# Decoding the Corticostriatal Dynamics in Tic Expression

Yuval El-Hanany[1], Katya Belelovsky[1], Anan Moran[2], Izhar Bar-Gad[1]

[1] The Gonda Multidisciplinary Brain Research Center, Bar-Ilan University, Ramat-Gan, Israel

[2] The Multidisciplinary School of Biochemistry Neurology Biophysics, Tel-Aviv University, Tel-Aviv, Israel

## Introduction

Motor tics are sudden, brief, repetitive movements that constitute the main symptom of Tourette syndrome. Multiple lines of evidence support the involvement of the Basal Ganglia, and specifically the Striatum, in the expression of tics. We utilize new technologies that enable wider spatial temporal coverage of the Cortex and the Basal Ganglia to explore wide scale interaction during tic expression.

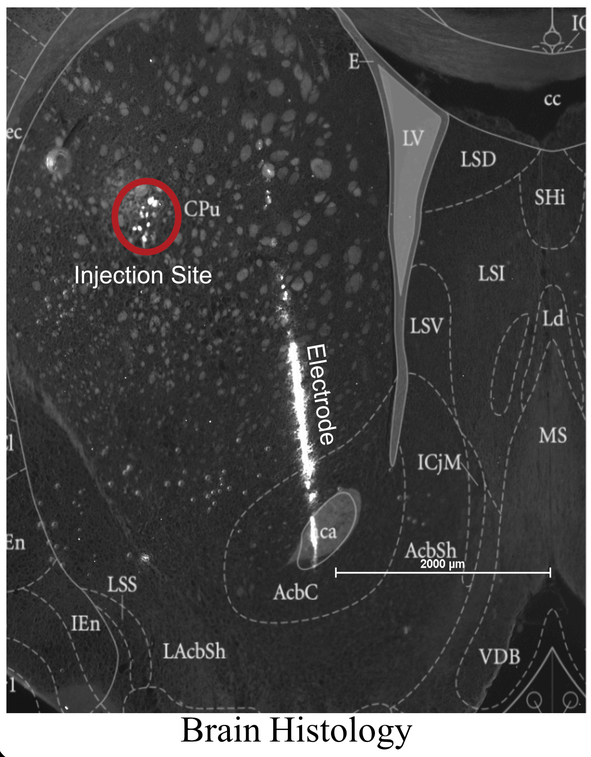
## Goal

Infer the spatial-temporal structure and the complex dynamics of tic disorders in GABAergic disinhibition animal models.

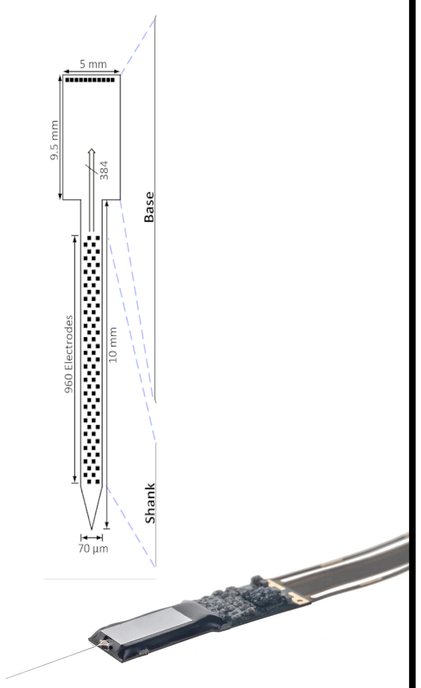
## Experimental Methods

Previous studies demonstrated that Bicuculline injection to the Dorsal Striatum induces tics in rats [1].

We implant a Neuropixel (1.0) probe in Ketamine-Xylazine anaesthesized rats. Using long shank configuration, we record multiple brain structures: Primary Motor Cortex (M1), Striatum and the Nucleus Accumbens concurrently.




Brain Histology

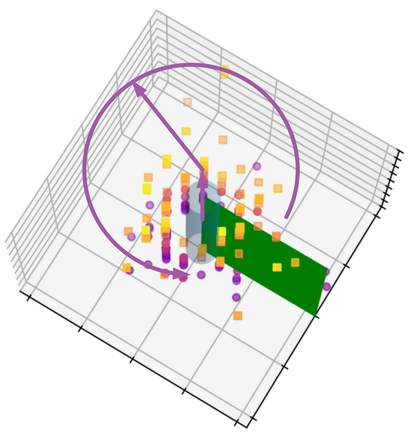



Neuropixel Probe

## Analysis Methods

Data is acquired before and after the injection.

