

Diverse Sounds



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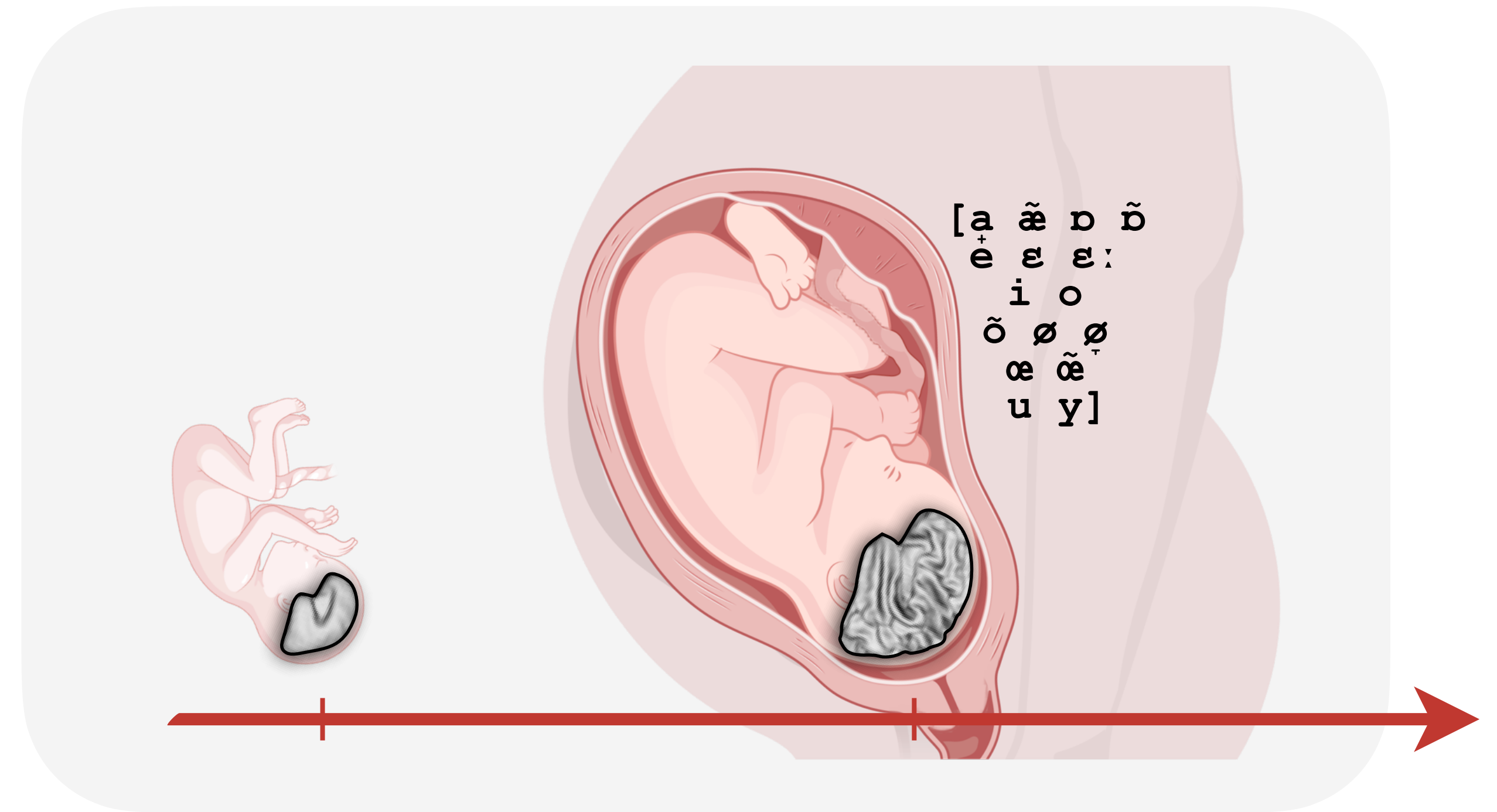


Monthly Neuroimaging Meeting (RMN)

Marseille, 8/10/2026

Diverse Sounds

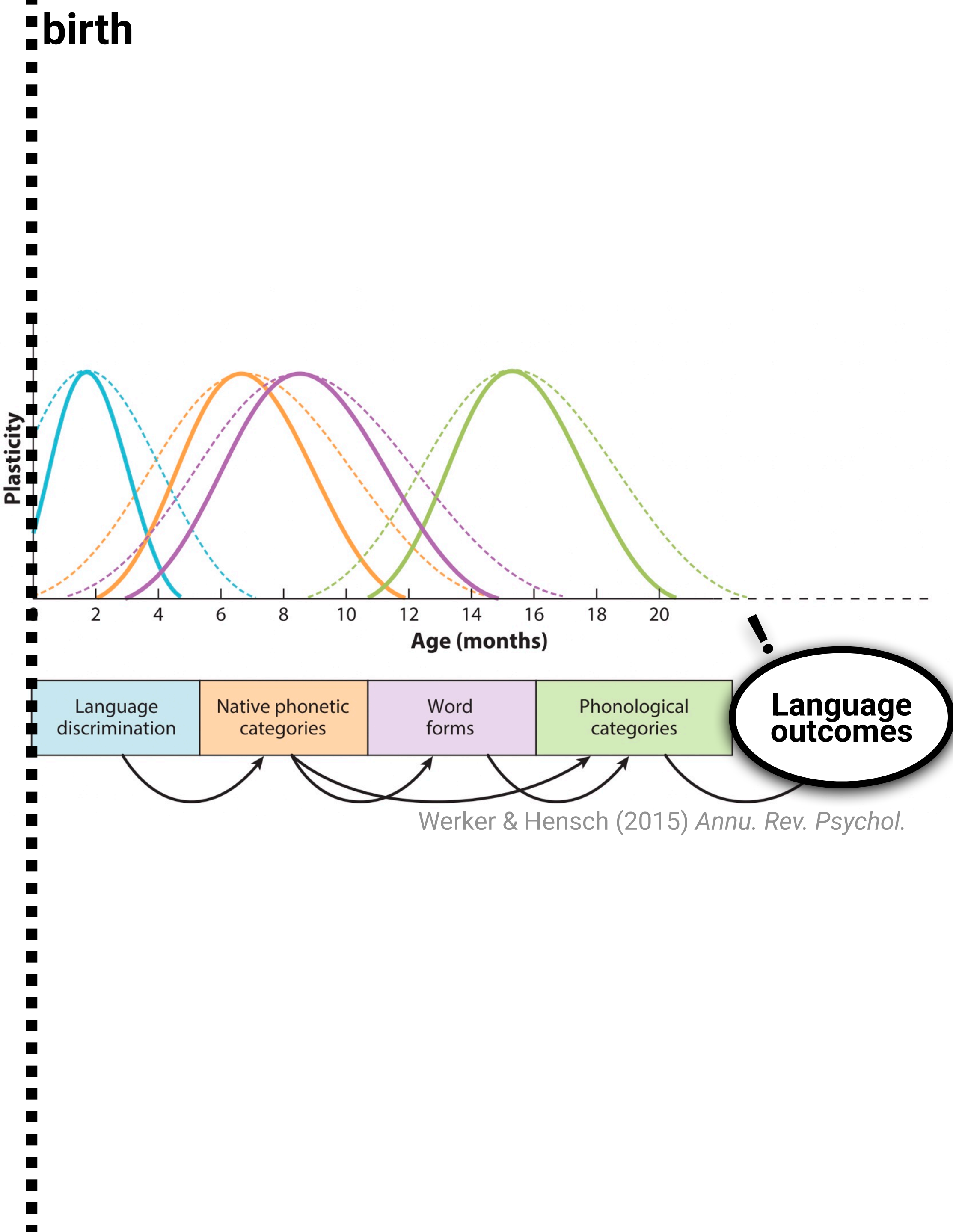
How **Prenatal Language Experience**
Shapes **Fetal Brain Development**
and **Later Language Learning**.



fetal MRI from Karolis, et al. (2023) OHBM

**FOUNDATIONS OF LANGUAGE AND
COGNITIVE DEVELOPMENT**

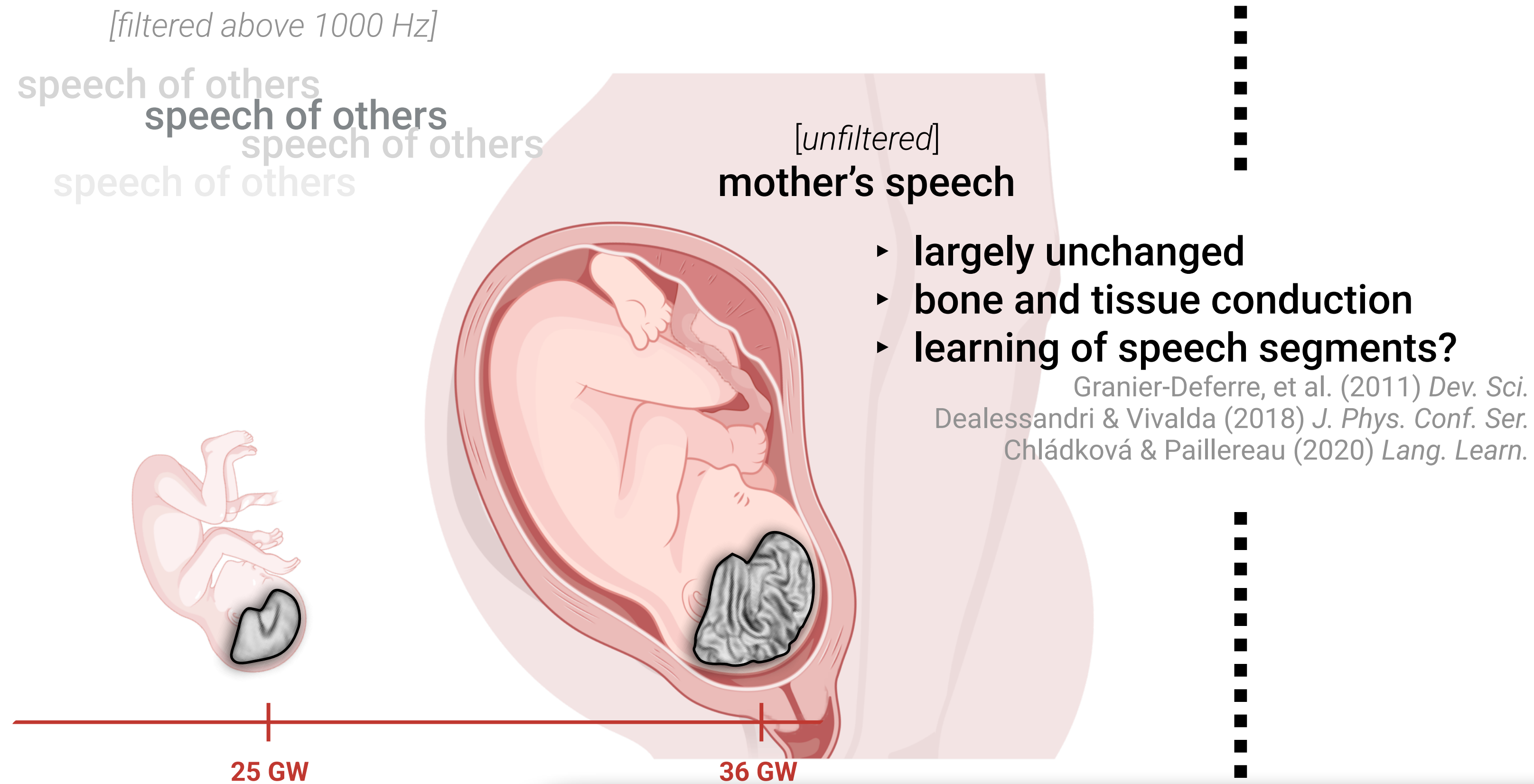
What happens prior to birth?



Why?

Diverse
Sounds

Kepinska



Important:

- (1) **Theoretically** (language & cognitive development)
- (2) **Clinically** (premature birth)
- (3) **Societally** (prenatal bonding)

Step 1. Existing prenatal data



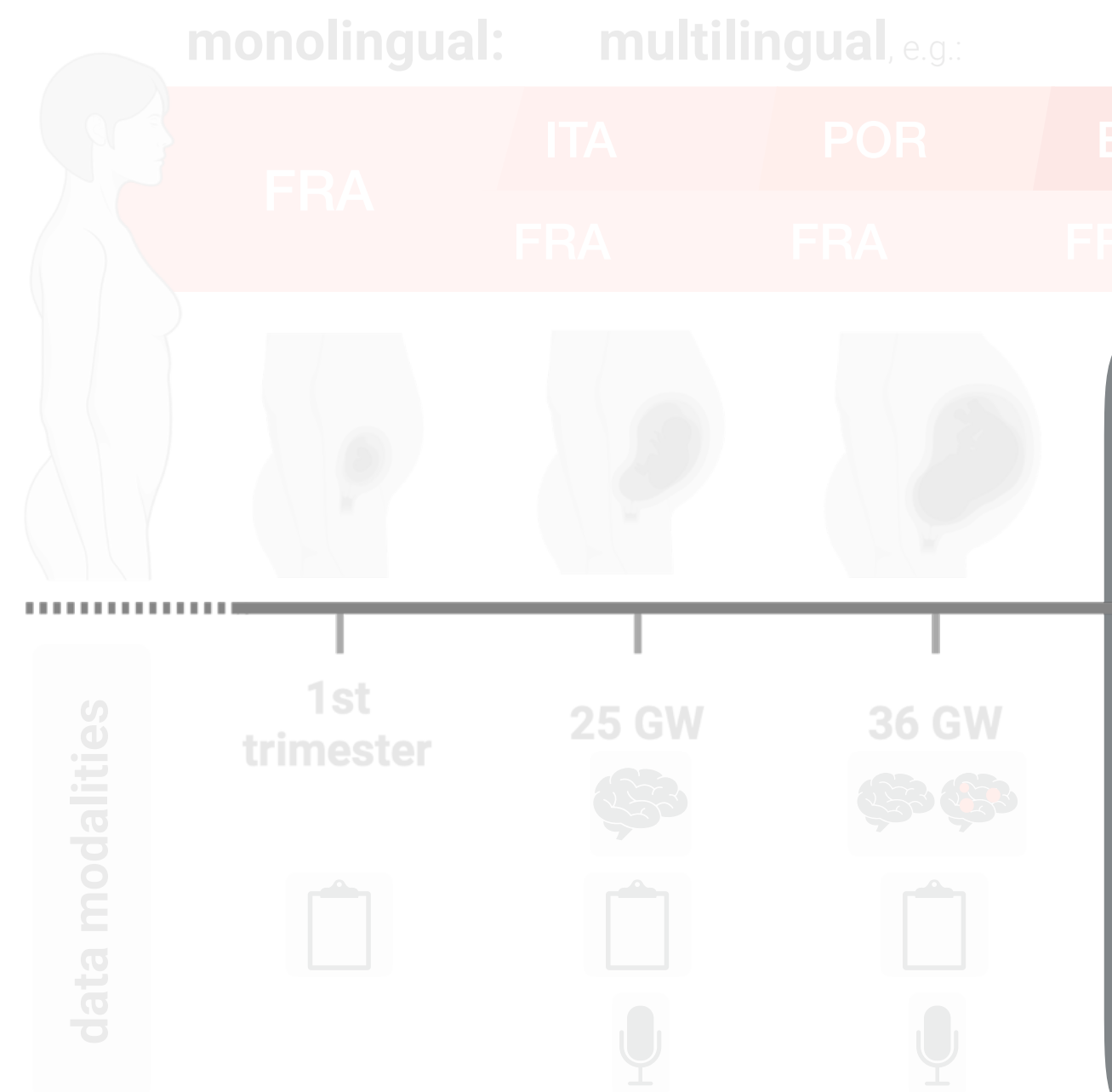
The
Developing Human Connectome
Project



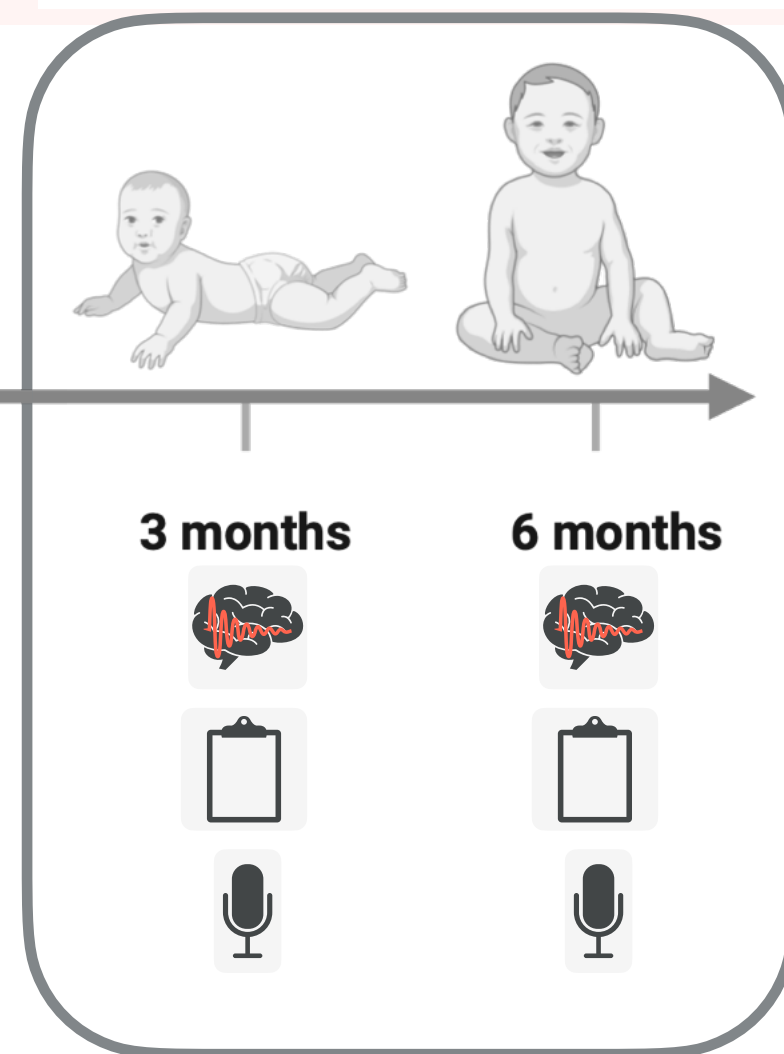
vs.



