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Localizing the sheep auditory cortex using functional magnetic resonance imaging

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The sheep auditory cortex is located in the anterior part of the posterior ectosylvian gyrus.



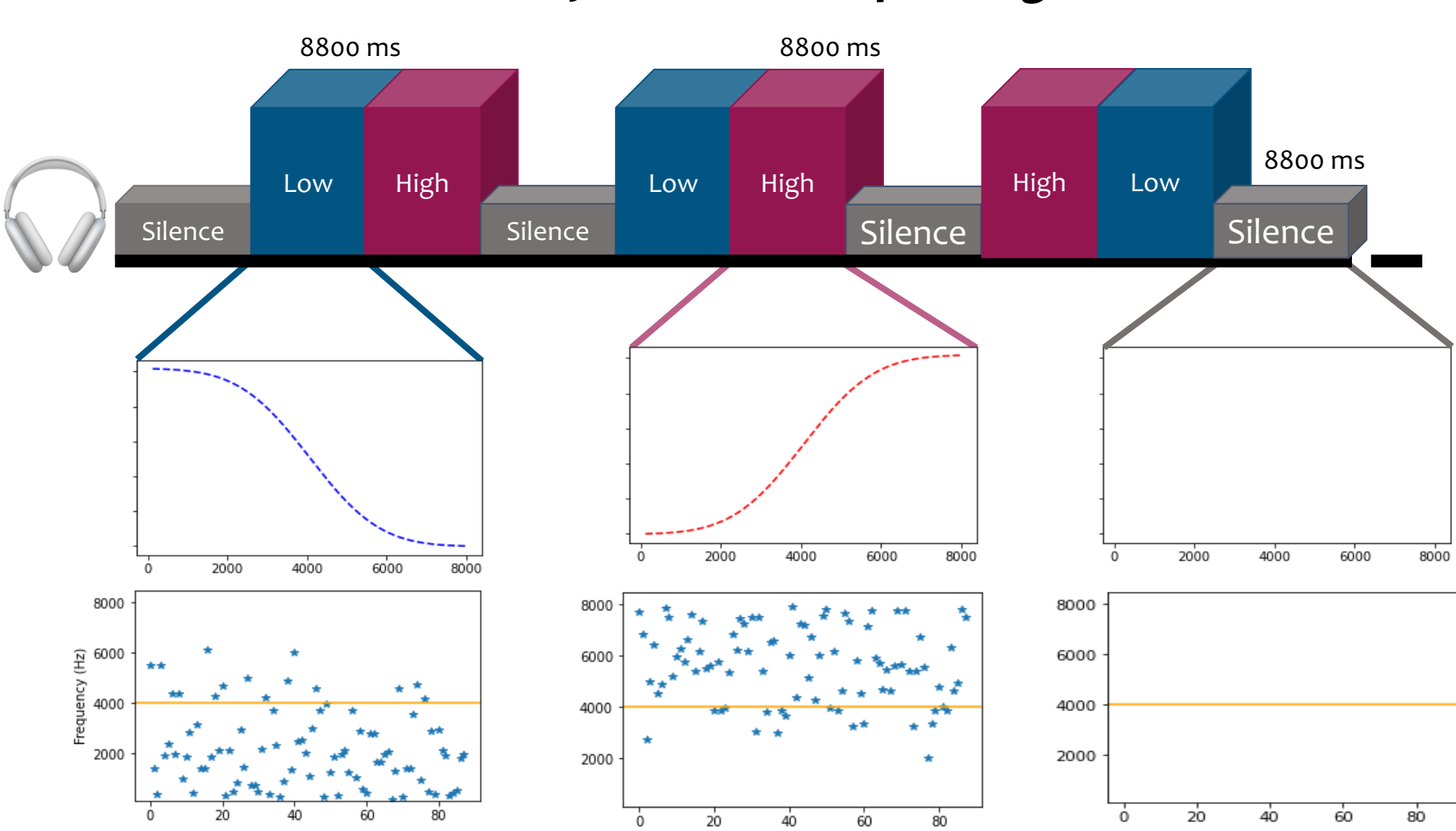
Sheep voluntarily participate in awake and unrestrained fMRI sessions.

Introduction

The precise 3D location of the sheep auditory cortex is unknown. A single neuronal tracer study highlighted that a small region of the rostral most part of the posterior ectosylvian gyrus may constitute the sheep auditory cortex (Michaloudi et al., 1986). This region received fibers from the ventral medial geniculate nucleus, which is believed to be exclusively auditory. Clearly, more evidence is required to accurately localize and understand the anatomical and functional properties of the sheep auditory cortex. To precisely map its 3D location, we use fMRI to acquire functional brain images from a group of anesthetized sheep. However, anesthesia can be detrimental to health, disrupt neurovascular coupling (Aksenov et al., 2015) and does not permit the study of higher-level cognition. Thus we also present a proof of concept that positive reinforcement training in sheep is sufficient to be able to acquire MRI of their brain.

