

## Abstract

fNIRS is a brain-imaging technology used to measure oxygenation and blood flow that reflect levels of brain activity. We examined links between music and executive function in 3-year-old children using fNIRS. Participants were randomly assigned to a music or coloring group. In session one, participants took a music or coloring assessment, followed by partaking in a Bear-Dragon task and a Dimensional Card Change Sort. In session two, children either received a general music lesson with singing and simple instruments or colored. We predict that higher levels of Oxy and HbT will be seen during portions of tasks that are required for inhibition or cognitive flexibility, as well as during music lessons. Analyses of results are still ongoing.



## Introduction

Research to date supports the hypothetical connection between the prefrontal lobe and executive functioning in adults (Diamond, 2013); however, minimal research has been done with children. Levels of oxygenated and deoxygenated hemoglobin, oxy-Hb and deoxy-Hb respectively, correspond with activity in the prefrontal cortex (Izzetoglu, 2007). Music has been identified as a strong intervention to enhance executive functions (Joret, 2016). However, no one has looked at brain activity during a music intervention in children and its effects on executive functioning.

Three-year-olds are at an ideal age to study; they are young enough that they likely have not had intense musical experiences and can begin to learn about and understand music. Oxy and HbT levels from the prefrontal cortex were collected with the use of a fNIRS device on the left side of the child's forehead. fNIRS (functional near-infrared spectroscopy) is a non-invasive system and has the ability to measure the amount of oxy-Hb and deoxy-Hb through light emitting diodes (LED) and optical sensors.

The fNIRS device was worn by participants during all sessions to record brain activity. Participants were randomly assigned to a coloring group or a music group and attended two sessions held at either the participant's daycare facility or the Cognition Lab in Williams Hall. In the first session, the music group participants were given a musical aptitude assessment and the coloring group participants were asked to identify colors. Afterwards, all participants were asked to play two executive functioning games, the Bear-Dragon Task and the Dimensional Card Change Sort Task. For the following session, participants received either general music lessons or had freestyle coloring sessions. We predict that those in the music group would have higher levels of Oxy and HbT during music lessons than those in the coloring lessons. We also predict that portions of the executive functioning tasks will have higher Oxy and HbT when inhibition and cognitive flexibility is required.

Due to the COVID-19 pandemic the intended design and hypotheses of this experiment had to be altered. It was intended there would be 12 sessions total composed of 10 music or coloring lessons and a pre and post assessment session. The original hypothesis was that those in the music group would lower levels of Oxy and HbT during the second trial of executive functioning tasks than those in the coloring group.

## Methods

### Design & Participants

- This study used a mixed design with two separate conditions: music and coloring
- Participants were 10 typically developing 3-year-old children with no prior musical instruction

### Materials

- fNIRS device from BIOPAC Systems, Inc.
  - 2-ch wireless pediatric sensor
- GIA Music Assessment - Audie

### Measures

- Oxy: Oxygenation concentration changes determined by the difference between oxy-Hb and deoxy-Hb relative to baseline
- HbT: Sum of oxy-Hb and deoxy-Hb relative to the local baseline
  - Higher HbT levels indicate an increase in blood volume
- Baseline: Measurement of oxygenation and blood flow that occurs when participant is at rest

### Procedures

- Session 1
  - Music Assessment
    - The music assessment had 2 sections, rhythm and melody, with 10 questions in each
    - Participants were asked if a short melody played was the same or different based on rhythmic or melodic changes
  - Coloring Assessment
    - Participants were presented with 10 cards twice and asked if the color was red or not
  - Bear-Dragon Task
    - Directions were given by a bear and dragon puppet
    - Participants were instructed to do what the bear asked and not do what the dragon asked
  - Dimensional Card Change Sort (DCCS)
    - Children sorted cards by shape and color
    - There were 2 practice rounds and one active portion
    - The order of sorting by shape or color first was counterbalanced across participants
- Session 2
  - Coloring Lessons
    - Participants were shown body part cards and taught movement associated with each body part
    - Children were provided with markers and blank paper to draw
  - Music Lessons
    - Participants were shown body part cards and taught movement associated with each body part
    - Children sang nursery rhymes that coincided with simple movements



## References

- Diamond, A. (2013). Executive functions. *Annual Review of Psychology, 64*(1), 135–168.
- Joret, M., Germeys, F., & Gidron, Y. (2016). Cognitive inhibitory control in children following early childhood music education. *Musicae Scientiae, 21*(3), 303-315.
- Izzetoglu, M., Bunce, S. C., Izzetoglu, K., Onaral, B., & Pourrezaei, K. (2007). Functional brain imaging using near-infrared technology. *IEEE Engineering in Medicine and Biology Magazine, 38*-46.

## Acknowledgements

We would like to acknowledge the Humanities and Sciences Summer Scholar Program for its support and the members of Research Team 4 of the Ithaca College Psychology Department for their contributions to this research.