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► **To cite this version:**

Estelle Hervé, Anne-Sophie Dubarry, Thierry Legou, Béatrice Desnous, Laurent Prévot, et al.. Development of cortical and subcortical responses to speech sounds during infancy. Society for the Neurobiology of Language 2023, Oct 2023, Marseille (13), France. hal-04459708

**HAL Id: hal-04459708**

**<https://hal.science/hal-04459708v1>**

Submitted on 15 Feb 2024

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# Development of cortical and subcortical responses to speech sounds during infancy

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## Introduction

Event-related brain potentials to speech sounds are efficient tools for studying speech perception development in young infants. (Thierry, 2005; Hervé et al, 2021)

**M Mismatch Response**, a cortical component evoked by **M** change detection in a series of similar auditory stimuli **R** → speech sound discrimination (Cheour et al, 1998; Dehaene-Lambertz & Pena, 2001; Näätänen et al, 2007)

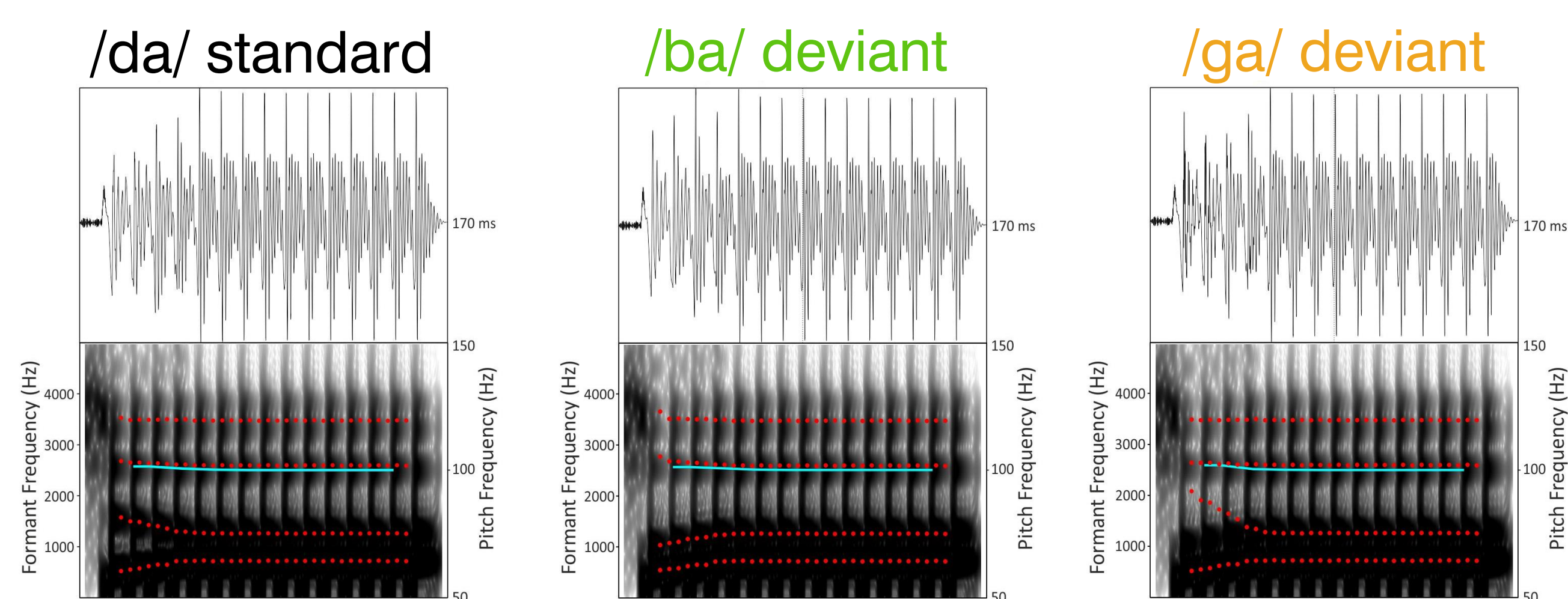
**F Frequency-Following Response**, a subcortical brain response that **F** follows the spectro-temporal features of the auditory stimulus **R** → fine-grained encoding of speech sounds' characteristics (Anderson, 2015; Ribas-Prat et al, 2019, Arenillas-Alcón et al, 2021)



- Evaluate the feasibility of simultaneous cortical and subcortical EEG recordings in infants.
- Understand the mutual contribution of subcortical and cortical structures during speech processing .
- Decipher the neuroplasticity mechanisms supporting the maturation of the auditory system during early development.