Method

Auditory stimulation paradigm



1- Awake & unrestrained sheep

1. Step-by-step training protocol with 10 lambs (5♂ - 5♀)

→ Lying motionless on the MRI table for the minimum time required for an acquisition (~10 min)

- **Sheepfold training phase** (mock MRI table and coil, scanner noise desensitization)
- **MRI room training phase** (table movements, scanner bore, MRI coil, headphones)

2. MRI sequences

T1-weighted structural scan: TR = 2200 ms, TE = 2.64 ms, flip angle = 12°, voxel size = 1.12 mm³, TA = 2 min 36 sec

Gradient echo fieldmap: TR = 500 ms, TE = 4.92/7.38 ms, flip angle = 55°, voxel size = 1.5 x 1.5 x 2 mm, TA = 1 min 57 sec

EPI functional images: multiband acceleration factor = 2, TR = 2000 ms, TE = 40 ms, flip angle = 12°, number of slices = 40, voxel size = 1.51 mm³, number of volumes = 112, TA = 4 min 04 sec

2- Anesthetized sheep

1. Participants (2♂ - 2♀)

2. MRI sequences

T1-weighted structural scan: TR = 2200 ms, TE = 2.99 ms, flip angle = 12°, voxel size = 0.6 mm³, TA = 2 min 36 sec

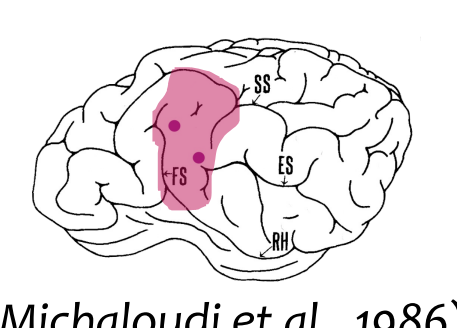
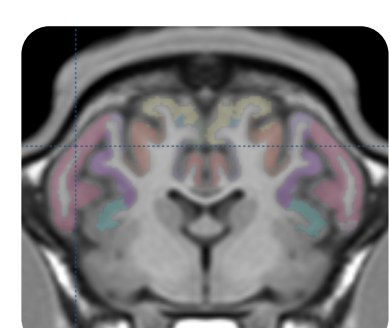
Gradient echo fieldmap: TR = 500 ms, TE = 4.92/7.38 ms, flip angle = 55°, voxel size = 1.5 x 1.5 x 2 mm, TA = 1 min 57 sec

EPI functional images: multiband acceleration factor = 2, TR = 1564 ms, TE = 35 ms, flip angle = 80°, number of slices = 40, voxel size = 1.51 mm³, number of volumes = 846, TA = 22 min 19 sec

Discussion

❖ Except for one run in an anesthetized sheep, no brain activation in response to auditory stimuli was found.

❖ The preliminary awake sheep fMRI results localize the auditory cortex similarly to the putative region proposed by Michaloudi and colleagues.



(Michaloudi et al., 1986)

