Development of a Screening Tool for Auditory Processing Deficits after TBI

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What is Auditory Processing?

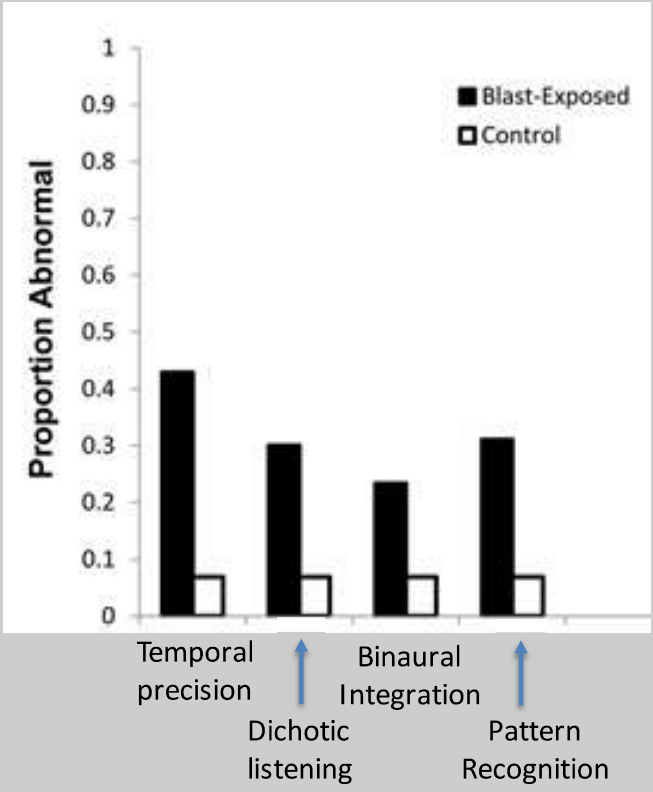
- *How the brain reconstructs and makes "sense" of sounds waves that are broken down and encoded in the cochlea*

- Encompasses a WIDE range of processing, such as:
  - Stream segregation and binaural comparisons
  - Auditory discrimination and recognition
  - Auditory memory and sequencing

- *Symptoms of auditory processing deficits may include:*
  - Mishearing or misinterpreting words or speech patterns
  - Difficulty understanding speech in the presence of other sound sources
  - Problems keeping up with conversations, especially with multiple talkers
  - Problems recalling spoken information
  - Difficulty understanding rapidly spoken or accented speech
  - Easily fatigued by listening
  - And more!

Challenges in Auditory Processing Disorder (APD) Assessment

- Similar symptoms/complaints may be caused by different underlying deficits
  - E.g., speech in noise difficulties
- Auditory processing outcomes of patients with previous mTBI are heterogenous
  - E.g., patients with blast-related mTBI can have deficits in very different domains of auditory processing
  - Not everyone with an mTBI develops chronic auditory difficulties
- Full evaluation of auditory processing abilities is time consuming and requires specialist audiological care



Gallun et al., (2016). Chronic effects of exposure to high-intensity blasts: Results of tests of central auditory processing, *JRRD, 53*(6), 705-720.

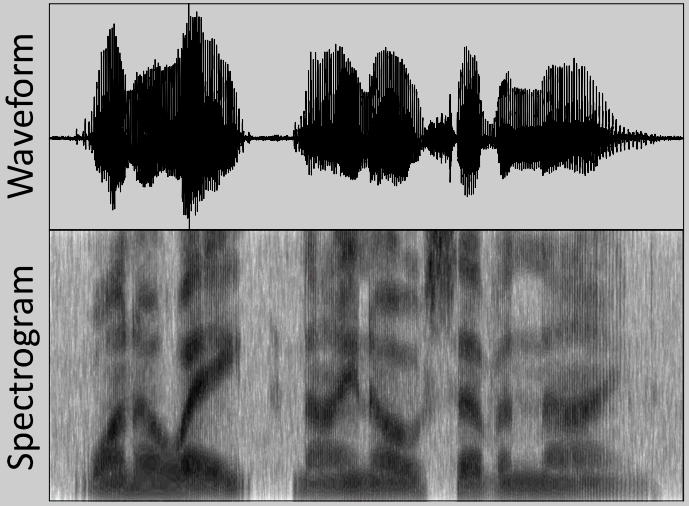
The Goal:

