Oral Presentation #6
Clinical Analysis of Speech Rhythms in Language Development using MATLAB

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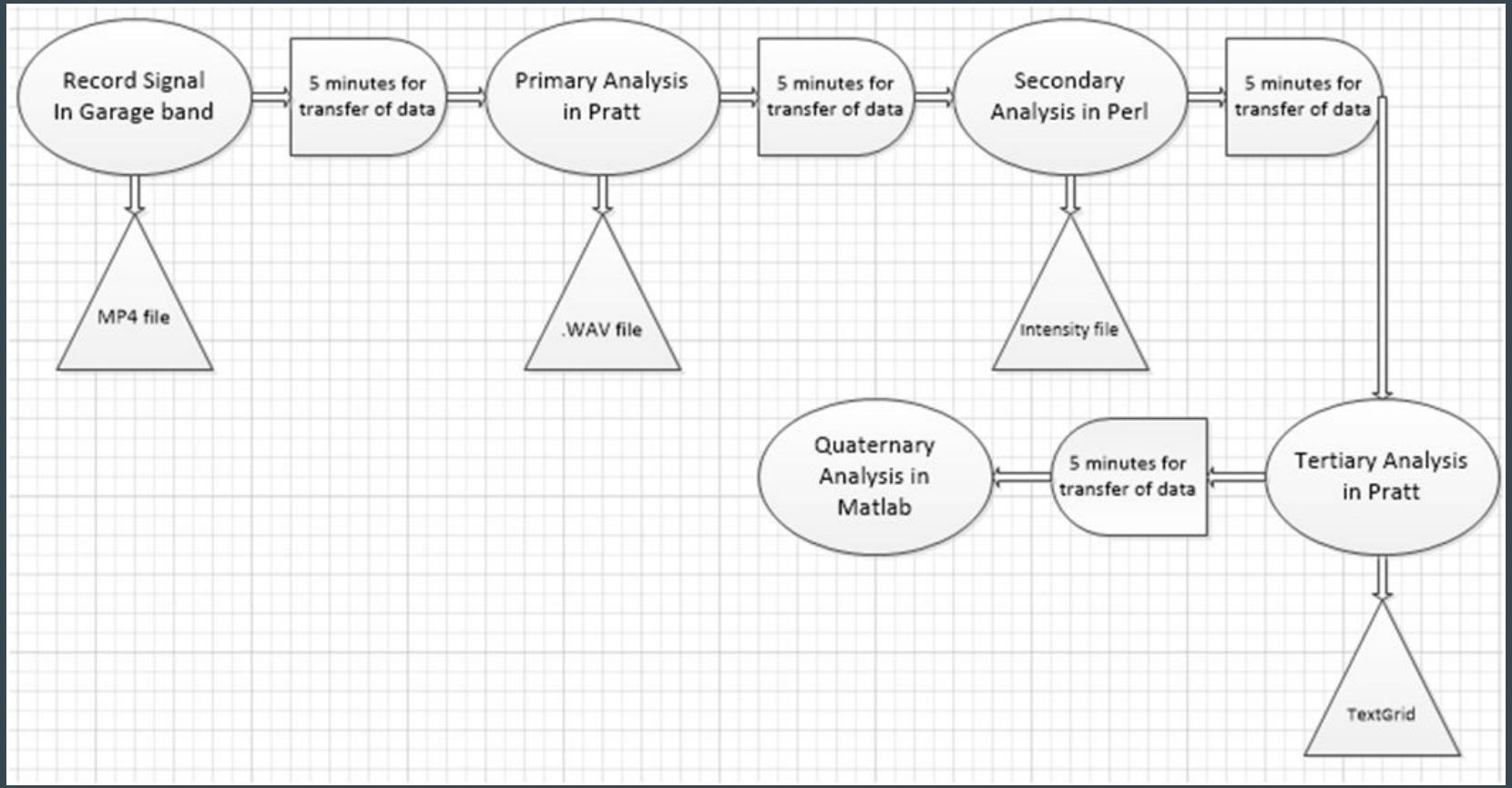
Problem Statement

Preliminary research has been conducted that indicates a correlation exists between an **individual's rhythmic capabilities and language development.**

Currently, the data analysis process used to determine an individual's rhythmic abilities is **inefficient** and **impractical** in a clinical setting.

No data analysis process or system exists to assess an individual's speech rhythm. There is a need in the industry for **a diagnostic technique** that efficiently analyzes the individual's recorded speech to determine whether their rhythm is considered good or bad.

There is an immediate need in the Gordon lab for **a data analysis** process that quickly and efficiently judges rhythm in speech. Beyond the Gordon lab, there is a **clinical need for a device** with an intuitive interface that is capable of immediate analysis and display of feedback


Record Signal In Garage band
5 minutes for transfer of data
Primary Analysis in Pratt
5 minutes for transfer of data
Secondary Analysis in Perl
5 minutes for transfer of data
MP4 file
.WAV file
Intensity file
Quaternary Analysis in Matlab
5 minutes for transfer of data
Tertiary Analysis in Pratt
TextGrid

Needs Assessment

- Must (simultaneously):
  - Detect the rhythm of the English language
  - Detect the rhythm of musical metronomes
- Must streamline data in one software program
- Must reduce time needed to analyze data
- Must use consistent analytics
- Must provide feedback to user and lab staff
- Must have intuitive interface
- Must store data for future analysis and retrieval
- Must be safe, physically compatible with children, and comfortable

