SPL. Off-lined filtered 100-1500 Hz.*

Norms:	V	A	D	E	F	O
Expected						
Right						
Left						

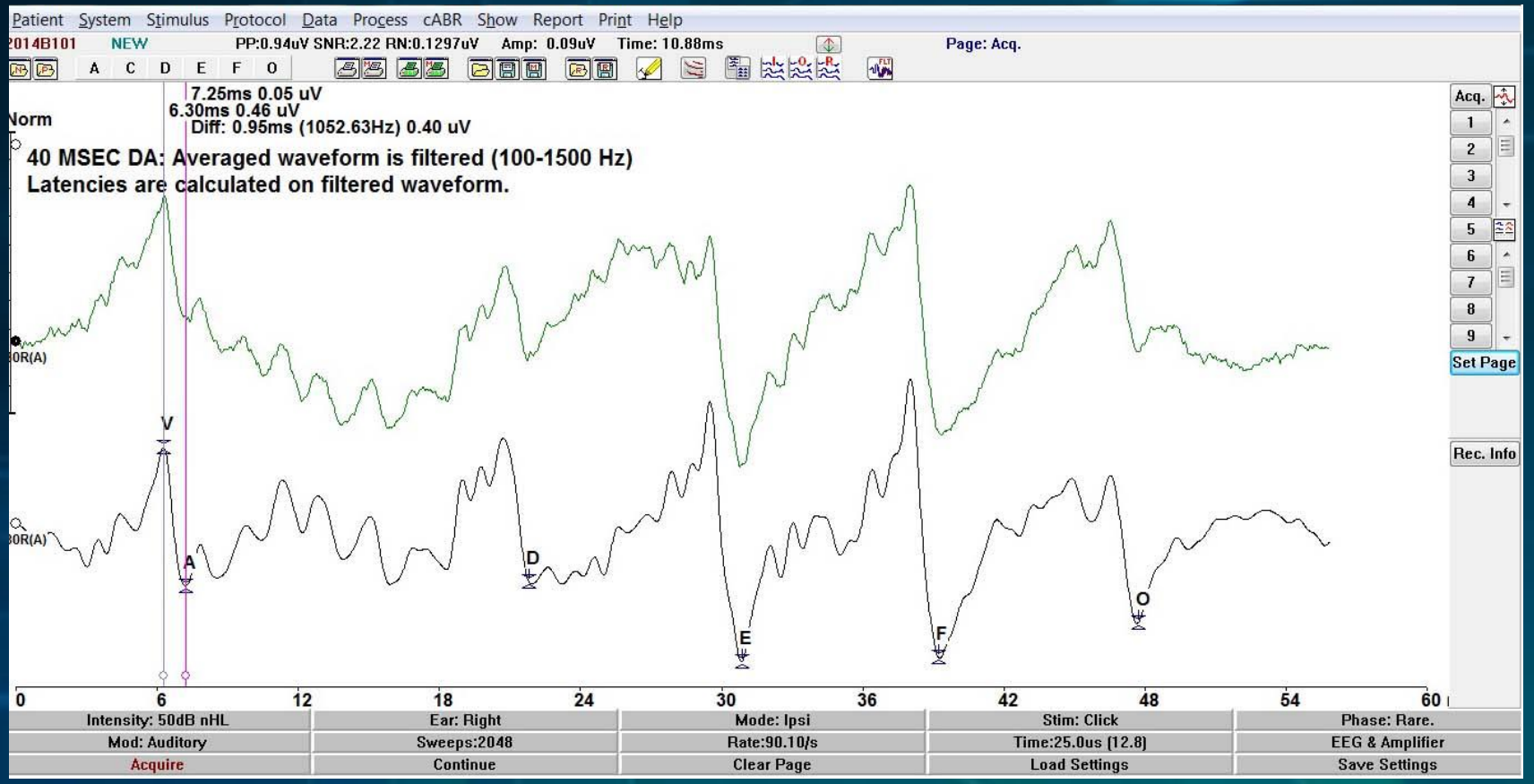
3. Slope for Wave V/A of 40 msec /DA/

Ear	Wave V/A amplitude	Wave V/A latency	Wave V/A slope	(**6-42** ms): CC: $1^{st} - 3^{rd}$
Expected: greater than	At least 0.30	Less than 1.40	At least 0.26	At least 0.70
Right				
Left				
		CC: R /DA/ to L /DA/		

