Predicting spikes of Barrel Cortex neurons from sensory data during active sensation

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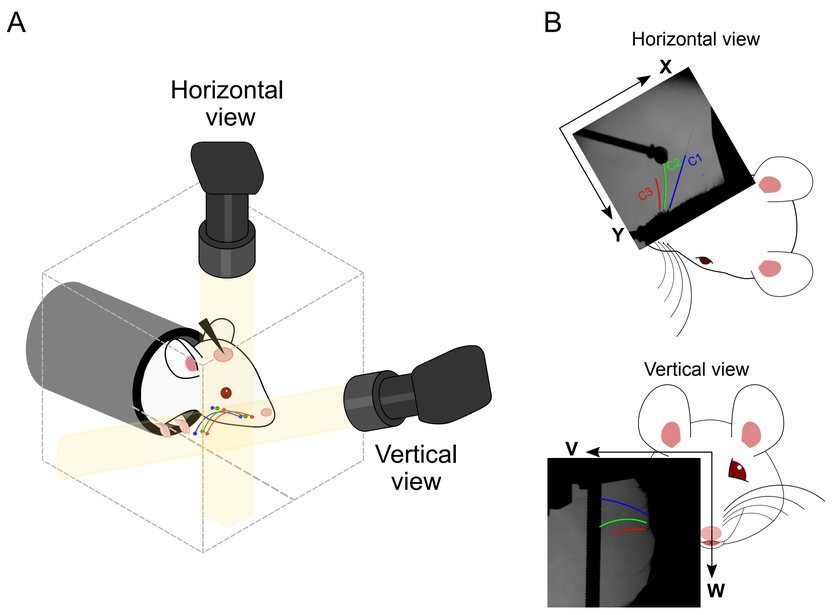
Introduction

The whisker system is a widely used model to study principles of neural coding. However, what sensory signals are represented in barrel cortex during active sensation is not well understood. Previous works that characterised sensory variables in 2D showed both touches and slips-sticks trigger responses in barrel cortex [1–3]. These events are temporally and spatially correlated during active object exploration, making the relationship between these individual events and neural activity unclear. This work aims to analyse how touches and slip-sticks affect cortical activity and develop a model able to predict responses of neurons in awake, behaving mice.

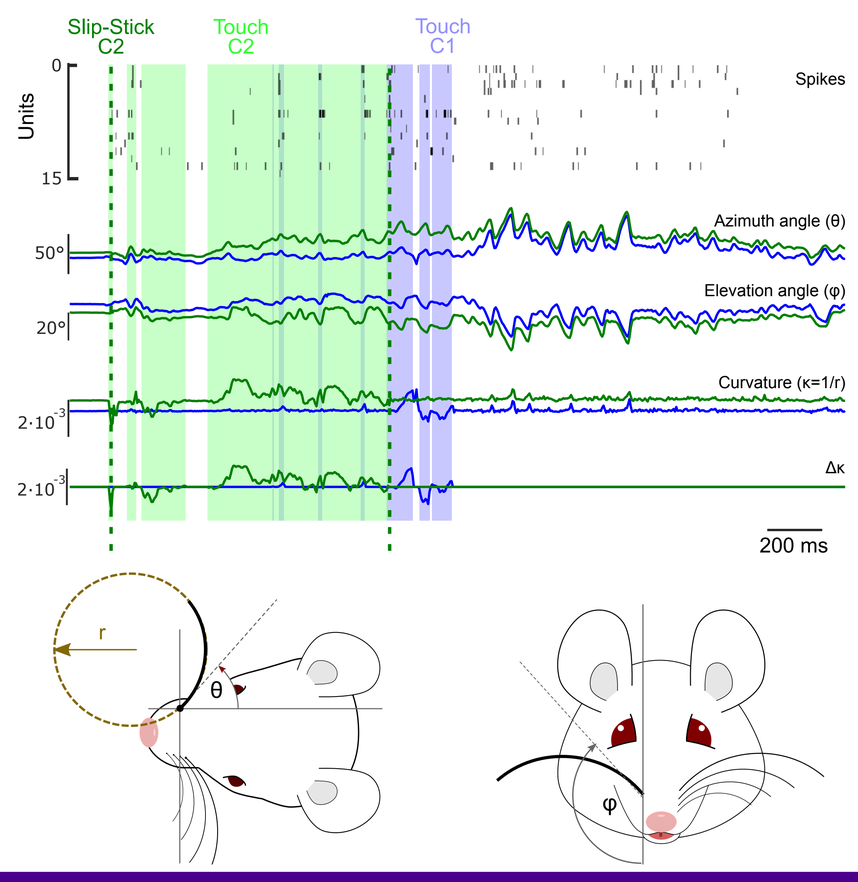
Electrophysiologycal and behavioural recordings