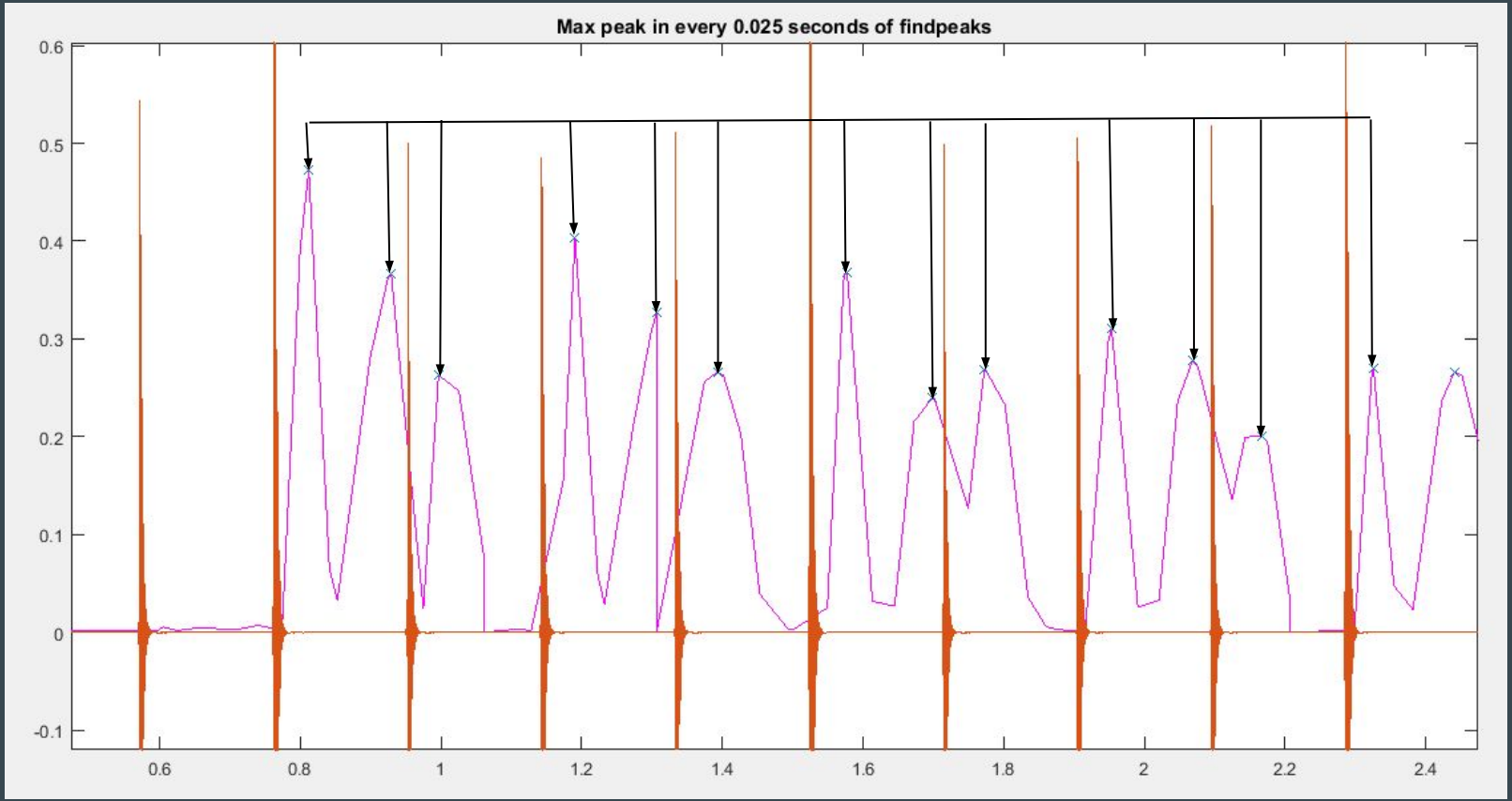
Specific Language Impairment

- A “disorder that delays the mastery of language skills in children who have no hearing loss or other developmental delays” [1]
- About 7-8% of kindergartners have SLI
- The cause is unknown but there does seem to be a genetic link
- Symptoms:
  - Beginning to talk after 2 years of age
  - Not being understood after 3 years of age
  - Difficulty with verbs- dropping the ‘s’ in present tense, avoiding past tense, etc.
  - Studies have shown that there is difficulty in processing rhythm in speech & music [2]
  - Also limited phonological awareness with rhyming, syllable deleting, segmentation and blending [3]
  - General lack of confidence when speaking

