EEG correlates of implicit rhythmic abilities in 8-13 year old children

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Introduction

- The temporal structure of auditory events can be processed either explicitly, i.e. voluntarily and consciously, or implicitly, i.e. incidentally, when attention is not directed to time [1]
- Implicit rhythm processing in adults is associated with behavioral benefits [2,3], as well as ERP differences, in particular an increase in the P3 wave for processing events following a rhythmic sequence [4,5]
- A recent study has also highlighted the behavioral benefits of implicit rhythm processing on auditory target detection and their cognitive correlates in neurotypical-13 year old children (Guinamard et al., in preparation [6]). However, to date, the EEG correlates of this implicit processing have not been examined in children

Investigate the ERP correlates of the implicit rhythm processing in 8-13 year old children

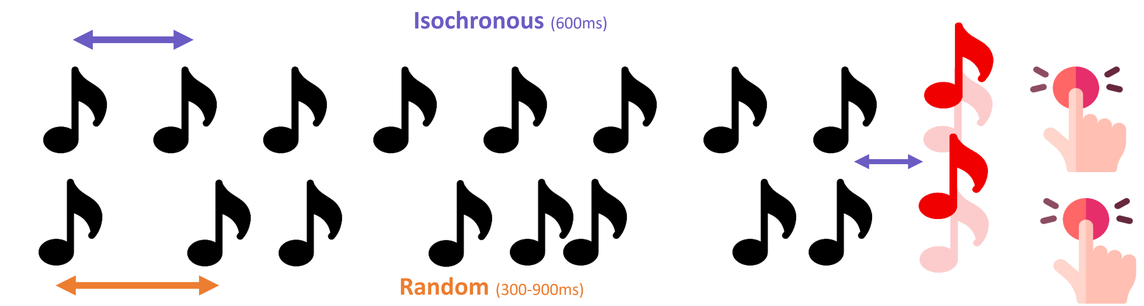
Method

N= 26 children aged 8-13 (mean = 11.5 years ; SD = 1.6)

IMPLICIT RHYTHMIC TASK

a new gamified task designed for children

(adapted from Guinamard et al., in preparation)



Instructions/goal not linked to rhythm: pitch detection task

"press the button if the last sound has a higher pitch than the previous ones" (i.e., deviant).

2 conditions: temporally regular vs irregular

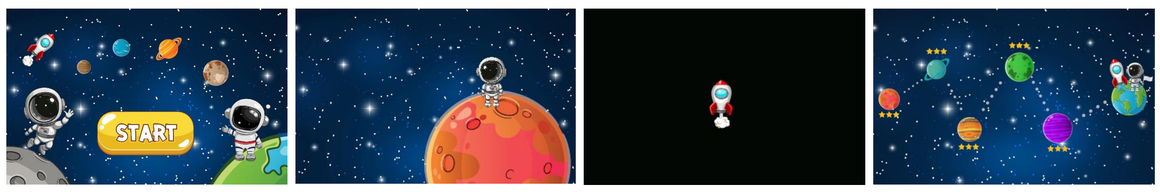
Children performed **12 blocks of 30 trials**
(50% regular, 33% non-deviant target, 1block ~4min).

- During the task, EEG was recorded using a BioSemi ActiveTwo system (64 electrodes)
- Signal was bandpass filtered (Butterworth filter; 0.1-30Hz; 12dB/oct)
- Artifact correction was performed for eyes movements using Independent Components Analysis (ICA)
- Rejection was performed for other artifacts
- Epochs were extracted from -200 to 800ms around the target sound
- Reference = average of mastoids

Expected: if children process the rhythm implicitly, they will anticipate the onset of the auditory events and **improve their performance in the temporally regular condition:**

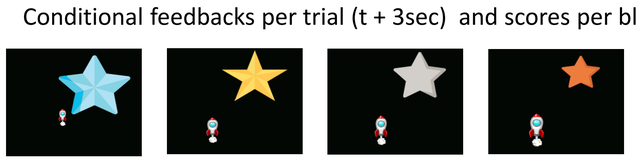
↘ Reaction Time (RT) and/or ↗ Accuracy (d') ↗ P3 amplitude

Gamified task to maintain motivation and attention in children

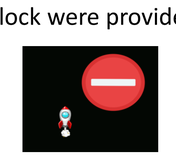


During each trial, a red rocket was displayed at the center of the screen and became green on the sound before the last sound of the sequence.