Measure 40 msec /DA/



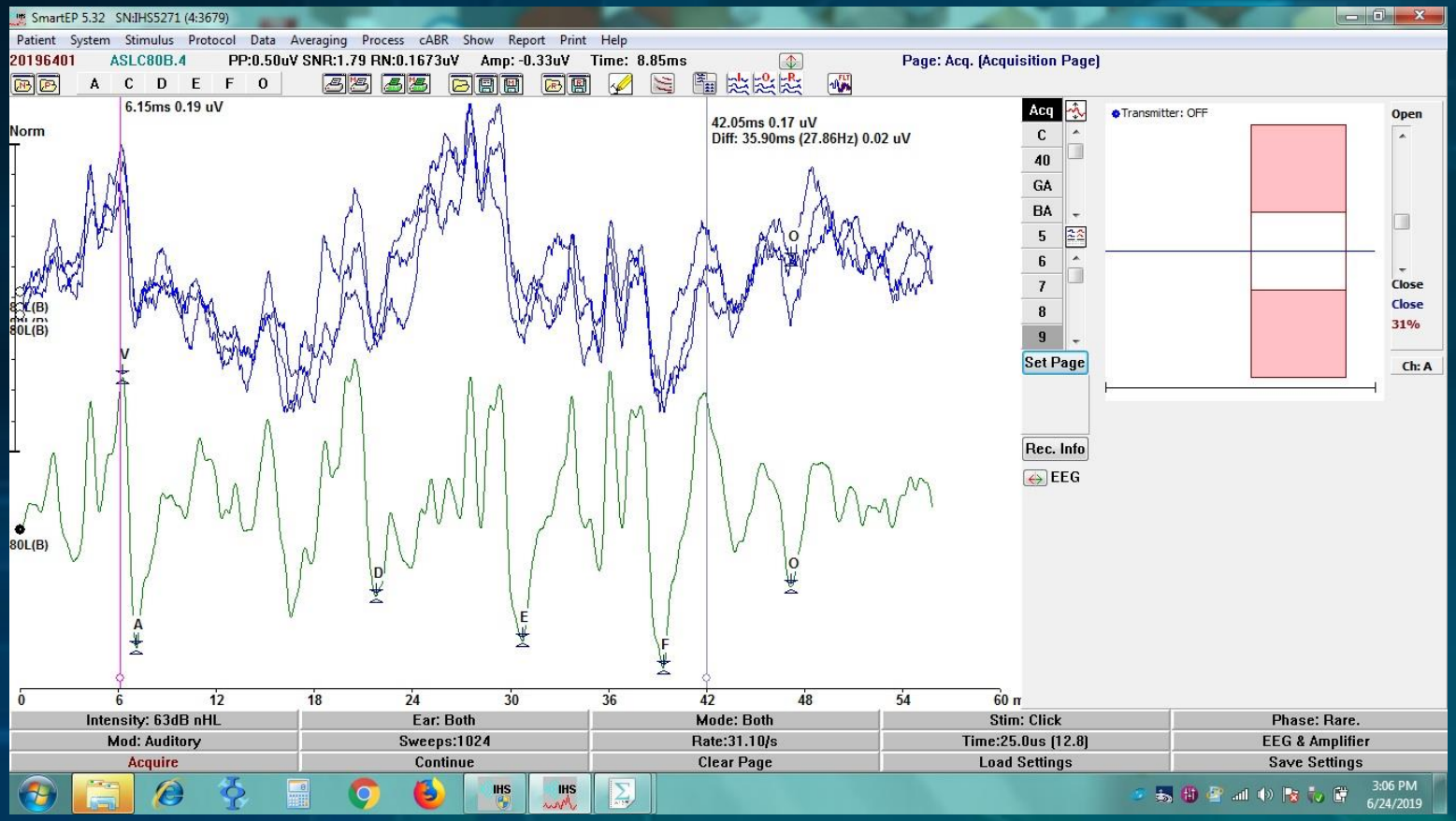
Latency of specific waveforms marked



Peak Marking for 40 ms DA

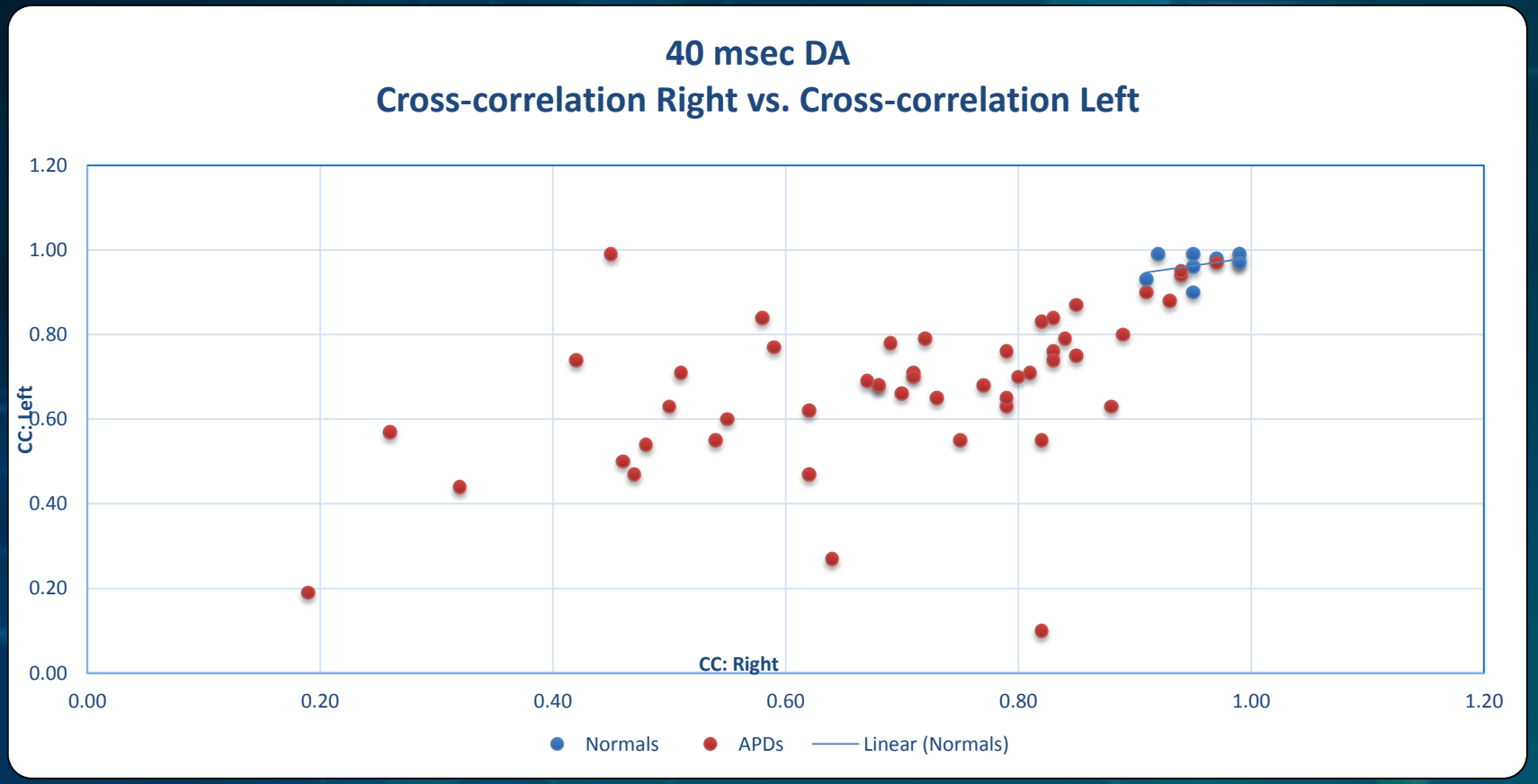
- Activate "show cursors"
- Smart EP allows latency/amplitude markings with cursors.
  - Mainly important with Wave V/A complex.
  - Amplitude of individual waves other than V/A not measured.
- Activate all sweeps on screen.
- Under Process: Add All on Page. Move summed wave down. It is active.
- Under Process: Filter: Bandwidth. High Pass = 100; Low Pass = 1000
- Under Process: Filter Active
  - Measure latency Waves V, A, D, E, F, O. Right and left.
- Calculate slope
- Calculate Response Consistency for DA (6 to 42 ms).

Normal 40 ms DA (2 of 3 rule)



Response Consistency: 40 msec DA

normals: tight cluster; abnormals: wide scatter



170 msec GA and BA

4. Pitch Tracking: 3 runs (2048) /GA/ and 3 runs (2048) each /BA/]

Syllable	Waveform #	Pitch Error	Pitch Strength	S-R Highest Correlation	At (Latency)	CC: 1st to 3rd (**15-60** msec)	CC: 1st to 3rd (**60-150**)
Cutoff		Less than 1.73	At least 0.43	At least 0.43		At least 0.66	At least 0.55
/GA/							
/BA/							