1. **Spike Sorting** - Individual neurons are identified using KiloSort 4 and manually tested for stability across the experiment period. Each neuron is assigned a depth corresponding to the recording site closest to the neuron.
2. **High Synchrony Events (HSE)** - Using the detected spikes and depths, we identify HSE in the Striatum and Cortex which are periods where multiple neurons fire concurrently.
3. **Firing Patterns** - We search for typical patterns around the HSEs. We represent each spike as a complex number of magnitude 1 and whose phase represents the firing time. Each neuron is then represented by the sum of all its firing events in the window. We average the signatures of all events in the observed period to obtain the typical firing signature and reduce the variance of the pattern [2].



4. **Salient Neuron Units** - We examine the patterns for neurons that are synchronous with the HSE.

## References

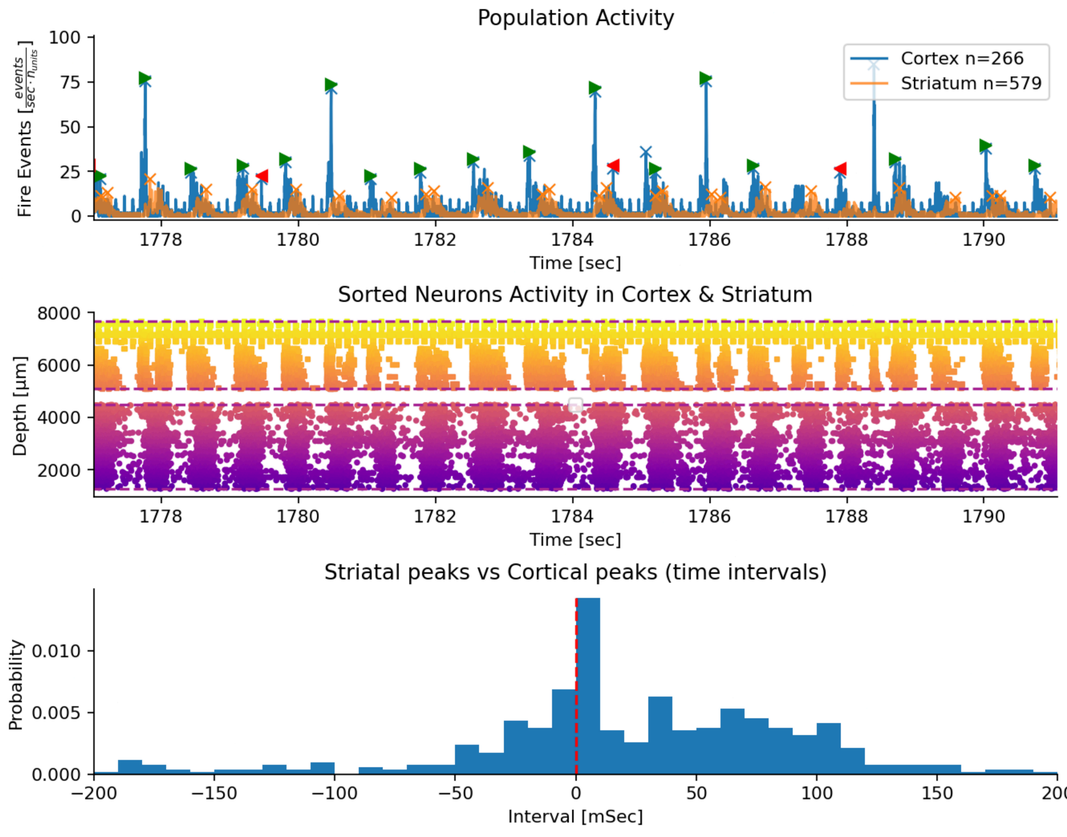
[1] Bronfeld, Maya, Dorin Yael, Katya Belelovsky, and Izhar Bar-Gad. 2013. "Motor Tics Evoked by Striatal Disinhibition in the Rat." Frontiers in Systems Neuroscience 7. https://doi.org/10.3389/fnsys.2013.00050.

[2] Busch, Alexandra N., Roberto C. Budzinski, Federico W. Pasini, Ján Mináč, Jonathan A. Michaels, Megan Roussy, Roberto A. Gulli, et al. 2024. "A Mathematical Language for Linking Fine-Scale Structure in Spikes from Hundreds to Thousands of Neurons with Behaviour." arXiv. https://doi.org/10.48550/arXiv.2412.03804.