LOCALIZING THE SHEEP AUDITORY CORTEX USING FUNCTIONAL MAGNETIC RESONANCE IMAGING

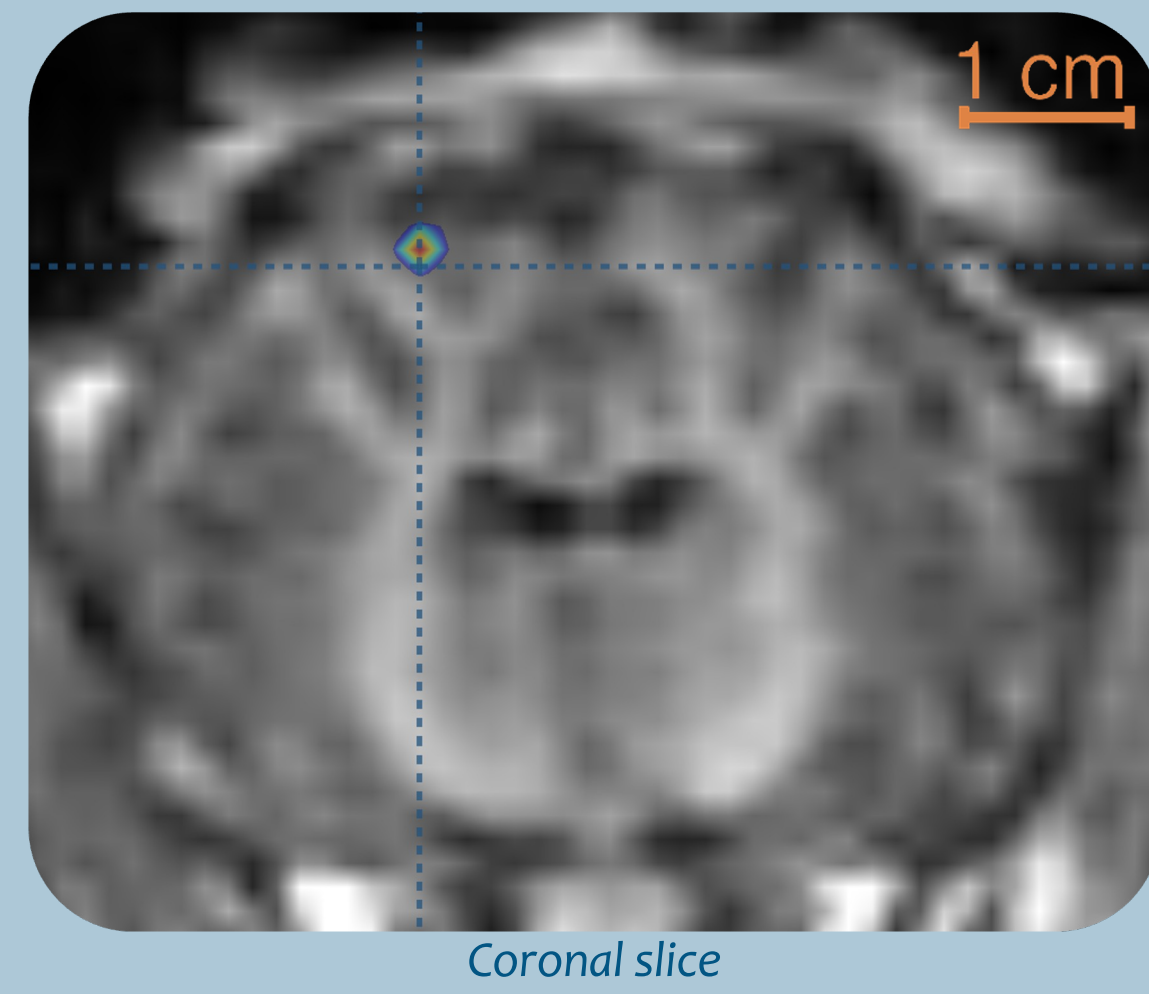
C. Pluchot¹, H. Adriaensen¹, C. Parias¹, C. Arnould¹, D. Dubreuil², O. Lasserre², K. Larose², F. Elleboudt¹, J.-N. Couet¹, E. Chaillou¹, S. Love¹

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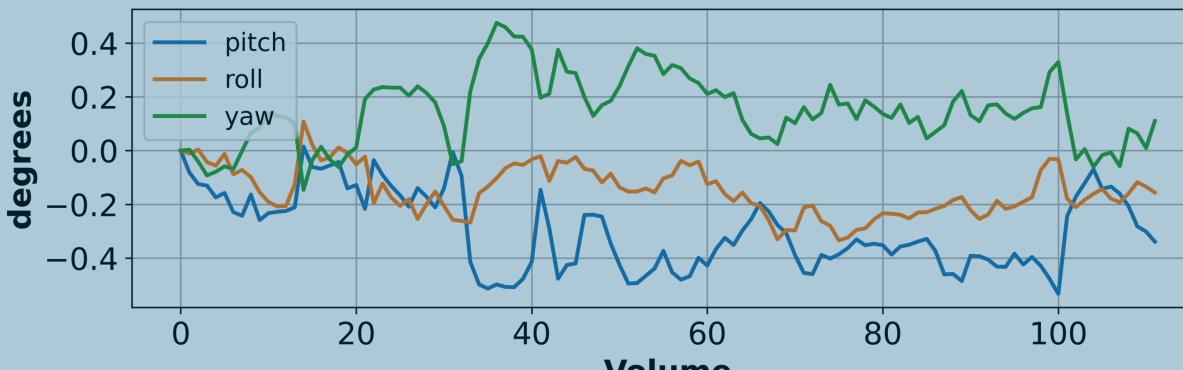
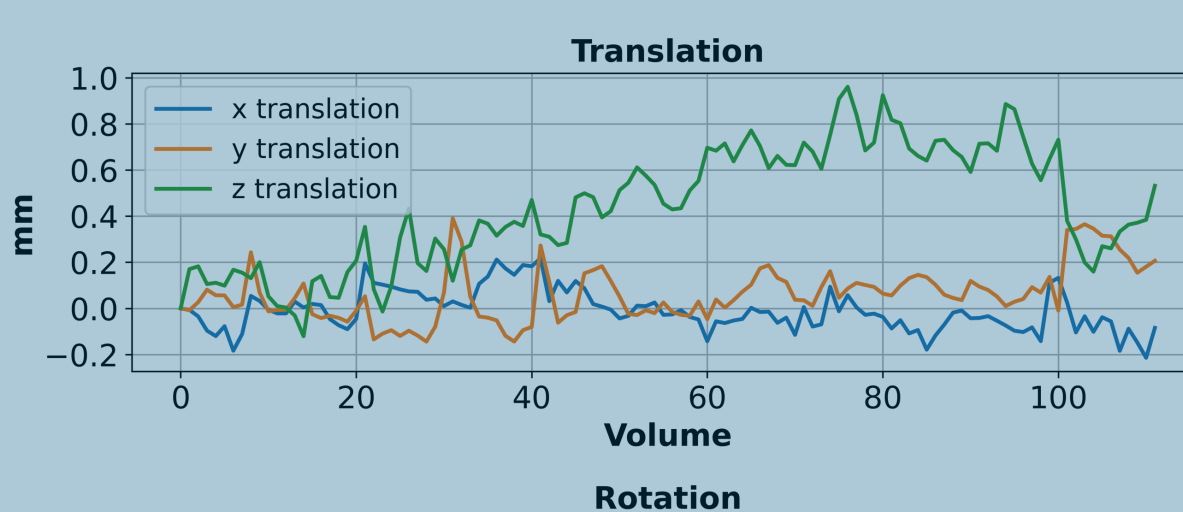
1- Awake & unrestrained sheep