Conditional feedbacks per trial (t + 3sec) and scores per block were provided.



Hits (star's color as a function of RT)



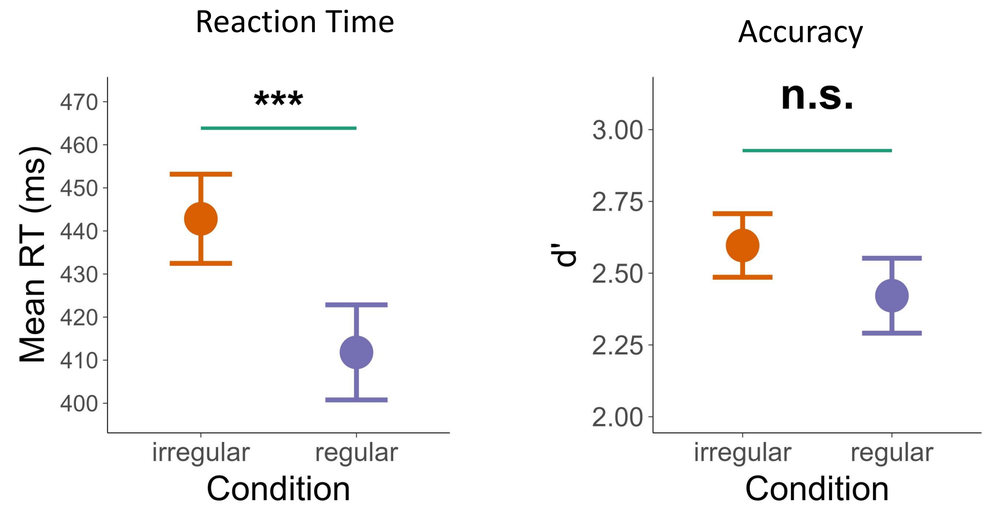
False Alarm

Block score

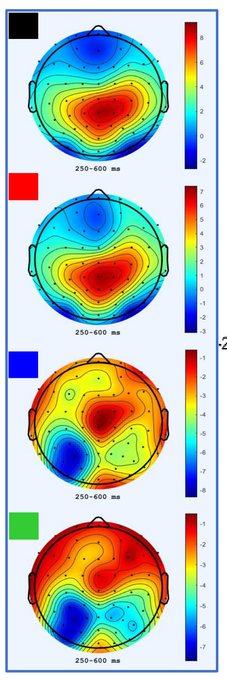
To further increase focus and maintain motivation the level of difficulty of the task started easy and then increased progressively with each block.