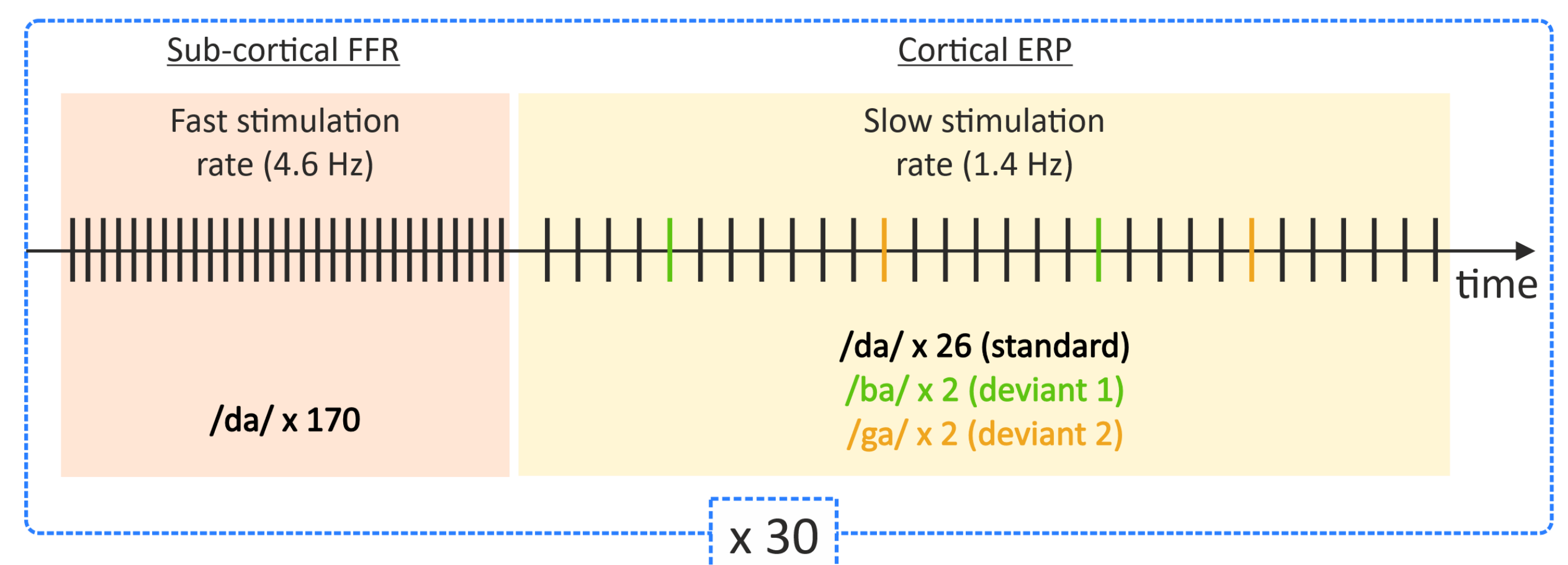
## Materials and Methods

**FIG.1a: Stimuli : synthetic CV syllables**



From Skoe & Kraus, 2010. F0 = 100.4 Hz, duration: 170 ms

**FIG.1b: Procedure: passive listening oddball paradigm**

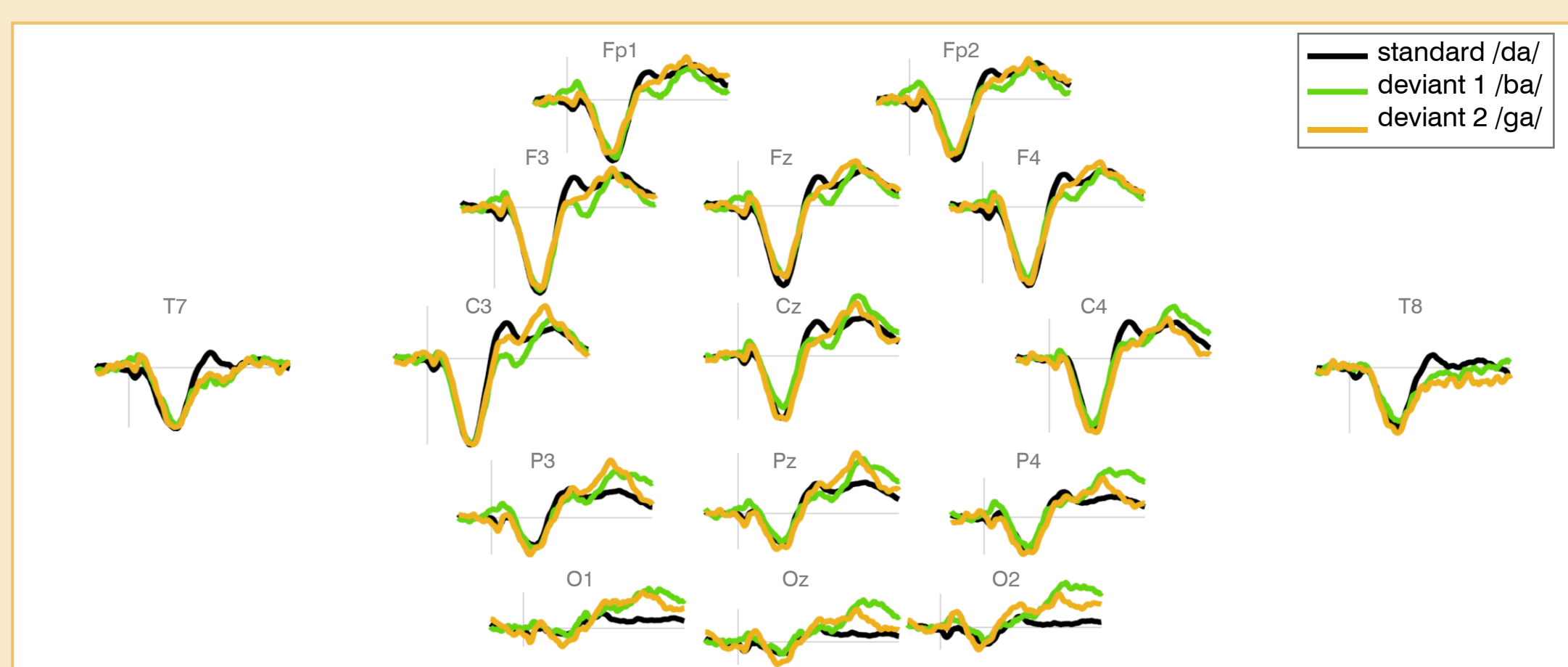


