Hierarchical gradients in prefrontal cortex and hippocampus support context-dependent rule learning

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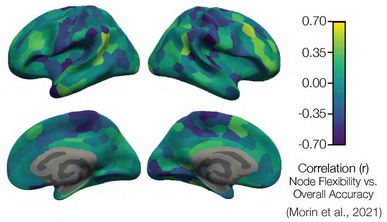
Background

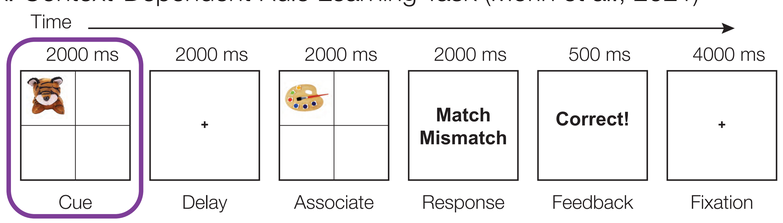
- The human hippocampus exhibits an anterior-posterior gradient organization when retrieving hierarchical rules (Brown et al., 2021).
- Prefrontal cortex is organized along a rostro-caudal axis with rostral regions important for incorporating abstract information and caudal regions implementing immediate motor actions (Badre & Nee, 2018).
- Previously, we showed that a more stable ventral attention network and more flexible cognitive control network support the formation of rule representations in successful learners (Morin et al., 2021).



We propose that a hierarchical functional connectivity gradient between the hippocampus and prefrontal cortex emerges as context-dependent rules are learned.

Methods

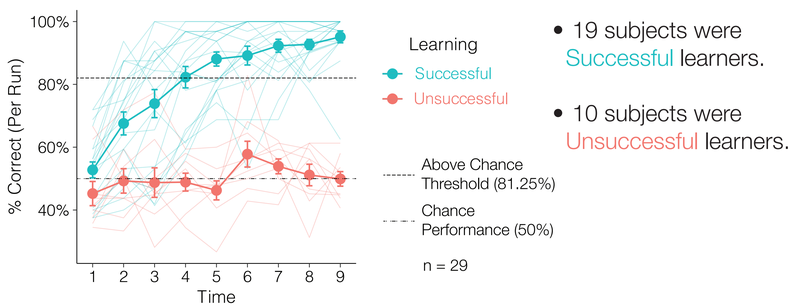
A. Context-Dependent Rule Learning Task (Morin et al., 2021)



B. Context-Dependent Rule Structure

- Subjects attempted to learn the context-dependent rules across nine scanning runs.
- We used a beta-series correlation to calculate seed-based functional connectivity during each task period.
- Results shown on this poster are from the Cue Period.

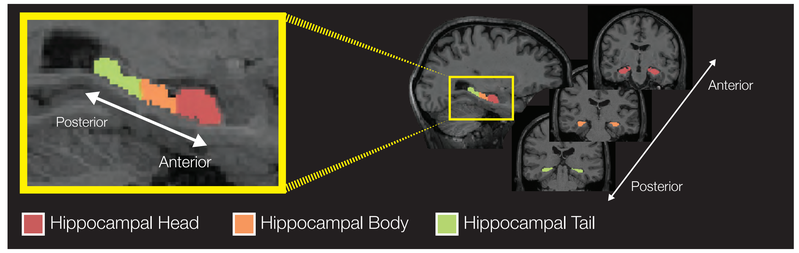
Behavioral Results



- 19 subjects were Successful learners.
- 10 subjects were Unsuccessful learners.