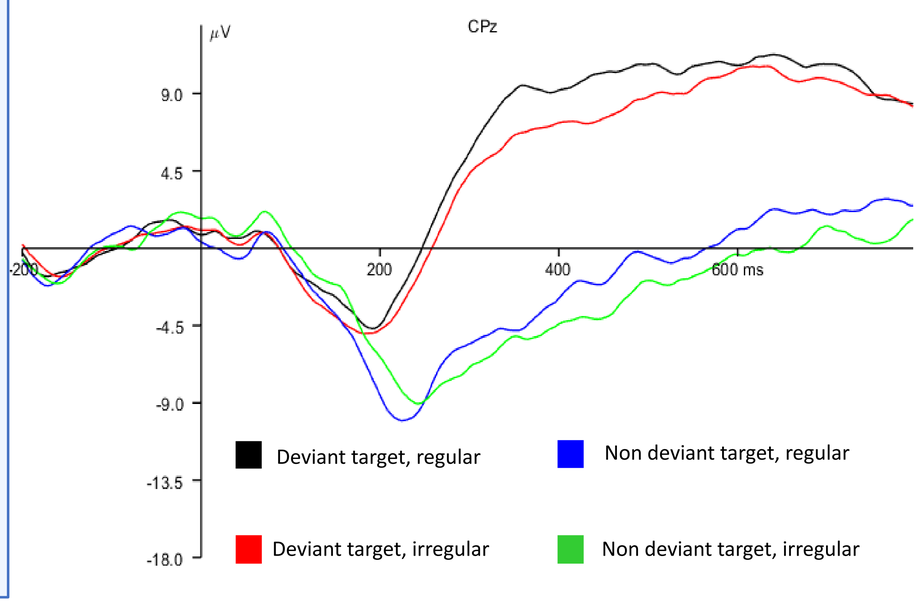
Results

Children were faster to detect deviant sounds after a temporally regular sequence

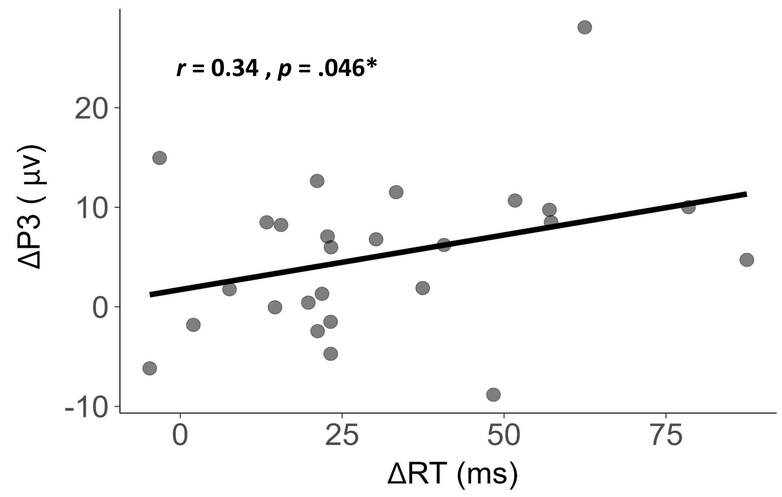


Children responded faster when the sequence of sounds preceding the target was temporally regular than irregular ($p < .001$). No benefit was found on accuracy.





Mean voltage was measured for the centro-parietal region of interest of the P3 wave, within a 250-600 ms time window [5].
A main effect of the type of target (deviant vs non-deviant, $p < .001$) as well as a main effect of temporal regularity (regular vs irregular, $p < .001$) were found on the P3 wave amplitude.
There was no sound x condition interaction ($p = .385$).



A positive association was found between the RT enhancement and the P3 amplitude increase.

Discussion

Behavioral and neurophysiological evidence for implicit rhythm processing in children

- Children showed faster reaction times after temporally regular sequences, consistent with previous findings (Guinamard et al., in preparation). The observed increase of the P3 amplitude for targets following regular sequences is consistent with results reported in adults [4,5].
- The correlation between RT improvements and P3 increases suggests that behavioral benefits of temporal regularity in children are linked to attentional mechanisms that facilitate late cognitive processes [4]

Future directions:

- Further analyses will focus on links between the P3 and explicit rhythmic abilities, and with executive functions.
- The results obtained with children will be compared with that of a group of adults tested with the same protocol.

Perspectives:

- First study to our knowledge to investigate both behavioral and ERP of implicit auditory rhythm processing in neurotypical children school-aged children.
- Documenting implicit rhythmic abilities in children and their typical development will pave the way for investigating these abilities in children with neurodevelopmental disorders known for deficits in explicit rhythmic abilities such as Dyslexia [7] or ADHD [8].

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