5. Cross-phaseogram: Compare /GA/ to /BA/. Save as .jpg

   10-50 msec: (bright red splotch) _____

   60-170 msec: (green) _____

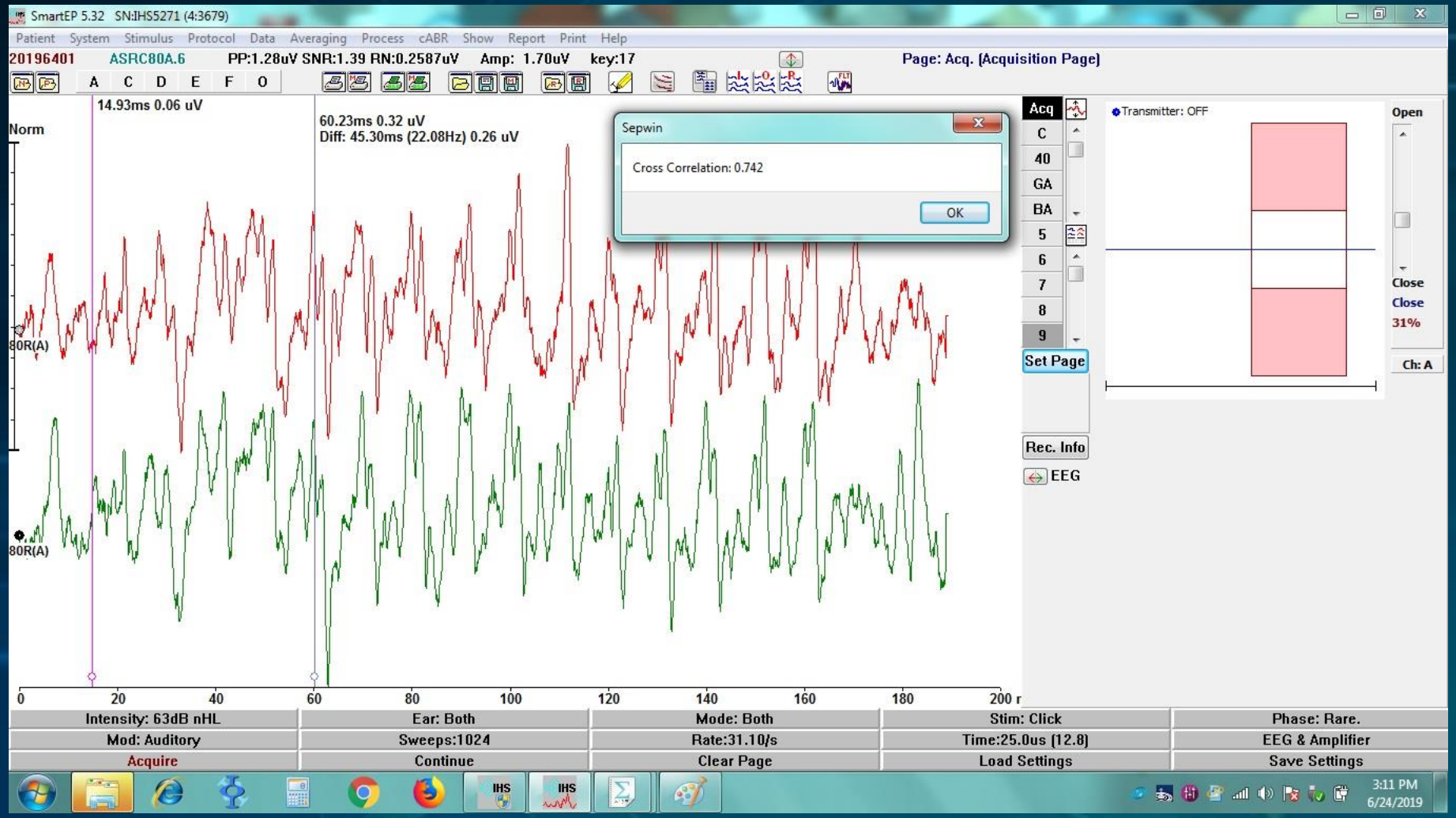
6. Save copy of waveforms as .pdf

- Whereas the DA seems less prone to artifact, the GA and BA are more affected.

180 ms waveforms: GA first, then BA

- Place all sweeps on screen
- Measure Response Consistency for:
  - 1. Onset: 15-60 ms
  - 2. Vowel: 70-150 ms
- Add all sweeps, mark summed waveform (now active)
- Under "cABR" change filter settings (high pass: 75; low pass: 500). This changes Matlab module.
- Under "cABR" choose Display.
  - Find highest correlation in 6 ms to 10 ms range (absolute value)
  - Note waveform number