LÉONARD



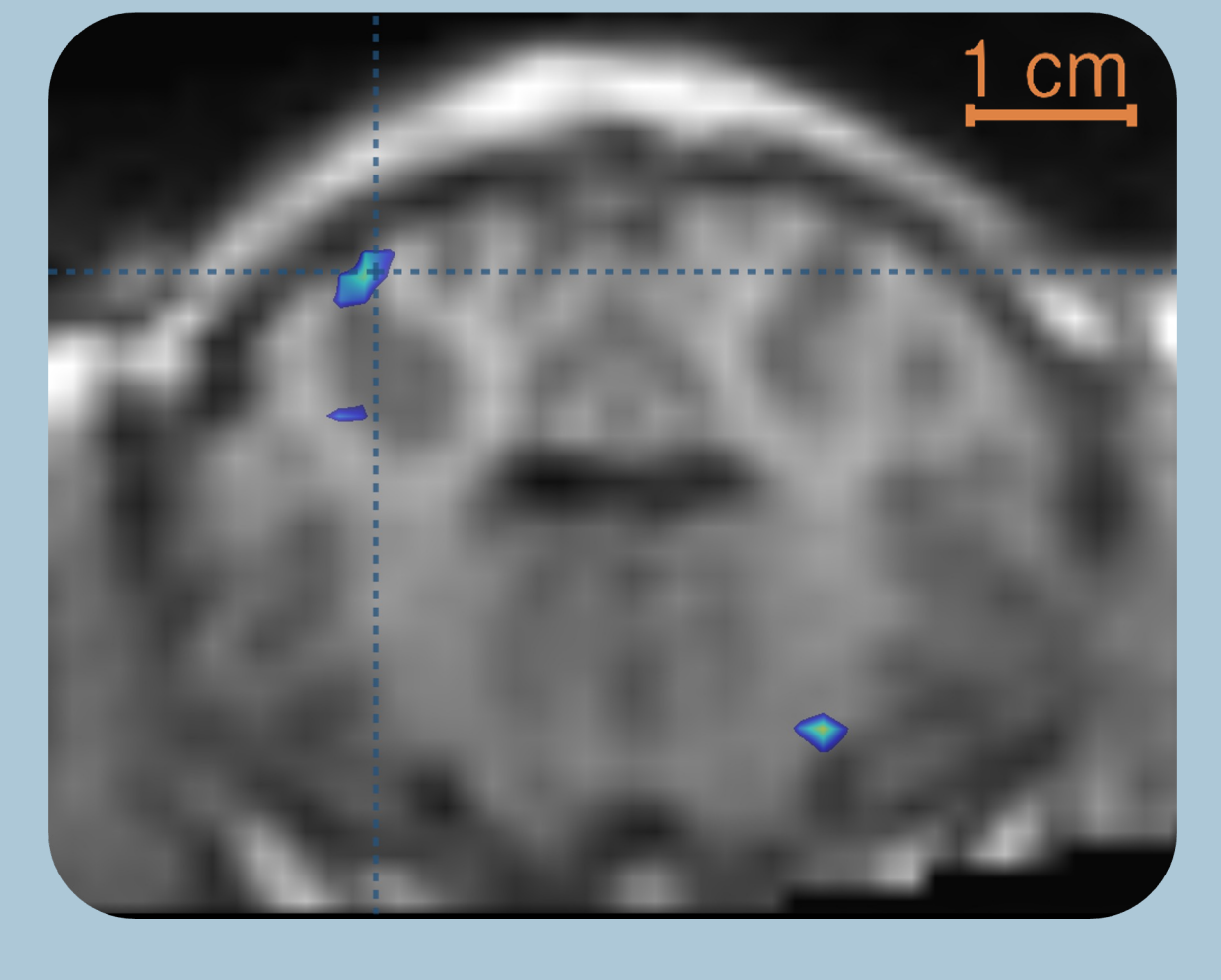
Coronal slice
T-value for sound > silence
The activation overlay is thresholded at p < 0.001 uncorrected



