Brain activation patterns in newborns: The influence of prenatal exposure to a foreign language

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INTRODUCTION

THE FŒTUS

- Perceives and processes sounds from mid-pregnancy, despite in utero sound distortion (attenuation of high frequencies) [1,2]
- Cardiac deceleration when listening to a familiar story [3]

THE NEWBORN

- Left-hemispheric dominance brain response to familiar sounds (native language, mother's voice) [4]
- Results are inconsistent regarding cerebral response to native and unfamiliar languages (left vs. right dominance [5], increase vs. decrease [6], no difference [7])
- Infants show a cardiac deceleration and a larger brain mismatch response to sounds that were repeatedly exposed in utero [8,9,10]

OBJECTIVE Characterize the influence of prenatal exposure to a new language on the newborn brain response in comparison to the native language and an unfamiliar language.

METHODOLOGY

39 healthy newborns (without gestational or neonatal complications) from French unilingual families
Mean age at NIRS recording: 31.6 ± 16 h

	Controls	Prenatal exposure to German	Prenatal exposure to Hebrew
N (♀ : ♂)	15 (8:7)	12 (6:6)	12 (5:8)
Gestational age (weeks:days)	39:6 ± 1:1	39:5 ± 0:5	39:5 ± 1:1
Weight (kg)	3.5 ± 0.6	3.5 ± 0.5	3.4 ± 0.3
APGAR (10m)	9.1 ± 0.3	8.8 ± 0.6	9.1 ± 0.3
Amount of prenatal exposure (times)	-	42 ± 19	53 ± 17

*No significant differences for sociodemographic, medical factors and prenatal exposure

EXPERIMENTAL CONDITION

Linguistic **prenatal exposure** to a new language

- 2x everyday from 35th week of pregnancy until birth
- Children's story in French + German or Hebrew (counterbalanced) through headphones places on the abdomen

NEAR-INFRARED SPECTROSCOPY (NIRS) AT BIRTH

Indirect measurement of neural activity through neurovascular coupling → Concentration changes of oxygenated (HbO) and deoxygenated (HbR) hemoglobin (ΔConc). [13, 14]

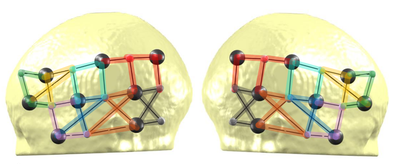
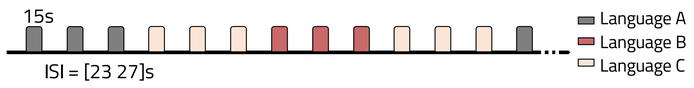


Fig.1 Head coverage from source-detector coupling and representation of regions of interest (ROIs)

Fig.2
NIRScout System (NIRx)
32 sources (760nm and 850 nm)
16 detectors
Sampling rate:7.8 Hz

Resting-state and **passive listening** of the same children's story

- French (native language) + German + Hebrew (foreign languages of different rhythmic classes and linguistic families from French)
- Block-design paradigm (18 blocks per language)



DATA ANALYSIS

Preprocessing

- Correction of motion artefacts (tPCA and interpolation), segmentation, normalization, rejection of noisy blocks*
- ΔConc HbO/HbR calculation using the modified Beer-Lambert's law: mean per participant, language and ROI

Statistical analyses:
Repeated-measure ANOVA / ANCOVA on the mean ΔConc HbO across ROIs

- Covariable: Amount of prenatal exposure
- Contrast Familiar with others for post analyses

Native vs. **Familiar** vs. **Unfamiliar**

From the prenatal exposure (either German or Hebrew according to the participant's group)

*In average, 14.6 ± 3 blocks per condition per participant were included for analyses

RESULTS

Significant/marginal difference of mean activation to the stories between conditions when controlling for the amount of prenatal exposure to the familiar language:

- **Anterior region of the left temporal lobe** F(2,36)=3.68, p=.035
  → Familiar > Unfamiliar (p=.038) → Familiar > Native (p=.064, marginal)
- **Posterior region of the left temporal lobe** F(2,36)=2.61, p=.088
  → Familiar > Unfamiliar (p=.082, marginal) → Familiar > Native (p=.065, marginal)

* n.s. when not controlling for the amount of prenatal exposure (ANOVA)
Amount of prenatal exposure is correlated to the familiar-unfamiliar differences in these regions

