Unraveling the Neural Mechanisms of Decision-Making in Uncertain Environments: Insights from a Probabilistic Foraging Task in Mongolian Gerbils

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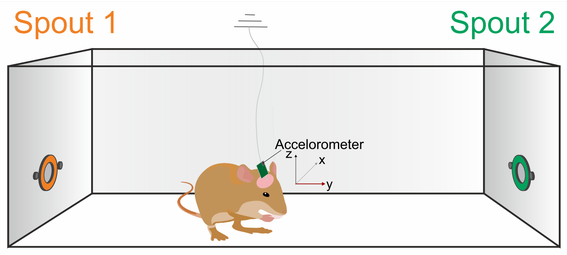
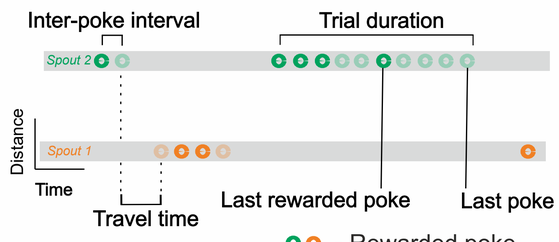
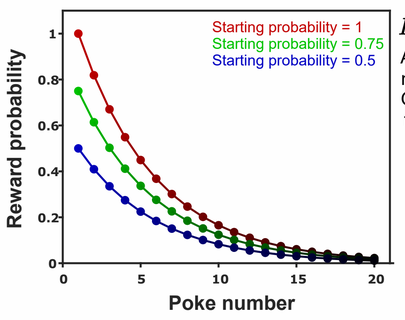
The situation - probabilistic foraging task







$P(O_n = 1|t_i) = A_i e^{-(n-1)/5}$

A_i = Starting probability (A_1 =1; A_2 = 0.75; A_3 = 0.5)
n = hit poke number
O_n = Outcome of n^{th} poke
t_i = trial type based on starting probability

★ **Different starting probabilities for reward and the subsequent exponential decrease over time imparts an exploration-exploitation dilemma to the animal**

Should I stay or should I go?

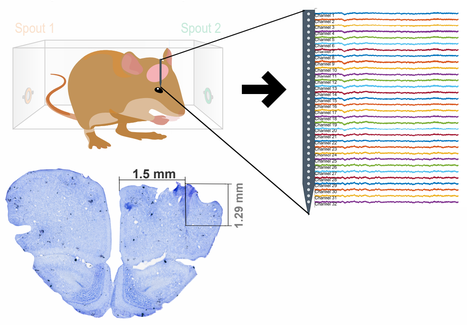
Frontal cortex shapes adaptive decision processes

How did we study this?

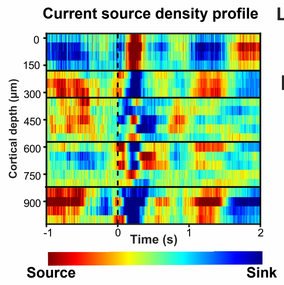
Chronic laminar recordings from Frontal field A (Bregma: 4.65 mm; ML: 1.5 mm) (N = 5 animals)

Pre-processing
Artefact correction
Channel rectification

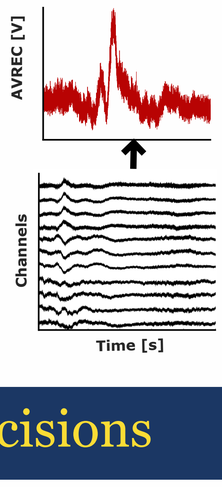
Local field potential (LP)



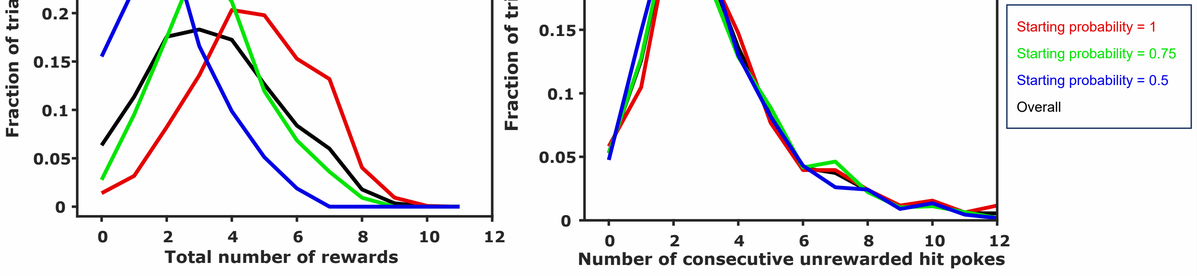
Channel layer specification



Average Rectified Signal (AVREC)