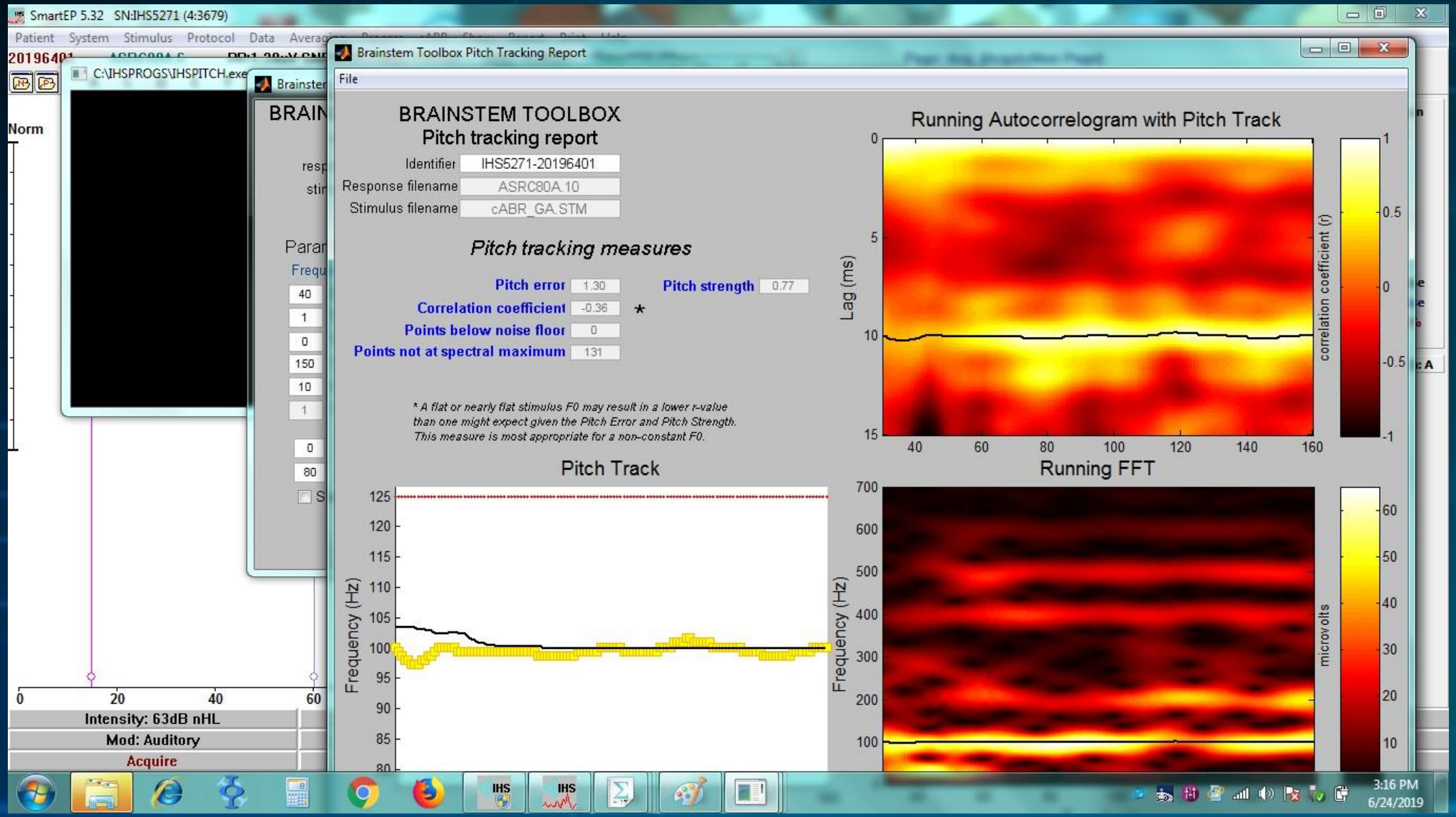
Normal CC, GA 15 to 60 ms



180 ms GA and BA

- Under "cABR" choose Pitch-tracking
  - Find client's file
  - Choose summed waveform for analysis
- Matlab module calculates Pitch-Tracking info and outputs a graphic
- Under "cABR" choose Crossphaseogram
  - Choose summed waveform for GA, then summed waveform for BA.
  - Matlab module calculates Cross-phaseogram for 15 to 60 ms.
  - Change Matlab module to 70-150, remeasure.