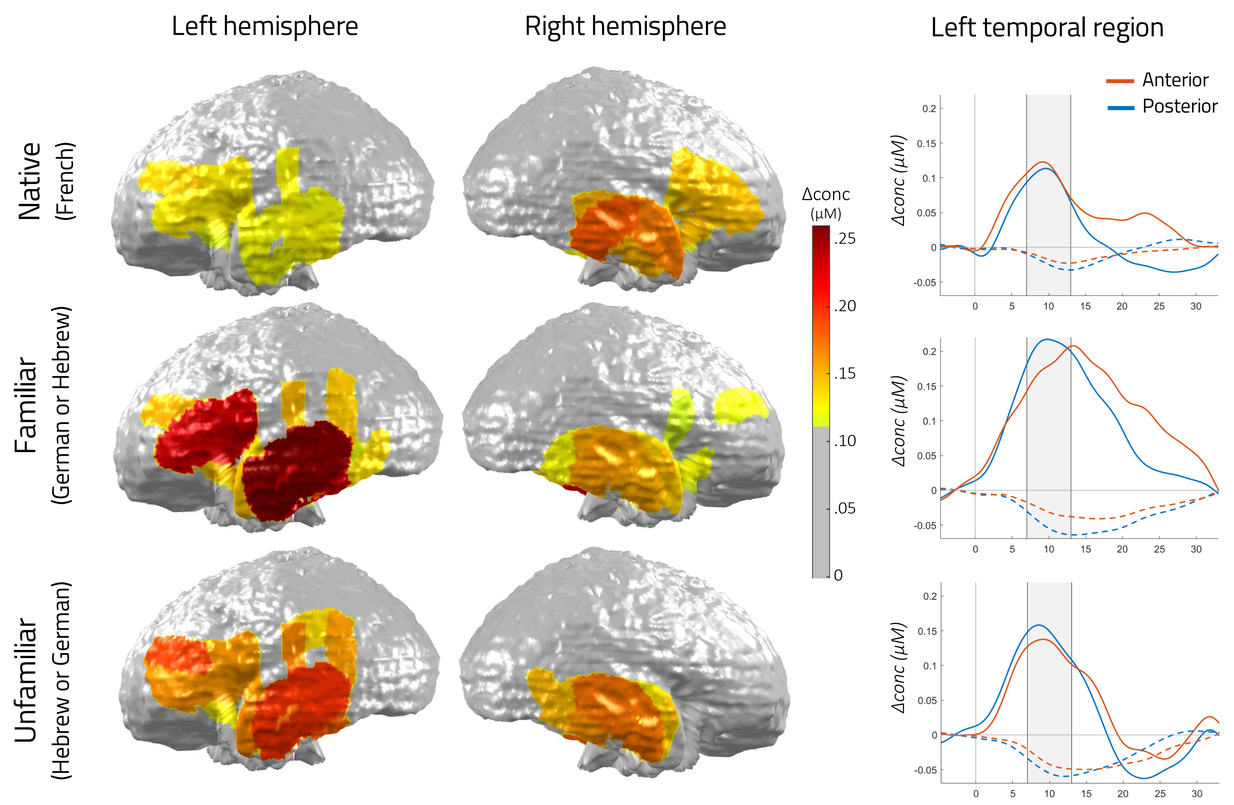


Fig.3 Mean HbO concentration changes from 7 to 13 sec‡ after stimulus onset (from participants of the experimental groups) — HbO -- HbR

‡ Interval is represented by gray area in graphs (right)

DISCUSSION

Bilateral temporal activations in all three languages/conditions

- Would reflect the auditory processing specific to any language stimulus. [7-11, 13]

Stronger activation for the prenatal familiar language in the left temporal region

- Regardless of the specific acoustical characteristics of our speech stimuli, experimental exposure to a non-native language modulates cerebral activation in regions associated with auditory and language processing. [2, 5,11,12,13]
- The amount of prenatal exposure seems to influence activation patterns and differences between the native, familiar and unfamiliar languages. [4,5,9,10]
- These results suggest the presence of prenatal learning in response to environmental stimuli.

FUTURE AVENUES OF RESEARCH

- Increase sample size
- Explore language pre-networks with functional connectivity analysis [15]
- Longitudinal follow-up with NIRS imaging and developmental assessment

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