The Effect of Anterior Thalamus Lesions on Bursting In The Subiculum

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Introduction

The hippocampal formation, anterior thalamic nuclei (ATN), and retrosplenial cortex (RSC) are vital for spatial memory and navigation. The ATN project directly to dorsal subiculum, and our experiments show that ATN lesions produce a significant deficit in spatial navigation. Subicular cells have been shown to classify as bursting and non-bursting, with evidence showing that bursting in the subiculum links to spatial processing. Here, we investigate the effect of ATN lesion-induced dysfunction on the bursting properties of subicular cells.

Methods

- Rats had ATN lesions (0.4 µl NMDA in PBS bilaterally; $n = 3$), sham lesions (PBS only; $n = 2$) or no lesion ($n = 2$), then electrodes implanted.
- Anti-NeuN was used to quantify lesion size, and showed lesioned ATN had 81% fewer nuclei than control.
- Single-unit and local field potential recordings in the dorsal subiculum were performed during free exploration and behavioural tasks.
- Four rats underwent single-unit and LFP recordings in the dorsal subiculum during temporary inactivation of the ATN using muscimol.

Subicular Cell Properties

Place cells, Grid cells, Head-Direction cells (HD), Boundary Vector cells (BVC), and Non-Spatial cells (NS) were recorded in the dorsal subiculum of control and sham animals. ATN lesions reduced performance in a spatial alternation task to chance level, and no spatially tuned cells were obtained in ATN lesioned animals.