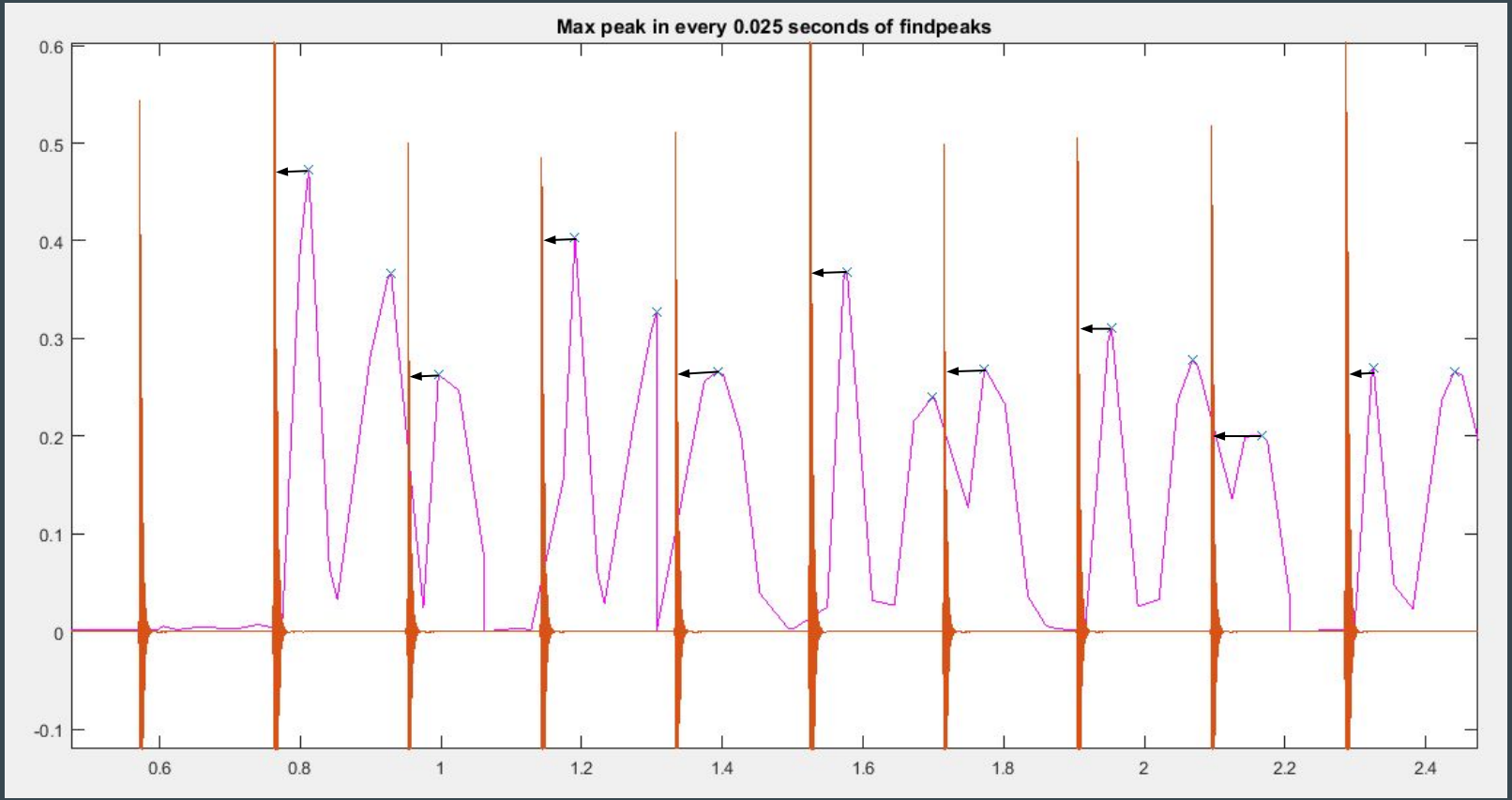
Music Cognition Lab Participants

- Identification of SLI:
  - Often identified by parents and/or teachers
  - There are numerous identification tools but they all focus on grammar and verb usage
- Potential subjects are found from pediatric speech clinics, flyers, and word of mouth
- How are subjects chosen for the study?
  - Potential subjects have screening visits to quantify language skills
  - Occurs by administering the SPELT-3 exam
  - This data excludes late talkers and untrue SLI

Manifestation of SLI- Nuclear Synchrony



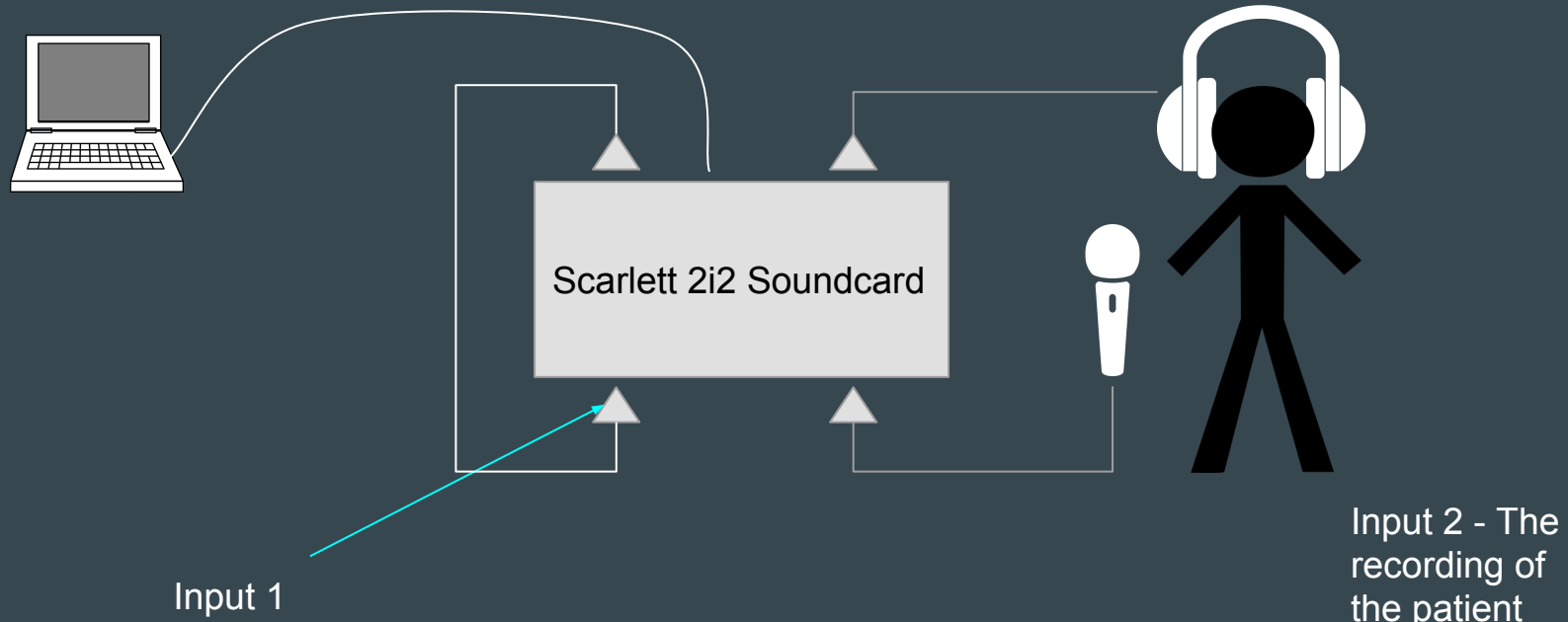
Manifestation of SLI- Global Synchrony



Design Components

- *MATLAB program:*
  - *Collect and analyze speech and metronome tracks*
  - *Utilization of toolbox functions and circular statistics (PsychoPhysics toolbox, Gstreamer)*
  - *Feedback and user interface to assess patient rhythm consistency and accuracy*
- Data analysis program must be compatible with:
  - Various computer operating systems
  - A microphone (SM 58)
  - Headphones (any brand)
  - External Soundcard (Scarlett 2i2 system)
- The design of the study will:
  - Determine the rhythm baseline by sampling a population of individuals with normal speech development
  - Longitudinally assess impact of musical training on speech rhythm therapy