Normal Pitch Tracking



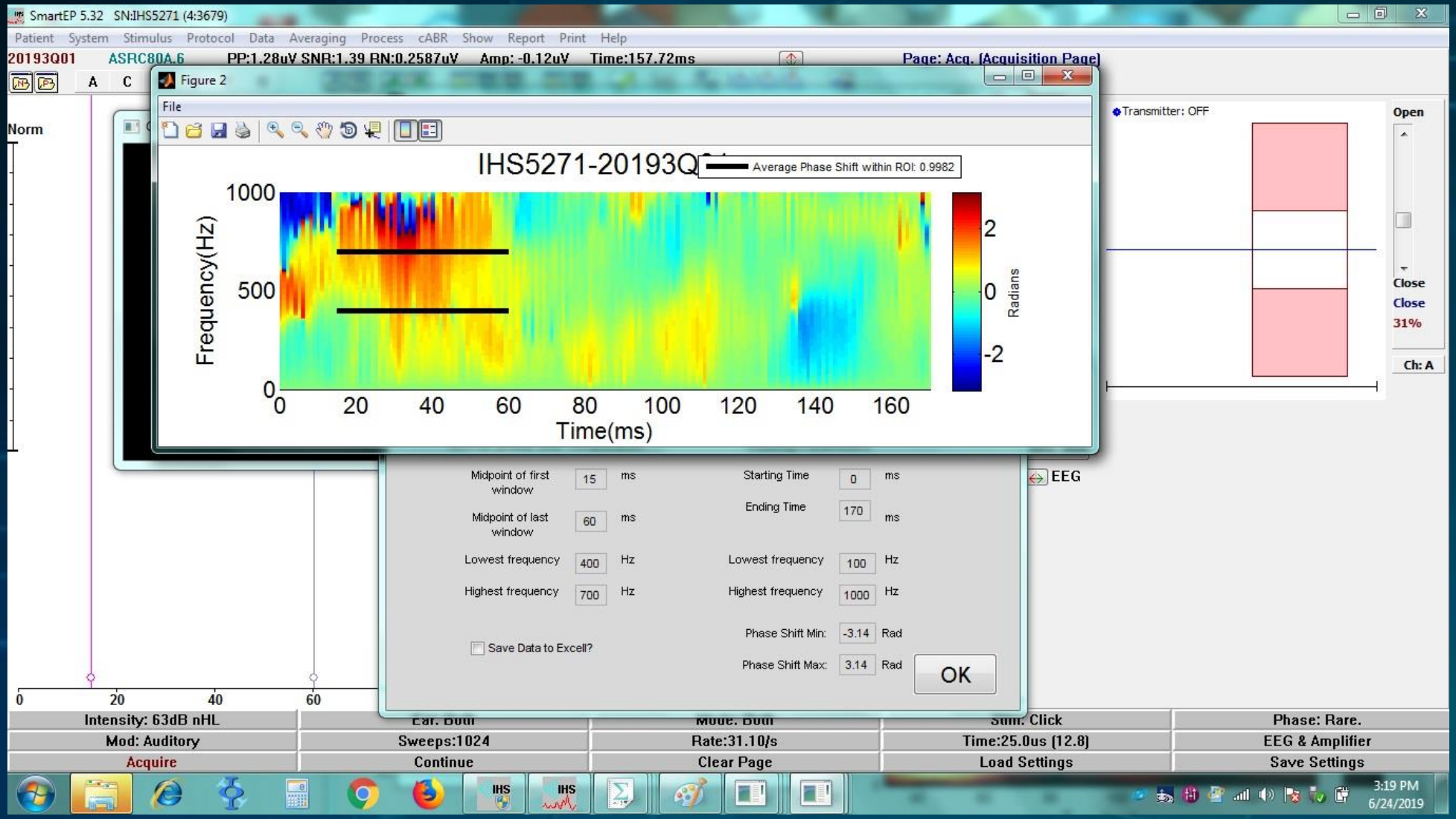
Pitch Tracking

- Pitch Track is plotted in the lower left of the graphic:
  - Black line represents the fundamental periodicity of the stimulus [pitch].
  - The 180 BA and 180 GA syllables have "flat" pitch that ranges from 90-110 Hz. *This is the easiest pitch to track*. There are other syllables that have distinct variation in pitch that have been used in some of the Lab's research studies, but are not used on a regular basis.
- Yellow boxes represent the response's periodicity. This has been time-shifted to line up with the stimulus.
- It is typical for FFR to closely follow the periodicity of the evoking stimulus, and it can be trained.

Pitch Tracking

- The yellow boxes show how much the response's periodicity varies from the stimulus.
  - The value is given in Hz.
  - Normal Pitch Error (from my norms) is 1.72 Hz or less.
  - This value is an absolute number. It does not matter whether response was sharp or flat versus stimulus.
- Correlation Coefficient is Pearson's r between stimulus-track and response-track.
- Pitch Strength is the mean of the correlations at the thin black line. Higher is better. Normal is high.

