Large-scale nested studies of the impact of music on brain and behavioural development

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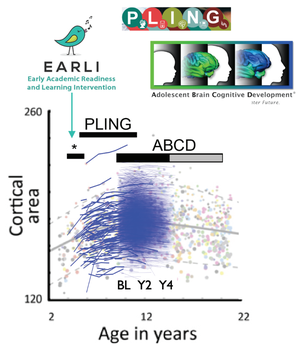
Question: How can arts experiences be best used to enhance the development of each individual?

EXPERIMENTAL APPROACH

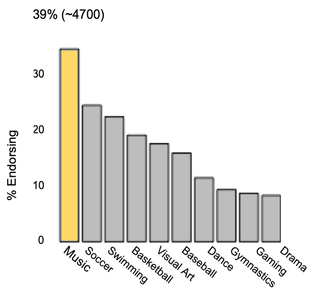
- Describe the relationships between music engagement and brain and behavioral developmental trajectories in childhood and adolescence

- Leverage large-scale longitudinal studies by nesting music studies
  - PLING: N = 206; ABCD: N = 11878
  - Rich characterization of brain, behavior, demographics, genetics
  - Aim to enrich studies with as much detail on music / arts phenotypes as possible to create a long-term resource for the field
- Complementary small-scale interventions
  - EARLI: N=63, TK, Daily singing classes

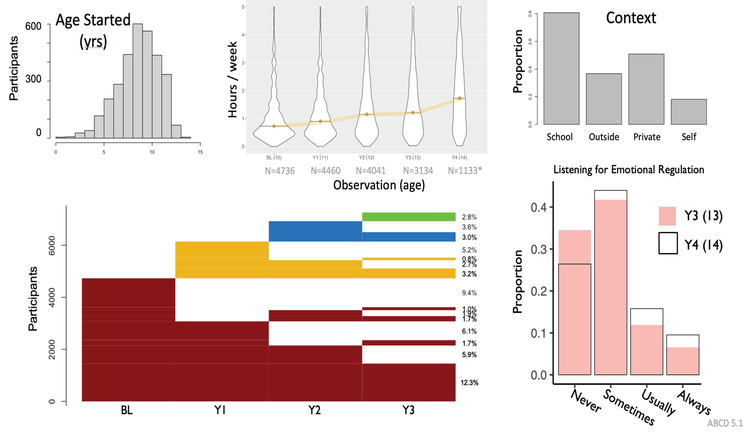


ARTS EXPERIENCE IN ABCD

- **Activities Questionnaire**
  - Includes detailed information about participation in a wide range of activities
    - Performance: Arts (music, dance, drama, visual, crafts), Sports
    - Detailed measures of context and intensity (months/year, days/week, hours/day)
    - Listening: Music (for emotion regulation, while studying)
  - Music (instrumental/singing) is highly represented



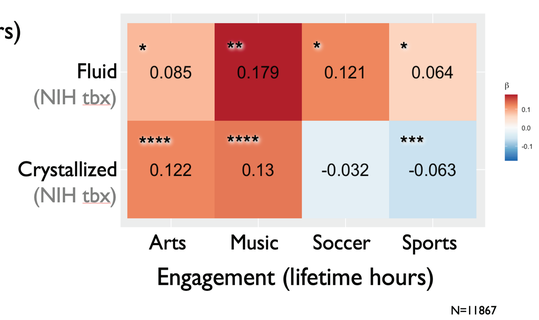
ABCD MUSIC INTENSITY AND CONTEXT



ABCD 5.1

ASSOCIATIONS BETWEEN ENGAGEMENT AND COGNITION

- Associate activities engagement (lifetime hours) with global cognition measures
- Music and Arts positively associated with fluid and crystallized intelligence

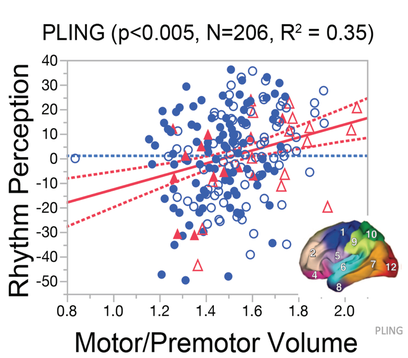


N=11867

ABCD 5.1

MOTOR/PREMOTOR CORTEX ASSOCIATED WITH RHYTHM PRODUCTION & *PERCEPTION*

- Increased cortical volume correlates with lower tapping error and better beat perception (**BAT**; Iversen, et al. 2008)
- Supports motor theories of beat perception (Patel & Iversen 2014; Ross, et al. 2016; Morillon, et al. 2014)



Effects of Music on Phonological Development A Secondary Longitudinal Analysis

Nikita Jacob

Hypothesis

If phonological improvements are mediated by rhythm performance, then phonological abilities would increase as rhythm performance increases.

Motivation

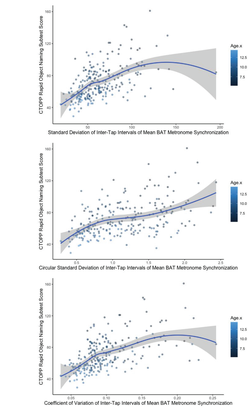
Musical training leads to improvements in phonology, the processing of language sounds (Moritz et al., 2013). However, the precise reason for this effect remains unclear.