Step 2. Prenatal longitudinal data



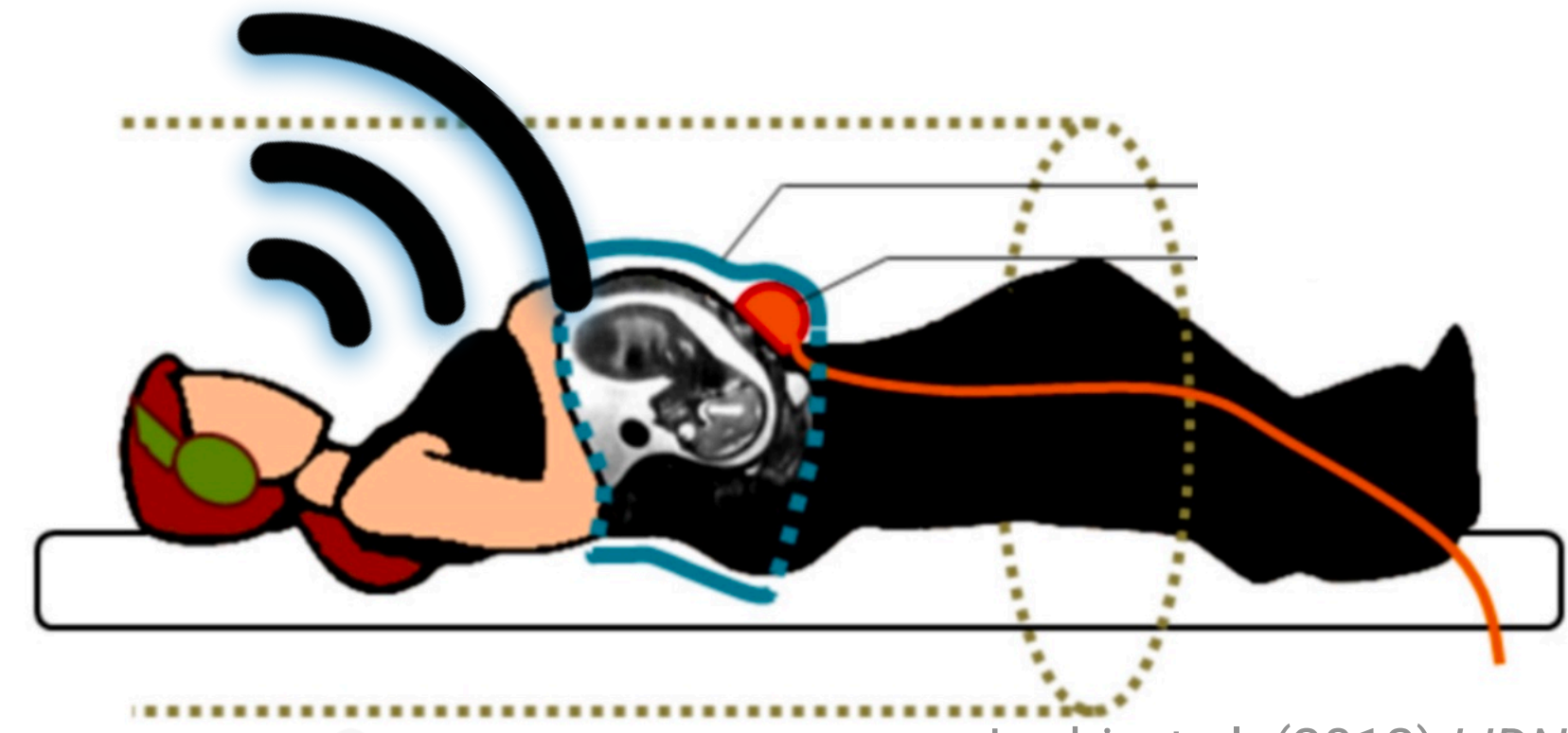
Step 3. Follow-up infant data



Hypothesis 1:
**Learning of speech
segments starts
prenatally.**

Hypothesis 2:
**This learning sets the
stage for later language
acquisition.**

Hypothesis 1:
Learning of speech segments
starts prenatally.

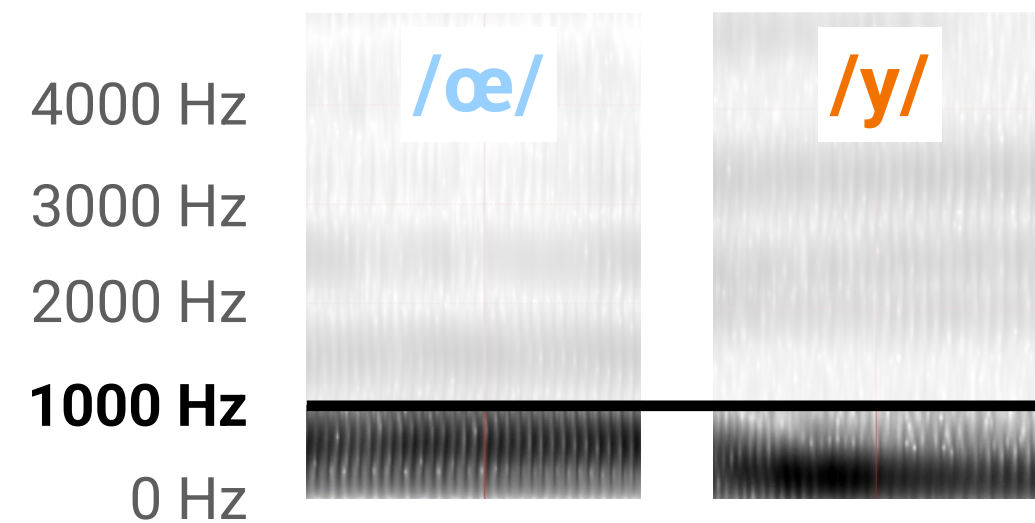
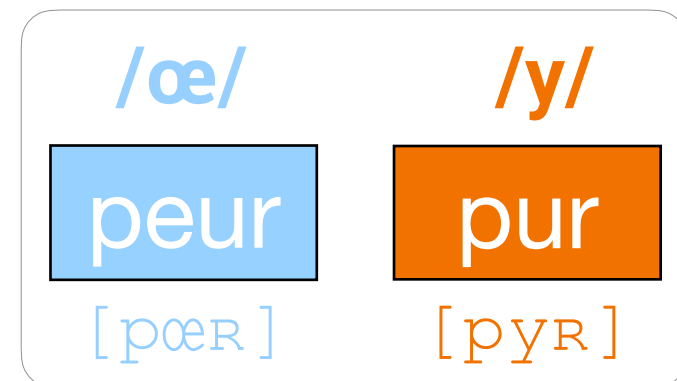


Jardri, et al. (2012) *IJDN*

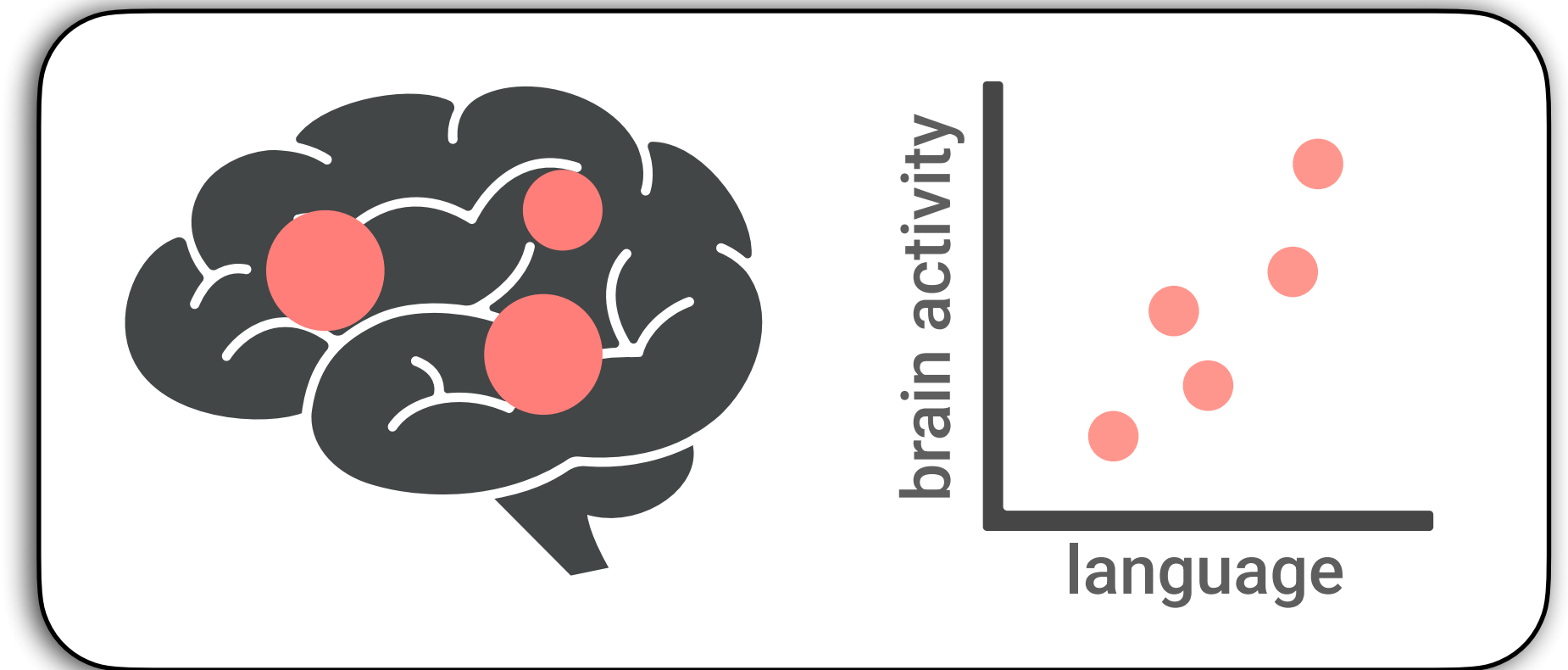
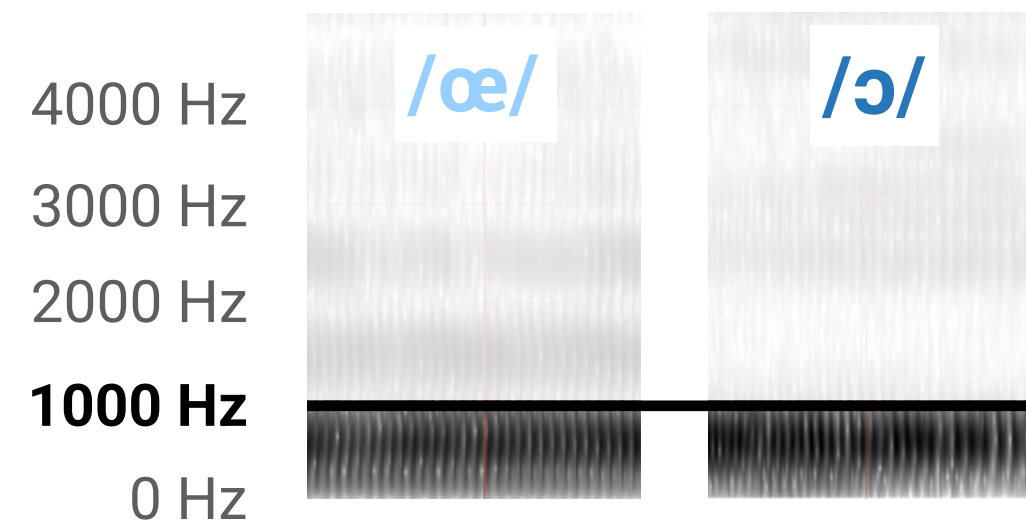
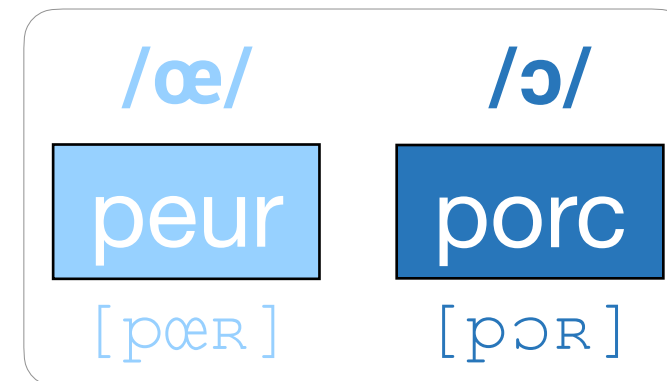
Experiment 1

**Does maternal speech contribute to fetal learning of speech segments,
beyond the established prosodic learning?**

discriminated < 1000 Hz:

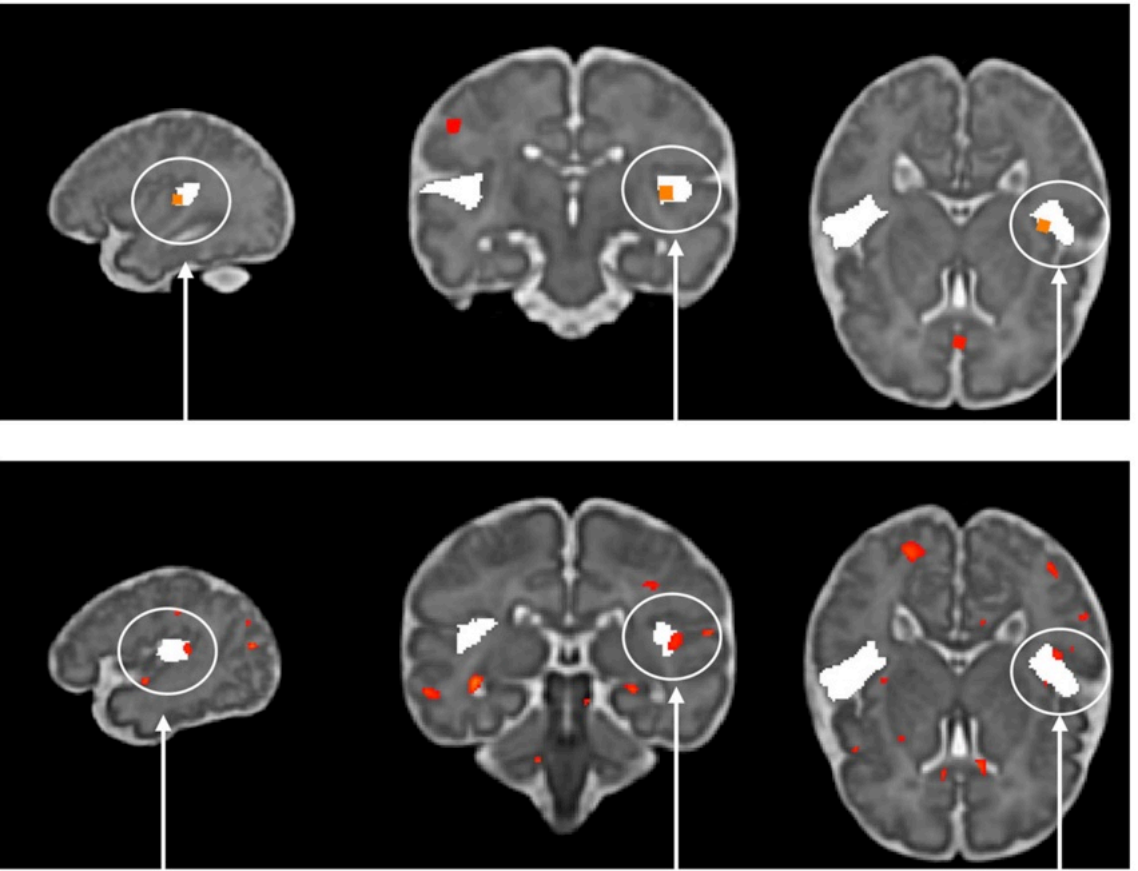


discriminated > 1000 Hz:



fMRI paradigm

Goldberg et al., 2020



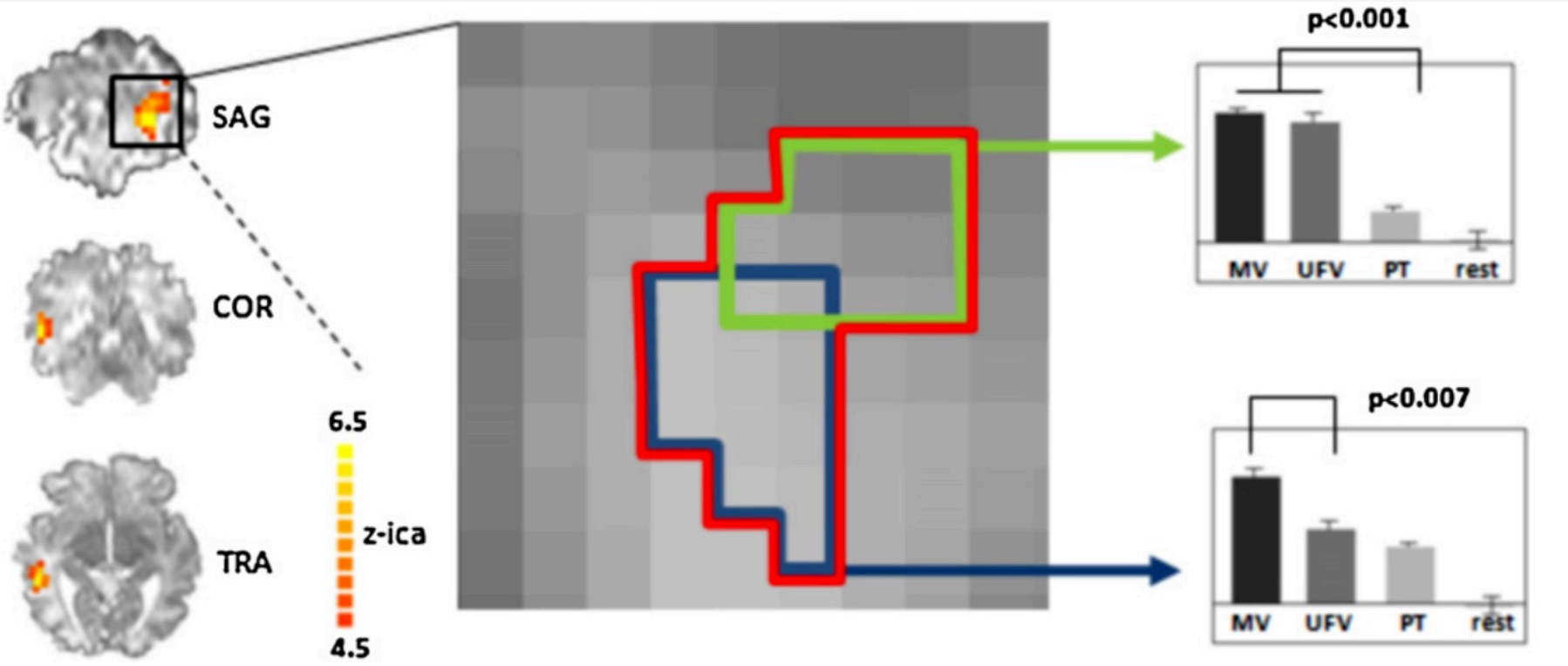
fetus; 36 GW
3T fMRI
maternal voice, 3:44 min

fetus; 38 GW
1.5T fMRI
maternal voice, 3:44 min

Jardri et al., 2012

group-average
(3 fetuses; 31-34 GW)
1.5T fMRI

Discrimination of external sounds:
maternal voice (MV, 3:15 min)
unknown female voice (UFV, 3:15 min)
pure tone (PT, 3:15 min)



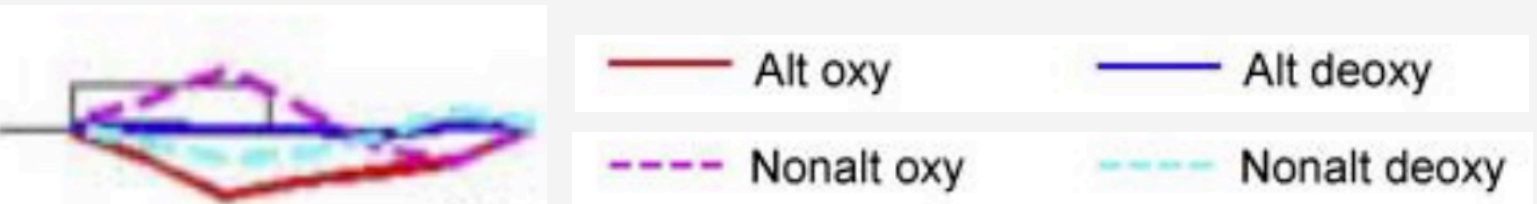
MV+UFV > PT

MV > UFV

Gervain et al., 2012

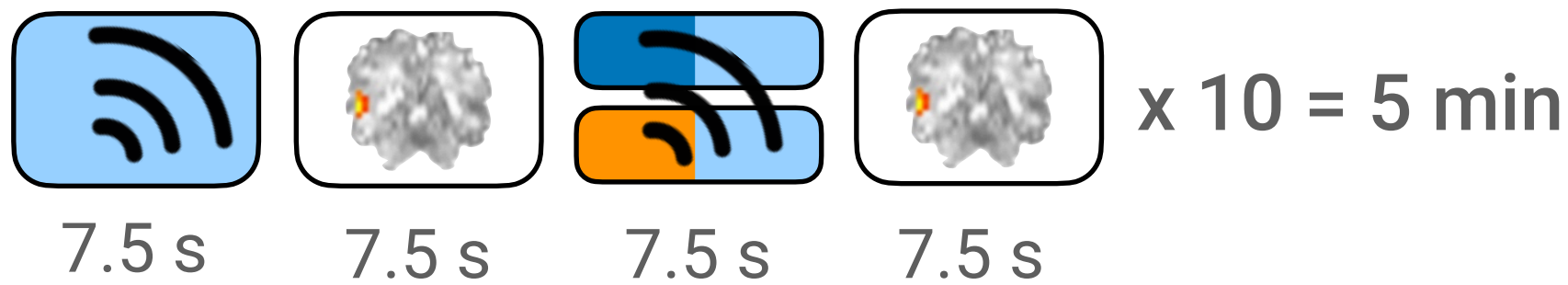
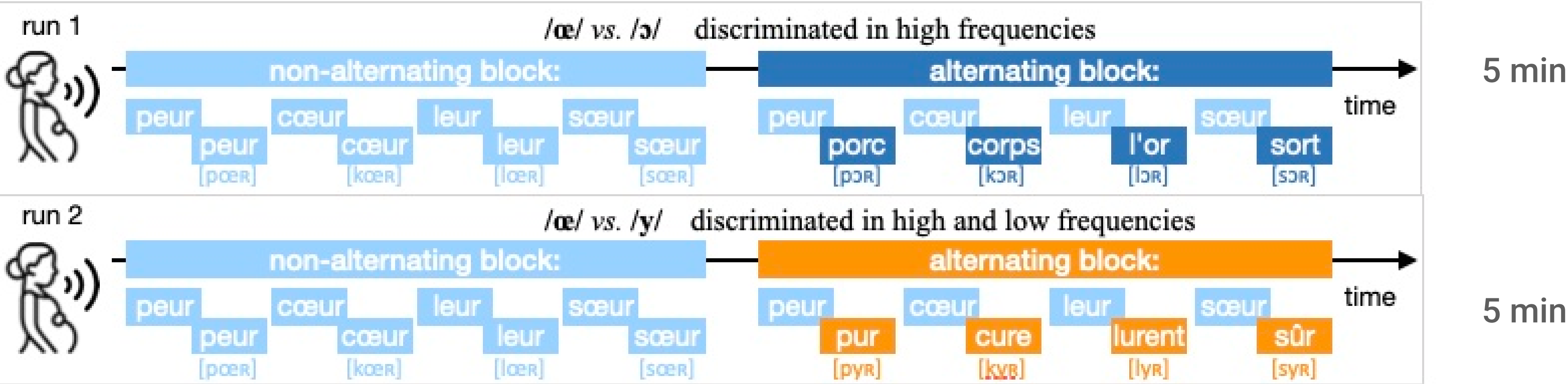
group-average
(20 newborns; 0-3 days)
fNIRS*

Discrimination of grammar:
alternating blocks (Alt, 4:20 min)
non-alternating blocks (Noalt, 4:20 min)



*fetal fMRI signal is stronger than fNIRS (Desrosiers et al., 2024)

fMRI paradigm



"clustered sparse" protocol (cf. Trapeau et al., 2024)

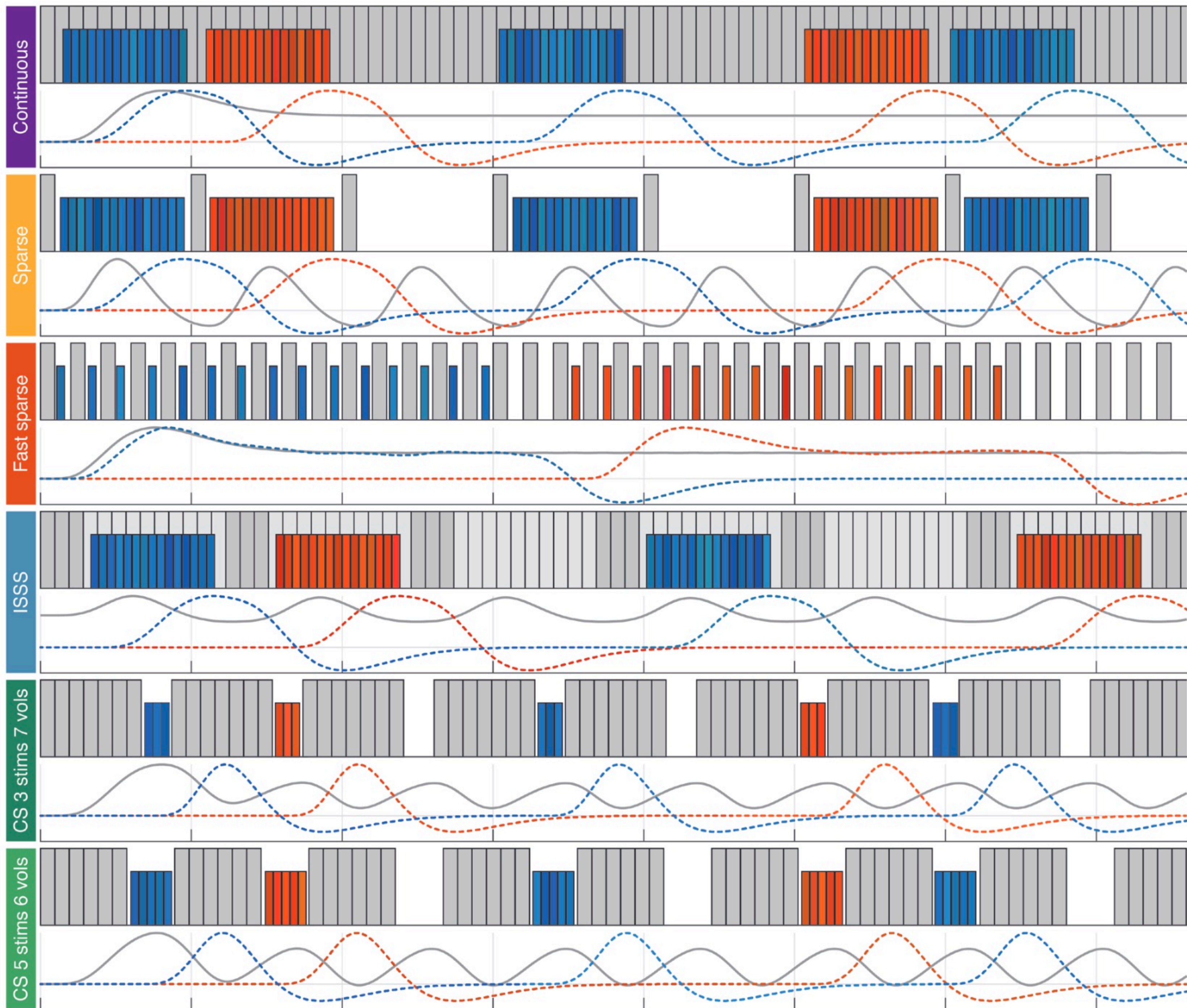
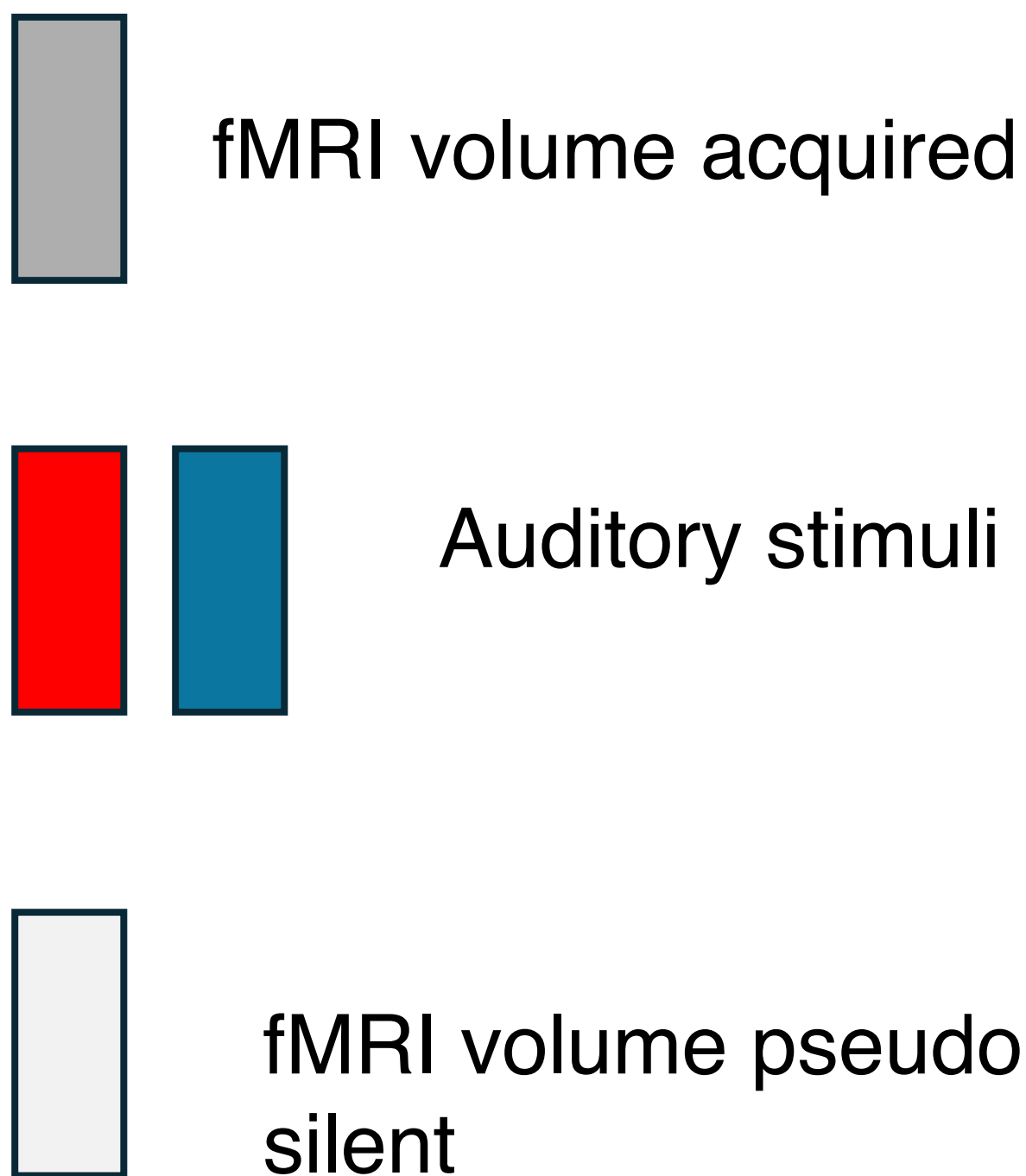
fMRI sequence

- Goal: record fmri volumes for task fMRI
- Task: Baby is listening to mother's speech
- Sequence: The standard GRE-EPI sequence is very noisy (around 100 dB at 3 T), which could affect the baby's ability to listen and the mother's ability to produce speech.