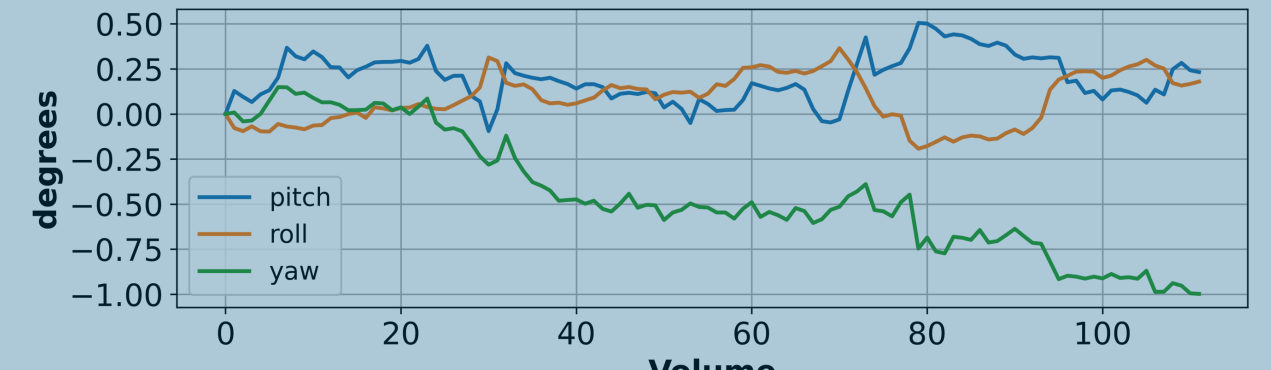
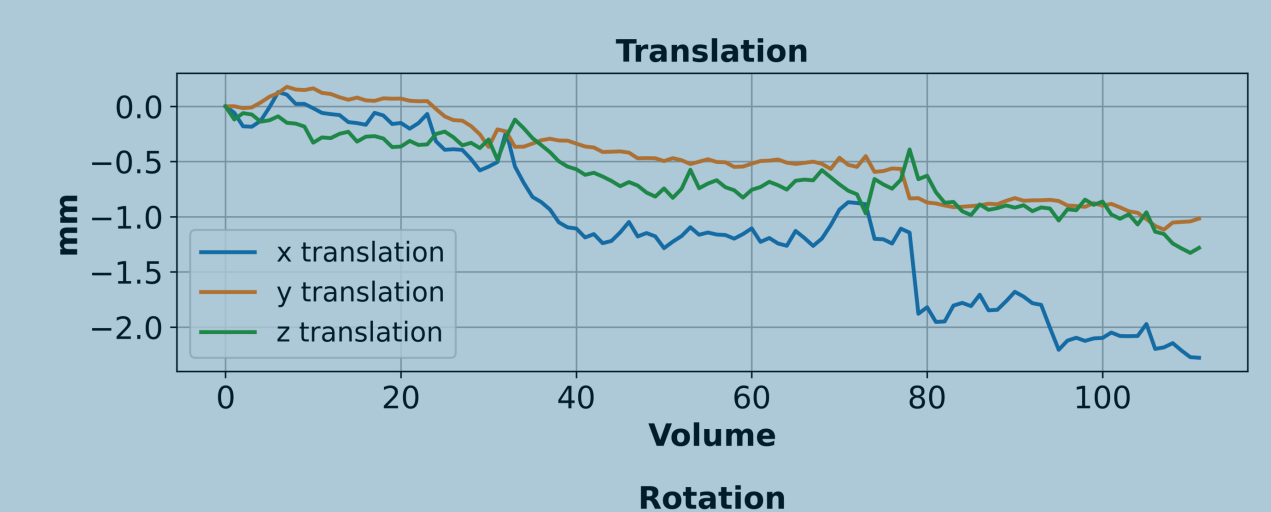
Motion parameters representing the amount of motion in each of the six directions for each volume acquired.