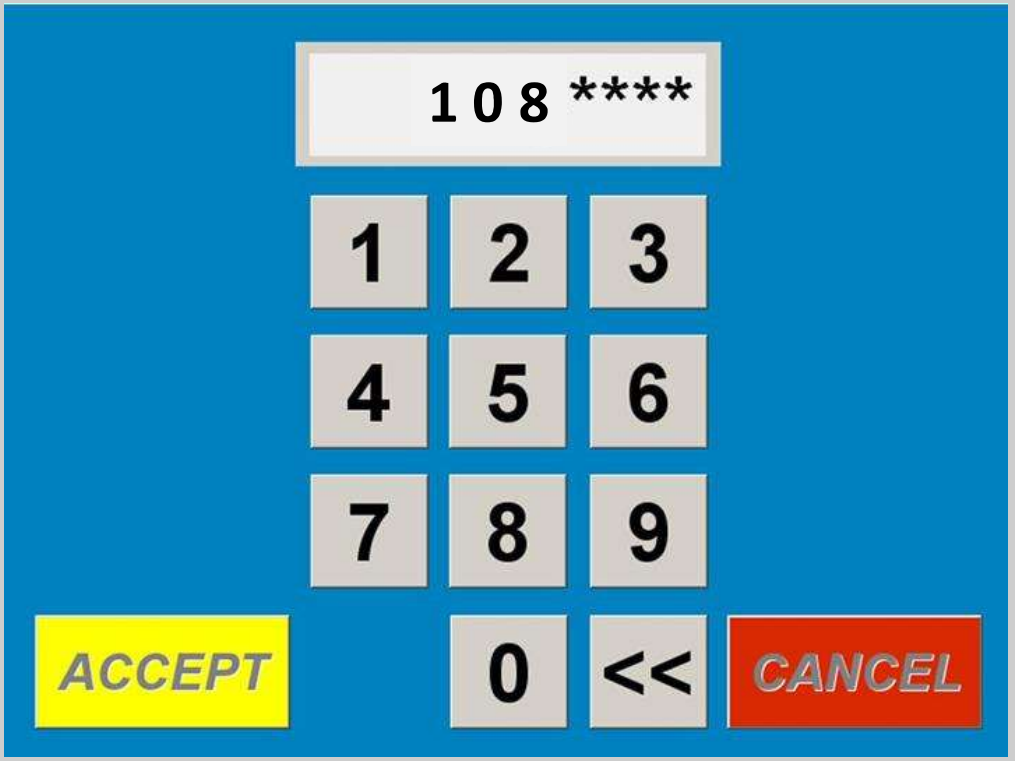
- Develop a screening test for APD in patients with previous TBI:
  - Determine which patients are likely to fail a diagnostic APD test battery
  - Point towards possible domains of processing weakness to better focus diagnostic protocols
  - Should be fast, repeatable, and able to be administered by non-specialists

Time Compressed Digits Test

Normal Speaking Rate

"108 – 9079"





Time Compressed Digits Test

Normal Speaking Rate

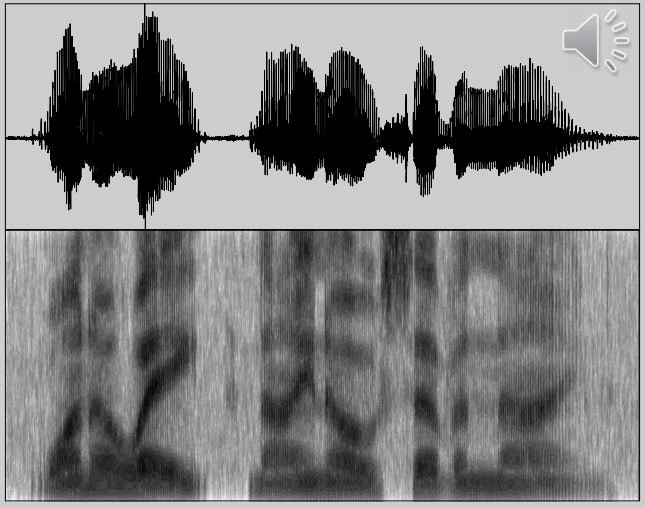
"108 – 9079"