30 alternating blocks of fast and slow stimulation frequency (Fs). (Bidelman et al., 2015)

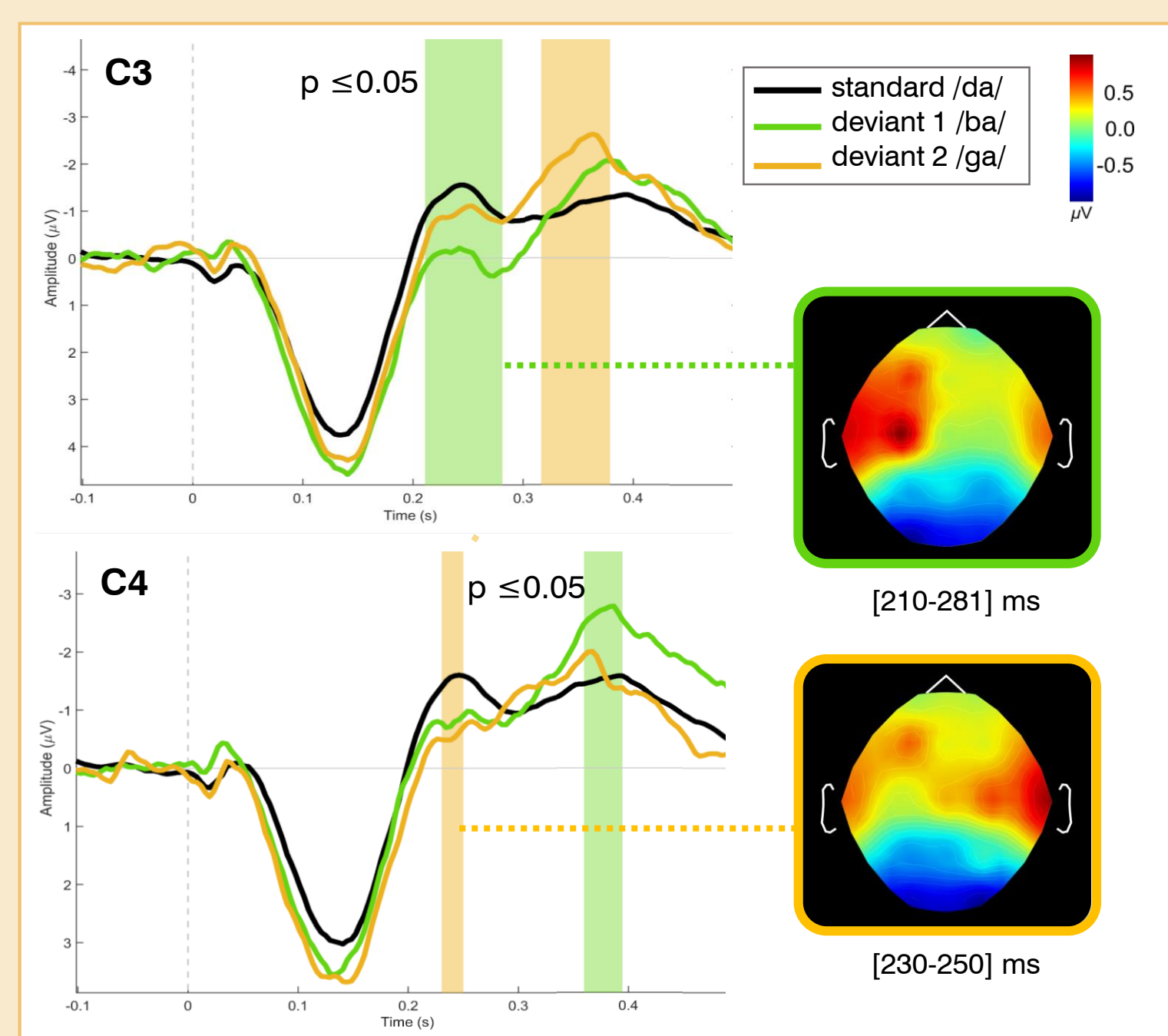
90 infants, aged 6 to 24 months; healthy, no developmental or hearing disorder. Recorded semi-longitudinally and separated into two age groups: the younger (6- to 10-month-olds) and the older (18- to 24-month-olds).