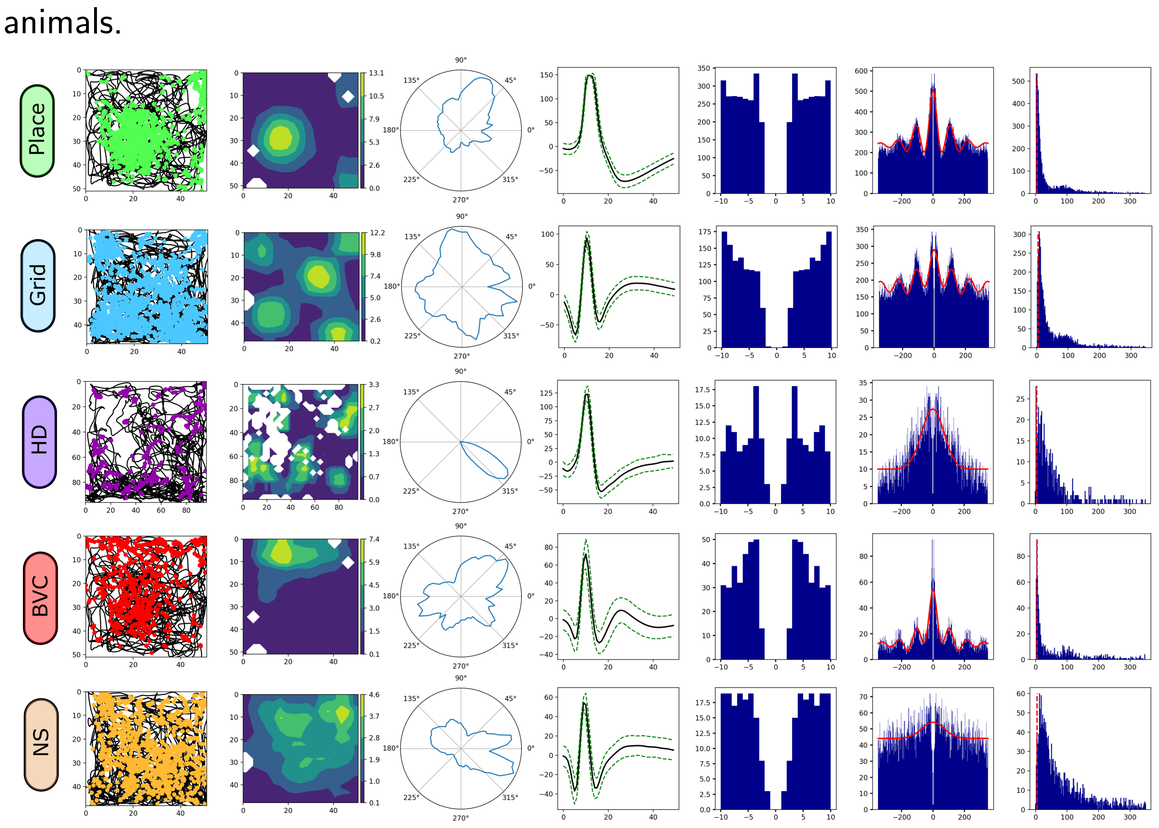

Figure 1: Sample subicular cells from control and sham animals.

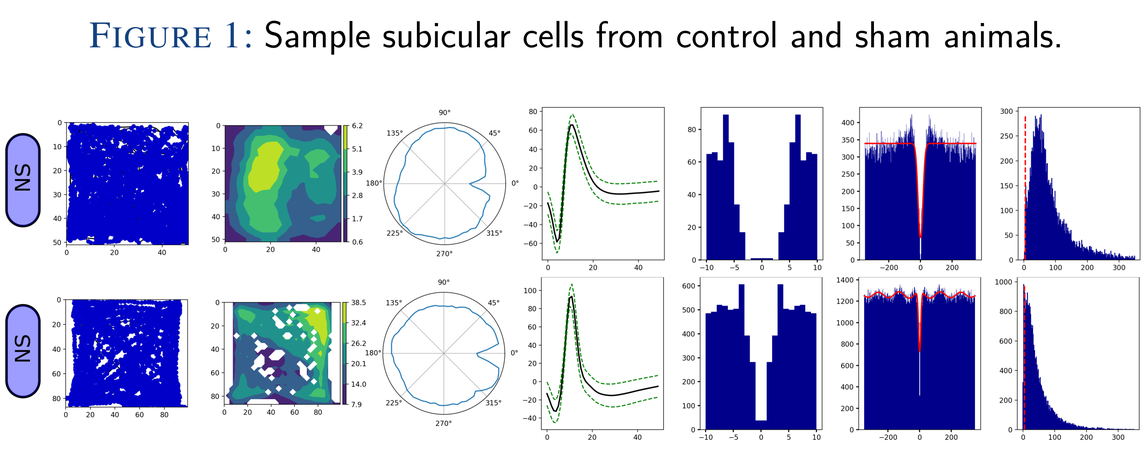

Figure 2: Sample subicular cells from ATN lesioned animals.

Clustering Bursting Cells

Subicular cells were hierarchically clustered from the principal components of the auto-correlation and log interspike-interval histograms. This revealed two well separated groups, bursting and regular spiking cells.

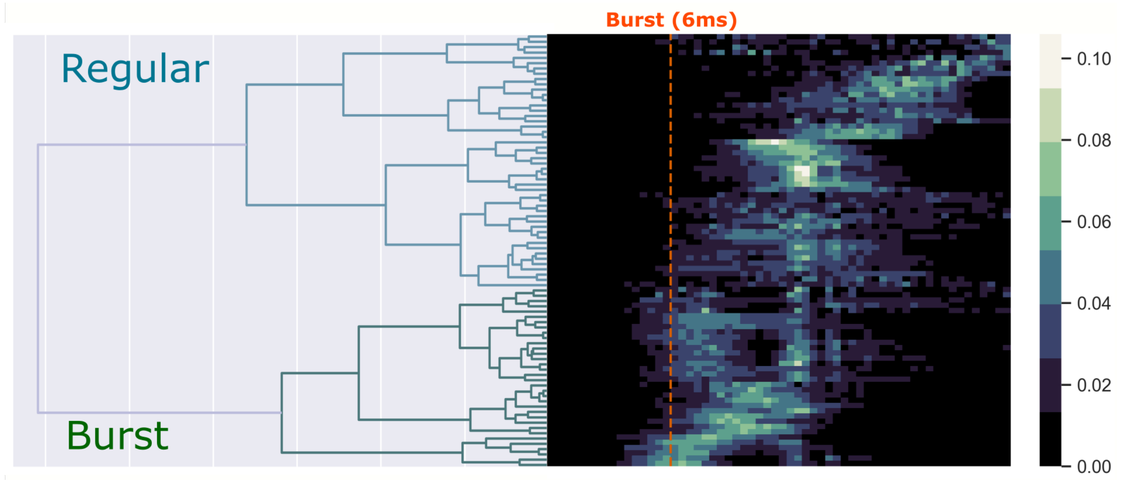

Figure 3: Dendogram clustering and log ISIH Heatmap.

