The Development of Predictive Coding in Young Children

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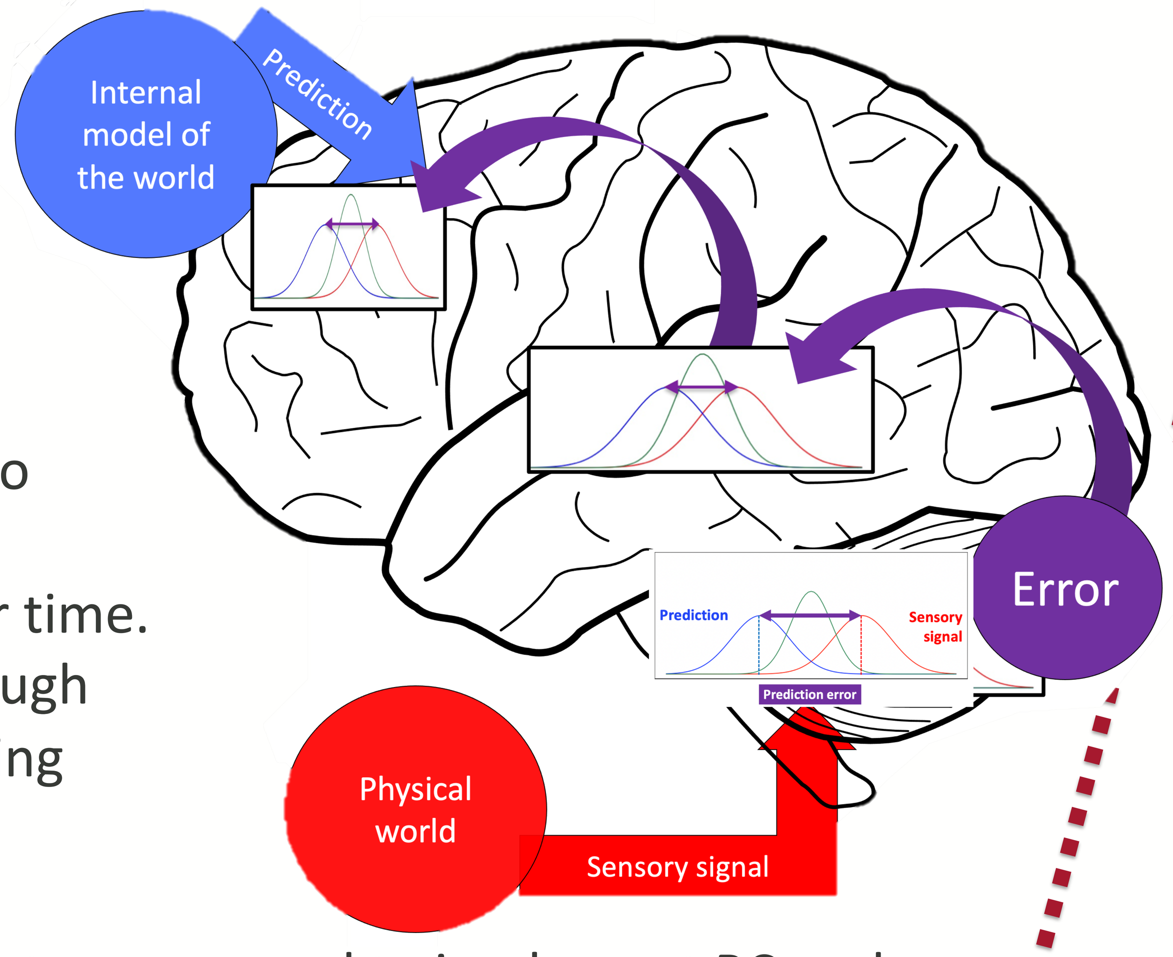
OSF PREREGISTRATION

BACKGROUND

Brain function according to **predictive coding theory…**

Processing prediction error is taxing. To reduce neural bandwidth, the brain devotes itself to minimising prediction error over time. This is achieved through revising and optimising its internal model.



The neural architecture assumed to implement PC undergoes significant maturation across childhood. In particular, prolonged maturation of the prefrontal cortex – thought to play a key role in tracking complex statistical regularities in the environment – may support increasingly sophisticated predictive brain function across childhood.

RQs:

1. Do children become better predictors with age?
2. If so, is this improved prediction supported by increasing involvement of the frontal cortex?

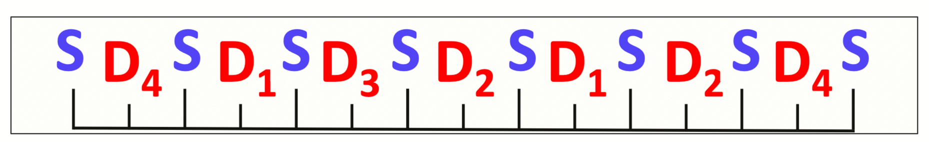
METHOD

- 37 children (19 older, *M* = 6yrs; 18 younger, *M* = 4 yrs)

Child MEG

Rapaport et al., 2019, *JoVE*

Multi-deviant auditory oddball paradigm



Näätänen et al., 2004; 15 mins; repetitive standards alternate with one of 4 types of deviants