## Results

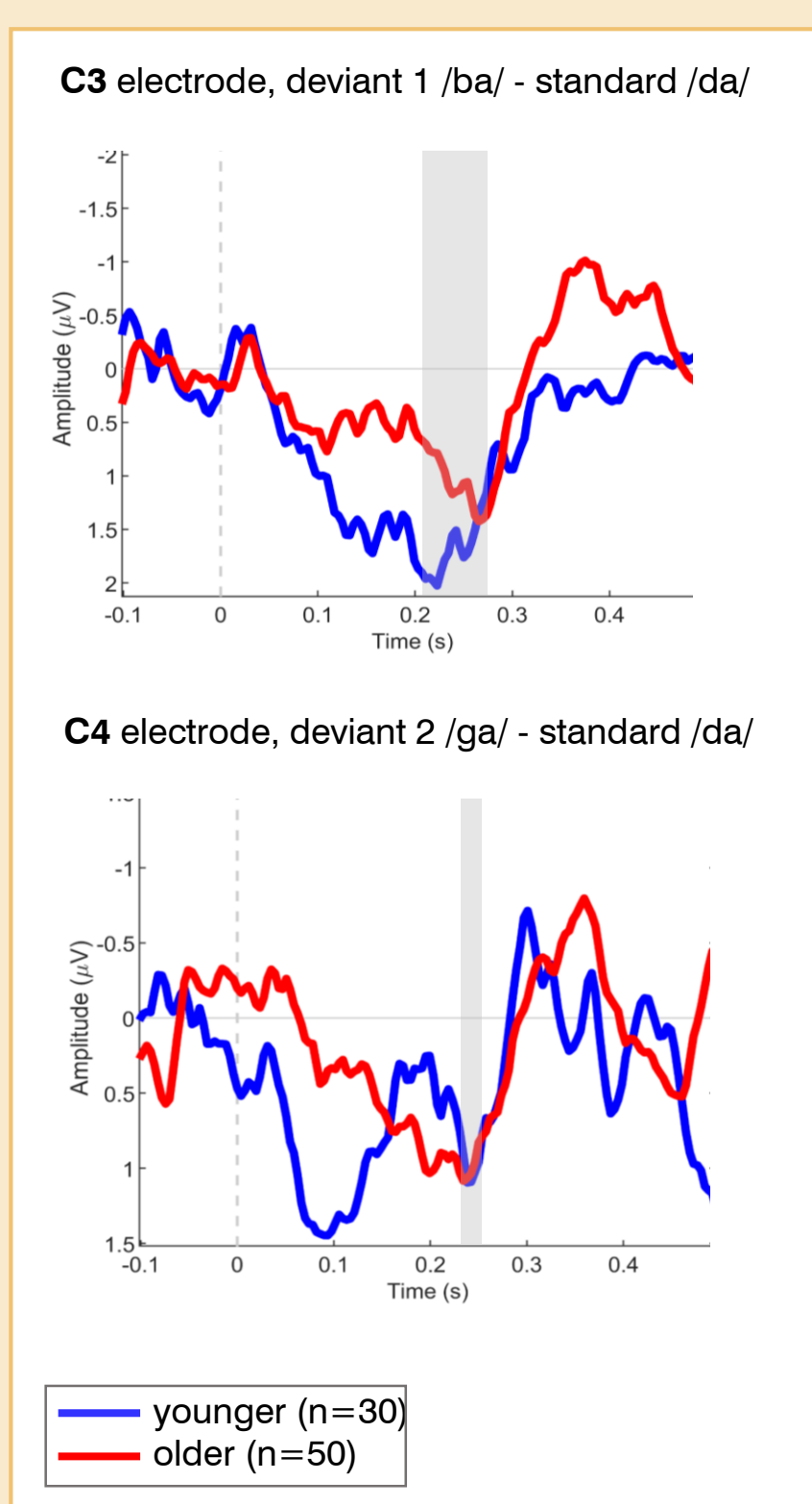
### Cortical Event-Related Potentials (n = 80)