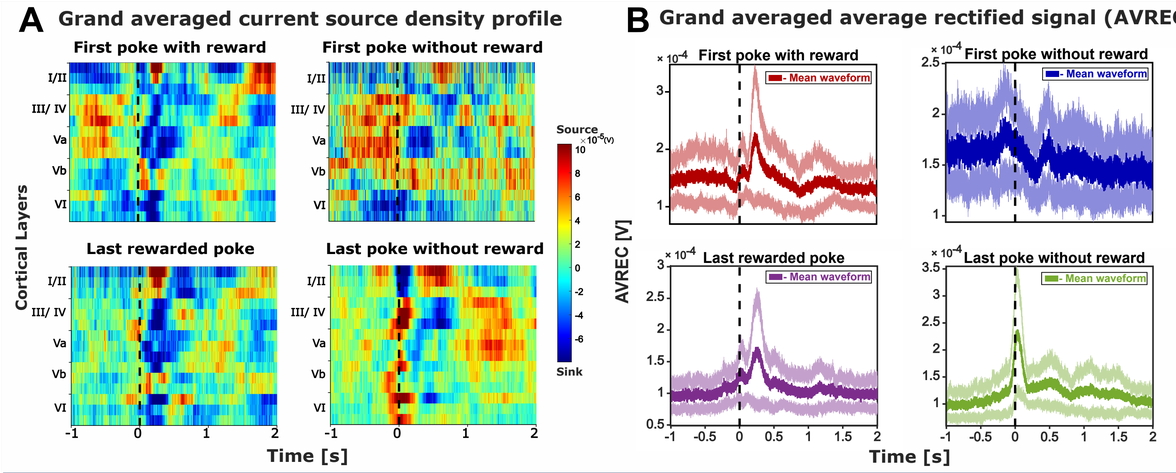


Animals make inference-based decisions



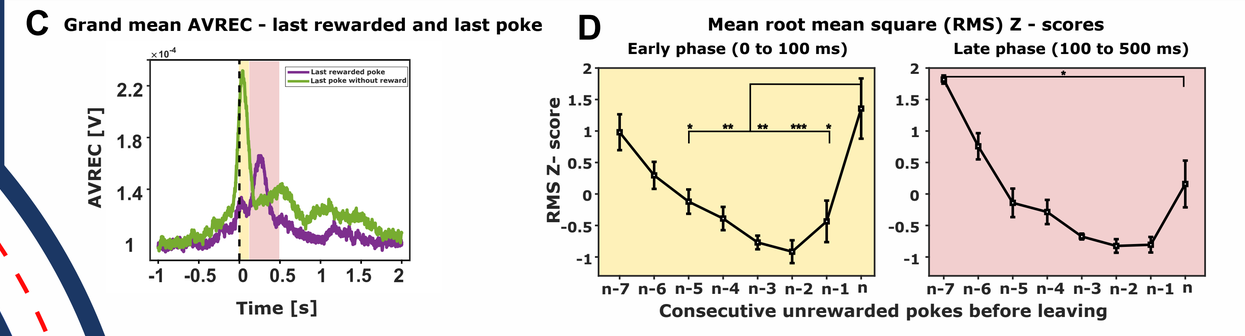
★ **Number of consecutive unrewarded pokes before leaving is independent of starting reward probability and total number of rewards received in a trial**

