Master de Sciences et Technologies
Mention Biologie Intégrative et Physiologie
Parcours : Neurosciences
Responsable : Professeur Régis Lambert

Internship Proposal
Academic Year 2018-2019

1. Host team :

Research Unit (e.g. Department or Institute) : Laboratoire des Systèmes Perceptifs
Research Unit Director : Pascal Mamassian
Research Team Director : Daniel Pressnitzer
Team name : Audition Team

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2. Internship project title:

Functional role of the ferret prefrontal cortex in attention-demanding auditory tasks

3. Internship Description :

Our brains are continuously barraged with sensory information from the environment, only a fraction of which is relevant for carrying out a given behavioral task. Often, behaviorally-useful stimuli are not the most salient ones – imagine attempting to have a quiet phone conversation with shouting nieces and nephews chasing each other around the room. In such situations, success in the task critically depends on the brain's ability to alter its representation of incoming signals by internally favoring the representation of the targets at the expense of competing distractors. The general term for such goal-oriented cognitive modification of perception is top-down attention.

While visual research had given us fundamental insights into the signature effects of top-down attention on stimulus representations [1] [2], most visual paradigms do not dissociate the subject's attention to the target location from attention directed at other features. As a consequence, attention to stimulus features other than spatial position has been little explored. In this regard, studies in the auditory modality allows us to investigate how attention directed to a given stimulus feature alters its cortical encoding. For example, in ferrets performing an auditory tone detection task, attention to the target frequency has been shown to produce real-time plastic changes in the receptive of single neurons of the primary auditory cortex, enhancing the representation of task-relevant stimuli [3]. Interestingly, these rapid task-relevant modulations of cell sensitivity depend on the difficulty of the task at hand [4], possibly indicating top-down influences involved in auditory distractor rejection. There is in agreement with evidence for functional connectivity between ferret PFC and auditory cortex: in animals engaged in auditory discrimination, a selective decrease in inter-areal coherence occurs between PFC and auditory cortical sites tuned to the target stimulus [5]. Whether that interaction has any impact on the animal's auditory perception or success in the task, however, is not known.

In this project, we thus propose to test the two following hypothesis:

(i) Does the prefrontal cortex have a causal impact on animal performance of attention-demanding auditory tasks, just as it has been shown in the visual domain?
(ii) Does the role of prefrontal cortex change with increasing task difficulty, given that attentional effects on behavior and neural activity are strongest in challenging task conditions?

To address these two research questions, we will inactivate PFC of trained ferrets by infusing muscimol, an agonist of GABAA receptors that temporarily silences neural activity, before each test behavioral session, and compare animal performance against control sessions in which saline solution is used. Animals will be tested on the task in trial blocks of varying difficulty, and behavior will be assessed in terms of reaction times and target discrimination rates in the muscimol versus the sham sessions. This will enable us to determine whether ferrets are in any way reliant for PFC activity in order to succeed in the task. Concurrent electrophysiological recordings will be performed to confirm the PFC inactivation and its effect on auditory cortex.

If pharmacological inactivation of PFC is shown to affect task performance, we will use optogenetic tools to perform temporally-precise disruptions of PFC activity at different time points in the trial, and therefore derive a more refined picture of the processes in which PFC is a key player.

The internship can be conducted indiscriminately in French or English.

References:

[1] G. G. Gregoriou, A. F. Rossi, L. G. Ungerleider, and R. Desimone, “Lesions of prefrontal cortex reduce attentional modulation of neuronal responses and synchrony in V4.,” *Nat Neurosci*, vol. 17, no. 7, pp. 1003–1011, 2014.
[2] M. Suzuki and J. Gottlieb, “Distinct neural mechanisms of distractor suppression in the frontal and parietal lobe.,” *Nat Neurosci*, vol. 16, no. 1, pp. 98–104, Jan. 2013.
[3] J. Fritz, S. Shamma, M. Elhilali, and D. Klein, “Rapid task-related plasticity of spectrotemporal receptive fields in primary auditory cortex.,” *Nat. Neurosci.*, vol. 6, no. 11, pp. 1216–1223, 2003.
[4] S. Atiani, M. Elhilali, S. V David, J. B. Fritz, and S. A. Shamma, “Task Difficulty and Performance Induce Diverse Adaptive Patterns in Gain and Shape of Primary Auditory Cortical Receptive Fields,” *Neuron*, vol. 61, no. 3, pp. 467–480, 2009.
[5] J. B. Fritz, S. V David, S. Radtke-Schuller, P. Yin, and S. A. Shamma, “Adaptive, behaviorally gated, persistent encoding of task-relevant auditory information in ferret frontal cortex,” *Nat. Neurosci.*, vol. 13, no. 8, pp. 1011–1019, 2010.