**FIG.2a:** Mean evoked activity by electrode for each condition, all subjects (n = 80).

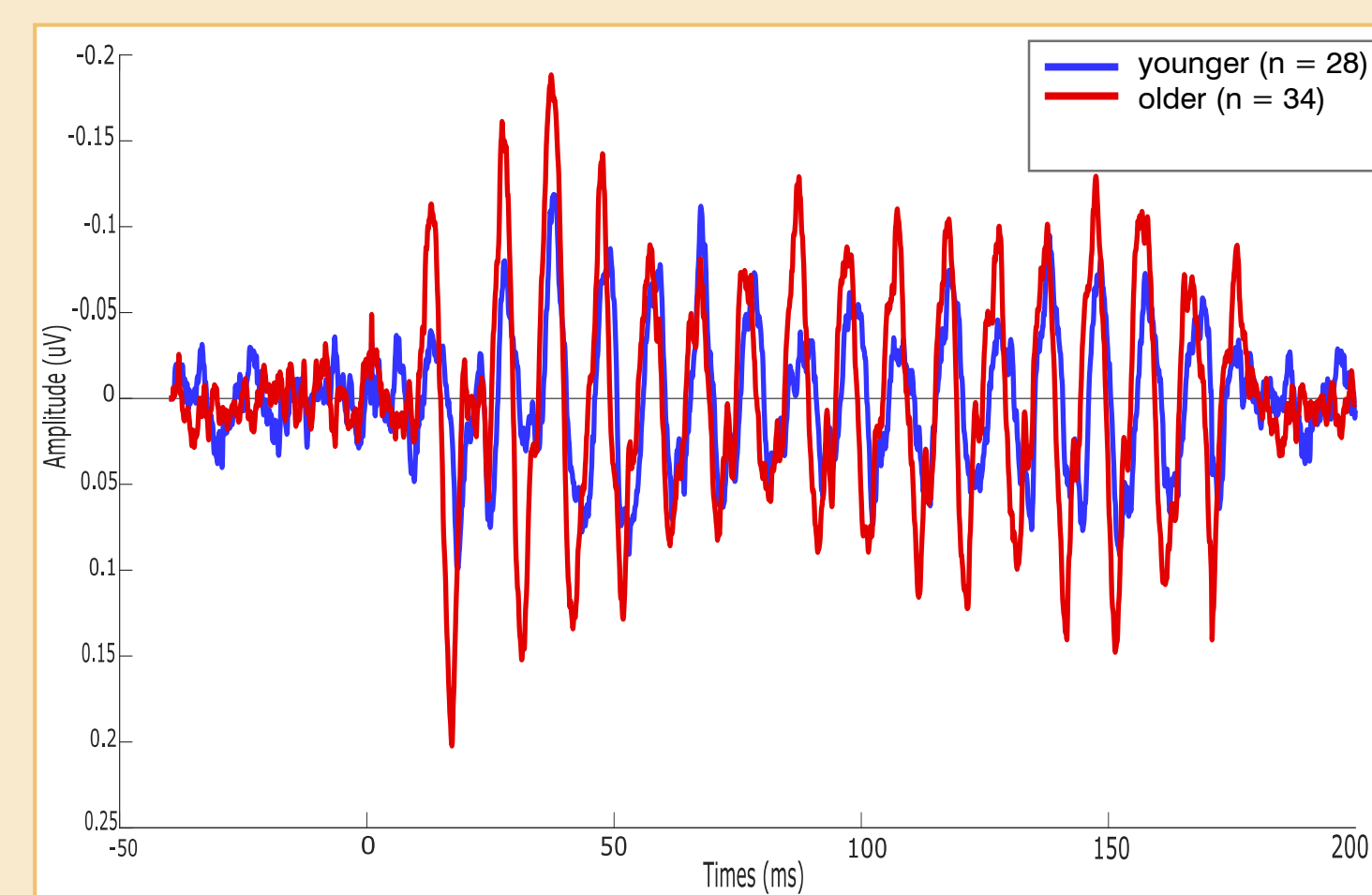


**FIG.2b:** (Left) Event-related potential (ERP) to standard /da/ stimulus, deviant 1 /ba/ stimulus and deviant 2 /ga/ stimulus at central C3 (top) and C4 (bottom) electrodes. Colored areas: significant results to Student's t-test between standard and deviant for each condition ( $p \leq 0.05$ ). (Right) Spatial representation of brain activation at significant time windows (deviant minus standard).