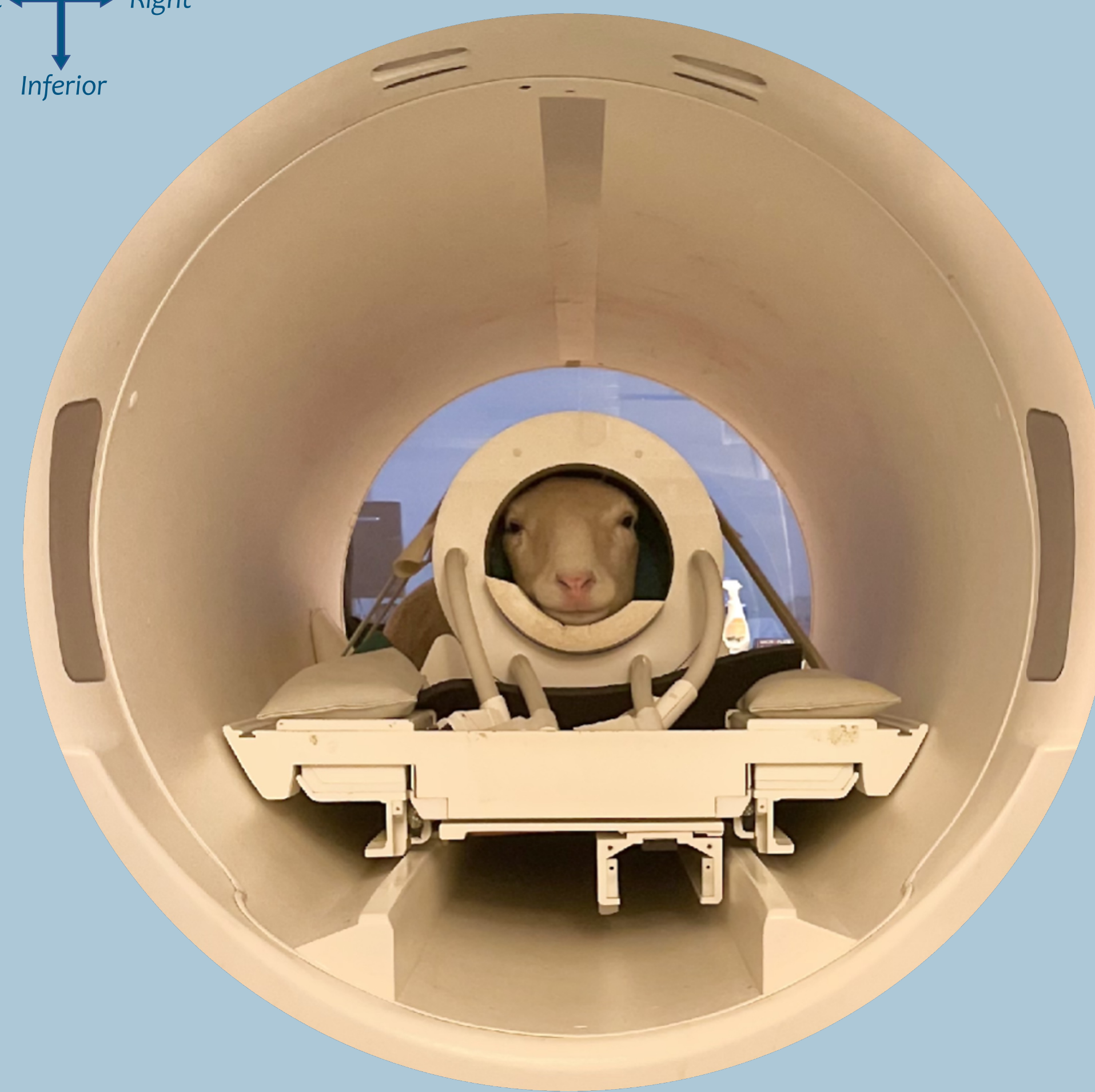
BROOK



T-value for sound > silence
The activation overlay is thresholded at p < 0.001 uncorrected



Motion parameters representing the amount of motion in each of the six directions for each volume acquired.



