

Effect of Citronellal Odor Puffs on Cockroach Neurons

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Goal

We study whether citronellal odor puff stimulation changes the firing rate of cockroach antennal lobe neurons. Specifically, we compare the response of three neurons and determine whether the stimulus effect is consistent across neurons. In this link we have a repository containing code that produced the visuals along with a markdown file explaining it.

Exploratory Analysis and Hypotheses

Raster plots show spike timing across trials. If stimulation affects firing rate, spike density should change during the stimulus window (5.99–6.49 seconds).

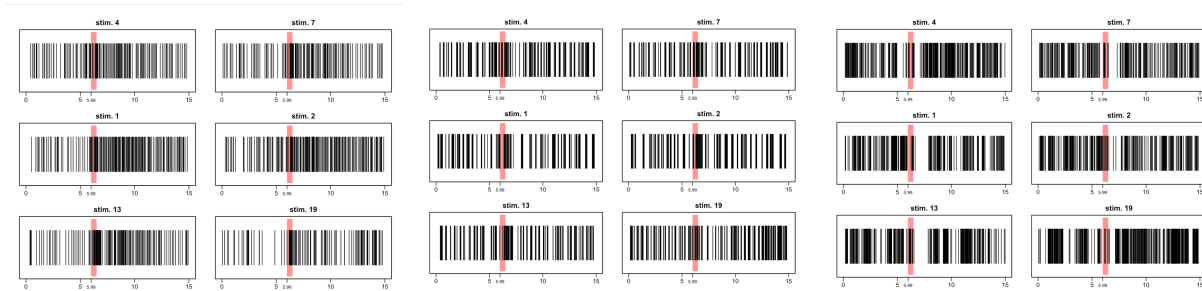


Figure 1: Raster plots for Neurons 1–3. The red band indicates the odor stimulus window.

Visual inspection suggests neuron-specific responses:

- **Neuron 1:** Spike density increases during and immediately after the stimulus.
- **Neuron 2:** Activity clusters around the stimulus period.
- **Neuron 3:** Reduced spike activity during the stimulus window.

Hypotheses

- Neuron 1: stimulus increases firing rate
- Neuron 2: stimulus increases firing rate
- Neuron 3: stimulus suppresses firing rate

Model Specification

We approximate the spike train using a non-homogeneous Poisson process by binning time into small intervals:

$$Y_{it} \sim \text{Poisson}(\lambda_i(t)\Delta t)$$

Using a log link:

$$\log(\lambda_i(t)) = \beta_0 + \beta_1 \text{stim}(t) + f(t) + b_{\text{trial}}$$

where

- β_1 = stimulus effect (log scale)
- $f(t)$ = smooth baseline firing pattern
- $b_{\text{trial}} \sim N(0, \sigma^2)$ = trial random effect
- $\log(\Delta t)$ = offset

This model allows firing intensity to vary smoothly in time while estimating the multiplicative effect of the odor stimulus.

Results

To interpret the stimulus effect we plot $\exp(\hat{f}(t))$, which represents the multiplicative change in firing intensity.

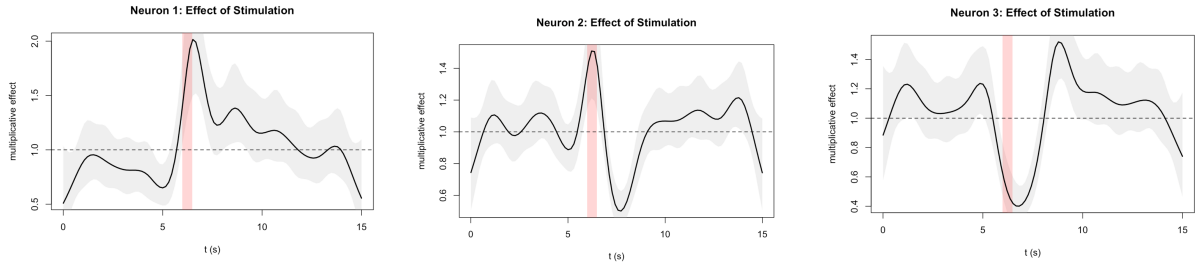


Figure 2: Estimated multiplicative stimulus effects for Neurons 1–3. The dashed line at 1 indicates baseline firing intensity. Values above 1 indicate increased firing, while values below 1 indicate suppression.

- **Neuron 1:** The curve and confidence bands lie above 1 during the stimulus window, indicating increased firing.
- **Neuron 2:** The multiplicative effect rises above 1 during the stimulus window, suggesting a moderate increase in firing.
- **Neuron 3:** The curve falls below 1 during the stimulus, indicating suppression of firing rate.

Conclusion

Do citronellal odor puffs affect firing rate?

Yes. All neurons show stimulus effects that differ from baseline.

Is the effect uniform across neurons?

No. The response differs across neurons. Neurons 1 and 2 exhibit increased firing during the stimulus, while Neuron 3 shows suppressed activity.

These results suggest that citronellal odor stimulation produces neuron-specific responses in the cockroach antennal lobe.