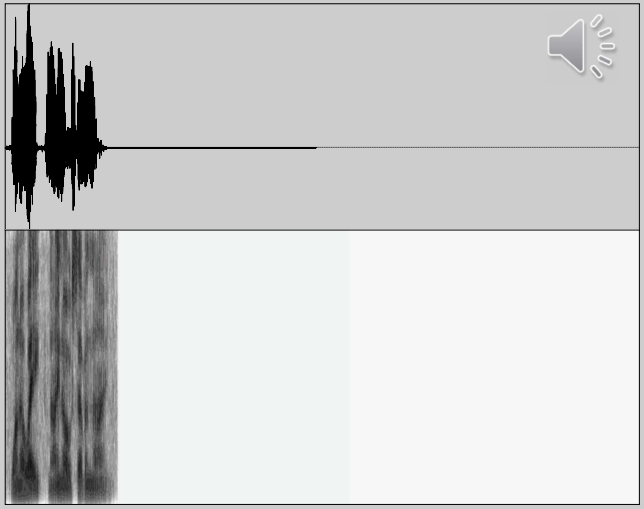
Compressed to 1/5 original length

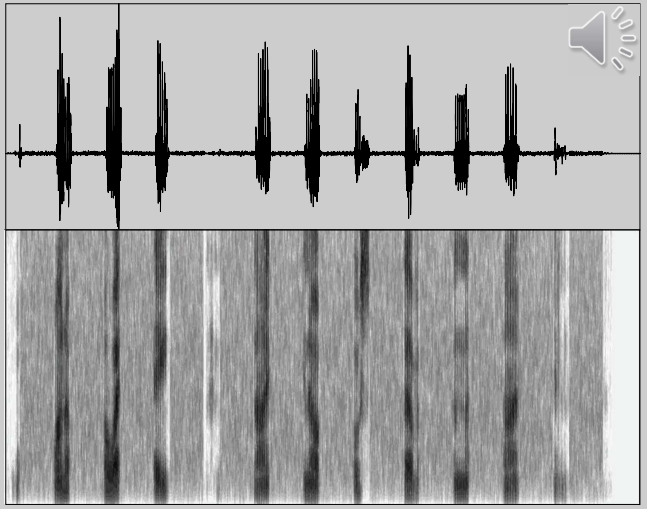
Compressed with silent gaps inserted

Waveform

Spectrogram







- Measured with & without background noise
- Scored with both "strict" and "lax" methods

- How long of a silent gap is needed to "recover" the speech information?

Why Time Compressed Digits?

- Targets several domains of Auditory Processing:
  - Temporal acuity
  - Temporal pattern recognition and recall
  - Monaural low redundancy
  - Auditory processing speed and information recovery
  - Speech-in-noise understanding

- Also repeatable, low language requirements, ecologically valid, automated administration

Pilot: Methods & Hypothesis

Participants (all normal hearing sensitivity):

- Previously diagnosed mTBI (n = 36)
  - Avg. age: 35.7 years (range: 23 to 50)
  - Borderline or abnormal performance on ≥1 APD test