Distinct motor- and reward-related frontal activity



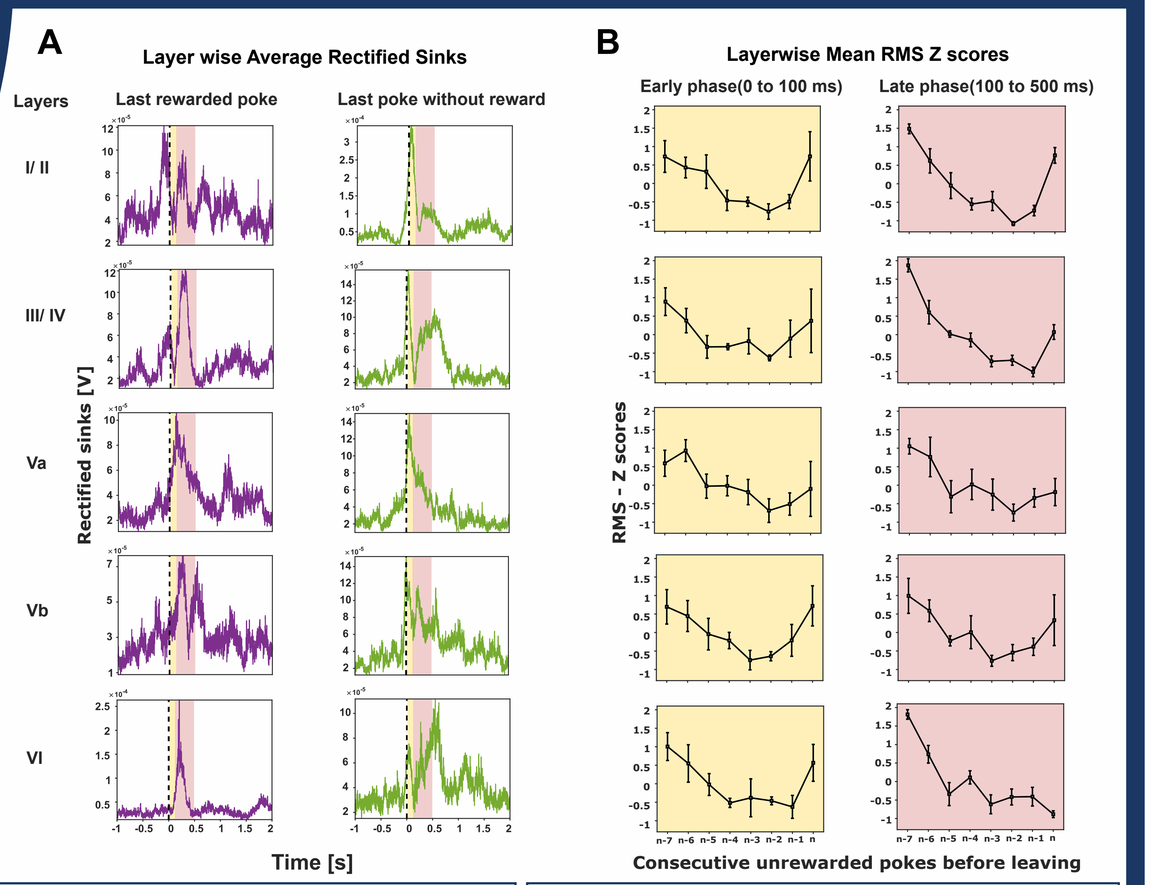
★ **Distinct neural representations within frontal field A encode both the poke and the ensuing reward**

★ **Frontal field A encodes heightened neural activity solely during the last poke without a reward**



★ **A sharp RMS spike distinguishes the last poke in the early phase, setting it apart from the preceding unrewarded pokes**

Layer-specific frontal motor- and reward-related activity



★ **The neural transition from deeper to superficial layers might effectively communicate to the animal that the current spout has exhausted its rewards, thereby altering its current expectations**

★ **A sharp RMS spike for the last poke in layer I/II during the early phase might reinforce the neural transition, prompting a seamless behavioral shift from exploitation to exploration**

Conclusions & perspectives

Conclusions

- **Probabilistic foraging** in the Mongolian gerbil can be used to investigate the **role of frontal cortex** in **exploration/exploitation dilemma** and attentional resource allocation
- **Cortical layers** in frontal cortex seem to play a **decisive role** to integrate current reward expectation and adequate search strategies

Perspectives

- **Reinforcement Learning Modeling** can help to investigate the trial-by-trial parameters, that underlie animal's **inference-bound adaptive decision-making behavior**, providing insights into the neural circuitry of attentional resource allocation

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