Mismatch Field (MMF) =

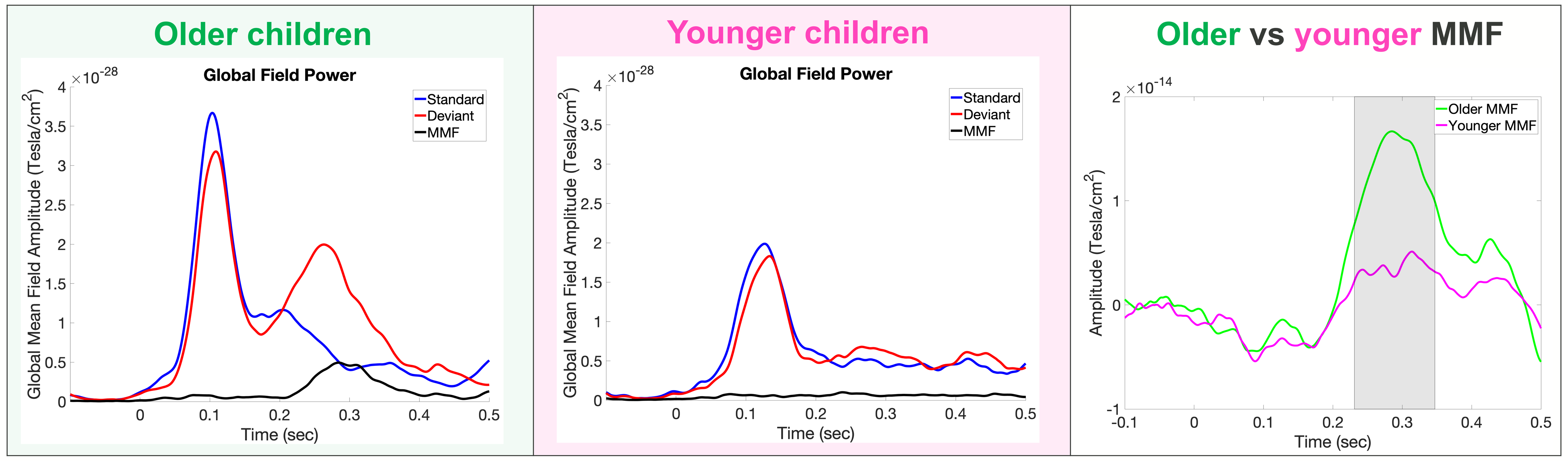
(brain response to deviants) – (brain response to standards)

- Under predictive coding, each brain response is understood as an index of prediction error: the worse the brain's prediction, the **larger the prediction error** (or 'neural 'surprise'), and the **larger the amplitude of the evoked response.**
- Statistical analysis: Non-parametric cluster-based random permutation tests (α-level = 0.05).

SENSOR-LEVEL ANALYSIS

D – S = **MMF**

Hypotheses: If the **older children** are better able to predict the 'standards' relative to the 'deviants', we should see a large difference in the evoked response between the two conditions, as indexed by a **large MMF amplitude**.
By contrast, if the **younger children** are relatively worse at predicting both the 'standards' and the 'deviants', we should see a smaller difference in the evoked response between the conditions, as indexed by a **smaller MMF amplitude**.

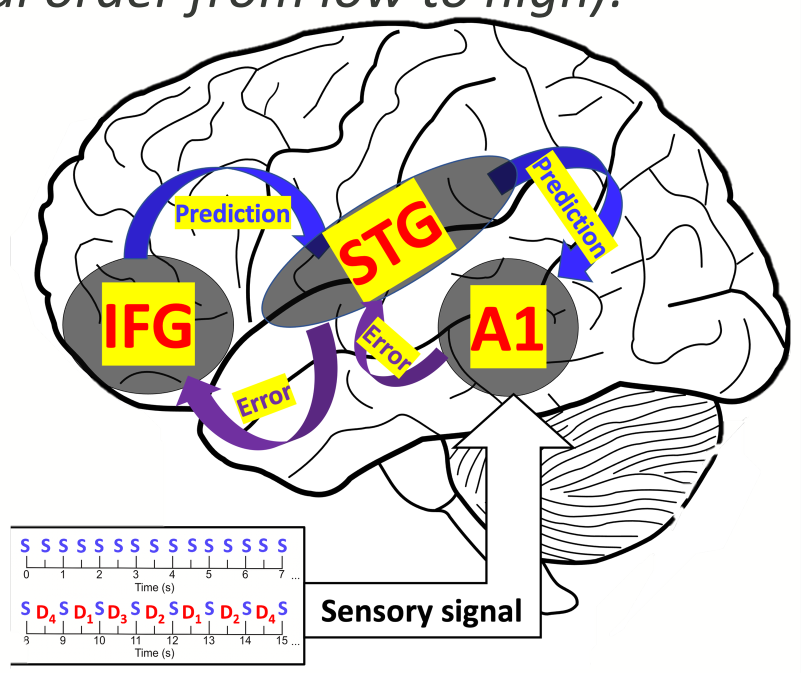


GLOBAL FIELD POWER: *Absolute magnetic field change at each timepoint across all MEG 125 channels.*

Results: The older children showed a sig. larger MMF between 230—346 ms (***p*** **= 0.02**) compared to the younger children. This suggests that the older children were better able to predict the repetitive standards (relative to the more-random deviants) as indicated by a larger MMF amplitude.