Extracellular electrophysiological recordings (62 units) were performed from barrel cortex from mice trained to detect the presence of an object with their whiskers. Whisker movements were imaged in 3D using a pair of high-speed cameras (1000 frames/s) and tracked using a new 3D whisker tracker.



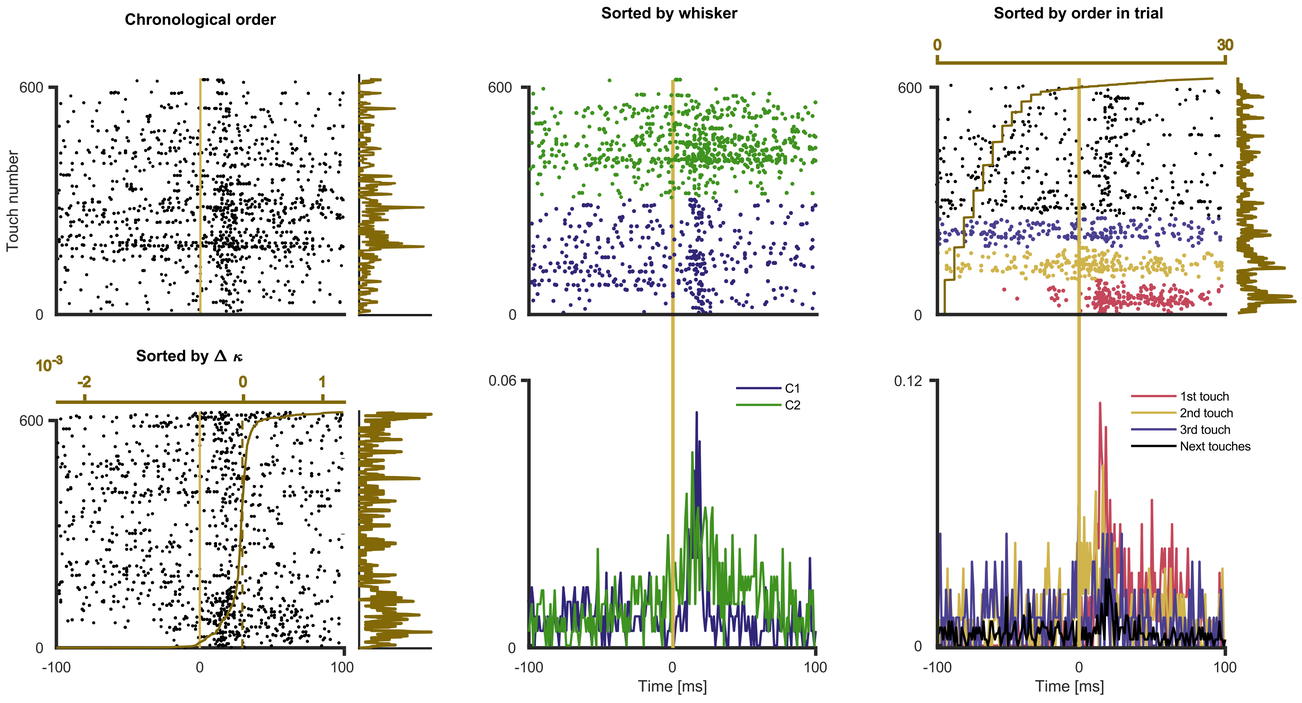
Extracting sensory variables

Fundamental sensory variables were identified for all frames: Angles in the horizontal and vertical plane, curvatures, touches and slip-sticks.



