Functional MRI of the sheep auditory cortex

Scott Love, Hans Adriaensen, Camille Pluchot, Céline Parias, Matteo Chincarini, Elodie Chaillou

RÉPUBLIQUE FRANÇAISE

Liberté
Égalité
Fraternité

INRAE

1 UMR-PRC NECOS
2 UMR-PRC PIXANIM
3 University of Teramo

Functional MRI of the sheep auditory cortex

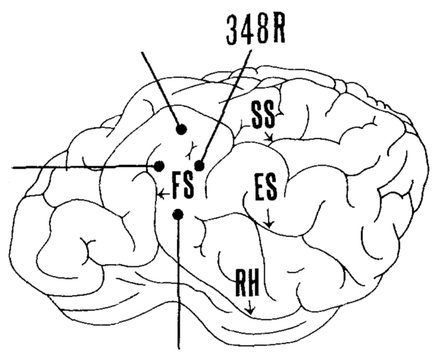
Scott Love[1], Hans Adriaensen[2], Camille Pluchot[1], Céline Parias[1], Matteo Chincarini[3], Elodie Chaillou[1]

Cognitive neuroscience has enormous potential to infer and investigate the mental lives of animals. In humans, and to lesser extents in non-human primates and rodents, functional magnetic resonance imaging (fMRI) is routinely used to infer perceptual processes, cognitive mechanisms, emotions, mental states and ultimately consciousness. With the inclusion of concepts such as "positive mental state", "expectations", and "perception" in a recent definition of animal welfare (ANSES, 2018), it is evident that cognitive neuroscience can help us understand the welfare needs of animals. Even when not investigating welfare per se cognitive neuroimaging can inform us about the perceptual and cognitive capacities and preferences of animals – determining factors of the welfare needs of a particular species or even individual (Nawroth 2019). Such knowledge would also contribute to the debate on the legal status of animals, in which cognitive capacities are an important consideration. Despite its potential impact, livestock *cognitive* neuroimaging is only at the stage of conception. Sheep use visual, olfactory and auditory cues for social communication. The neural substrates of olfactory and visual social interaction, in particular between a mother and her lamb, have been studied by cellular or electrophysiological approaches (Lévy 2017), while their auditory system remains unexplored.

Objectives

1. Provide fundamental functional and structural knowledge about the auditory sensory system of the sheep brain and in particular its social information-processing network.
2. Pioneer the use of *functional* MRI to investigate perceptual and cognitive capacities of livestock.

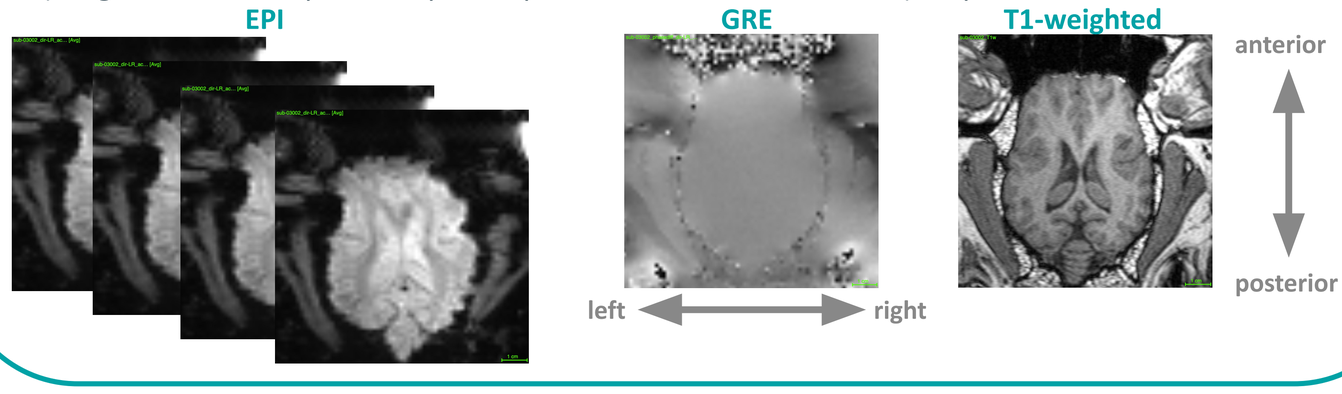
Where is the sheep auditory cortex?