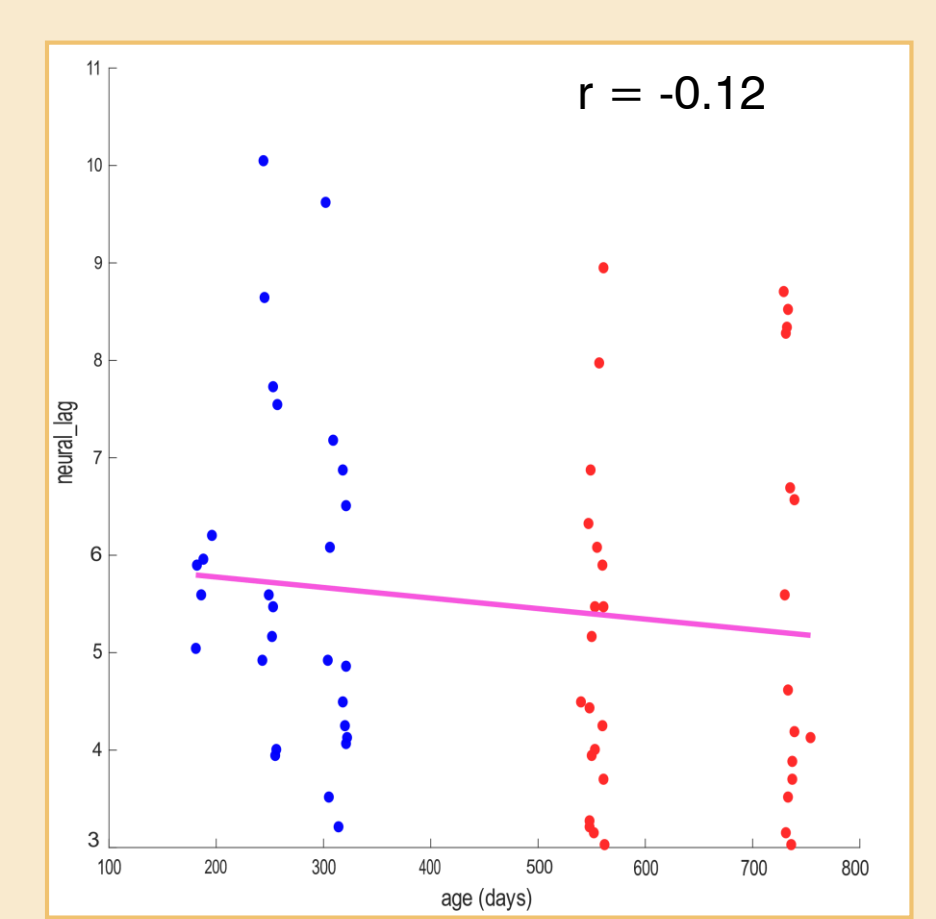


**FIG.2c:** Subtracted activity (deviant - standard) for each deviant, group comparison. Grey areas: group-level time window for MMR (see Fig.2b).

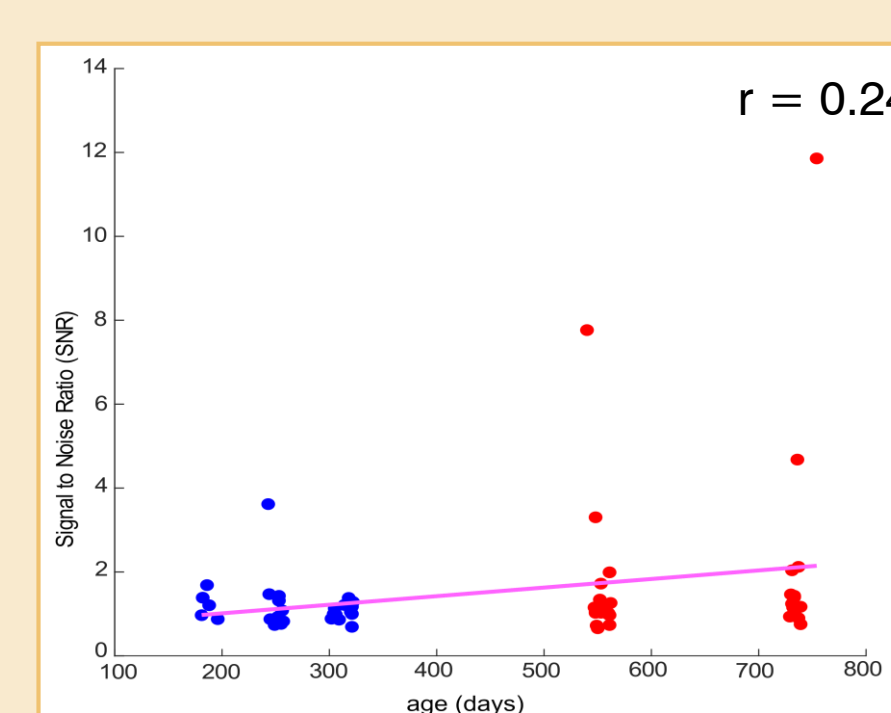
### Subcortical response: FFR (n = 62)