=> solution 1: GRE-EPI sequence with clustered sparse acquisition (Trapeau et al. 2025)

=> Question: which TR/TE , FA to chose in addition to the fMRI sequence paradigm?

fMRI sequence paradigm



Looping star sequence

- Patent by GE in 2018

(12) **United States Patent**
Wiesinger et al.

(10) **Patent No.:** **US 10,088,539 B2**
(45) **Date of Patent:** **Oct. 2, 2018**

(54) **SILENT MULTI-GRADIENT ECHO
MAGNETIC RESONANCE IMAGING**

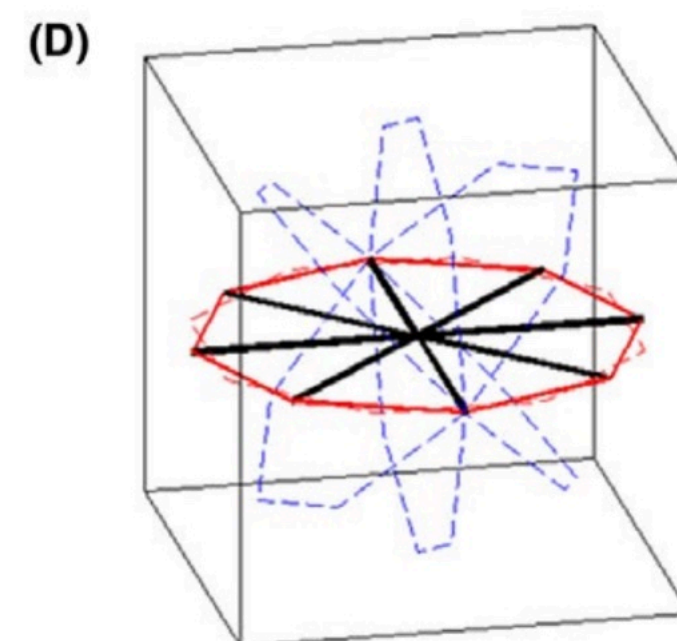
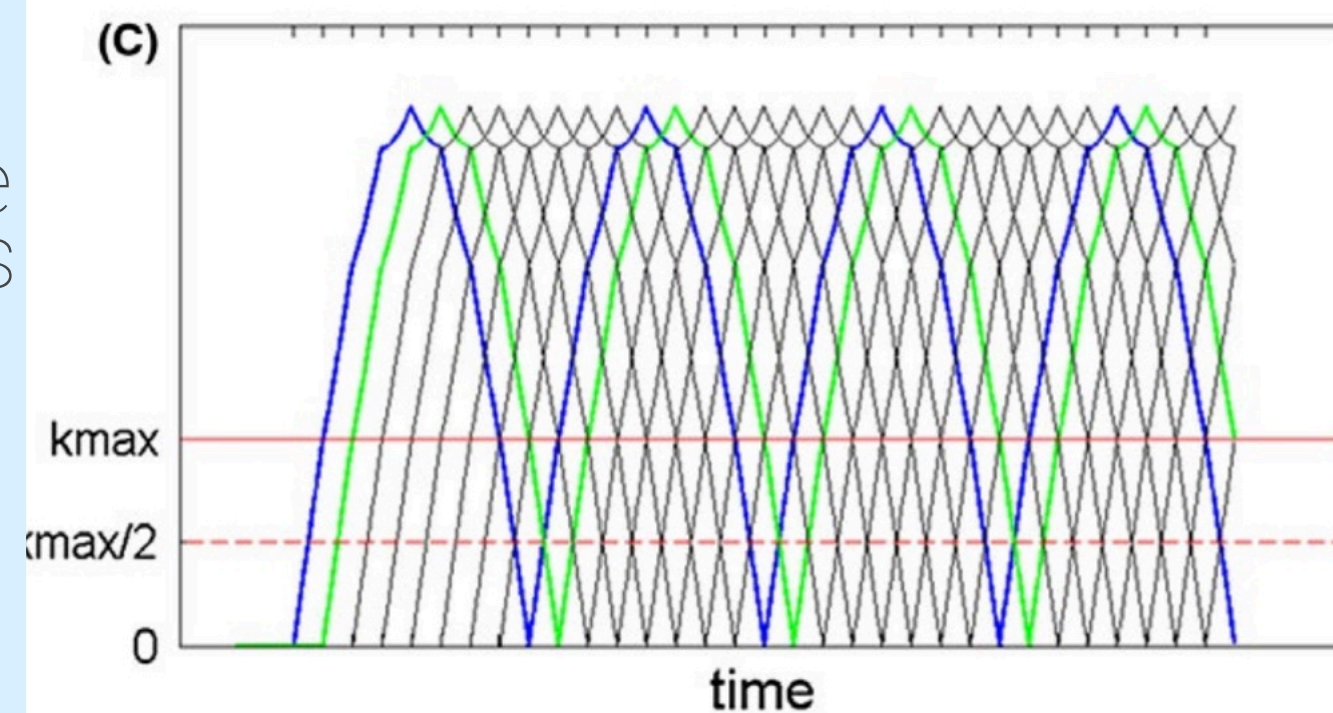
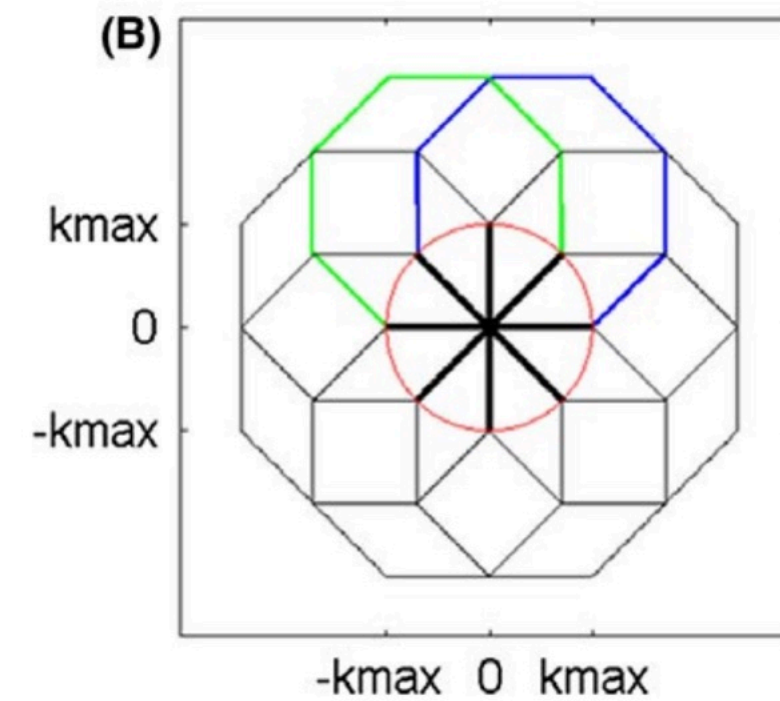
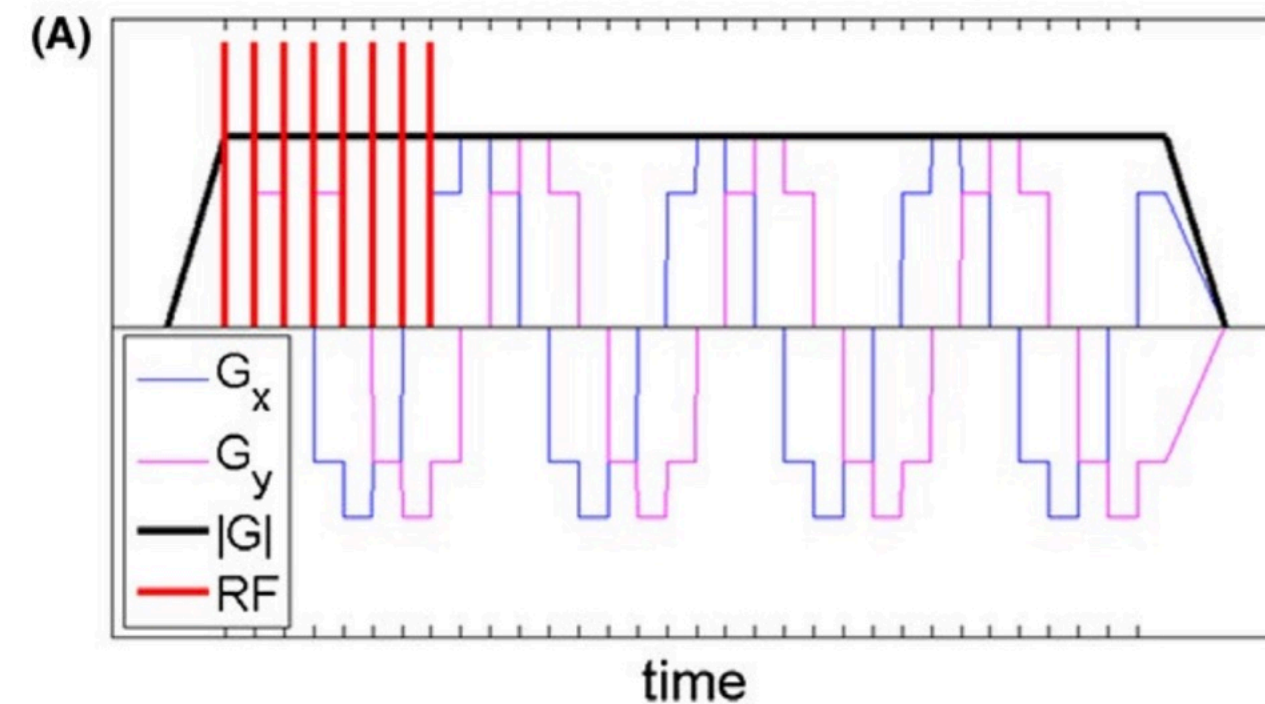
(71) Applicant: **General Electric Company,**
Schenectady, NY (US)

(56) **References Cited**
U.S. PATENT DOCUMENTS

6,445,184 B1 9/2002 Tantt
2004/0160221 A1* 8/2004 Kiefer G01R 33/482

« In a way, Looping Star can be understood as time-multiplexed,
3D radial gradient echo imaging. »

