Decision-making can become challenging, particularly in situations that lack certainty. Making the best decisions often requires understanding past events and engaging in intricate statistical calculations. However, in constantly changing environments with limited information, we are required to adapt and adopt a set of simplified rules that help us reduce the complex task of assessing probability and deriving predictions into simpler judgmental operations. Although researchers have explored various behavioral experiments in humans to determine the impact of using these simplified rules in decision making under uncertainty [ref], there is limited knowledge regarding their implementation in the brain. Therefore, the objective of this study is to examine the neural mechanisms underlying the decision-making process in uncertain situations using an animal model.

To study this, we used data from Mongolian gerbils performing a probabilistic foraging task (adapted from Lottem et al). Here, the the gerbil is put in an exploitation/exploration dilemma: Should it exploit the current spout further or should it explore an alternative spout, suffering travel costs but achieving potentially higher food density? The patch-leaving decision needs to be made based on probabilistic information (how much food is usually available in the alternative patch?) in a potentially changing environment (reward probability). This situation, in addition to imposing a decision uncertainty also requires the animal to adaptively reallocate resources at the cortical level in order to shift from exploitation to exploration and vice versa. Previous studies have suggested that the anterior prefrontal cortex (aPFC) plays a decisive role as for the neuronal realization of exploratory resource allocation in human and non-human primates (*Daw et al., 2006*). Hence, in this study, we used in vivo laminar recordings from the Frontal field A (FrA) of Mongolian gerbils using 32 channel chronic electrodes (Neuronexus probes).

The current source density (CSD) profiles from the FrA revealed distinct poke (task/event) and reward related cortical activity. Further, the AVREC RMS from the CSD show a continuous build-up of evidence through increasing cortical activity before the switch to exploration, as modelled by random walk models (Gold & Shadlen, 2007). Furthermore, layer specific analysis revealed a strong recruitment of infragranular and supragranular layers in the FrA that correlates with exploitation and exploration behaviour respectively. Our results show first evidence in rodents that the choice between exploitation or exploration strategies is differentially orchestrated by the FrA neural circuitry in a layer-dependent manner, thereby gaining a better insights of the neural mechanisms underlying the decision-making process in uncertain situations

Major results

1. Distinct poke (task/event) and reward related cortical activity is seen in the FrA from the AVREC analysis.
   1. Exploitation phase (first poke to last reward poke) – low cortical representation of the task (poke) and high cortical representation of consequence of the task (reward and reward prediction error)
   2. Exploration phase (last reward poke to last poke) – high cortical representation of the task (poke) along with cortical representation of the consequence of the task (reward prediction error).
2. The AVREC RMS from the CSD show a continuous build-up of evidence before the switch to exploration
3. Greater activation of infragranular and supragranular layers in the FrA correlates with exploitation and exploration behaviour respectively

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Decision-making can be challenging when faced with uncertain situations. Optimal decision-making typically involves understanding past events and complex statistical computations. However, in constantly changing environments with limited information, we rely on simplified rules to make judgments about probabilities and predictions. While researchers have investigated the impact of these simple heuristic approach on decision-making through different behavioural experiments, little is known about how they are implemented in the brain. Therefore, our study aims to explore the neural mechanisms involved in decision-making under uncertainty using an animal model.

We utilized data from Mongolian gerbils engaged in a probabilistic foraging task (*adapted from* Lottem et al., 2018*, Nat Comm.*). The task presented the gerbils with an exploitation/exploration dilemma, where they had to decide whether to continue exploiting a current food source or explore an alternative source, suffering travel costs but benefit from potentially higher food density. This decision required the gerbils to consider probabilistic information about food availability in a changing environment. Additionally, at the cortical level, the task necessitated adaptive resource allocation, switching between exploitation and exploration. Previous studies showed the decisive role of the frontopolar cortex in humans during exploratory decisions in gambling (Daw et al., 2006). Based on this, in our study, we chronically recorded from the anterior frontal field A (FrA) of gerbils with laminar multielectrode, while gerbils perform the probabilistic foraging task.

Analysis of the current source density (CSD) profiles from the FrA revealed distinct cortical activity related to task (pokes) and rewards. The root mean square (RMS) of the CSD's average rectified signal showed a gradual increase in cortical activity before the switch to exploration, consistent with random walk models of evidence accumulation (Gold & Shadlen, 2007). Moreover, layer-specific CSD profiles demonstrated the selective recruitment of infragranular and supragranular layers in the FrA, correlating with exploitation and exploration behaviors, respectively. Our findings provide the initial evidence in rodents that the FrA neural circuitry orchestrates the choice between exploitation and exploration strategies in a layer-dependent manner, shedding light on the neural mechanisms underlying decision-making in uncertain situations.