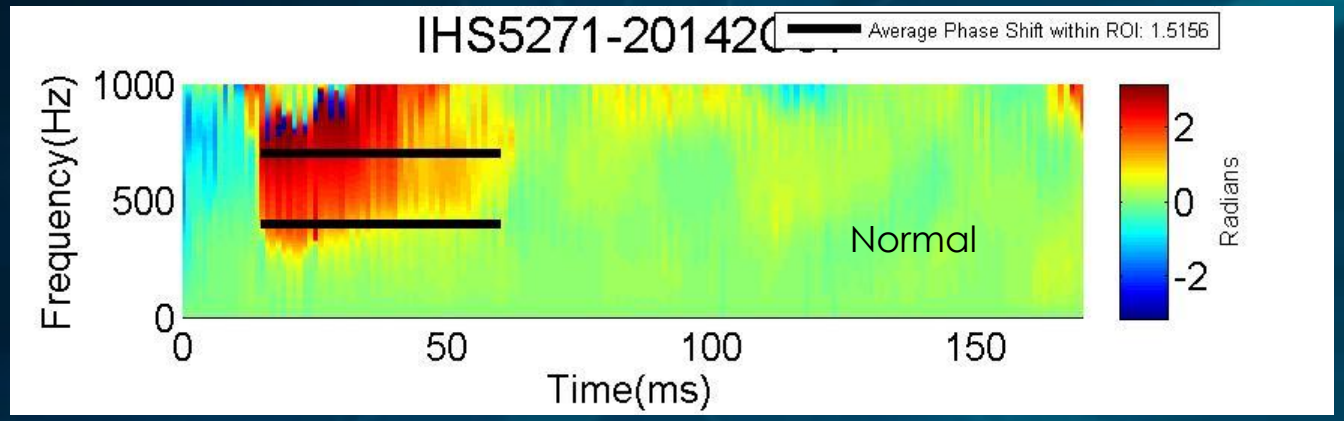
Cross-phaseogram



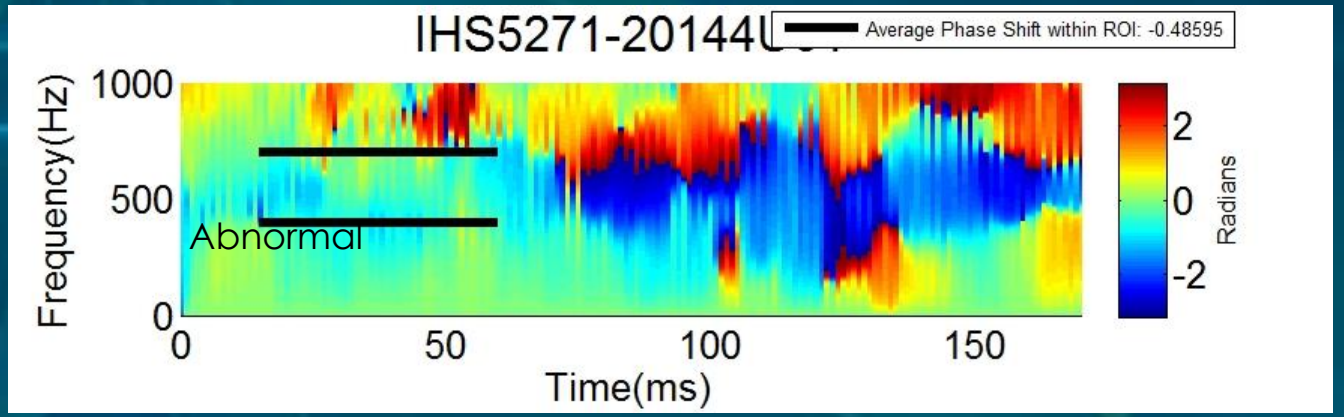
Crossphaseogram

- Speech sound contrasts found in input stimuli are preserved in the phase of responses.
- The crossphaseogram shows phase shift as a function of time and frequency for the comparison
  - X-axis: time
  - Y-axis: frequency
  - Color-axis: Phase shift in radians