Wiesinger et al. MRM, 2018

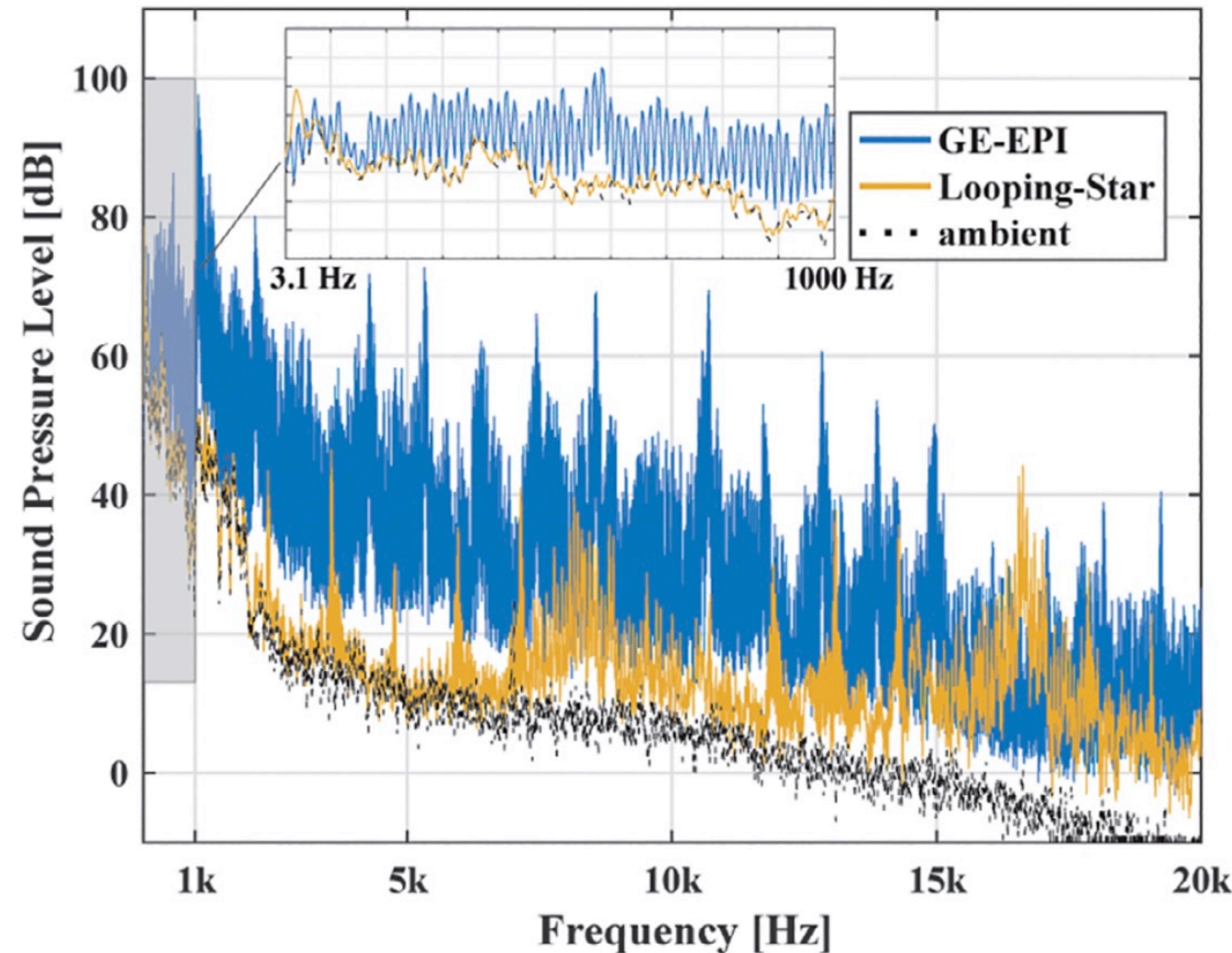


Dionisio-Parra et al. JMRI 2020

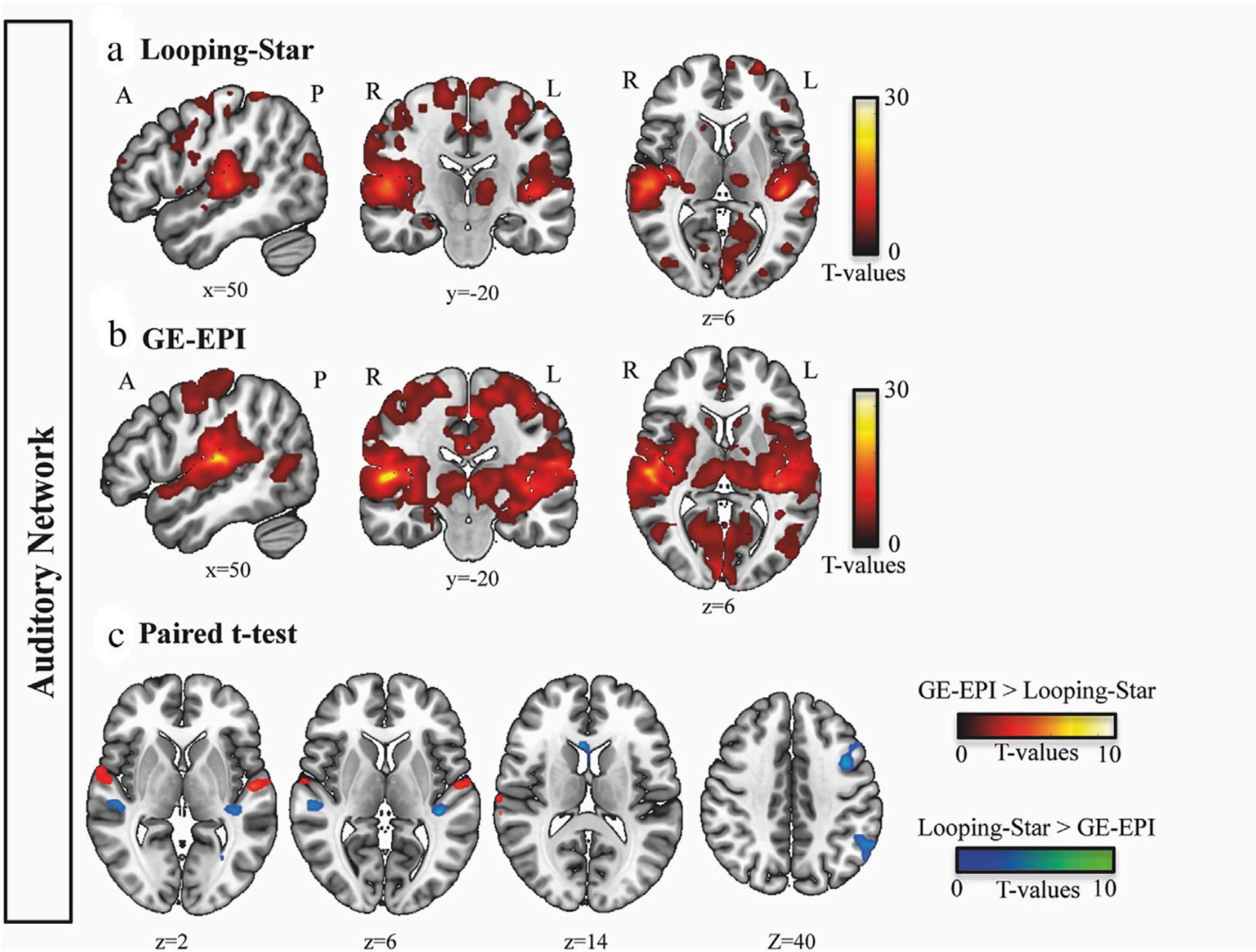
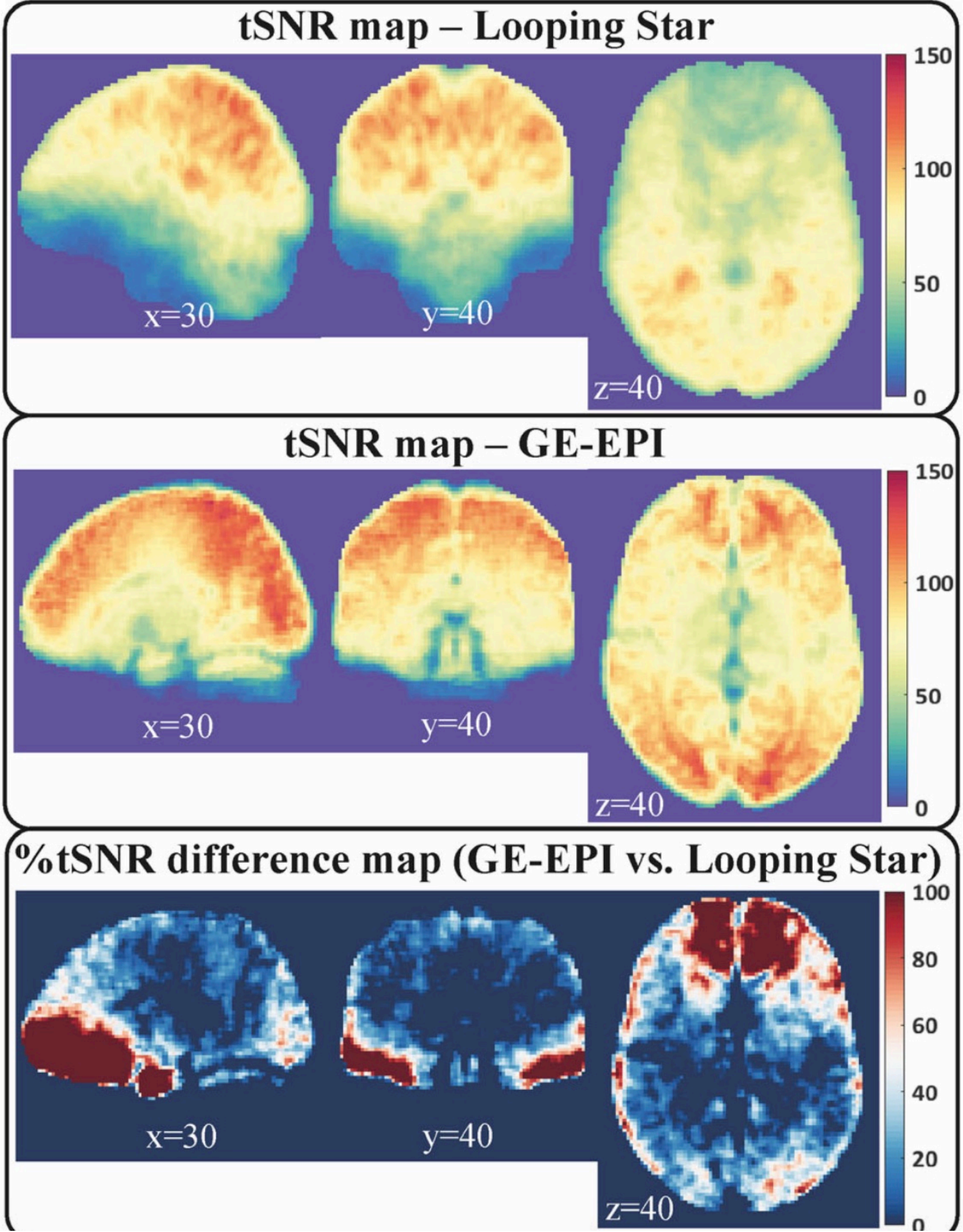
TABLE 1. Mean Acoustic Noise Levels for Looping Star, GE-EPI, and Ambient

	LAeq, dB(A)	Lpeak, dB
GE-EPI	103.3 ± 0.05	114.4 ± 0.11
Looping Star	71.4 ± 0.04	93.6 ± 1.31
Ambient noise	70.9 ± 0.1	89.3 ± 1.21

LAeq = A-weighted noise level; Lpeak = peak noise level. Ambient refers to the background noise level in the scanner room.



Dionisio-Parra et al. JMRI 2020



How?

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Looping Star sequence

- Product GE sequence available to research customers
- Whole-brain coverage with sufficient spatiotemporal resolution and BOLD sensitivity at just 0.5 dB above ambient noise
- Fung et al. OHBM 2026 (3 male healthy volunteers)

EPI

TE = 30 ms
TR = 2000 ms
2.6 mm isometric
Flip angle = 71°
Multiband factor 2

Looping Star

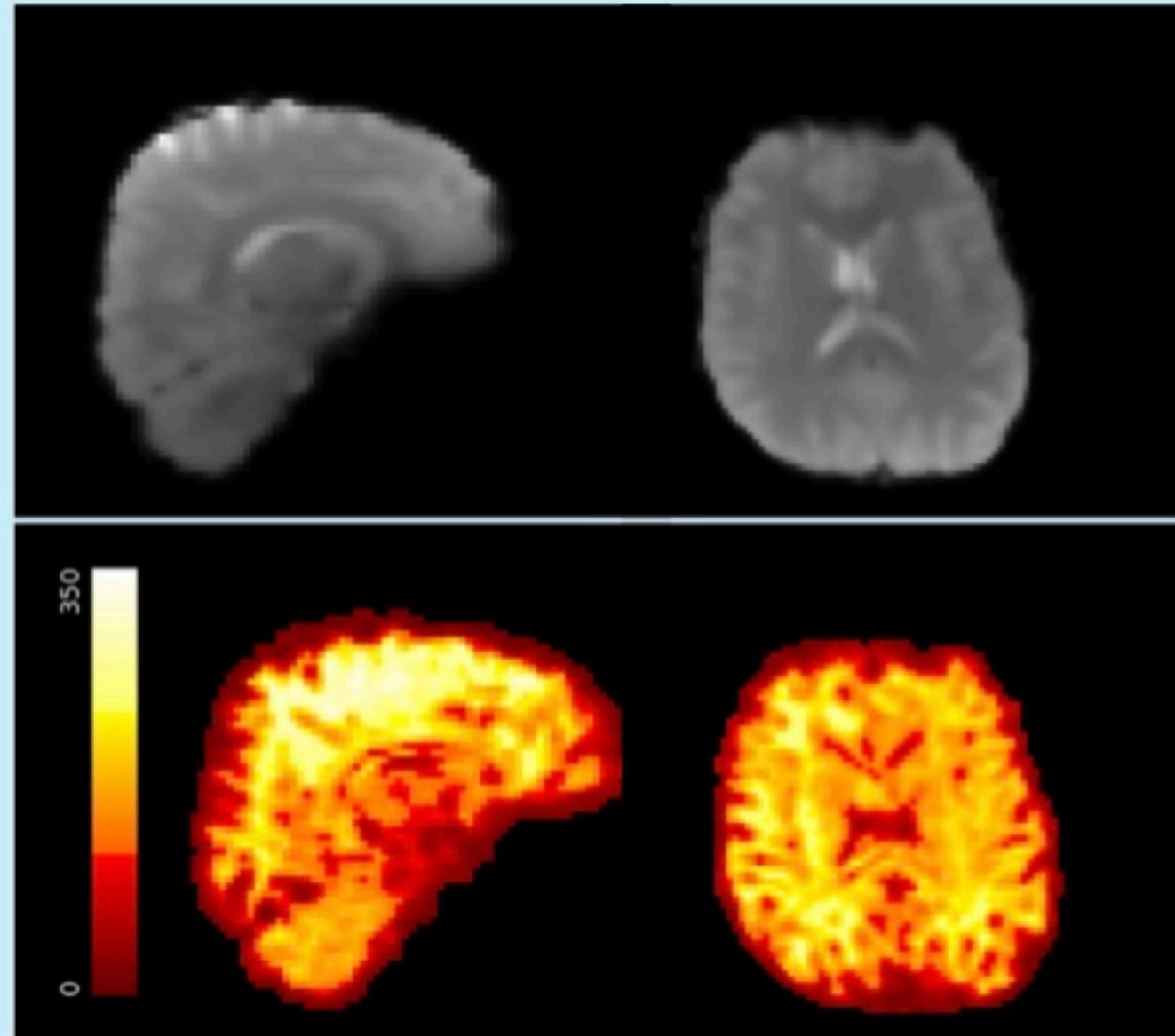
TEs = 0/16.1/32.2 ms
TR = 1628 ms · 3 mm
isometric · Flip angle = 1°
3D radial, 1,080 spokes/vol
Acceleration factor 2

Looping Star sequence

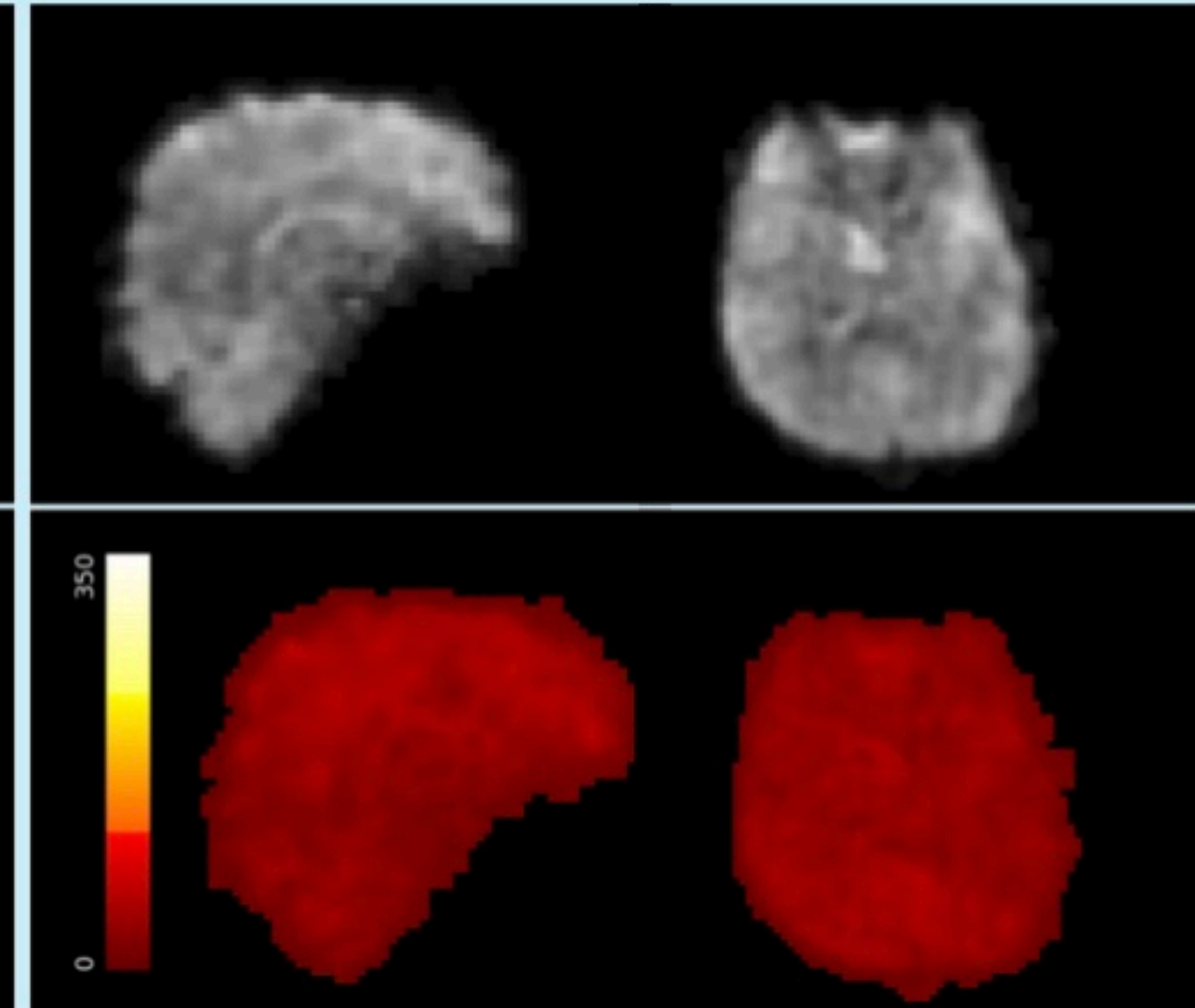
Data quality

- EPI: higher tSNR, geometric distortions
- Looping Star: lower tSNR, spatial blurring