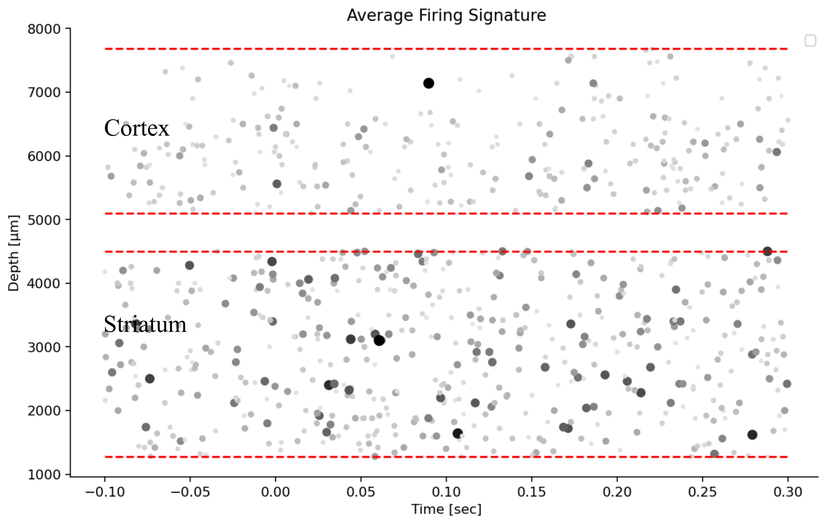
[3] Bharioke, Arjun, Martin Munz, Alexandra Brignall, Georg Kosche, Max Ferdinand Eizinger, Nicole Ledergerber, Daniel Hillier, et al. 2022. "General Anesthesia Globally Synchronizes Activity Selectively in Layer 5 Cortical Pyramidal Neurons." Neuron 110 (12): 2024-2040.e10. https://doi.org/10.1016/j.neuron.2022.03.032.

## Results

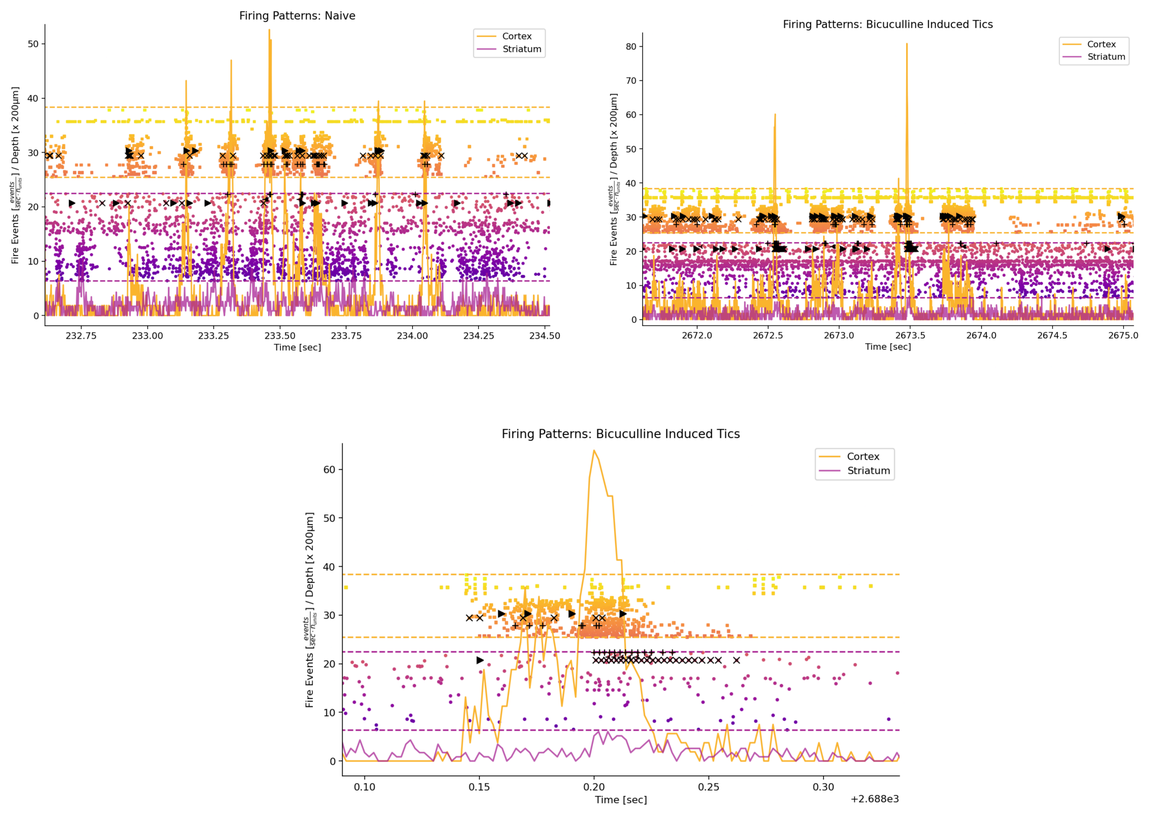
**A.** The population activity events in the Cortex precede the Striatal events.




**B.** The average neuronal signature centred on tic events in the Cortex, reveals neurons with high temporal correlation to the Cortex tic-related neural activity.




**C.** Studying the salient neurons in the signature reveals striatal neurons that correlate with tic-related neural activity, as well as other neurons that correlate with what, we hypothesize, is Ketamine related neural activity [3].




## Summary

Wide spatial recording uncover complex dynamics between the Striatum & the Cortex in Bicuculline induced tics, with different response patterns in different regions of the Striatum.