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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Acetylcholine contributes to head direction cell stability during path integration and landmark navigation

Ryan M. Yoder*  Jeremy H.M. Chan2  William N. Butler2  Jeffrey S. Taube2
1Department of Psychology  Indiana University - Purdue University Fort Wayne  Fort Wayne, Indiana 46805
2Department 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, $F(1,12) = 0.056, p = 0.816$.

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, $F(1,34) = 0.006, p = 0.937$.

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.

References

Financial Support:
NS053917 & DC009318 to JST; Dartmouth Undergraduate Research Fellowship to JHMC; DC008416s RMY