Response latencies across six visual areas in the mouse

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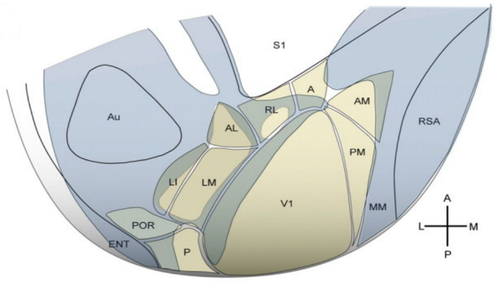
Introduction

- ***Goal: Explore effects of visual stimulus on firing rates of individual and ensembles of neurons in six distinct mouse brain regions.***

- Recordings were made from **six mouse brain regions** presumably involved in visual processing: the Primary Visual Cortex (**V1**), the Lateromedial Area (**LM**), the Anterolateral Area (**AL**), the Rostrolateral Area (**RL**), the Posteromedial Area (**PM**), and the Anteromedial Area (**AM**).



Data and the experiment

- Data were collected from three individual mice, using **six NeuroPixels probes, which provided simultaneous recordings of many spiking neurons from all six brain regions** mentioned above.

- Each mouse was presented with drifting gratings under different combination of parameters, **15 times each** for **two seconds,** which provided **600 trials** of data.

- The two parameters accounted for **orientation (0º, 45º, 90º, 135º, 180º, 225º, 270º, 315º) and temporal frequency (1 Hz, 2 Hz, 4 Hz, 8 Hz, and 15 Hz) of the gratings.**

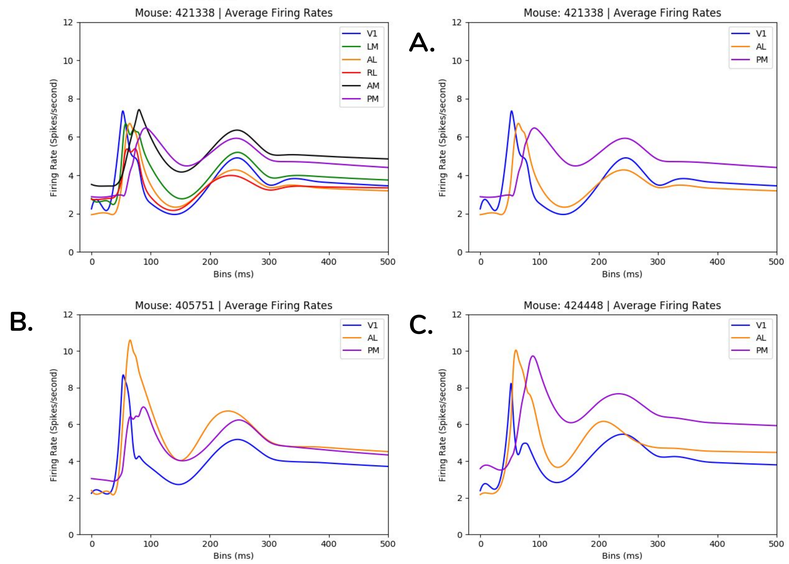
Methods

- **For each brain area, univariate regression splines** with 17 knots were used to **smooth population peri-stimulus time histograms** based on spikes pooled across all neurons within each region. We used the fitted curves to **find the time of maximal population firing rate.**

- **Within-trial analyses** were based on two-way analysis of variance (**ANOVA**) and **paired differences.**

Population spiking rates reveal order of firing

- In all cases, **V1 is the first region to reach its maximum firing rate and PM is the last.**
- All curves have roughly the same behavior, peaking for the first time between 50ms and 100ms and again between 200ms and 250ms. Let time of the **first peak** be $\mathbf{t_{max1}}$ and the **second** be $\mathbf{t_{max2}}$.



- Average firing rate graphs for Mice **A, B,** and **C** demonstrates ordering based on $\mathbf{t_{max1}}$:

$$V1 < AL < PM$$

- Table 1 solidifies that paired differences between **AL - V1** and **PM - AL,** based on above ordering, are highly significant since p values for the pairs in all mice are less than 10^{-6}.

Table 1: t_{max1}

Mouse	Paired Difference	Mean Time (ms)	95% Confidence Interval	p-value
A	AL - V1	6.2	(5.2, 7.3)	$p << 10^{-6}$
A	PM - AL	4.8	(3.6, 6.1)	$p << 10^{-6}$
B	AL - V1	6.5	(5.4, 7.6)	$p << 10^{-6}$
B	PM - AL	3.0	(1.8, 4.1)	$p = 6.0 \times 10^{-7}$
C	AL - V1	4.4	(3.2, 5.6)	$p << 10^{-6}$
C	PM - AL	5.5	(4.3, 6.8)	$p << 10^{-6}$

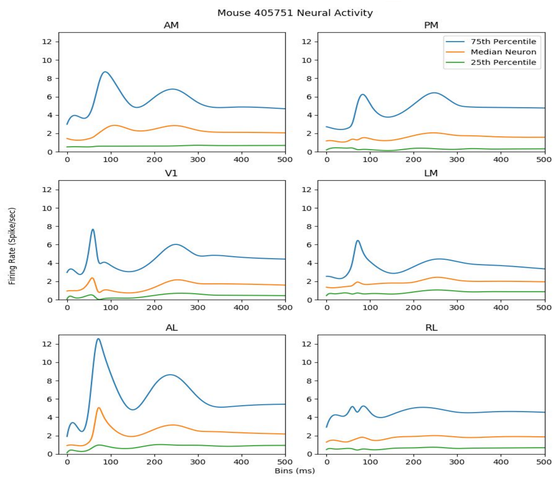
- Results from two-way ANOVA shows that **area means are highly significantly different** $p << 10^{-6}(R^2 = 7.9\%)$.
- **Trial-to-trial variation is highly significant** $p \approx 10^{-6}(R^2 = 19.6\%)$.
- **All paired differences** between **AL, RL, and LM, and also between AM and PM** were **insignificant,** $p = 0.023$ with **exceptions in** mouse **B** (**RL-AL,** $p \approx 10^{-6}$ **)** and in mouse **C** (**AL-RL,** $p \approx 10^{-6}$ **, PM-AM,** $p \approx 10^{-6}$).

Percentiles show limited variation in the slowest firing neurons

- For every time bin we compute the 25th, 50th, and 75th percentiles of firing rates among neurons, in each brain region. Curves are shown for mouse B.

75th percentile → follows the shape of the population average

25th percentile → shows almost no variation



Discussion

- We took advantage of the simultaneous records from each area by using a within-trial analysis, which provided very strong evidence of the time ordering:

$$V1 < \begin{pmatrix} RL \\ AL \\ LM \end{pmatrix} < \begin{pmatrix} AM \\ PM \end{pmatrix}$$

- Many of our analyses revealed substantial noise in the measurements. This suggests that finding additional relationships may be challenging.

Future plans

- Analyze separately neurons with high firing rates for each given direction.

- Determine correlation between change points of maximal firing rate curves, across all trials and across all regions.

- Refine the regression spline methodology in order to do addition within trial analysis.

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References

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