Soundcard Application working diagram



Design Components: MATLAB Program

I. Load data into MATLAB
II. Filter the signal
    A. Take envelope of raw data: *abs(hilbert())*
    B. Butterworth lowpass filter: *butter*
III. Locate speech peaks
    A. *[pks, loc] = findpeaks(data)* returns peak amplitude and index
    B. *for* loop converts indices to time
    C. *for* loop runs through the vector of the location of peaks converted to time
        1. *if* statement locates time points within a specific, predetermined division of time.
        2. The maximum peak amplitude is found within the time division using an *if* statement. This value and its associated time value are saved to a new vectors.
        3. The process is repeated for the next time division.
    D. *findpeaks* locates absolute speech peak

Design Components: MATLAB Program

IV. Eliminate multiple points found on same speech peak

A. *for* loop runs through all peak locations. Two subsequent peak locations are looked at at a time.

1. *if* the two peak locations are spaced far enough in time (>=0.2s), both are valid peaks and saved to a new array. If not, only the first peak is saved to the final array.

V . Locate speech beats

B. *resample* filtered data to reduce array size

C. *interpolate* peak location and amplitude data to same size as resampled data

D. *for* loop runs through resampled data

1. *for* loop calculates 60% of each speech peak

a) *find* all values in the resampled array for each 60% value

b) *for* loop to compare indices found with the specific speech peak location. *if* the 60% value found is the last value found before the location of the associated speech peak, it is the speech beat associated with that peak. 60% indices and associated amplitudes are saved to a new array.

Design Components: MATLAB Program

VI. Nuclear Synchrony

A. locate the first, second, and third syllables of every phrase (ex: *syllable1 = t_60(1:3:end);*)

B. *for* loop to find the difference in time between first and second syllables of every phase and first syllables of subsequent phrases

~~C. phase = (difference between first and second syllables)/(difference in time between first syllables)~~

~~D. Nuclear synchrony score = *mean* of phase values~~

E. circ_r: mean resultant vector length

VII. Global Synchrony

A. *for* loop separates metronome beats into two vectors: first and second beats

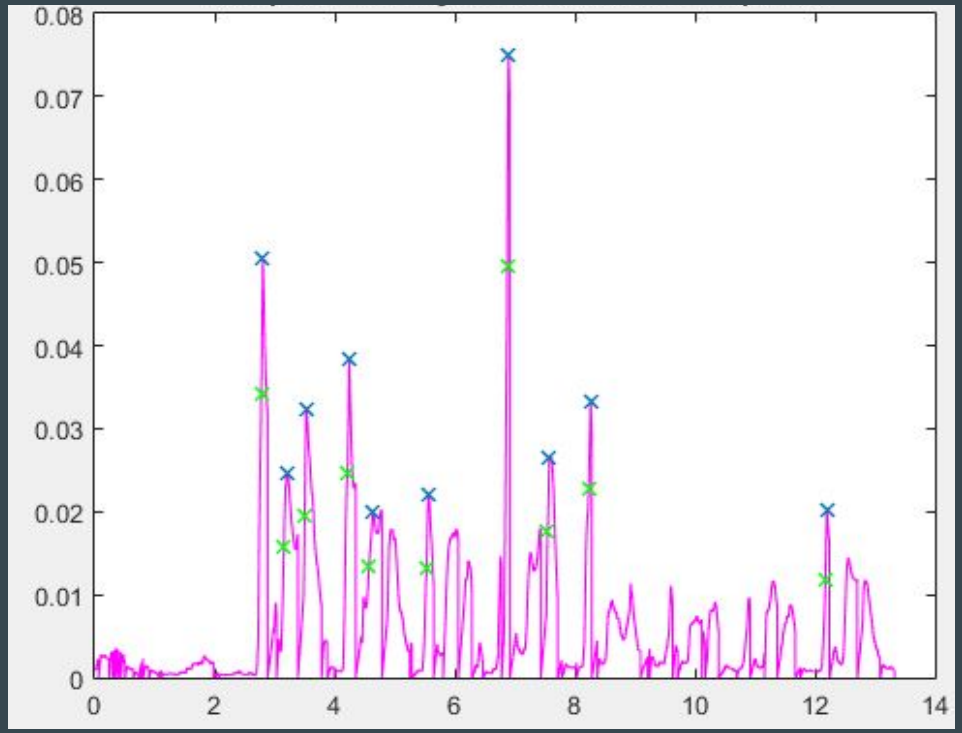
B. *for* loop calculates the time difference between the first syllable and first metronome beat and the third syllable and second metronome beat for each phrase