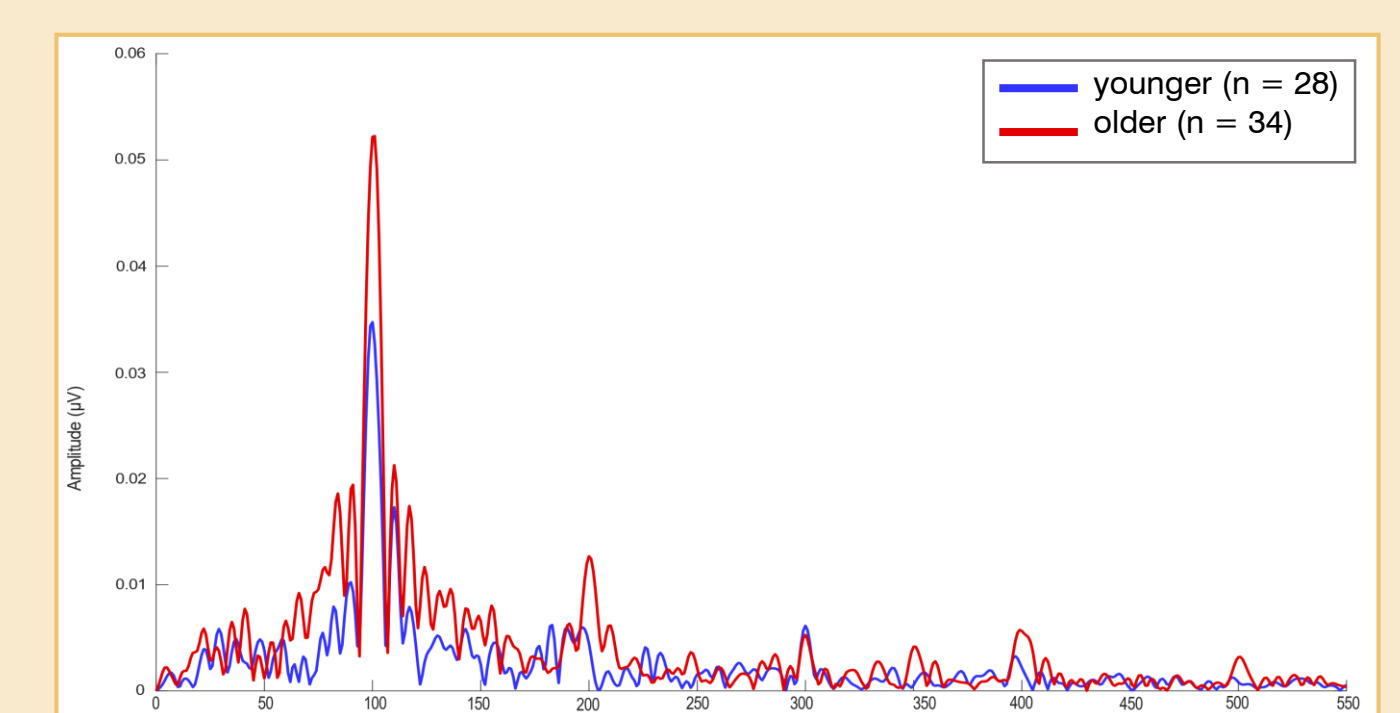
**FIG.3a:** Temporal domain, group comparison.



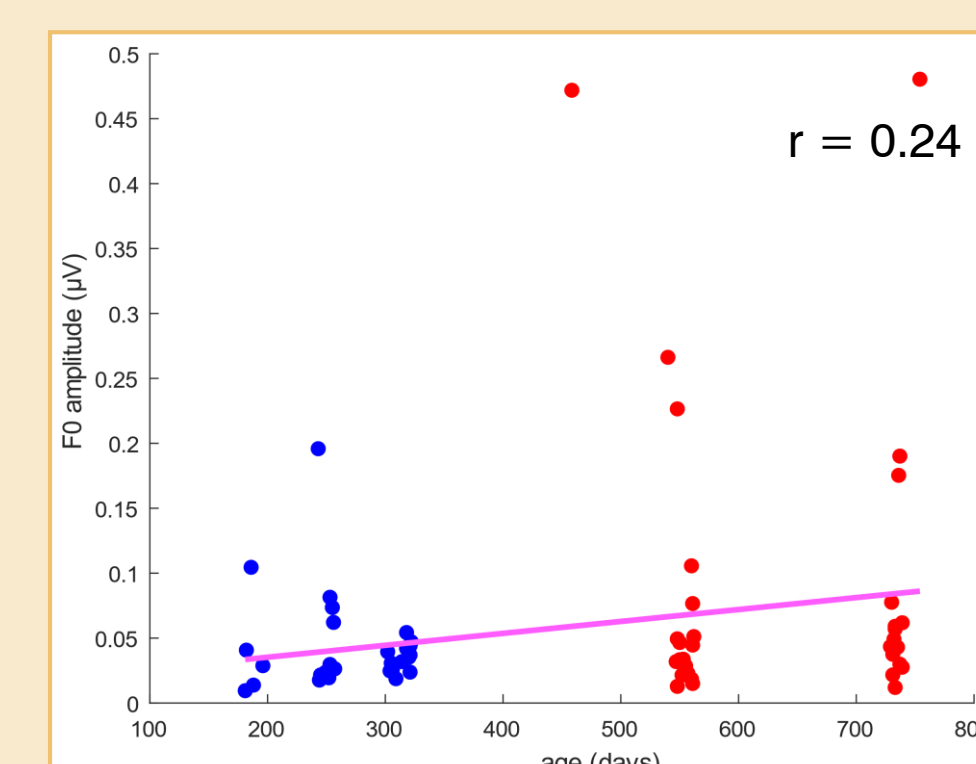
**FIG.3b:** Neural lag as a function of age.



