## Music's Impact on Neural entrainment, Working Memory, and **Reading Skills in Young Children**

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## Aims

Working memory and phonological awareness are key components in child's reading fluency and academic success. Both components can be facilitated by musical training, yet the cognitive mechanisms of such facilitation are unclear. We propose that neural entrainment plays the key role. We aim to uncover the relationship between musical training and neural entrainment in shaping cognitive abilities facilitating memory and phonological skills relevant for reading in young children.



## **Experiment 2**: **Music training, Entrainment and Reading**

**Hypotheses:** We hypothesize that individuals who exhibit better entrainment to speech and music, specifically in the delta (1-4 Hz) and theta (4-8 Hz) frequency bands, will demonstrate higher scores in rhythm abilities and reading fluency tasks.

#### Tasks **READING FLUENCY WIF scores from Experiment 1.**

**MUSIC ABILITY - Tap-to-metronome task** [5]





# **General Methods**

#### **Participants**

N = 80, children between 6-8 years old

- **1.** Music Learners. Playing instruments or singing, music classes.
- **2.** Non-Music Learners. Enrolled in an alternative sports-related extracurricular activity (e.g. football, swimming).

*Exclusion criteria:* bilinguals, diagnosis of developmental disorder, auditory impairments.

## **ONLINE QUESTIONNAIRES**

- **Demographics** (SES, parent's educational level)
- **Music@Home** (Music Experience at home) [1]  $\succ$
- **BRIEF** (Executive Functions) [2]  $\succ$
- Familial Risk of Dyslexia (Adult Reading History Questionnaire -ARHQ-, Lefly and Pennington, 2000) [3]

### FOLLOW-UP SESSION - 1 year after

## **Data Analysis**

#### Music ability task.

Inter-tap intervals, response count

#### **Entrainment:**

- **Time-Frequency** for speech and music (in delta and theta bands)
- **Oscillatory entrainment index** (phase-locking, power, and phase consistency)
- **Connectivity Analyses**, how brain regions communicate and coordinate
- Synchronisation & Heart-Rate Variability for EEG+ECG (cross-correlation & coherence)
- Machine Learning. Predict entrainment patterns, individual differences
- **Correlations** of rhythm ability and RF scores with Entrainment to music and speech + Music@Home, Familial Risk of Dyslexia questionnaires

>Have they received any **Dyslexia or other SEN diagnoses**? **Rapid Online Assessment of Reading task** (ROAR) [7]

• Single Word Recognition, Phonological Awareness, Sentence Reading Efficiency, Receptive Vocabulary tasks.

## **Experiment 1**: Music training, Working Memory and Reading

**Hypotheses:** We expect sustained alpha phase synchrony with successful performance. Better performance in WM would correlated with higher scores in reading fluency. Parent-reported measures of WM would correlate with children's WM maintenance scores.

Tasks

#### READING FLUENCY (RF)

➤ Word Identification Fluency Task [4]

### **WORKING MEMORY TASK - Delayed Match-to-sample task** [6]

EEG+Behavioural Task





# **Experiment 3**:

# **Music Training and RS Neural Connectivity**

Tasks

**Hypotheses:** we expect higher power in theta and gamma and lower power in beta and delta will correlate with better rhythm ability

## **MUSIC ABILITY - Tap-to-metronome task scores from Experiment 2**



#### **RESTING STATE EEG**

 $\succ$  5 min RS EEG activity while looking at a landscape image

#### **Data Analysis**

- > Power Spectrum, for frequency bands delta, theta, beta, gamma.
- > Functional Connectivity, to identify patterns of synchrony
- > Network, small-worldness, modularity, and node centrality
- Graph Theory, degree, centrality, and efficiency and Clustering

## **General Discussion**

Through this series of studies, I aim to uncover complex neural mechanisms that link music training, working memory, speech processing,



#### **Data Analysis**

**RF Task:** accuracy, reaction time.

Working Memory Task: accuracy, reaction time. Other analyses:

- > Time Frequency local power changes in alpha
- > Functional connectivity (FC). Inter-regional phase synchronization over retention periods, weighted phase lag index (wPLI)
- **Correlations,** behavioural, RF and WM accuracy with FC, questionnaires
- Maintenance-related Network in left dorsolateral prefrontal cortex.  $\succ$

and neural entrainment in young children.

These findings may contribute to:

- Identifying individual differences in entrainment and potential biomarkers for speech-related disorders
- The development of new and more effective early interventions and educational strategies, enriching the lives of young learners and promoting academic success

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