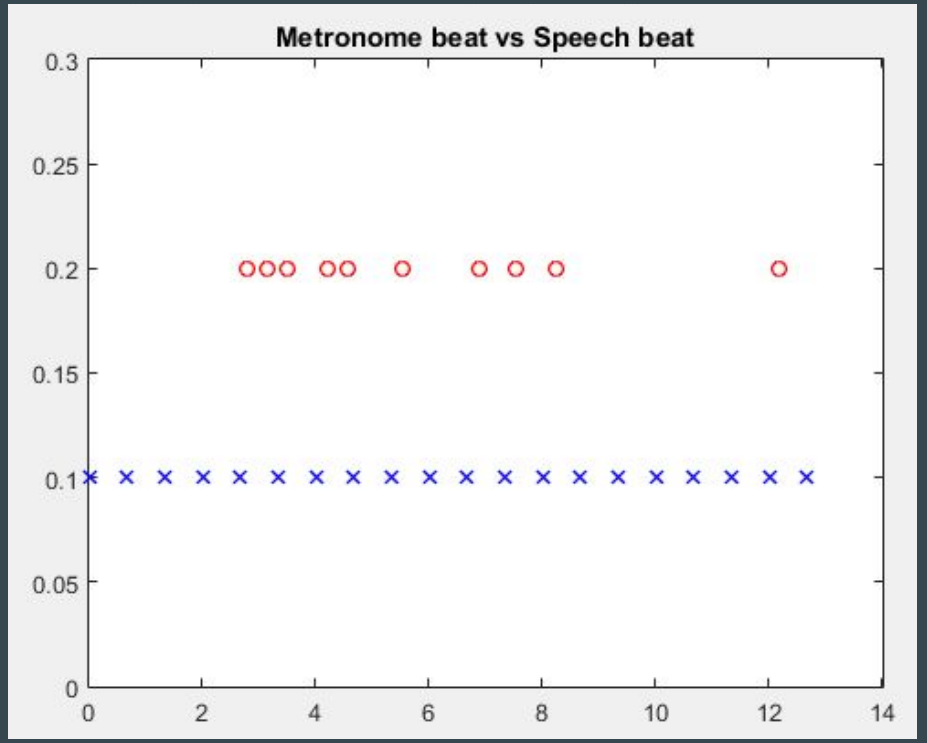
a. *if* both time differences are less than 0.666 seconds (one metronome beat), the phase is calculated

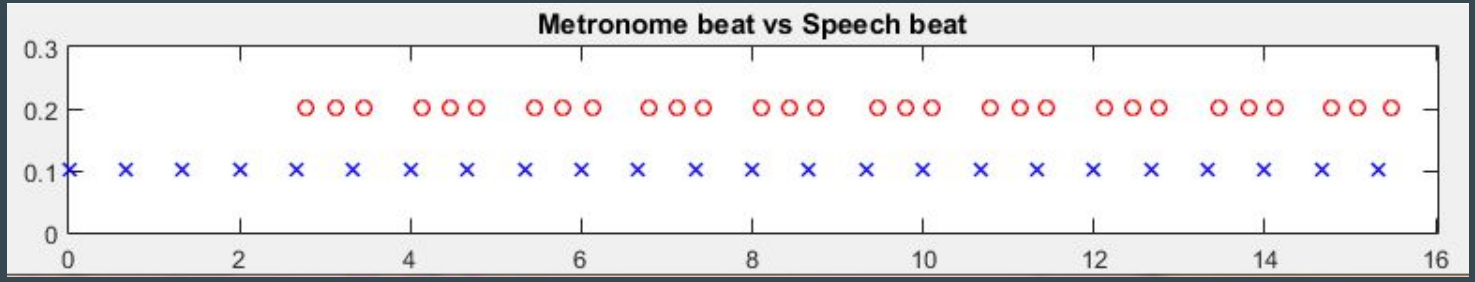
~~C. phase = (time difference)/0.666; Global synchrony score = *mean* of phase values~~