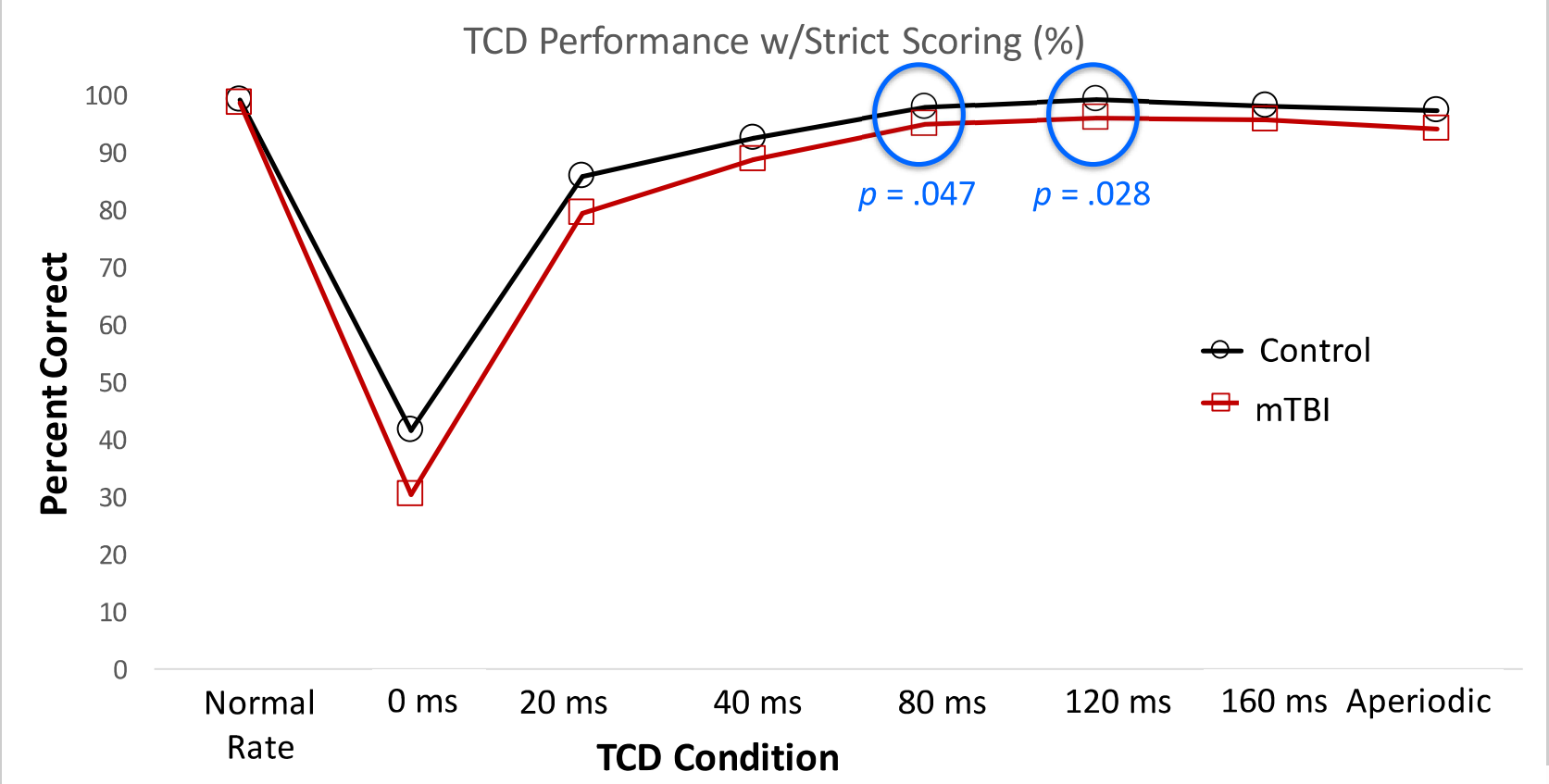
- Control participants (n = 26)
  - No history of head injury or blast exposure
  - Must pass all APD tests
  - Age- and sex-matched with TBI participants

Procedures:

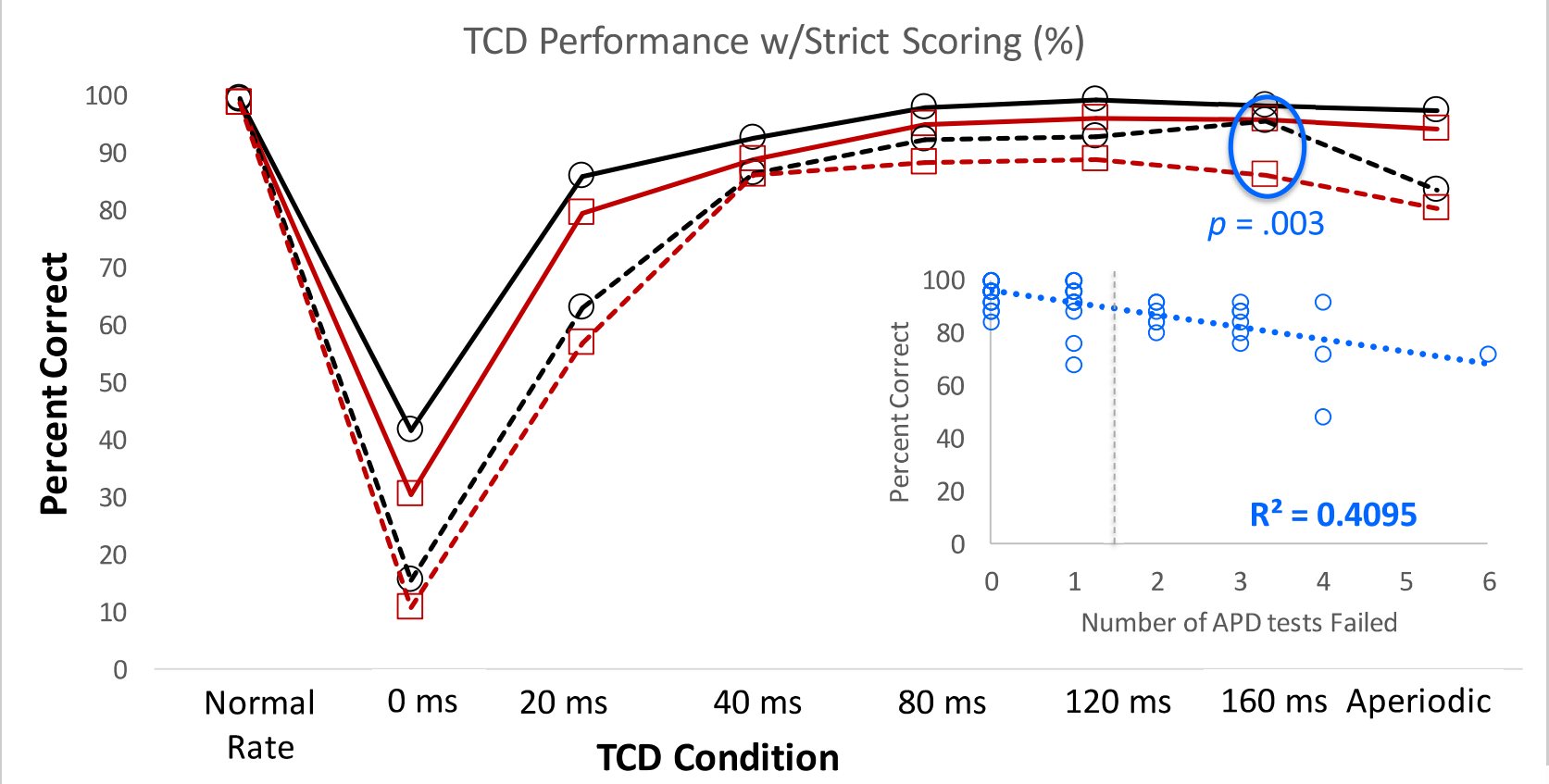
- Battery of 8 clinical diagnostic APD tests
- 16 TCD Conditions:
  - Quiet and Noise presentations of: Uncompressed and compressed digit strings with gap durations of 0, 20, 40, 80, 120, and 160 ms, and an Aperiodic gaps condition

Hypothesis: The conditions that will best separate participants with and without auditory processing deficits will be Compressed Digits with 40 ms gaps presented in background noise

Results


TCD Performance w/Strict Scoring (%)
Percent Correct
100
90
80
70
60
50
40
30
20
10
0
p = .047
p = .028
Control
mTBI
Normal Rate
0 ms
20 ms
40 ms
80 ms
120 ms
160 ms
Aperiodic
TCD Condition