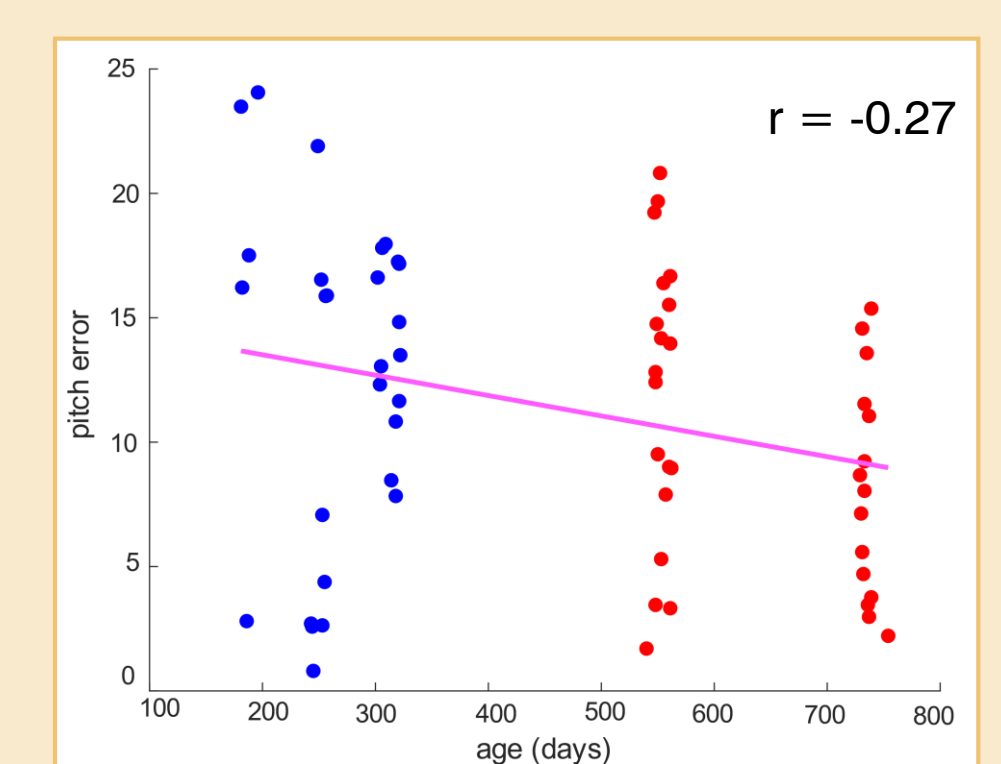
**FIG.3c:** SNR at vowel time-window as a function of age.



**FIG.3d:** Fast-Fourier transform of the FFR, group comparison



**FIG.3e:** Amplitude of the FFR F0 as a function of age.



**FIG.3f:** Pitch error as a function of age.

## Discussion

- ➔ Consistent results with literature for both cortical ERPs and FFR:
  - Better non-native speech sounds discrimination in younger infants (Kuhl et al, 2007)
  - Better encoding of speech sounds features (temporal and frequential domains) in older infants (Anderson et al, 2015)
- ➔ A new tool for neurodevelopment of speech perception abilities from lower to higher levels of processing?

**Limits:** • attrition rates varies between cortical ERPs analyses and FFR analyses; • large number of participants needed.

**Perspectives:** • longitudinal design; • correlations between cortical ERPs and FFR indices? • applicable at the individual level?

## References

This work was funded by the CNRS "80PRIME" grant, project DevLang, the French National Agency for Research (ANR), project BabyLang (ANR-20-CE28-0017) to CF. This work, carried out within the Institute of Convergence ILCB, was supported by grants from France 2030 (ANR-16-CONV-0002) and the Excellence Initiative of Aix-Marseille University (A\*MIDEX).