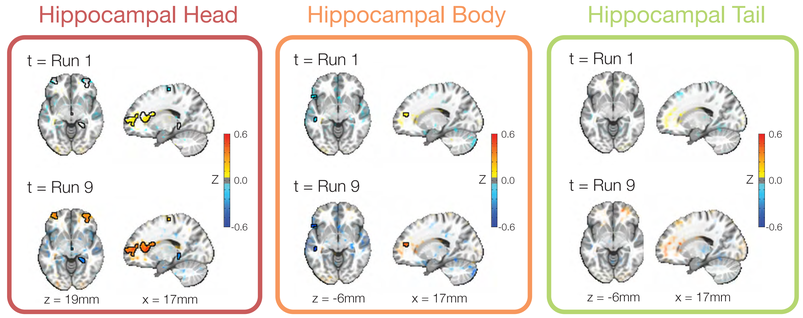
Results

Hippocampal Head, Body, and Tail seed regions were traced for each subject (Pruessner et al., 2000; Daugherty et al., 2015).



Seed-Based Functional Connectivity
Successful > Unsuccessful Learners

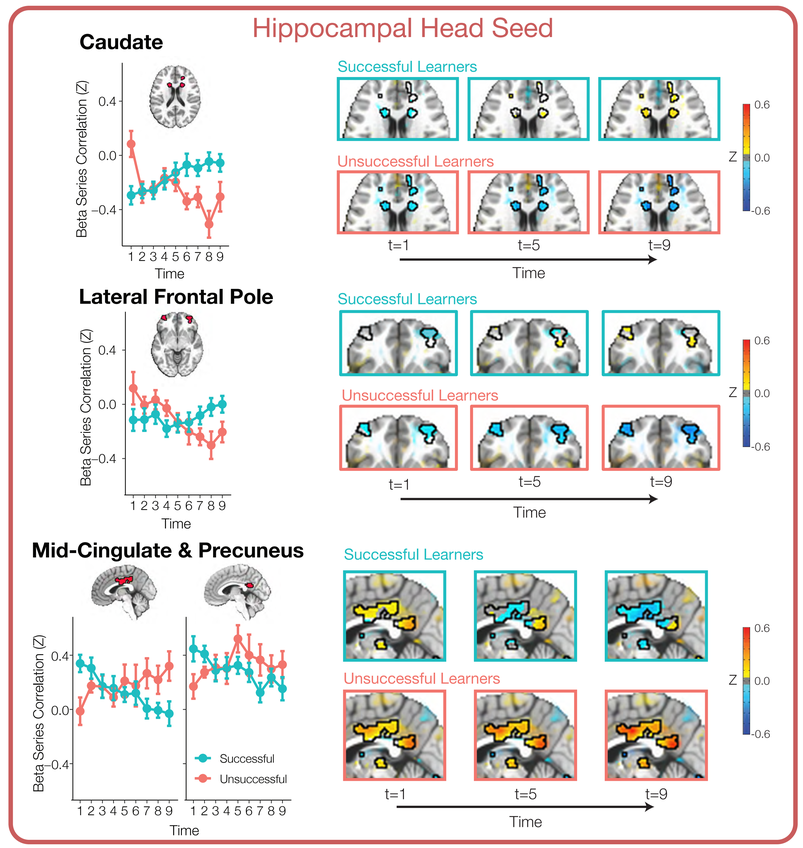
Hippocampal Head showed the greatest learning-related increase in functional connectivity with prefrontal cortex.



When examining functional connectivity with the Hippocampal Head over time...

Successful learners showed increasing hippocampal-head connectivity with caudate and lateral frontal pole throughout learning.

Successful learners showed decreasing hippocampal-head connectivity with the mid-cingulate and precuneus throughout learning.



Summary & Conclusions

- Observed functional connectivity changes were strongest during the Cue period of the task, when subjects retreived contextual information to determine which rule would apply.
- Increased functional connectivity between the hippocampal head and the frontal pole as well as the caudate supports the retrieval of successfuly learned contexts when implementing context-dependent rules.
- This connectivity patterns emerges in successful learners as they learn, but not in a natrual control group of unsuccessful learners.

The results suggest that the hippocampal head is uniquely positioned to represent higher order rules and contexts through a gradient organization that mirrors the hierarchical organization of the prefrontal cortex.

References & Acknowledgements

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Previous Related Work
(Morin et al., 2021)

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