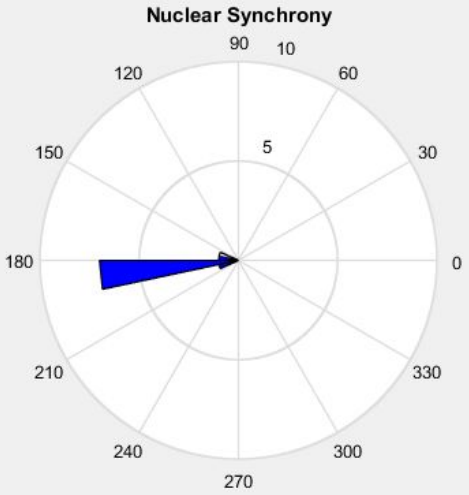
D. circ_r: mean resultant vector length

Progress: Hand Adjustments

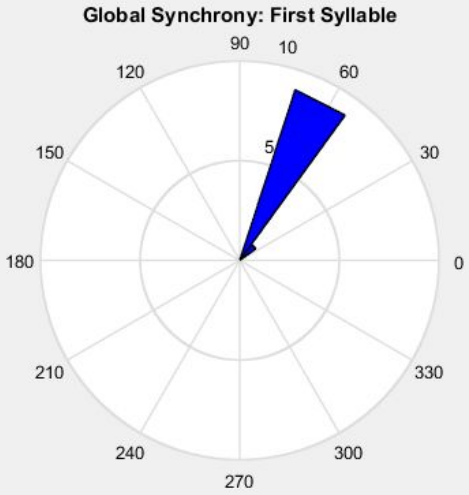




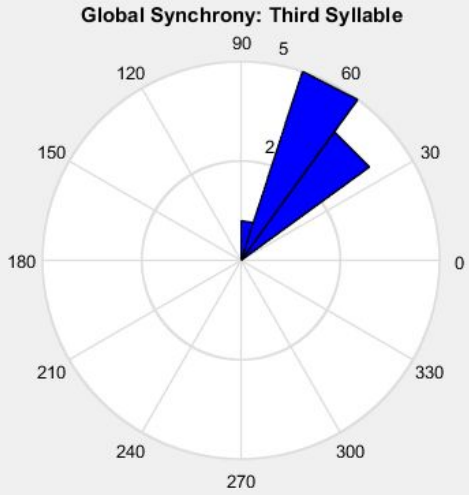




Nuclear Synchrony Score: 0.516273



Global Synchrony Score, Beat 1: 0.180323



Global Synchrony Score, Beat 3: 0.165212

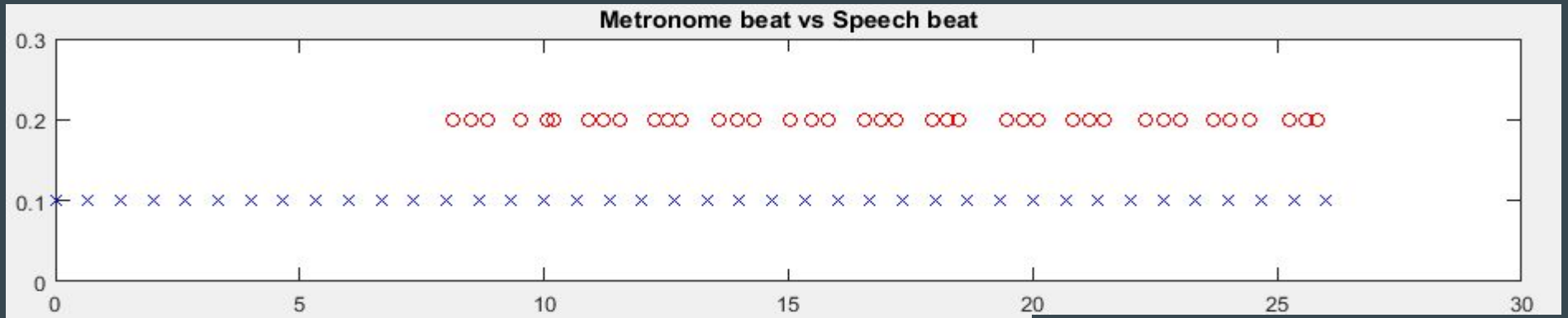
Global Synchrony Score, All: 0.172767

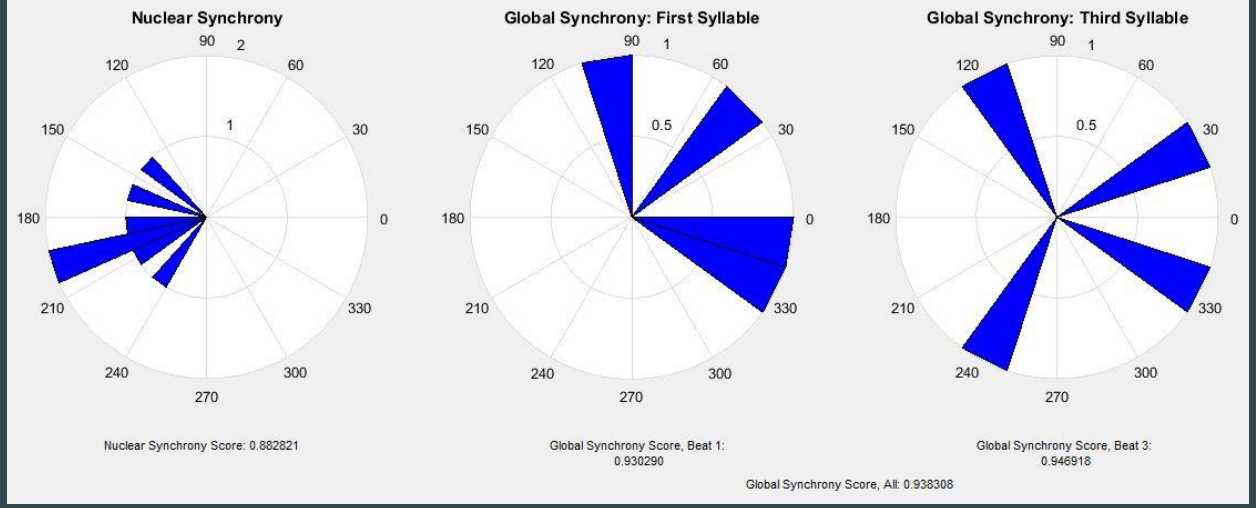
Data Summary

	Phrase	Nuclear Synchrony	Global 1st Syllable	Global 3rd Syllable	Global Synchrony
Pilot Study	Bad for a game	0.88282	0.93029	0.9469	0.938595
	Bank for a doll	0.91205	0.972687	0.96402	0.9683535
	Go for a boot	0.96706	0.973555	0.964241	0.968898
	Averages	**0.920643333**	--	--	**0.9586155**
Trial	Bad for a dance	0.941772	1.00	1.00	1.00
	Beg for a duck	0.947227	0.999888	0.999199	0.9995435
	Go for a boot	0.947483	0.991868	0.994896	0.993382
	Bad for a game	0.986405	1.00	1.00	1.00
	Bank for a doll	0.916409	0.993932	0.99292	0.993426
	Averages	**0.9478592**	--	--	**0.9972703**

- Elementary aged children considered to have good & normal speech
- It has been scheduled for us to collect more data in the upcoming weeks
  - 2-3 children with normal speech
  - 1 child with SLI

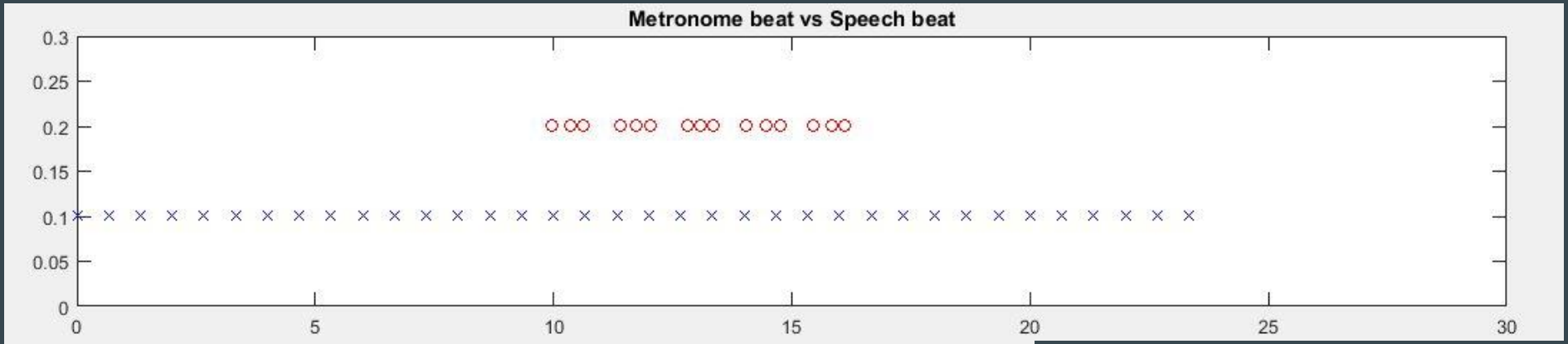
Pilot Study– “Bad for a game”