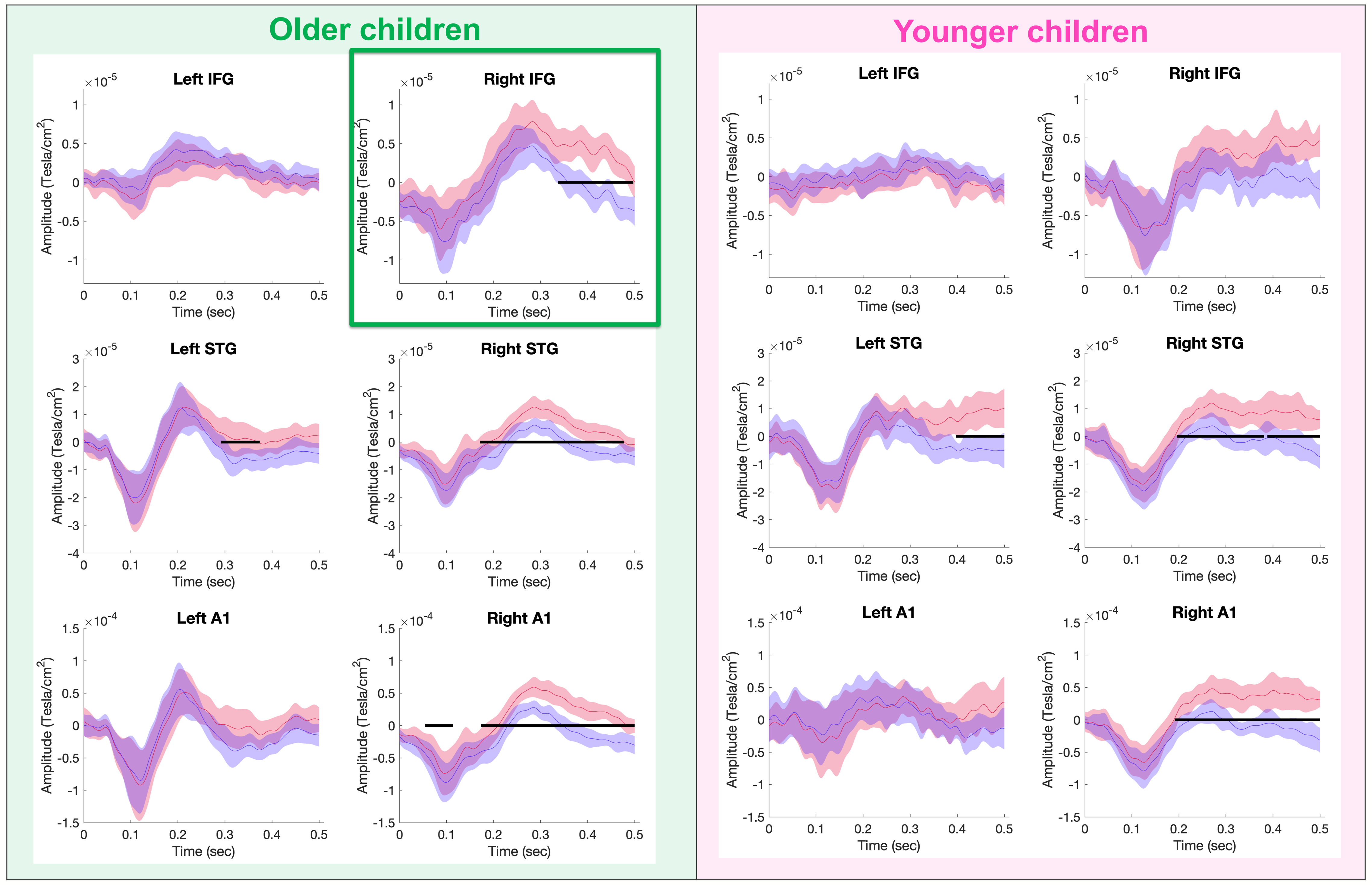
SOURCE-LEVEL ANALYSIS

We constrained the analysis to 6 regions involved in adult MMF generation *(listed in hierarchical order from low to high):* **bilateral** primary auditory cortices (**A1**), superior temporal gyri (**STG**) and inferior **frontal** gyri (**IFG**).



Hypotheses. (1) We expected **all children** to show an MMF in the lower-level **A1** and **STG** regions. (2) If the frontal cortex becomes increasingly involved in the prediction of sensory signals (and responding to prediction errors) then we might expect the **older children** to show a larger MMF amplitude in the **IFG** compared to younger children.

Results. All children showed significant MMFs in the right **A1** and bilateral **STG**. Only the **older children** showed a significant MMF in the **IFG**, suggesting more involvement of the frontal cortex in predicting sensory signals with age.



NB. The black lines (__) show the significant MMF clusters for each group at each ROI, separately.

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