Bursting And Spatial Tuning

In accordance with previous studies, we found a link between bursting and spatial information processing. Additionally, bursting was inhibited in ATN lesioned animals, concurring with this relationship. Spatial tuning of cells was assessed by the ability to predict the firing rate of the cell using spatial information.

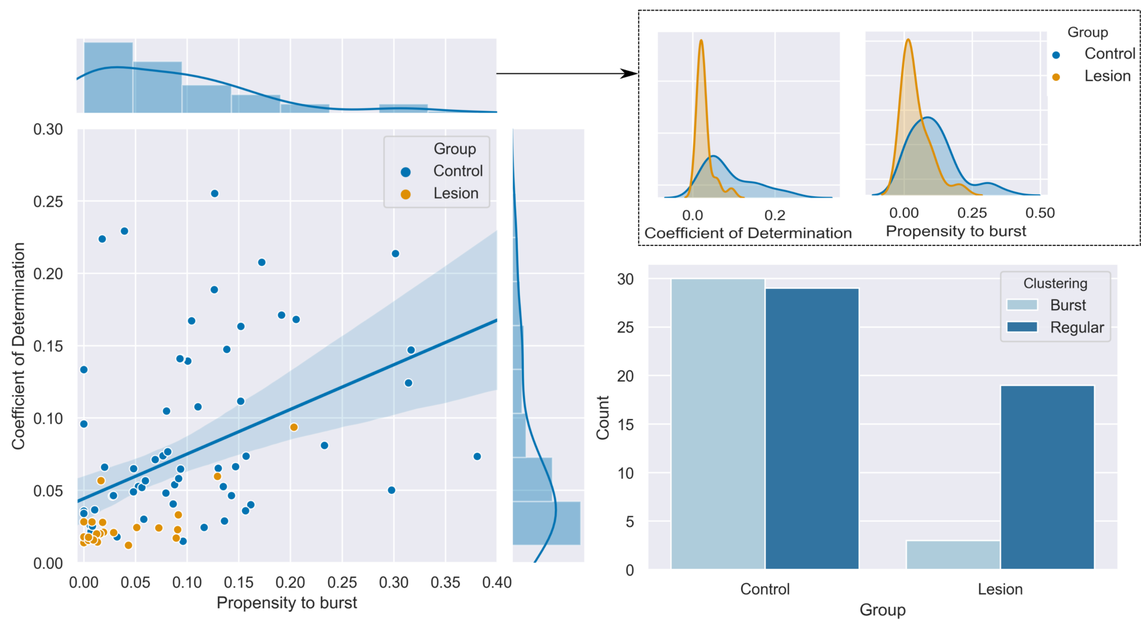

Figure 4: Correlation between spatial tuning and bursting (left) and the clustering of lesion and control cells into bursting and non-bursting (right). A higher Coefficient of Determination indicates greater spatial tuning.

Results

- Spatial cells were recorded in the dorsal subiculum of control rats.
- No spatial cells were recorded in ATN lesioned rats and performance in a spatial alternation task reduced to chance level.
- The propensity of a subicular cell to burst showed strong correlation to the spatial tuning of the cell.
- Cells recorded from ATN lesioned animals demonstrated less bursting.

Conclusion

The absence of ATN input to the hippocampal formation led to a degradation in spatial properties of subicular cells, suggesting that ATN are necessary to spatial responses in the dorsal subiculum. Furthermore, cells from ATN lesioned rats were largely non-bursting, indicating that bursting may indeed be a form of efficient spatial information transfer.