EPI

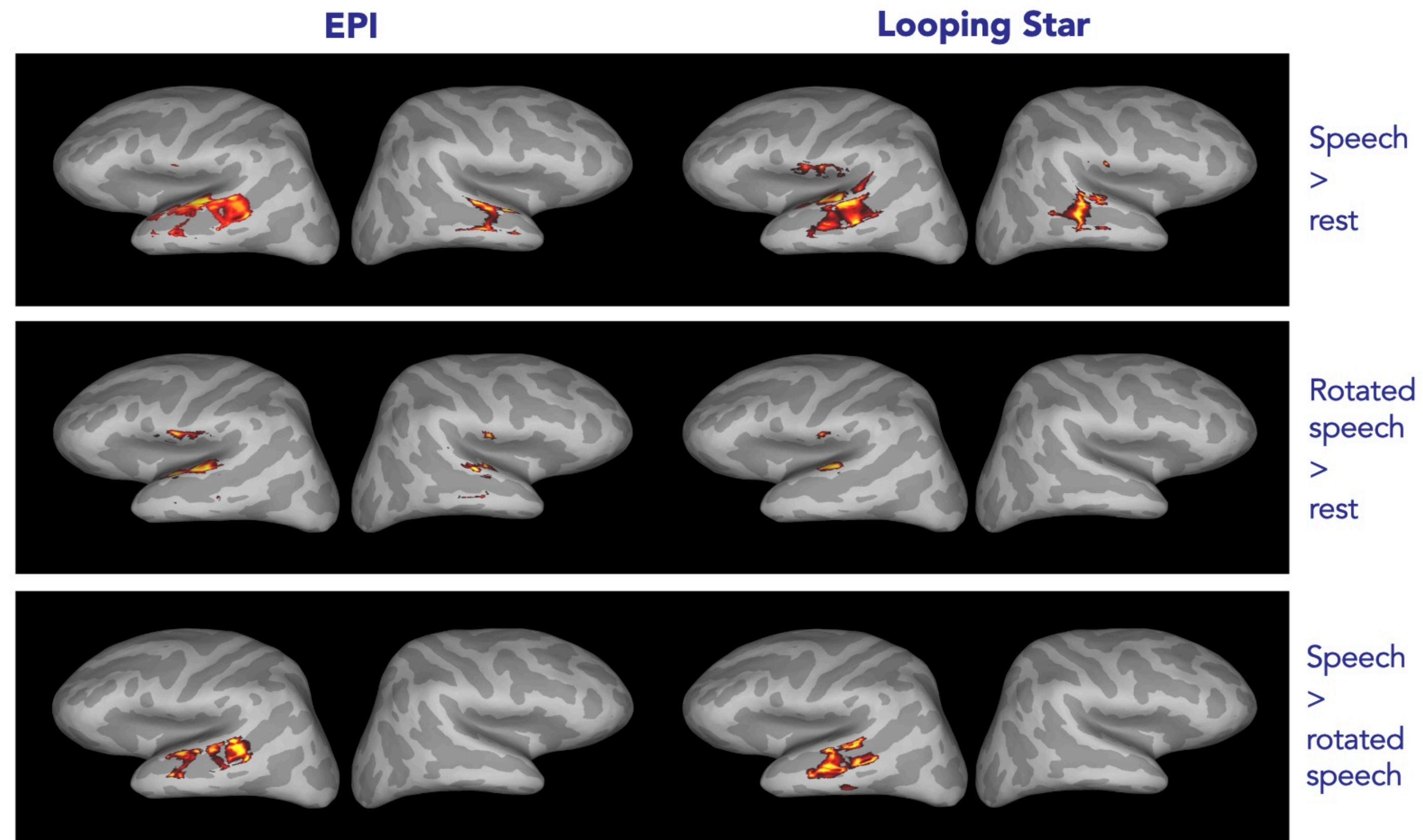


Looping Star



Example fMRI scans and temporal signal-to-noise ratio (tSNR) maps

Looping Star sequence

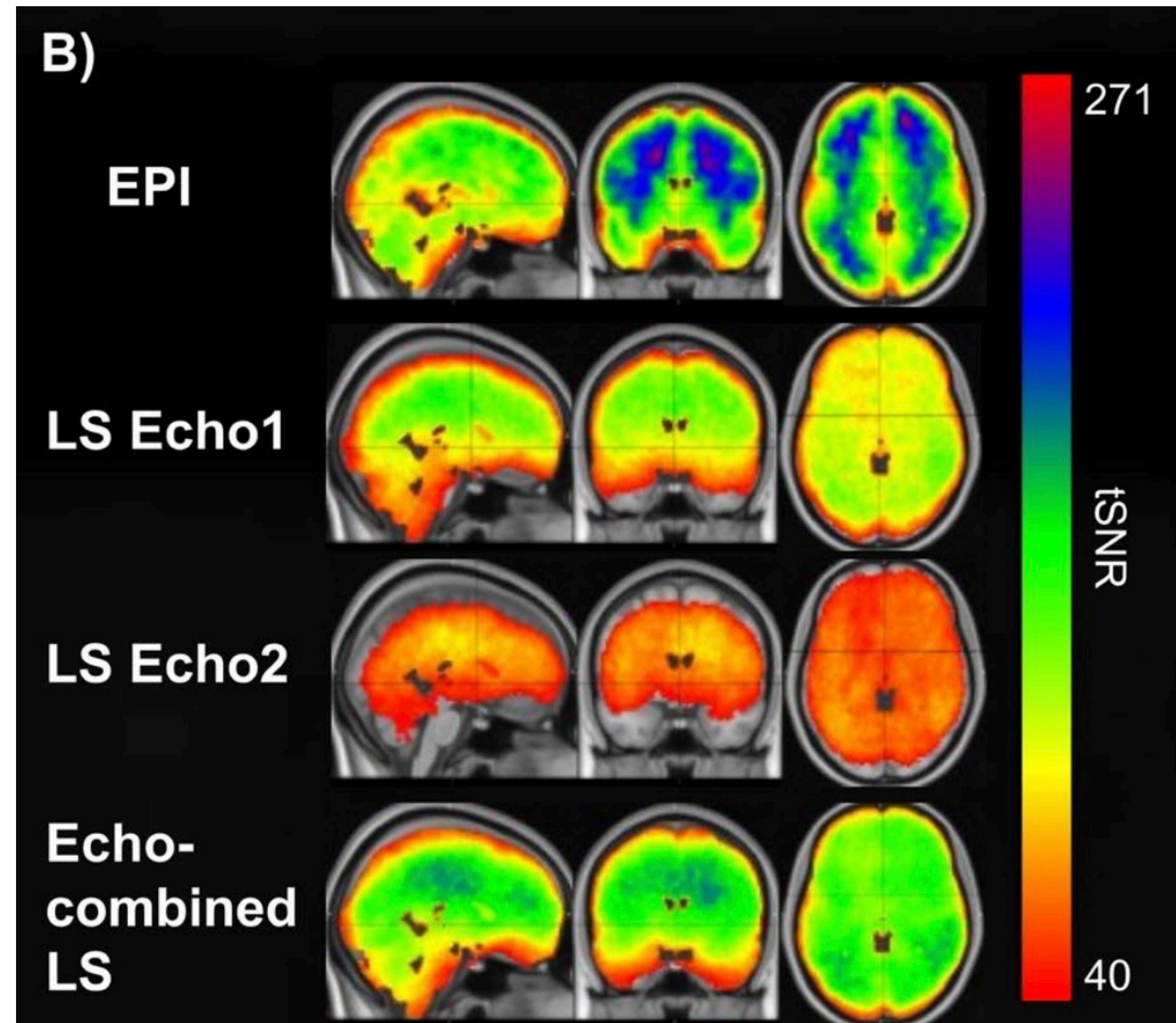


Activation maps for subject 2 using GLM (FSL FEAT), $Z > 3.1$, $p < 0.05$ cluster-corrected

Ritter et al. HBM 2026

- Multi-echo Looping star sequence
- Tested on 10 adults
- 3 speech conditions for
- « Alice in Wonderland ».

TSNR Maps



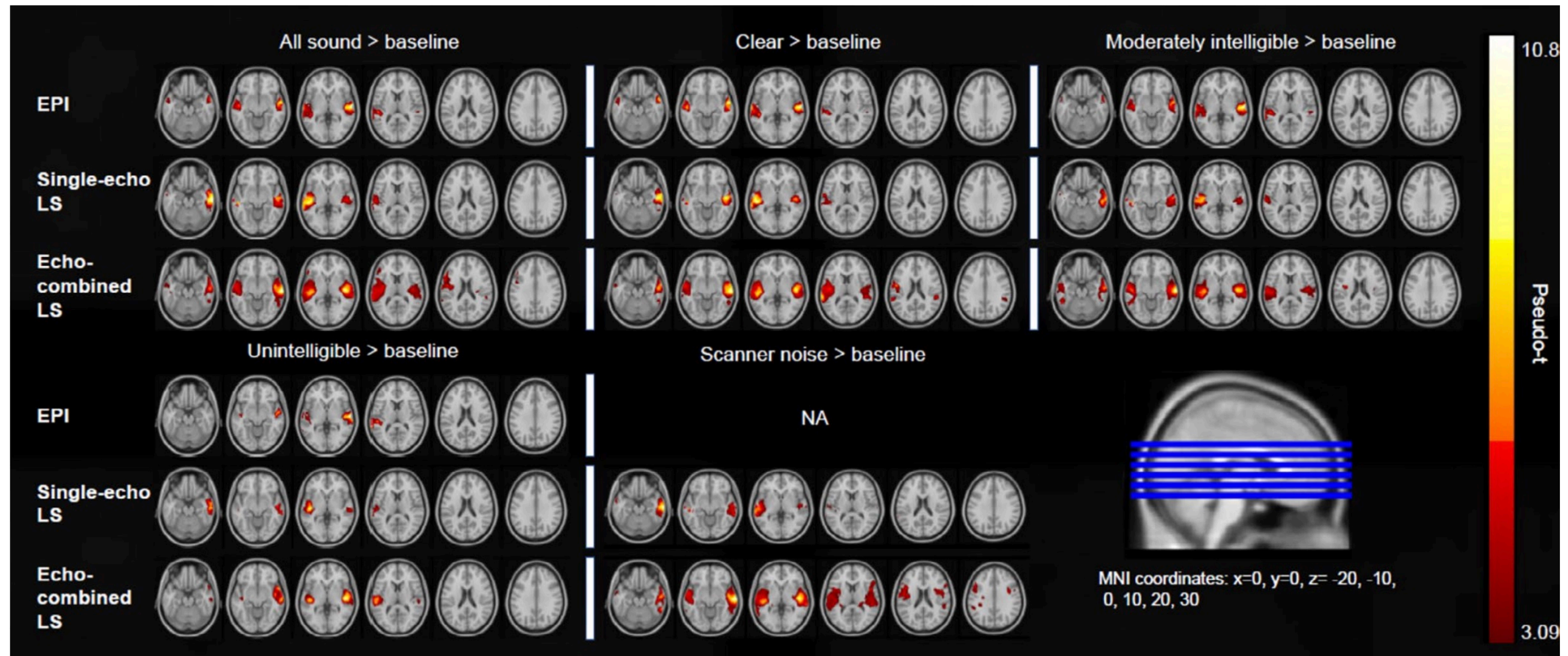
Ritter et al. HBM 2026

How?

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17



Unkown: Siemens implementation

- <https://github.com/fmrifrey/lps>
- Pulseq framework: vendor agnostic sequence code
- MATLAB reconstruction code provided

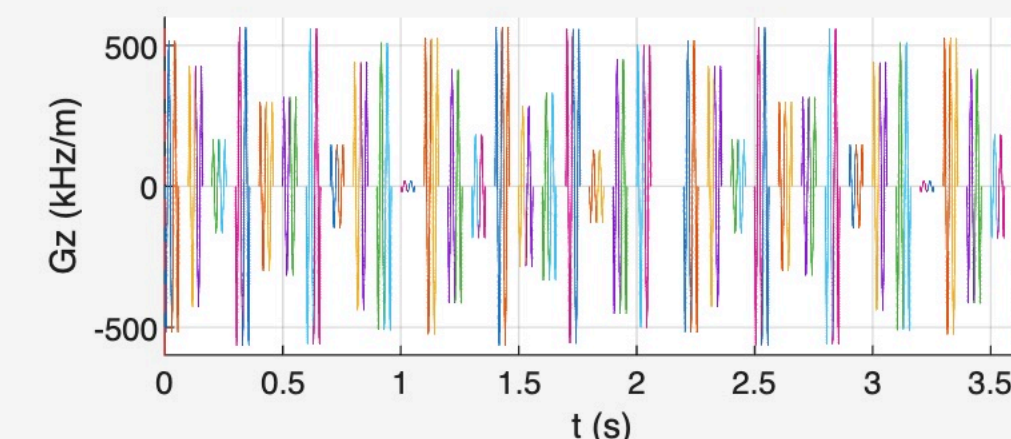
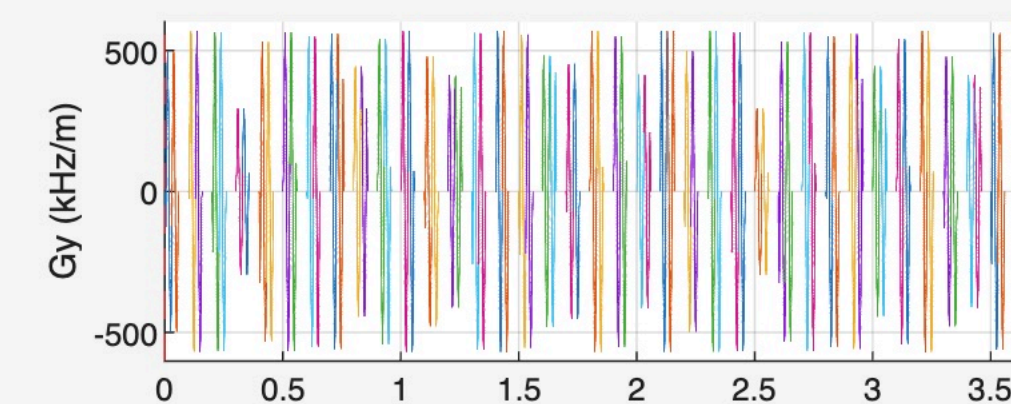
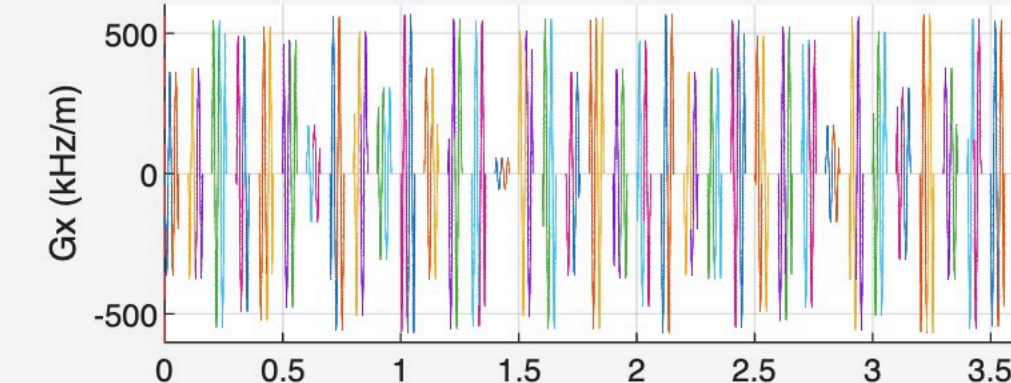
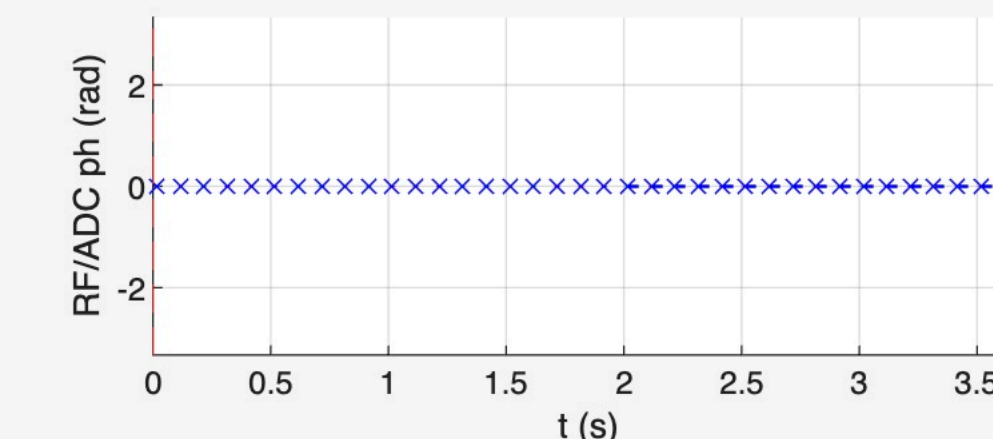
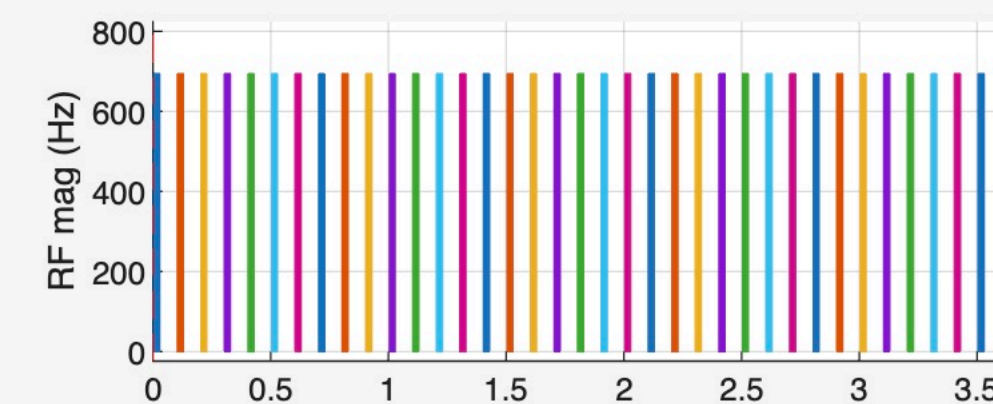
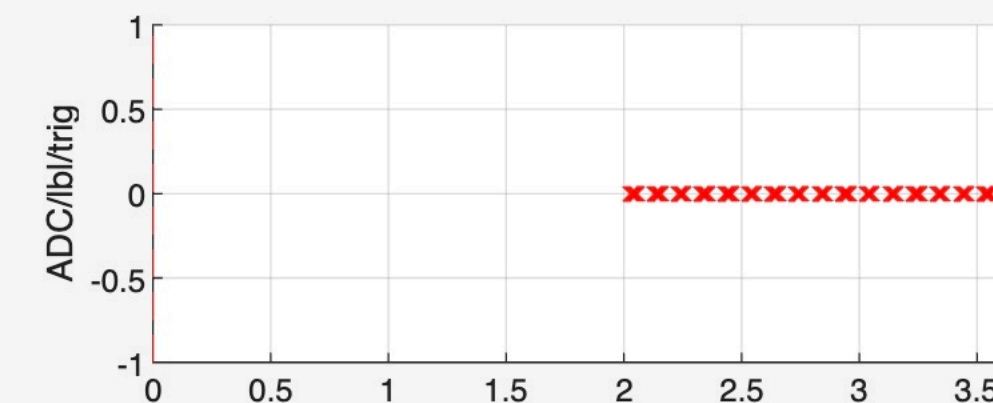
README MIT license