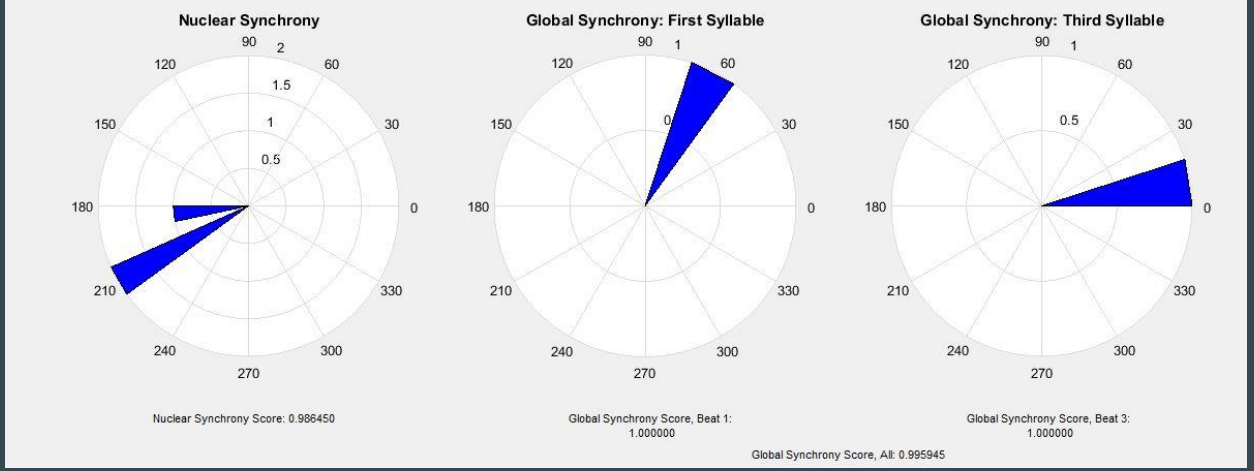




- Nuclear Synchrony=**0.88282**
- Global 1st Syllable=0.93029
- Global 3rd Syllable=0.9469
- Global Average=**0.938595**

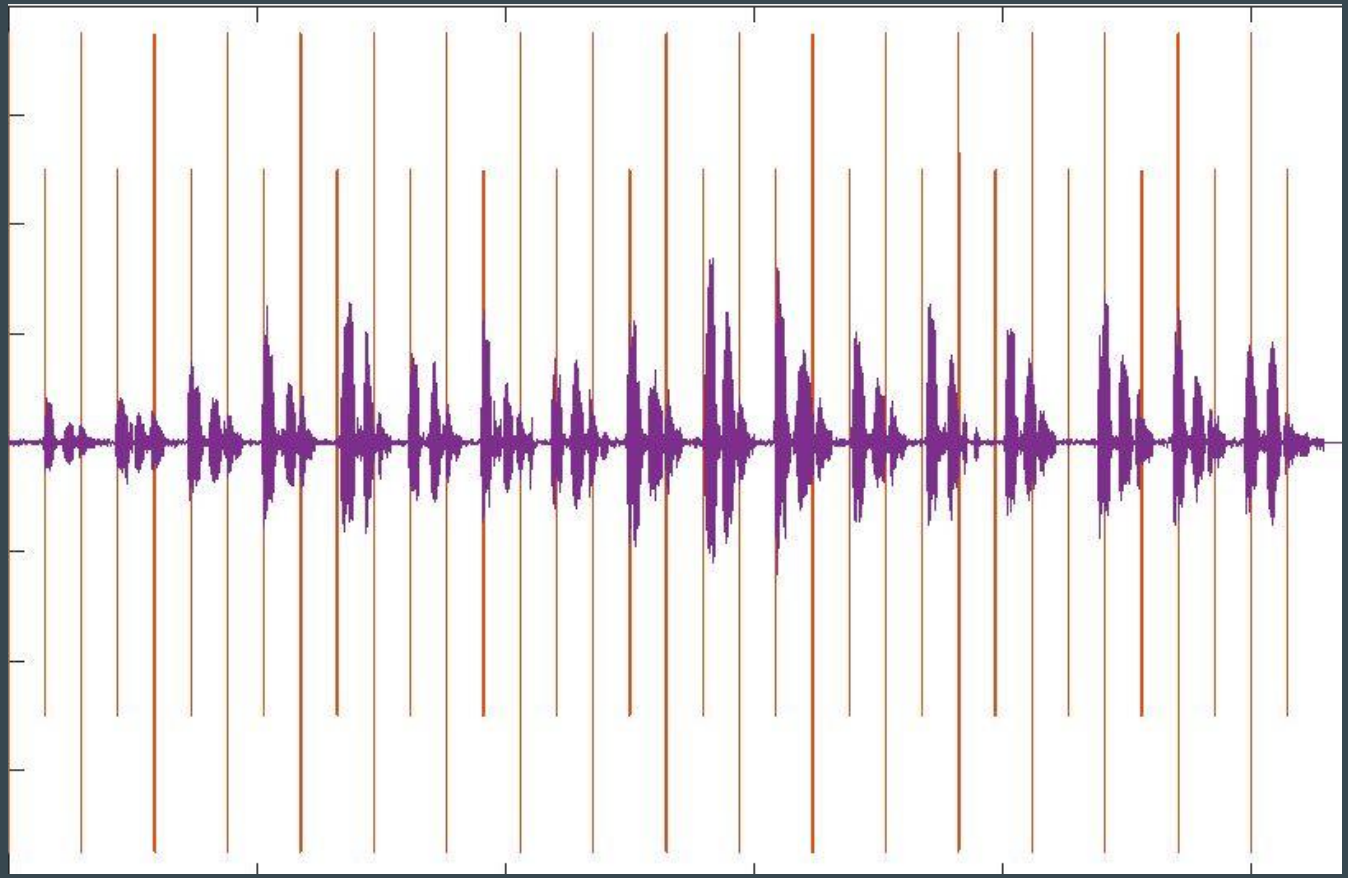
Trial- “Bad for a Game”