LAMB'S BIRTH

March 2022



GROUP SELECTION

- ❖ Male and female lamb's under artificial feeding
- ❖ Positive interactions with the lambs twice a day, 7 days a week
- ❖ New objects / Exercises [foam, ramp]

March 2022



SHEEPFOLD TRAINING PHASE

- ❖ Climb a ramp to reach the mock MRI
- ❖ Put their head inside the mock MRI coil
- ❖ Lie still on a moving table

March 2022 to September 2022



MRI ROOM TRAINING PHASE

- ❖ Accept headphones on their ears
- ❖ Put their head inside the real MRI coil
- ❖ Lie still on the moving table
- ❖ Stay motionless inside the scanner bore

September 2022 to now

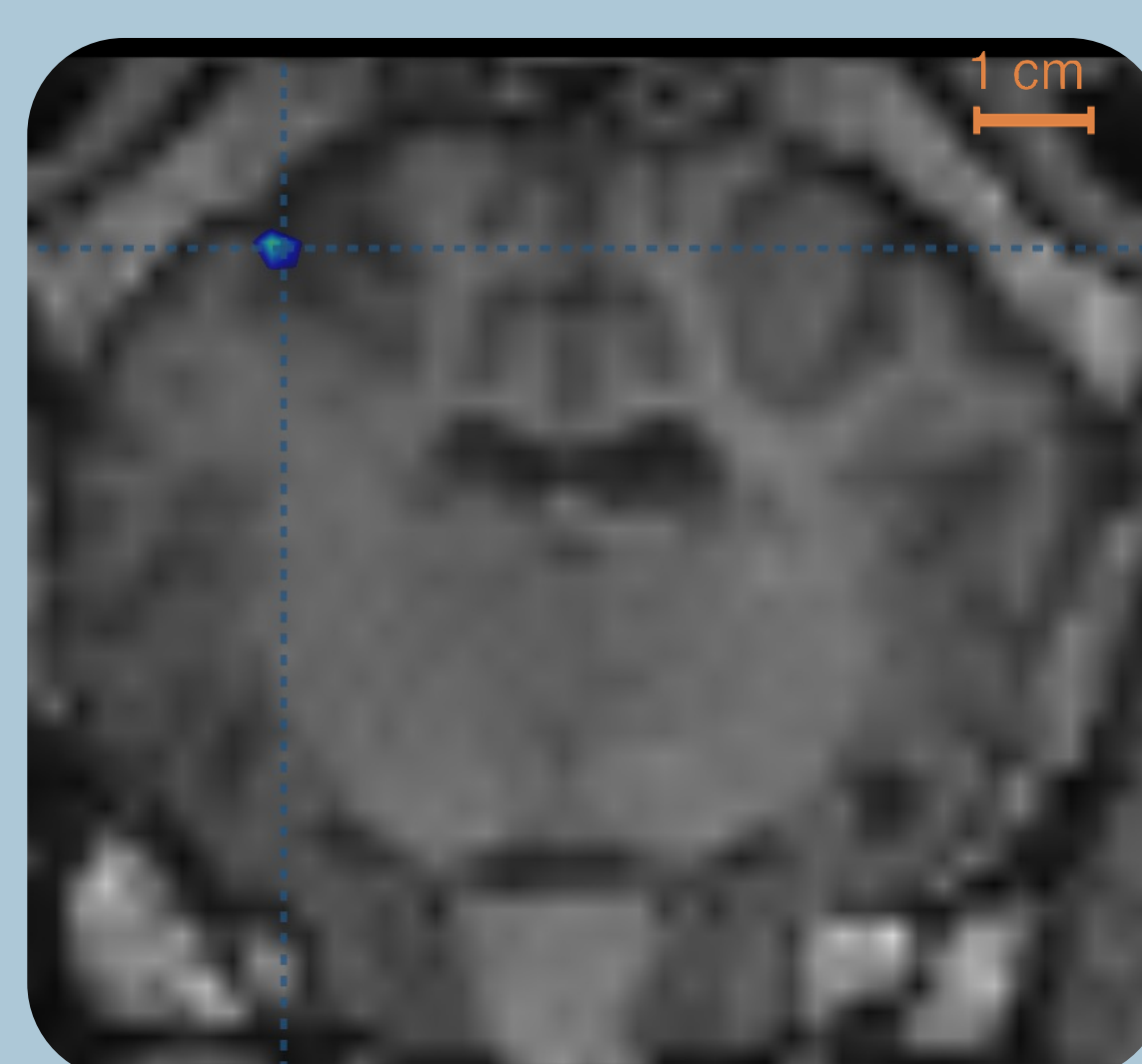
	Robin	Brook	Maggie	Ted	Léonard	Tony	Lily	Joe	Jackson	Barnita
Lie down on the table	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Wear headphones	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Head inside the coil	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Scanner bore	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Stay motionless (~10 min)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Training Progress. The different steps performed in the MRI room for each sheep
♂ : Robin, Brook, Maggie, Lily, Barnita ; ♀ : Ted, Léonard, Tony, Joe, Jackson