Harmonized Looping Star MRI (lps)

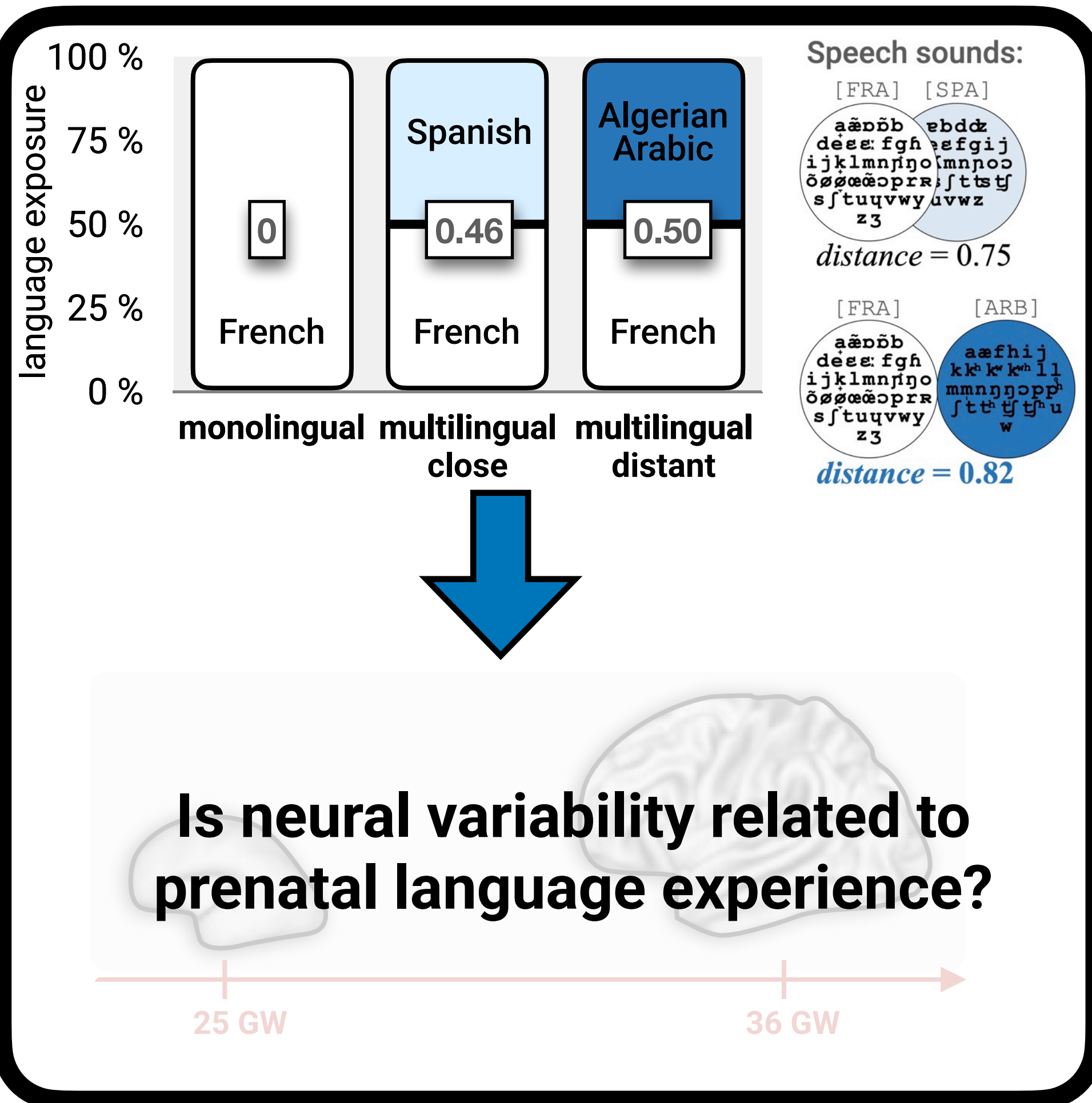
by David Frey (djfrey@umich.edu)

This repository contains vendor-agnostic pulse sequence programming and reconstruction for Looping Star MRI. This sequence has been extensively tested and used to acquire fMRI data on GE MR750 scanners. However, **this sequence is still being developed for use on Siemens scanners.**

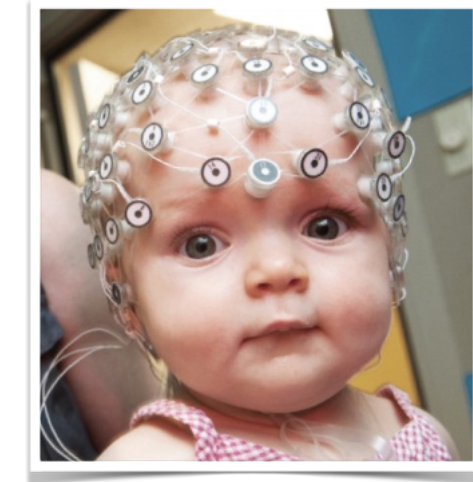


Hypothesis 1:
Learning of speech segments starts prenatally.

Experiment 2



Hypothesis 2:
**This learning sets the stage
for later language acquisition.**



Experiment 3

Language acquisition outcomes

- ▶ native and non-native vowel discrimination

Experiment 4

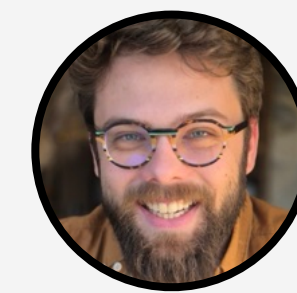
Language acquisition mechanisms

- distributional learning paradigm

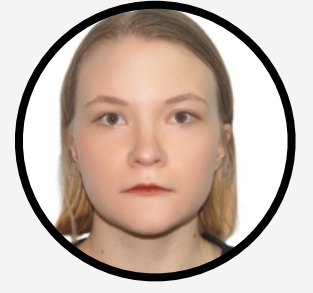
Can this variability *predict* later language acquisition?

dHCP data

Hypothesis 1:
Learning of speech sounds starts prenatally.



Pierre-Yves
Postic



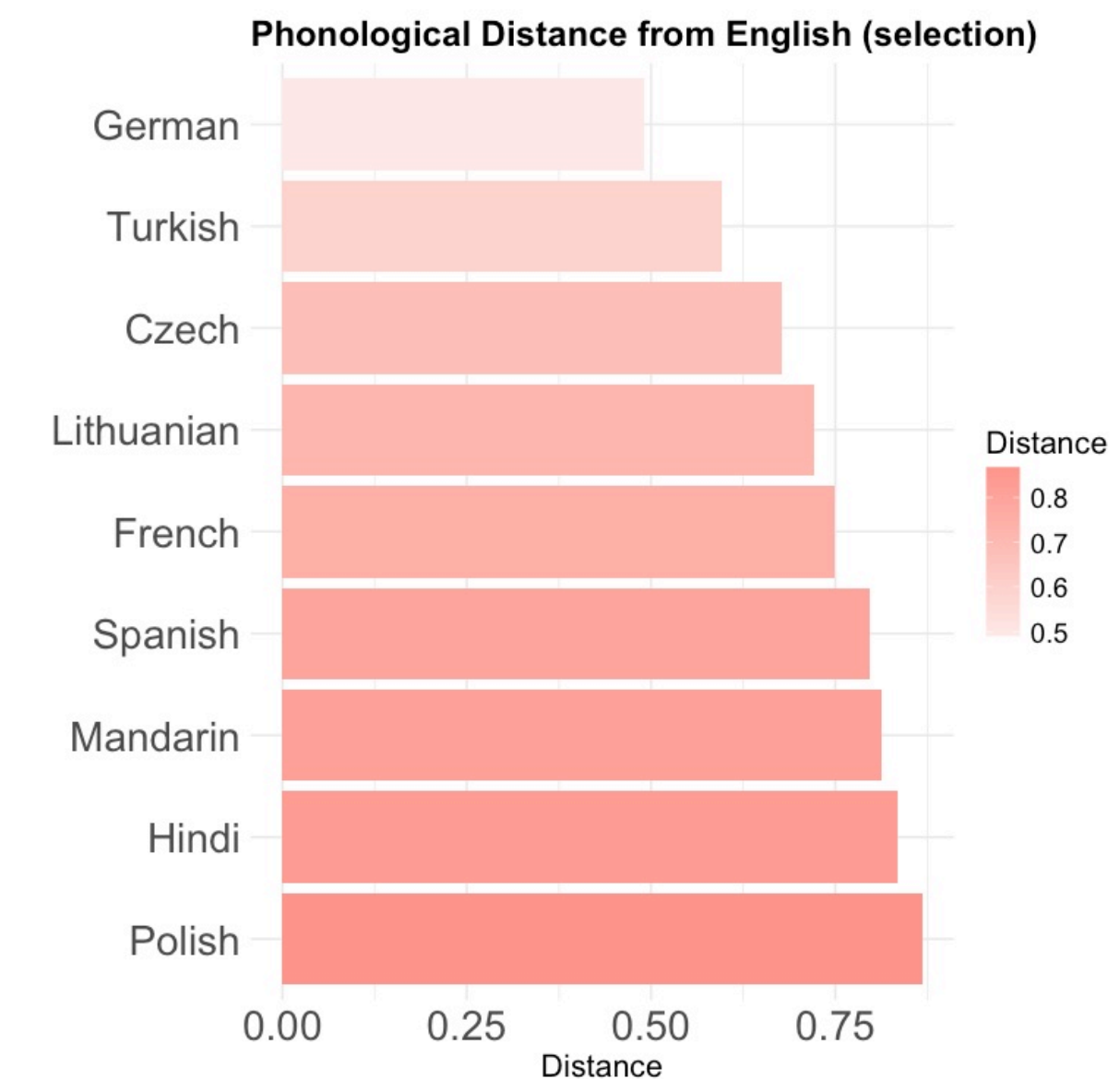
Anastasiia
Matushchak

Existing data: Developing Human Connectome



structural MRI of fetuses of monolingual and bilingual mothers
(English + $N = 29$ languages)

- Cantonese, Czech, Danish, Dutch, Estonian, French, German, Greek, Hindi, Hungarian, Italian, Korean, Lithuanian, Mandarin, Norwegian, Polish, Portuguese, Romanian, Russian, Slovak, Spanish, Swahili, Swedish, Swiss German, Tagalog, Telugu, Turkish, Turkmen, Vietnamese

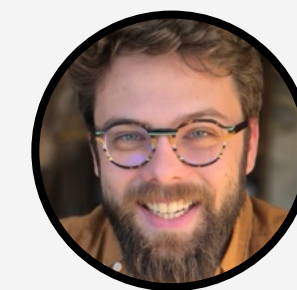


(1) Do fetuses of monolingual and bilingual mothers differ in brain structure?

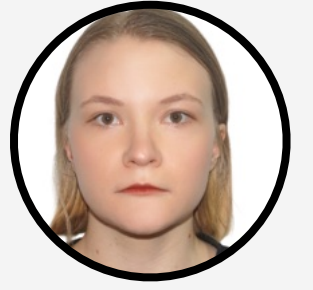
(2) Are these differences modulated by the phonological distance between the mother's L1 and English?

dHCP data

Hypothesis 1:
Learning of speech sounds starts prenatally.

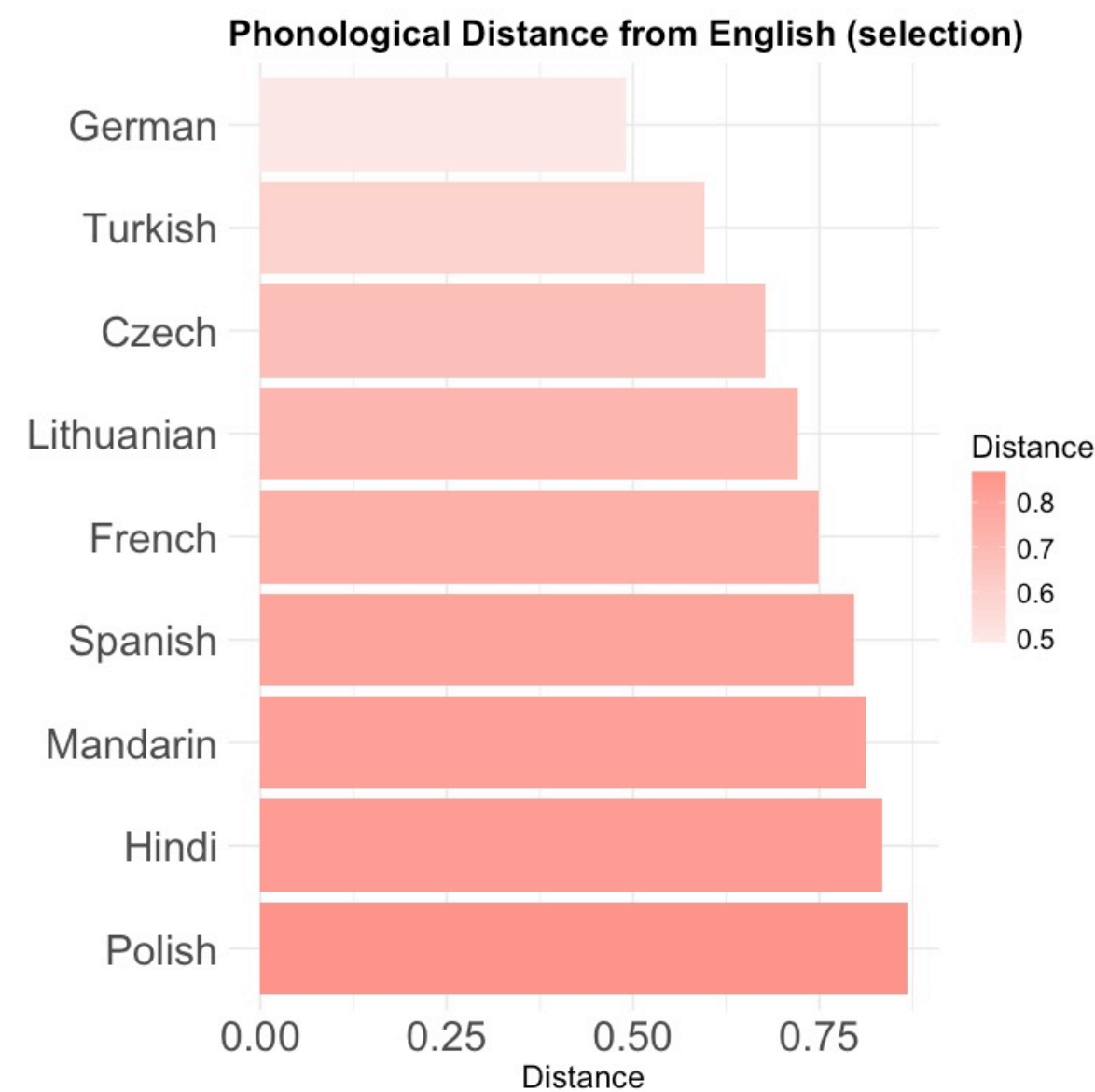


Pierre-Yves
Postic



Anastasiia
Matushchak

Existing data: Developing Human Connectome



Comparing Prosody Across Many Languages

Fred Cummins, Felix Gers, Jürgen Schmidhuber
Istituto Dalle Molle di Studie sull'Intelligenza Artificiale
Corso Elvezia 36
CH 6900 Lugano
Switzerland
{fred,felix,juergen}@idsia.ch