- Nuclear Synchrony=**0.986405**
- Global 1st Syllable=1.00
- Global 3rd Syllable=1.00
- Global Average=**1.00**

Trial- “Bad for a Game”



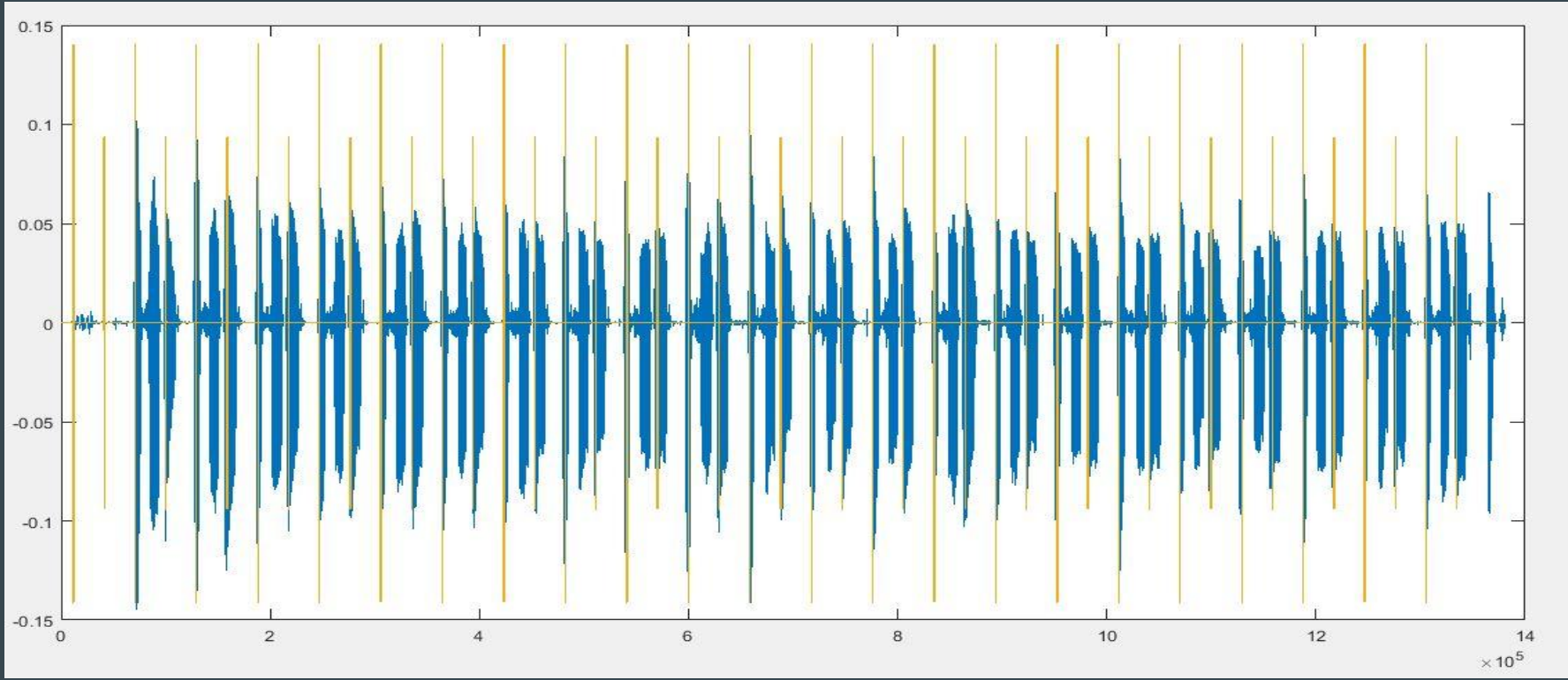
Temporary Setup for Analysis vs. Design Day Setup

- Recorded using FocusRite sound card
- Metronome played & speech recorded through Audio Live Lite
- Metronome and speech files were trimmed and exported as .wav files separately
- Using Simulink the .wav files were called and converted into MATLAB variables
- Analysis of metronome and speech workspace variables

- Recorded using FocusRite sound card
- Metronome played & speech recorded into MATLAB
- Analysis of metronome and speech workspace variables

Progress: Soundcard

- The Soundcard, using MATLAB code, now simultaneously plays the metronome while recording speech



Demonstration

- We are going to play a metronome for you, through headphones, using the soundcard
- While listening to the metronome we will say the phrase “Bad for a game” two times with you
- Then you will continue to say “Bad for a game” to the metronome on your own for 10 times

Next Steps

- Collect data in the upcoming trials for children both with and without SLI
- Continue to work on perfecting playing the metronome with the sound card
- Further improve consistency (improve ease of hand adjustments, etc.)
- Further investigate why our circular statistic output values are so high (and global synchrony code)
- Work with the Music and Cognition Lab to agree upon an appropriate metronome frequency

Questions & Comments

Resources

[1]http://www.nidcd.nih.gov/health/voice/pages/specific-language-impairment.aspx

[2]http://www.nuffieldfoundation.org/rhythmic-perception-music-and-language

[3]http://www.asha.org/PRPSpecificTopic.aspx?folderid=8589935327&section=Signs_and_Symptoms