Spectral Biomarkers of Spatial Memory Encoding in the Non-human Primate Hippocampus

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Highlights

- Rhesus macaques were trained to navigate an immersive 3D virtual environment to perform a spatial memory task.
- One monkey was implanted with electrode arrays containing 36 recording channels spanning the anterior-posterior axis of the hippocampus.
- Local field potentials (LFPs) were recorded from chronically implanted polyimide-based arrays (IMTEK/CorTec GmbH, Freiburg, Germany) in the right hippocampus of a rhesus macaque. LFPs were recorded using the Cerebus® Neural Signal Processing System from Blackrock Microsystems (Salt Lake City, UT).
- Power modulations across frequency bands during navigation were observed at each recording location, and were most prominent in the posterior hippocampus. This is consistent with previous research revealing functional differences along the long axis of the primate hippocampus related to navigation and spatial memory, similar to that seen in rodents.
- The use of a virtual navigation task in monkeys provides a means of investigating neural activity related to spatial memory in the primate medial temporal lobe.
- Power modulations across frequency bands during navigation were observed at each recording location, and were most prominent in the posterior hippocampus. This is consistent with previous research revealing functional differences along the long axis of the primate hippocampus related to navigation and spatial memory, similar to that seen in rodents.
- We found evidence for modulations in cross-channel synchrony at multiple frequencies throughout the encoding period, suggesting that interventions which enhance network connectivity may potentially improve spatial memory.

Introduction

- Evidence from rodents suggests that spatial memory is supported by neural activity in the hippocampal formation.
- Our lab has shown evidence for enhanced theta- and gamma-band activity in the hippocampus associated with successful encoding in a visual recognition memory task (Jutras et al., 2009, 2013).
- Previous research has drawn attention to potential functional differences along the long axis of the hippocampus in both rodents and primates (Strange et al., 2014); this research suggests that the dorsal hippocampus in rodents, or the posterior hippocampus in primates, may have a relatively greater contribution to processes involved in navigation and spatial memory.
- The ability to record simultaneously from multiple locations along the long axis of the hippocampus allows for the examination of differences across, and interactions among, different anterior-posterior regions during navigation and memory formation.

Virtual Water Maze

The monkey is trained to use a joystick mounted inside the primate chair to navigate through a virtual environment, obtaining reward for navigating to specific targets in the environment. The virtual environment is controlled using PandalPL (Solway et al., 2013) as well as additional programming in Panda3D. The joystick’s interaction with the virtual environment is handled by PyGame.

Array A: all trials

Array B: all trials

LFP power is modulated during spatial encoding

Local field potentials (LFPs) were recorded from chronically implanted polyimide-based arrays (IMTEK/CorTec GmbH, Freiburg, Germany) in the right hippocampus of a rhesus macaque. LFPs were recorded using the Cerebus® Neural Signal Processing System from Blackrock Microsystems (Salt Lake City, UT).

Cross-channel coherence during encoding predicts successful recall

Above: time-averaged coherence during the 5-second encoding period for two example A-C electrode pairs, showing higher theta-band (left) or gamma-band (right) field-field coherence during good memory encoding than during poor memory (n = 68 trials per condition). Shaded area: SEM.

Conclusions

- The use of a virtual navigation task in monkeys provides a means of investigating neural activity related to spatial memory in the primate medial temporal lobe.
- Power modulations across frequency bands during navigation were observed at each recording location, and were most prominent in the posterior hippocampus. This is consistent with previous research revealing functional differences along the long axis of the primate hippocampus related to navigation and spatial memory, similar to that seen in rodents.
- We found evidence for modulations in cross-channel synchrony at multiple frequencies throughout the encoding period, suggesting that interventions which enhance network connectivity may potentially improve spatial memory.

References


Spatial memory assessed using excess path length

Excess path length was calculated as the ratio of the actual path taken to the shortest possible path, during the retrieval phase. Performance factor is the excess path length for each trial, normalized by the maximum excess path length, subtracted from 1.

Acknowledgments

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