Stéphane
Rauzy



Amandine
Michelas

Cummins, et al. (1999)

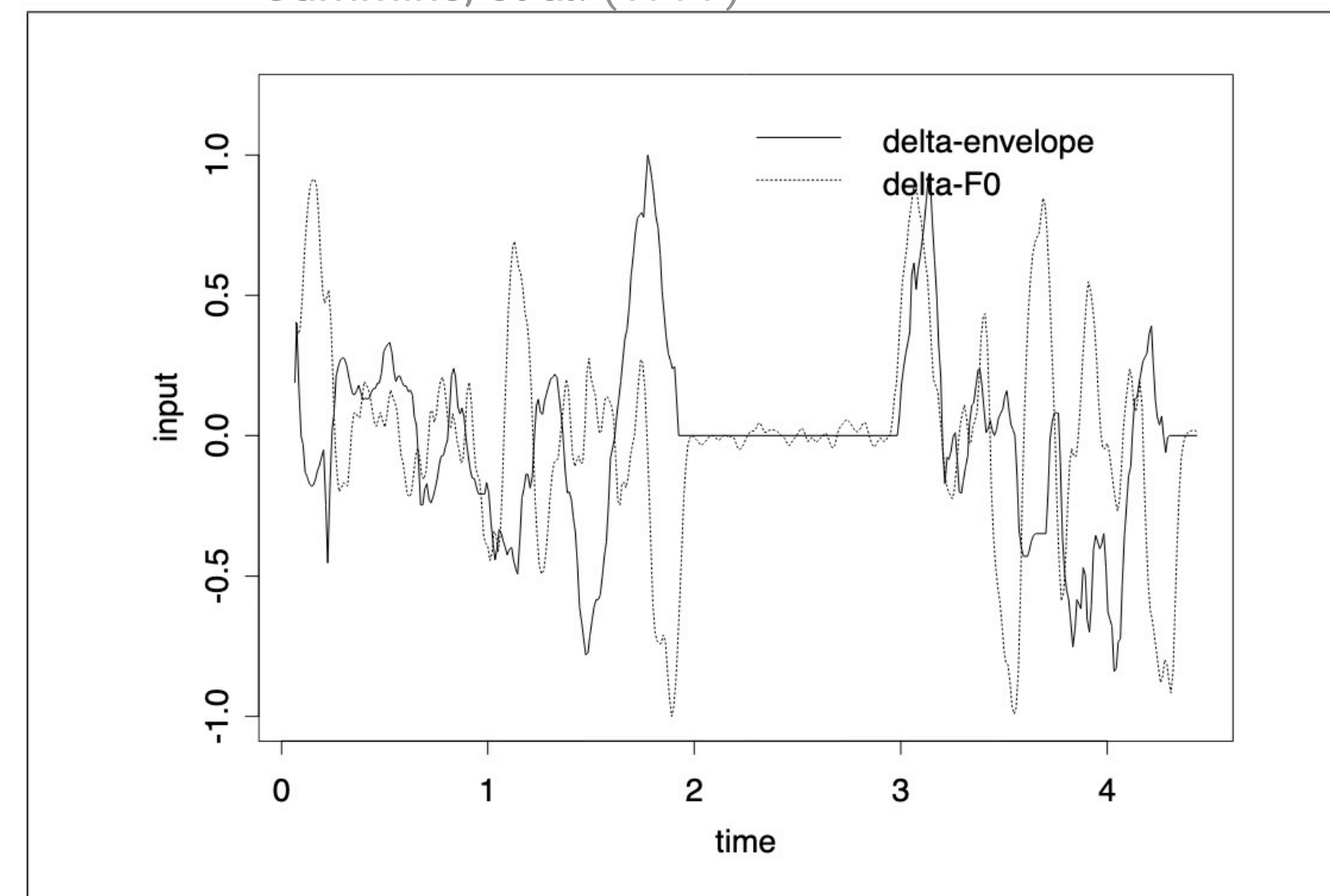
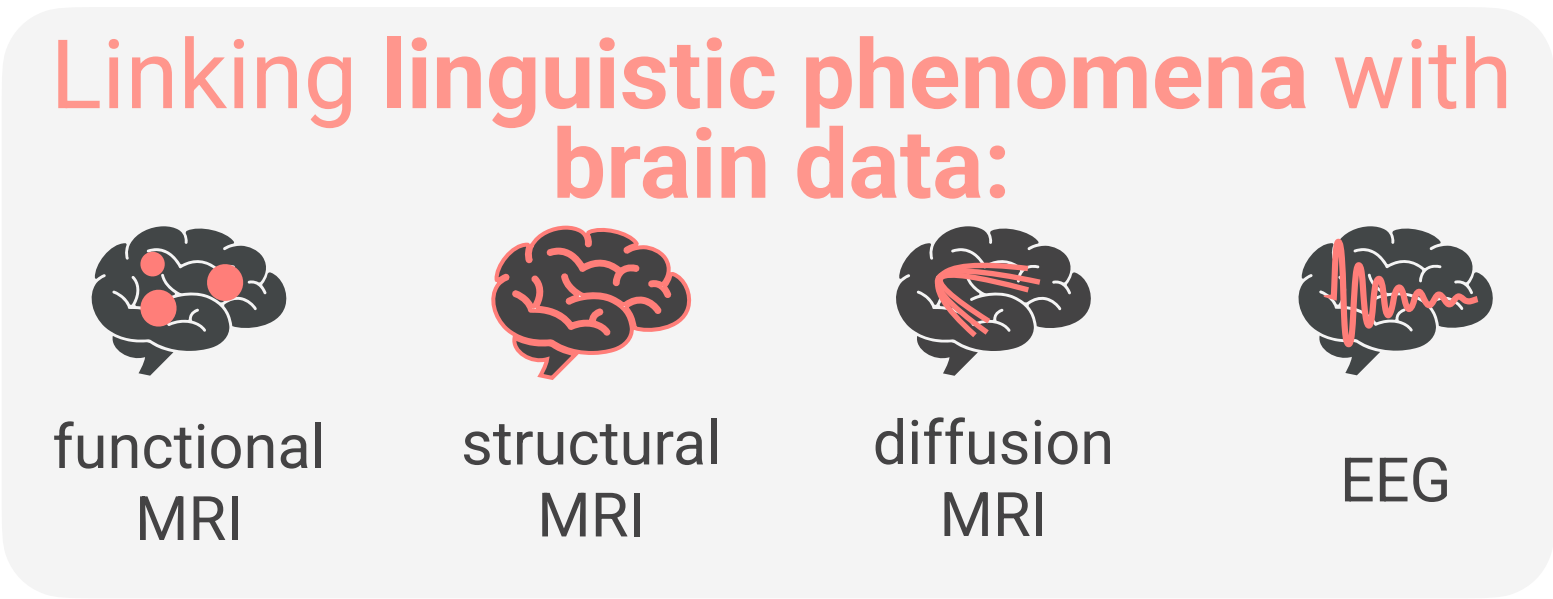


Figure 1: Network inputs for one English sound file. Solid line is the modulation of the band-limited amplitude envelope, ΔEnv , dashed line is change in F_0 , ΔF_0 .

Principal Investigator:



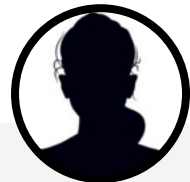
Team:



Postdoc
Dr Pierre-Yves Postic



PhD 1
TBD



PhD 2
TBD



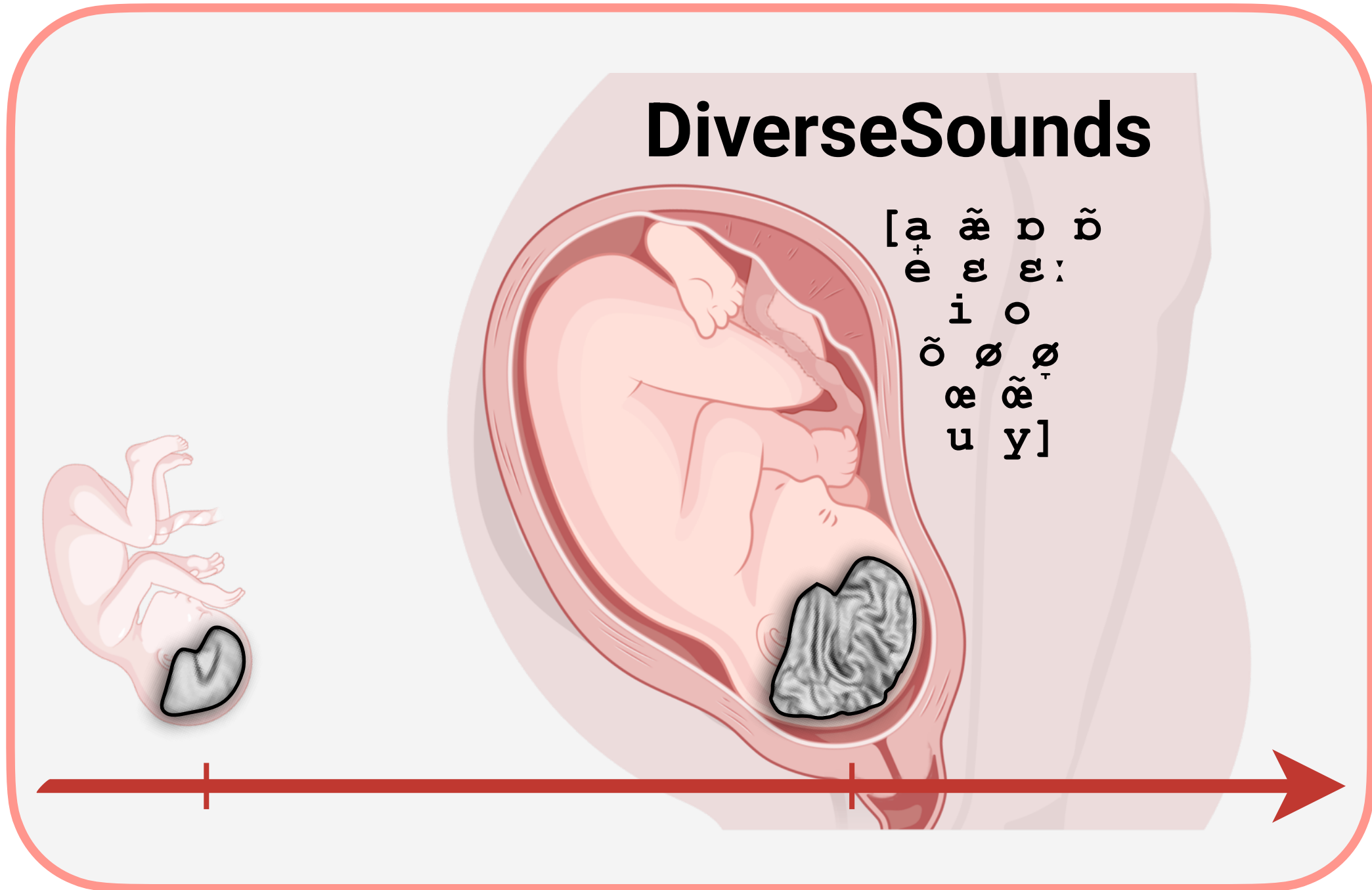
MA
Anastasiia Matushchak



prenatal clinical MRI
Dr Guillaume Auzias (INT)



infant EEG
Dr Clément François (LPL)



Advisory Board:

- Early Neurodevelopment
- Experimental Phonology
- Prenatal Auditory fMRI

Consultants:

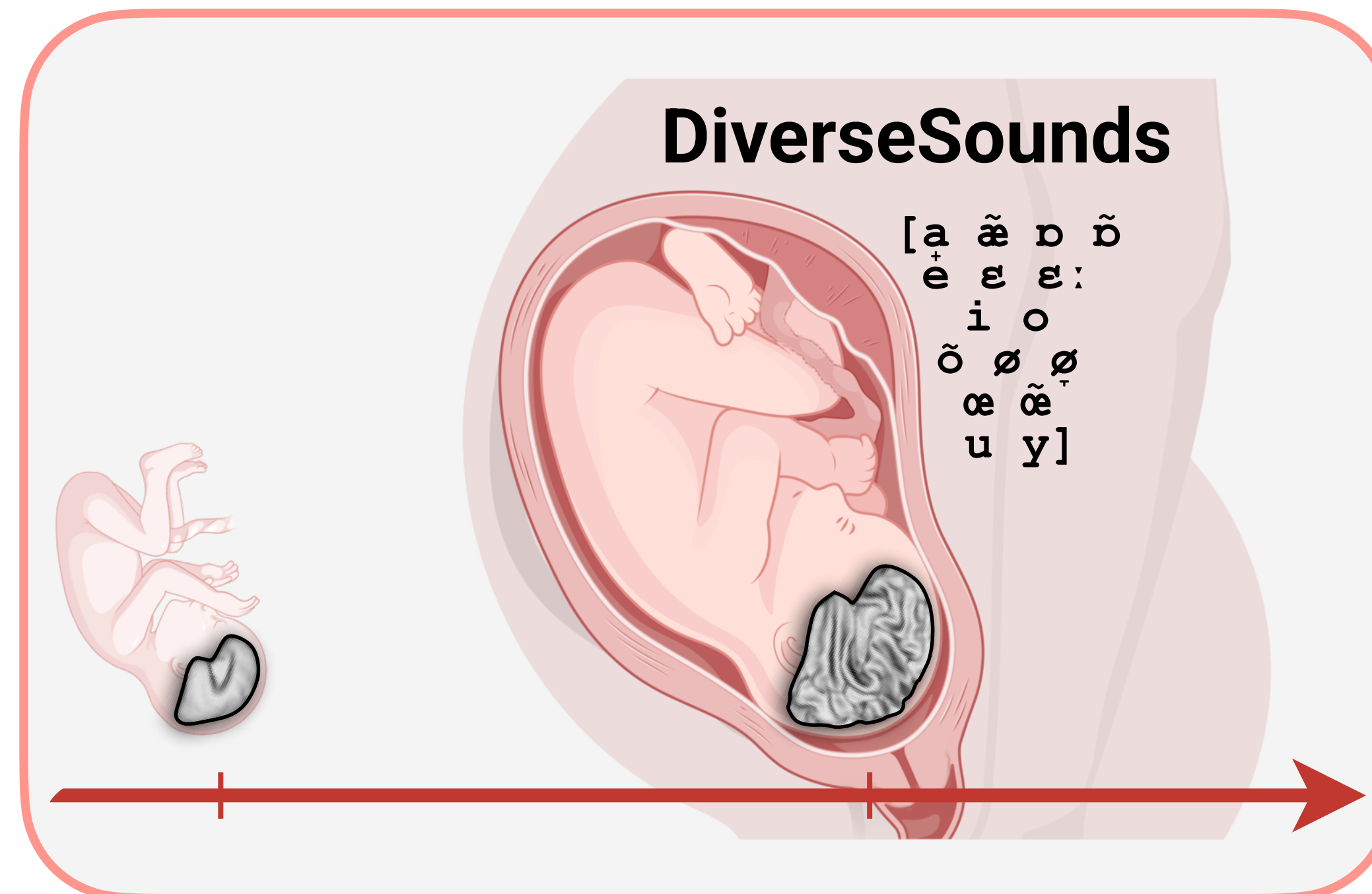
- Medical
- Ethical

Partner (APHM):

- Clinical
- Administrative

fetal MRI from Karolis, et al. (2023) OHBM

FOUNDATIONS OF LANGUAGE AND COGNITIVE DEVELOPMENT



fetal MRI from Karolis, et al. (2023) OHBM



questions ?

Thank you!

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019.181SG.006



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PI: Hoeft



SNSF
100014_182381
PI: Golestani



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Grant agreement ID: 101221485