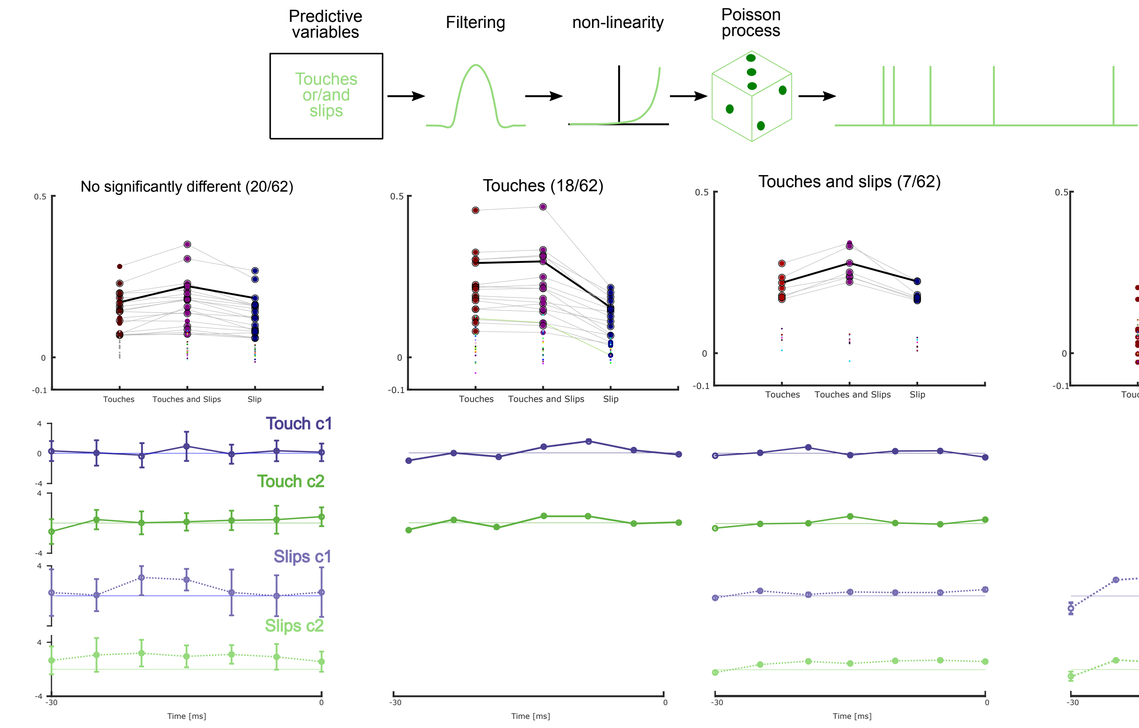
Predictive variables

Recorded units typically responded after both touches and slip-stick events. Additionally, features of the touches and slip-stick events, such as curvature change at touch onset and the order of the events withing trials, modulated cortical responses.



Predicting activity of cortical neurons

A Generalised Linear Model approach was applied to attempt to predict spiking activity from these sensory variables.



Conclusions

The GLMs predict responses to touches and slip-stick events on single trials. Results showed a heterogeneous population, in which units are sensitive either to slip-sticks, touches or both. As a whole, these results suggest a rich representation of whisker dynamics in barrel cortex.

References

[1] Hires, S. A. *et al.*. Low-noise encoding of active touch by layer 4 in the somatosensory cortex. eLife (2015).

[2] Isett, B. *et al.*. Slip-Based Coding of Local Shape and Texture in Mouse S1. Neuron (2018).

[3] Jadhav, S. *et al.*. Sparse temporal coding of elementary tactile features during active whisker sensation. Nature neuroscience (2009).

Acknowledgments

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