Approach

Measurements of phonological processing (CTOPP) and music abilities (BAT) collected at multiple time points were statistically analyzed using linear mixed-effects modelling to test the relationship between rhythmic abilities and phonological abilities

Findings

We found significant effects for CTOPP Rapid Object Naming (RON) with free tapping, metronome synchronisation and music synchronisation. Of the three different measures we examined to define synchronisation ability, cvITI, a tempo-normalised measure of tempo variability, was most consistently associated with phonological processing and was the variable with the most significant association for the free and metronome synchronisation conditions. sdITI was associated, but less significantly, suggesting the importance of normalising variability by the tempo. For the two conditions with external pacing stimuli, circsd significantly predicted phonological processing. The results of the full linear mixed effects model revealed that the CTOPP subtests Elision (EI) and Blending Words (BW) were less strongly predicted by rhythm performance. The only significant predictors for the EI subtest was for circular deviation of the metronome synchronization BAT test. The BW subtest showed no significant values.



CTOPP RON vs mean isochronous BAT test variables (n=263). Scatterplot points are coloured based on age with darker points referring to younger participants and the bluer points referring to older participants. Lower CTOPP RON scores indicates better phonological abilities and lower standard deviation indicates better rhythm performance.

Discussion

These results suggest that rhythm may be correlated with a specific subset of phonological abilities. The significant association between rhythm perception and at least some aspects of phonological processing suggests that interventions targeting rhythm skills may have potential benefits for individuals with language impairments or developmental disorders that affects phonological processing. Incorporating rhythmic training into language intervention programs could enhance phonological processing abilities and improve language outcomes.

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The Impact of Music Engagement on Brain Connectivity and Development in Children

Victoria Li

Research Question

How does music engagement influence brain connectivity and development in children, particularly in white matter structures such as the corpus callosum, compared to children without musical involvement?

Hypothesis

Children who engage in music training over time will show enhanced structural connectivity, particularly in key white matter tracts (e.g., corpus callosum, arcuate fasciculus) compared to non-musicians. This will correlate with improvements in cognitive abilities such as language processing, memory, and attention.

Motivation

Music is powerful — it is a multi-sensory, social experience, and it has been suggested that music influences various brain structures[1-3]. Additionally, musical involvement has been hypothesized to drive neuroplasticity, particularly in language, attention, and social/reward circuits[4-6]. However, there remains a need for longitudinal studies that track child brain development over time and assess the causal impact of music involvement. We are looking to contribute to this gap by analyzing changes in brain structure and function in relation to length and depth of participation in music.

Planned Approaches

We will utilize the data from the ABCD study, a large-scale effort in the United States aiming to follow over 11 000 youth for 10 years from ages 9-10 at enrolment. Among its wide breadth of variables, a Sports and Activities Involvement Questionnaire (SAIQ) includes queries for parents about child participation in music. We plan to analyze slopes between music and non-music groups for a variety of brain measures including cortical area, cortical thickness, cortical volume, subcortical structure volumes (including white matter tracts with evidence of deviation in musicians vs. non-musicians), and measures of diffusivity and intensity.

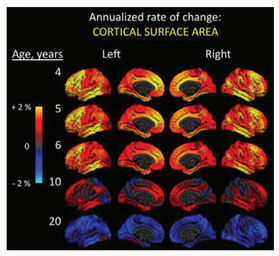

Figure 1. Annualized rate of change in cortical surface area from ages 4 to 20. Colour indicates percent change in cortical thickness. Adapted from 7.

Potential Significance

We hope to enlighten how musical training influences brain development in children, particularly given the link between structural and functional brain measures and cognitive abilities. Demonstrating that music involvement enhances brain connectivity could support the integration of music into educational curricula as a tool for cognitive development. Additionally, this work may provide insights into music's role in fostering neuroplasticity, and may influence the development of interventions for children with developmental challenges.

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Music and Alcohol: What is the tipping point between stability and risk?

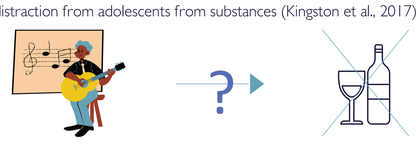
A. Karina Király

Motivation

Adolescents are a vulnerable population for the development of substance use, with a survey from Grade 12s from Ontario revealing that 75% reported lifetime alcohol use (Aderibigbe et al., 2022). Music is an enormous part of an adolescent's life, whether through casual listening or structured engagement.

Does music engagement influence patterns of alcohol use?

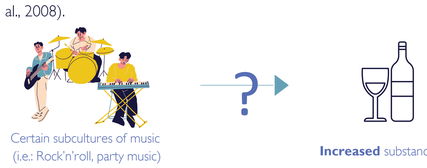
From a positive perspective, Aderibigbe et al. (2022), suggest that the structural aspects of a school in environment could reduce the level of substance use. Extra-curricular activities could provide goals and distraction from adolescents from substances (Kingston et al., 2017).



Traditional music education and musical extra-curriculars

Decreased substance use

From a negative perspective, certain musical subcultures, such as rock'n'roll and party music, are heavily integrated with substance use, through triggers and social distractions (Nikoulina et al., 2020; Guéguen et al., 2008).



Certain subcultures of music (i.e.: Rock'n'roll, party music)

Increased substance use

Planned approaches

Using the ABCD data set, a large longitudinal study about adolescent development, I aim to determine if there is an interaction between music engagement and alcohol use (U.S. Department of Health and Human Services., 2024). I plan to use an Elastic Net Penalized Quantile Regression model, building on prior work using the ABCD dataset and it's ability to robustly handle correlated variables (Green et al., 2024, Su & Wong, 2021). Many factors (i.e.: economic status, age, family stress and history) influence alcohol use, so I will control for these factors to see if music has a unique contribution to alcohol use.

Potential significance

The results could help predict an adolescent's alcohol use before substance use disorder develops. If a clear interaction is found, this would support the implementation of music activities to provide structure to the adolescent, hopefully lowering alcohol use.

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