Cross-phaseogram



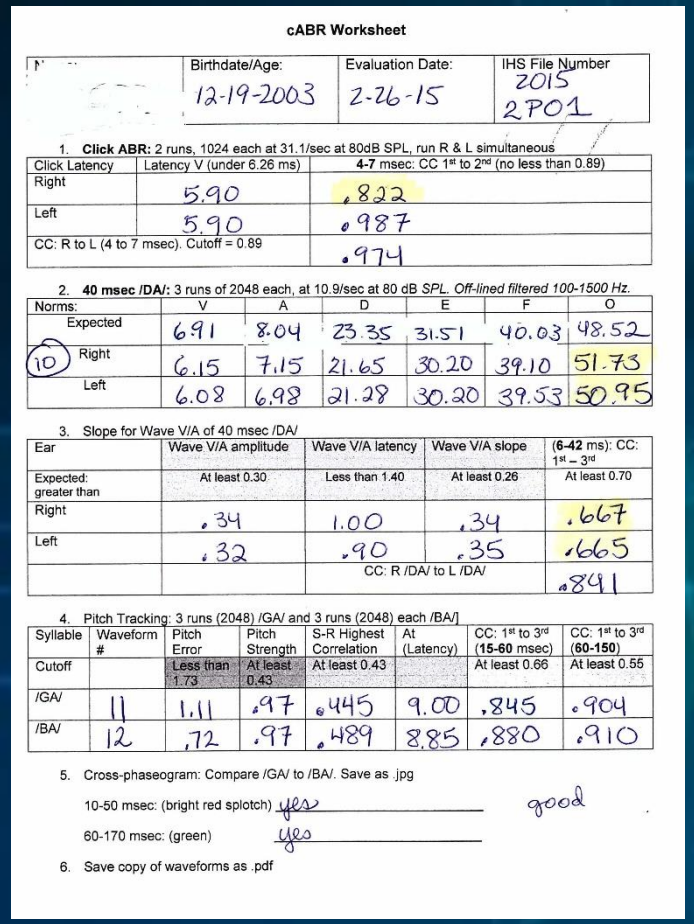
IHS allows these graphics
To be saved as .jpg.
I add them to the report.
Not so easy to add the
Waveforms to report.



Comparing GA to BA

- Expect significant phase shift in the 20-60 ms range[this is the formant transition period of the stimulus] because the syllables have different consonants and there should be a difference (color change: should be red)
- Do not expect a phase shift in the 60-170 ms range because both syllables have the same vowel (no color change: should be green).

Completed Worksheet: helpful to highlight abnormal results



cABR Worksheet

	Birthdate/Age:	Evaluation Date:	IHS File Number
	12-19-2003	2-26-15	2015 2P01

1. **Click ABR:** 2 runs, 1024 each at 31.1/sec at 80dB SPL, run R & L simultaneous

Click Latency	Latency V (under 6.26 ms)	**4-7** msec: CC 1st to 2nd (no less than 0.89)
Right	5.90	.822
Left	5.90	.987
CC: R to L (4 to 7 msec). Cutoff = 0.89		.974

2. **40 msec /DA/:** 3 runs of 2048 each, at 10.9/sec at 80 dB *SPL. Off-lined filtered 100-1500 Hz.*

Norms:	V	A	D	E	F	O
Expected	6.91	8.04	23.35	31.51	40.03	48.52
(10) Right	6.15	7.15	21.65	30.20	39.10	51.73
Left	6.08	6.98	21.28	30.20	39.53	50.95

3. Slope for Wave V/A of 40 msec /DA/

Ear	Wave V/A amplitude	Wave V/A latency	Wave V/A slope	(**6-42** ms): CC: 1st – 3rd
Expected: greater than	At least 0.30	Less than 1.40	At least 0.26	At least 0.70
Right	.34	1.00	.34	.667
Left	.32	.90	.35	.665
		CC: R /DA/ to L /DA/		.841

4. Pitch Tracking: 3 runs (2048) /GA/ and 3 runs (2048) each /BA/]

Syllable	Waveform #	Pitch Error	Pitch Strength	S-R Highest Correlation	At (Latency)	CC: 1st to 3rd (**15-60** msec)	CC: 1st to 3rd (**60-150**)
Cutoff		Less than 1.73	At least 0.43	At least 0.43		At least 0.66	At least 0.55
/GA/	11	1.11	.97	.445	9.00	.845	.904
/BA/	12	.72	.97	.489	8.85	.880	.910

5. Cross-phaseogram: Compare /GA/ to /BA/. Save as .jpg

   10-50 msec: (bright red splotch) yes

   60-170 msec: (green) yes

   good

6. Save copy of waveforms as .pdf

1. I collected my own click norms.
2. I use the 40 msec norms from ANL (published) for latency.
3. I collected my own slope norms and cross-correlation norms.
4. Collected own norms for GA and BA.
5. I find it helpful to highlight abnormal responses on the Worksheet so I can overview easily.

Suggested Patterns relevant to APD

- "Decoding" Deficit:
  - Poor neural encoding of transients (plosive burst) with preserved steady-state (vowel) encoding.
    - Delayed waveforms (in particular, Wave A and Wave O)
  - Poor slope for the Wave V/Wave A complex (amplitude/latency),
    - Due to either low amplitude or elongated V/A latency
- "Noise Exclusion Deficit" (Tolerance/Fading Memory):
  - Neural synchrony degraded by noise
  - Poor tracking of the fundamental frequency (Pitch Tracking)
  - Poor response consistency (ability to sustain response over time)
  - Poor stimulus-to-response correlation
- "Prosodic Deficit":
  - Would expect FFR, Pitch-tracking, and F0 measures to be affected.