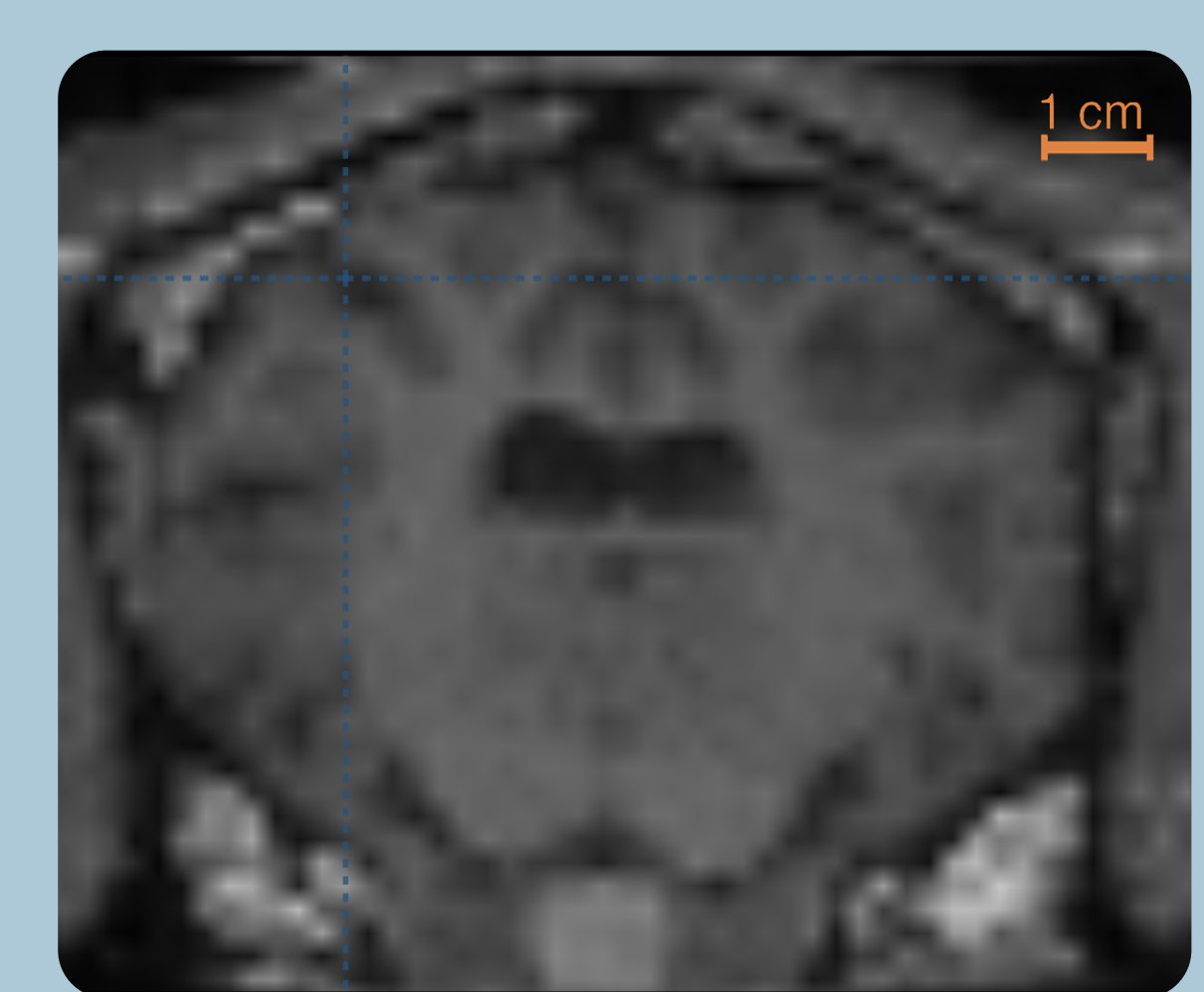
	Robin	Brook	Maggie	Ted	Léonard	Tony	Lily
LOCA (~30 sec)	✓	✓	✓	✓	✓	✓	✓
Run 1 (4 min 04)	✓	✓	✓	✓	✓	✓	✓
Fieldmap (1 min 57)	✓	✓	✓	✓	✓	✓	✓
T1 (2 min 36)	✓	✓	✓	✓	✓	✓	✓
Run 2 (4 min 04)	✓	✓	✓	✓	✓	✓	✓

Progress in MRI data collection during a single session

2- Anesthetized sheep



T-value for sound > silence
The activation overlay is thresholded at p < 0.001 uncorrected



Superior
Left Right
Inferior

Acknowledgements

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