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Acetylcholine Contributes to Head Direction Cell Stability During Path Integration and Landmark Navigation

Ryan M. Yoder
Indiana University - Purdue University Fort Wayne, yoderrm@ipfw.edu

Jeremy H.M. Chan
Dartmouth College, jeremy.chan@alum.dartmouth.org

William N. Butler
Dartmouth College, William.Butler@dartmouth.edu

Jeffrey S. Taube
Dartmouth College, Jeffrey.S.Taube@Dartmouth.edu

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Ryan M. Yoder[1]* Jeremy H.M. Chan[2] William N. Butler[2] Jeffrey S. Taube[2]

[1]Department of Psychology Indiana University - Purdue University Fort Wayne Fort Wayne, Indiana 46805

[2]Department of Psychological & Brain Sciences Center for Cognitive Neuroscience Dartmouth College Hanover, New Hampshire 03755

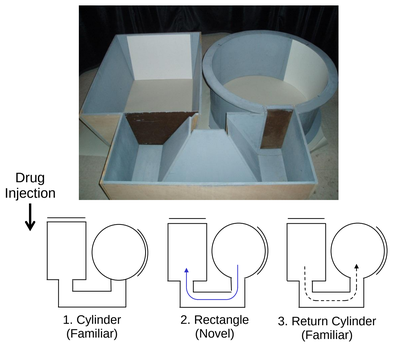
Introduction

- Head direction cells consistently show a high firing rate when the head is pointed in one direction within the yaw plane, referred to as a cell's "preferred firing direction" [1].
- Head direction signal stability can be maintained by path integration when familiar landmarks are absent [2,3].
- Cholinergic function is necessary for path integration [4].
- Acetylcholine may therefore be necessary for head direction signal stability during path integration tasks.

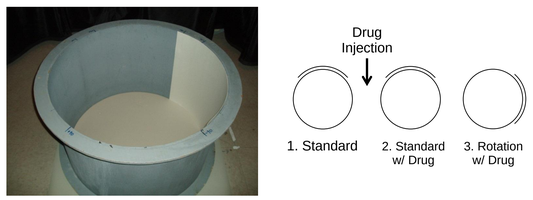
Methods

Head direction cell activity was recorded from the anterodorsal thalamus of female Long-Evans rats after intraperitoneal injection of the muscarinic receptor antagonist, atropine sulfate (50mg/kg body weight). Mean angular shift of the preferred firing direction was used as a measure of head direction signal stability between recording sessions.

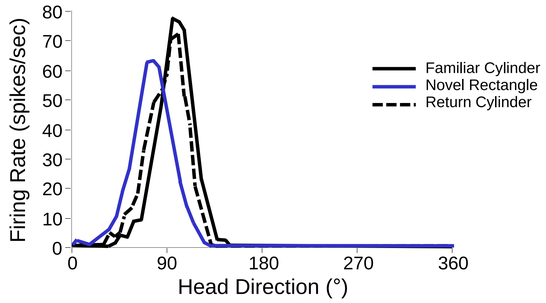
Task 1 – Dual Chamber Apparatus

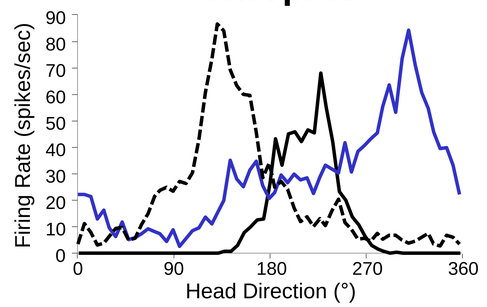


Task 2 – Landmark Rotation in Cylinder



Dual Chamber Task – Impaired Updating in HD cells



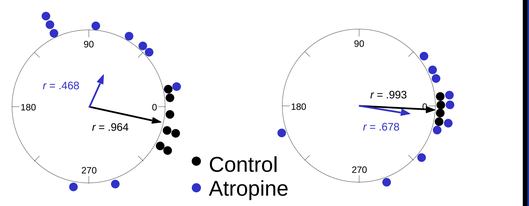


Path Integration – familiar cylinder vs. novel rectangle:
Atropine and control cells had different angular shifts, $F(1,15) = 8.042$, $p = 0.013$.

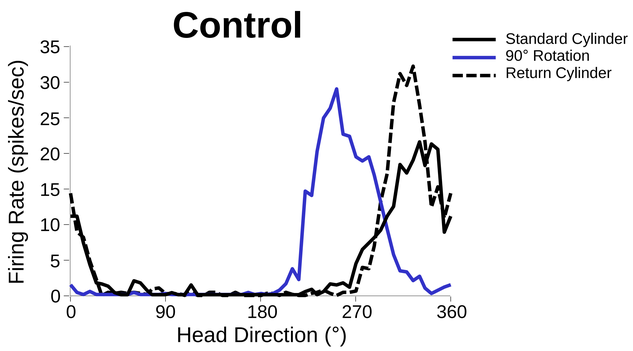
Landmark Control – familiar cylinder vs. return cylinder:
Atropine and control cells had similar angular shifts, $F(1,12) = 0.056$, $p = 0.816$.

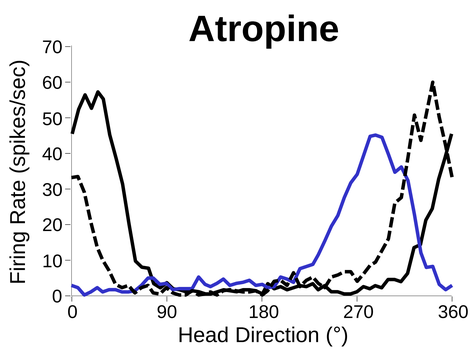
Familiar Cylinder vs. Novel Rectangle

Familiar Cylinder vs. Return Cylinder



Landmark Rotation Test



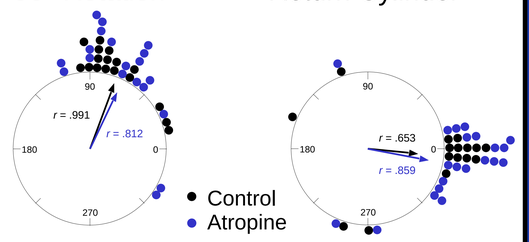


Landmark control – standard session vs. 90° rotation session:
Atropine and control cells had similar angular shifts, $F(1,34) = 0.276$, $p = 0.603$.

Landmark control – standard cylinder vs. return cylinder:
Atropine and control cells had similar angular shifts, $F(1,34) = 0.006$, $p = 0.937$.

Standard Cylinder vs. 90° Rotation

Standard Cylinder vs. Return Cylinder

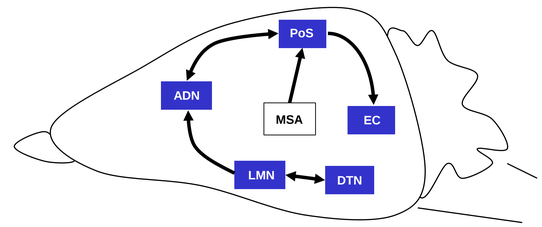


Discussion

- Systemic muscarinic receptor blockade disrupted head direction signal stability during path integration.
- The medial septal projection to postsubiculum provides the only known cholinergic input to the ascending head direction cell circuit [5].
- Both the medial septal cholinergic system and the postsubiculum are necessary for navigation via path integration [4,6].

Conclusion

The cholinergic projection from the medial septal area to postsubiculum contributes to path integration



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