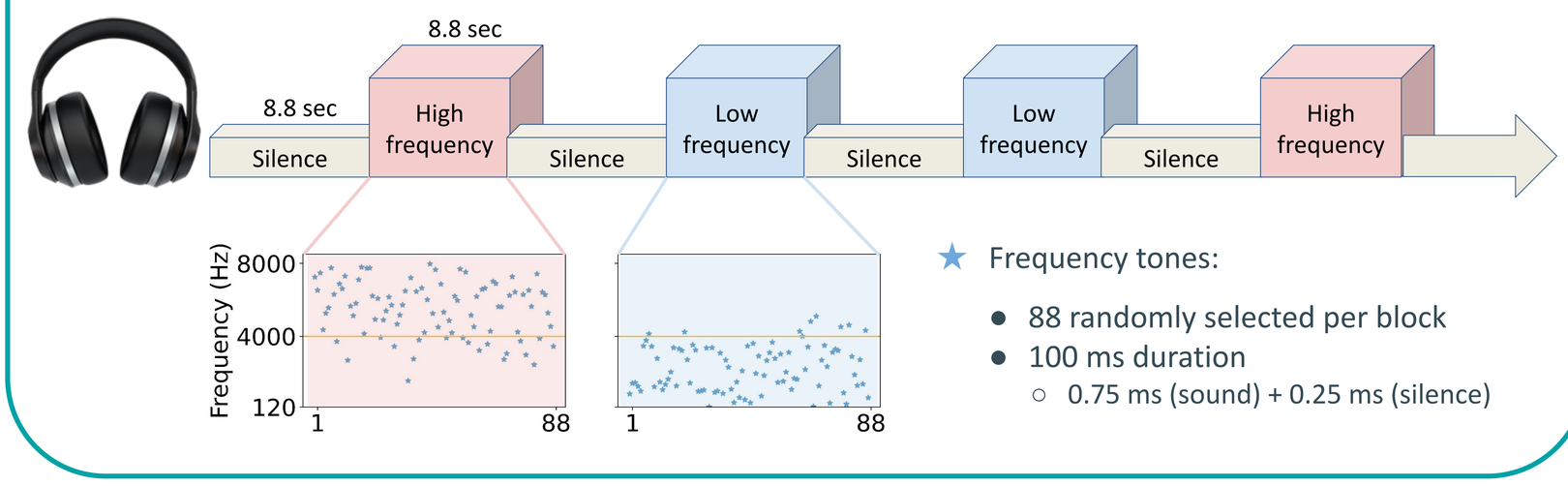
348R is our only indication of its location. It is directly connected to the Medial Geniculate Nucleus, which is thought to be exclusively auditory (Michaloudi et al 1986).
We do not know its precise 3D location!

MRI Acquisitions

- Multiband echo planar imaging (EPI) is used to measure the BOLD response ("brain function")
  - voxel size = 1.5 x 1.5 x 1.5 mm; repetition time = a whole brain image is acquired every 2 sec; echo time = 27.8 ms; Multiband accel. factor = 2
- Gradient echo (GRE) field mapping allows to correct spatial distortions present in the EPI
- Images highlighting brain anatomy (T1-weighted) are acquired with the 3D-MPRAGE (Magnetisation Prepared Rapid Acquisition with Gradient Echo) sequence



fMRI Auditory Stimulation Paradigm (an example)



★ Frequency tones:

- 88 randomly selected per block
- 100 ms duration
  - 0.75 ms (sound) + 0.25 ms (silence)

MRI With or Without Anesthesia?

- Advantages of anesthesia:
  - No time-consuming training required
  - No restraint required to prevent movement
  - Enables long duration MRI sessions
- Disadvantages of anesthesia:
  - Risks of general anesthesia
  - Not possible to record behavioral response
  - Anesthesia modifies the conscious state

Training sheep to do awake functional MRI

Objective: a small group of sheep who accept to lie still inside the MRI scanner for 5 minutes listening to sounds…

- From birth to…, **positive** interaction twice per day, 1 to 2 hours
- Step-by-step positive reinforcement training
  - physical and auditory social contact / encouragement
  - food reward
- Regular introduction of novel objects (toys)
- Diversity of trainers, clothing…
- Simulated MRI scanner - similar size, moving table…
- The MRI sound is played (sometimes) via speakers during training



Centre
Val de Loire - Nouzilly

37380 Nouzilly
Contact : scott.love@inrae.fr

Acknowledgments

Département PHASE
Platform PIXANIM
Atelier PRC
UE-PAO
ANR