Results

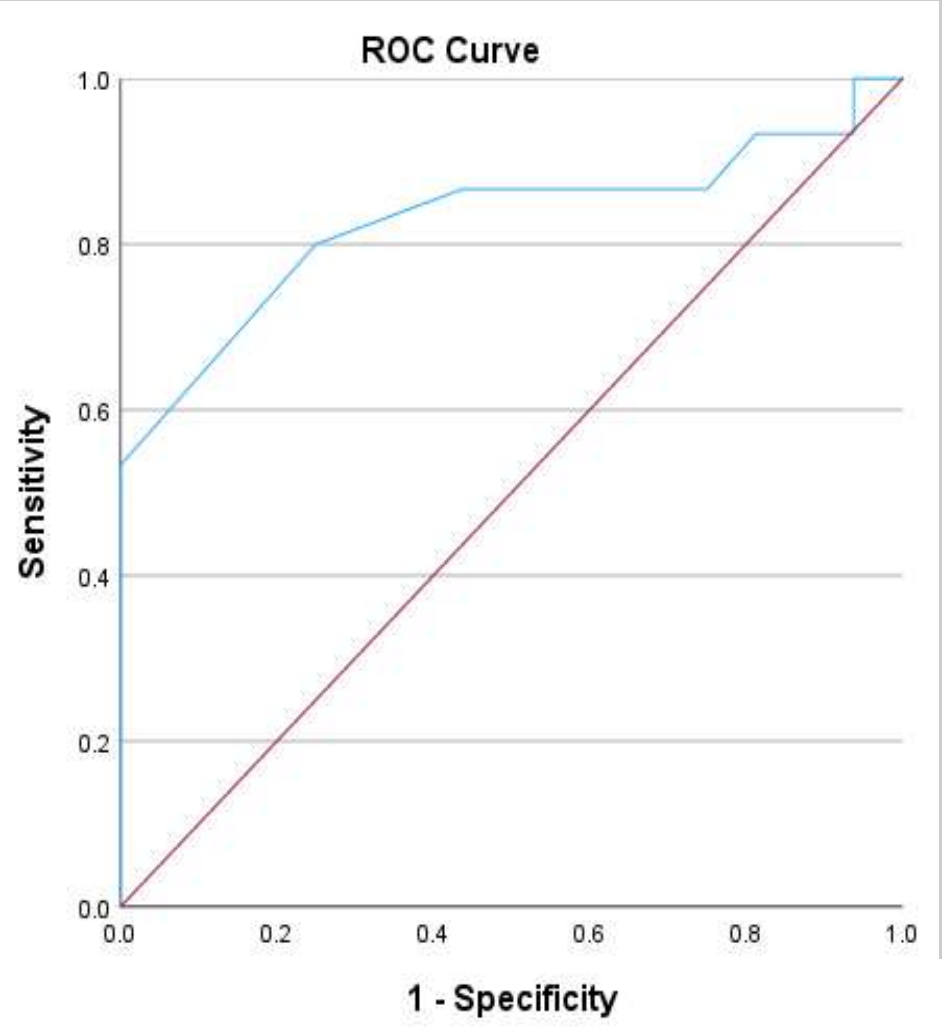

TCD Performance w/Strict Scoring (%)
Percent Correct
100
90
80
70
60
50
40
30
20
10
0
p = .003
Percent Correct
100
80
60
40
20
0
R² = 0.4095
0
1
2
3
4
5
6
Number of APD tests Failed
Normal Rate
0 ms
20 ms
40 ms
80 ms
120 ms
160 ms
Aperiodic
TCD Condition

Results

Compressed with 160ms gaps in Noise

- ROC based upon mTBI participants only
- Area Under the Curve (AUC) = 0.829!

Cut-off Score	Sensitivity	Specificity
90% Correct:	0.800	0.750
86% Correct:	0.867	0.563



Conclusions

- Compressed digits with 160 gaps presented in background noise does an excellent job of detecting who is and is not likely to fail an APD test battery!
- Proves again that it's often the conditions that are easy for control participants and slightly harder for patients that are most sensitive to deficits!

Further Analyses and Future Plans

- Explore whether specific patterns of performance or scoring are correlated with specific types of auditory processing deficits
- Apply TCD test to a wider population to determine whether results hold up
  - More patients with previous mTBI
  - Do these results apply to patients with APD from non-TBI causes?

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