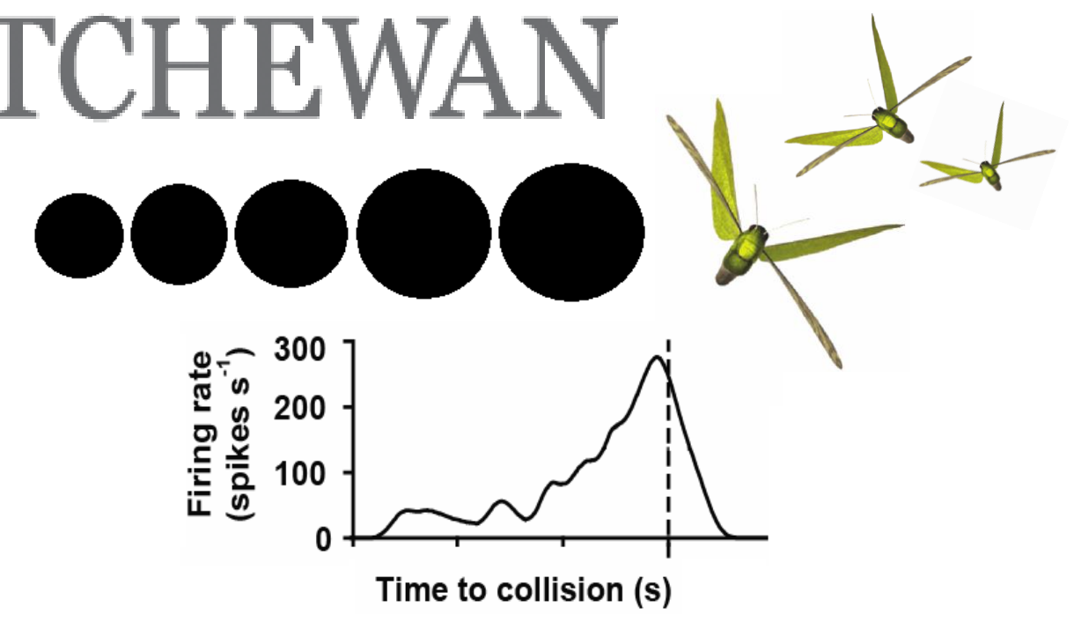


Response of a locust motion-sensitive neuron to objects deviating away from a collision course in the presence or absence of optic flow

Jasmine M. Yakubowski and John R. Gray

1. ABSTRACT

Stimulus complexity affects the response of looming sensitive neurons in many animals. In locusts, the lobula giant movement detector (LGMD) and descending contralateral movement detector (DCMD) pathway not only responds to simple objects approaching along a direct collision course (i.e., looming), but also more complex motion, such as changes in velocity, trajectory and background environments. We presented 20 *Locusta migratoria* with a sequence of complex 3-dimensional visual stimuli in simple, scattered and progressive flow field backgrounds while concurrently recording DCMD activity extracellularly. Data from this research will contribute to a growing computational model that describes how the DCMD encodes object motion.

2. METHODS

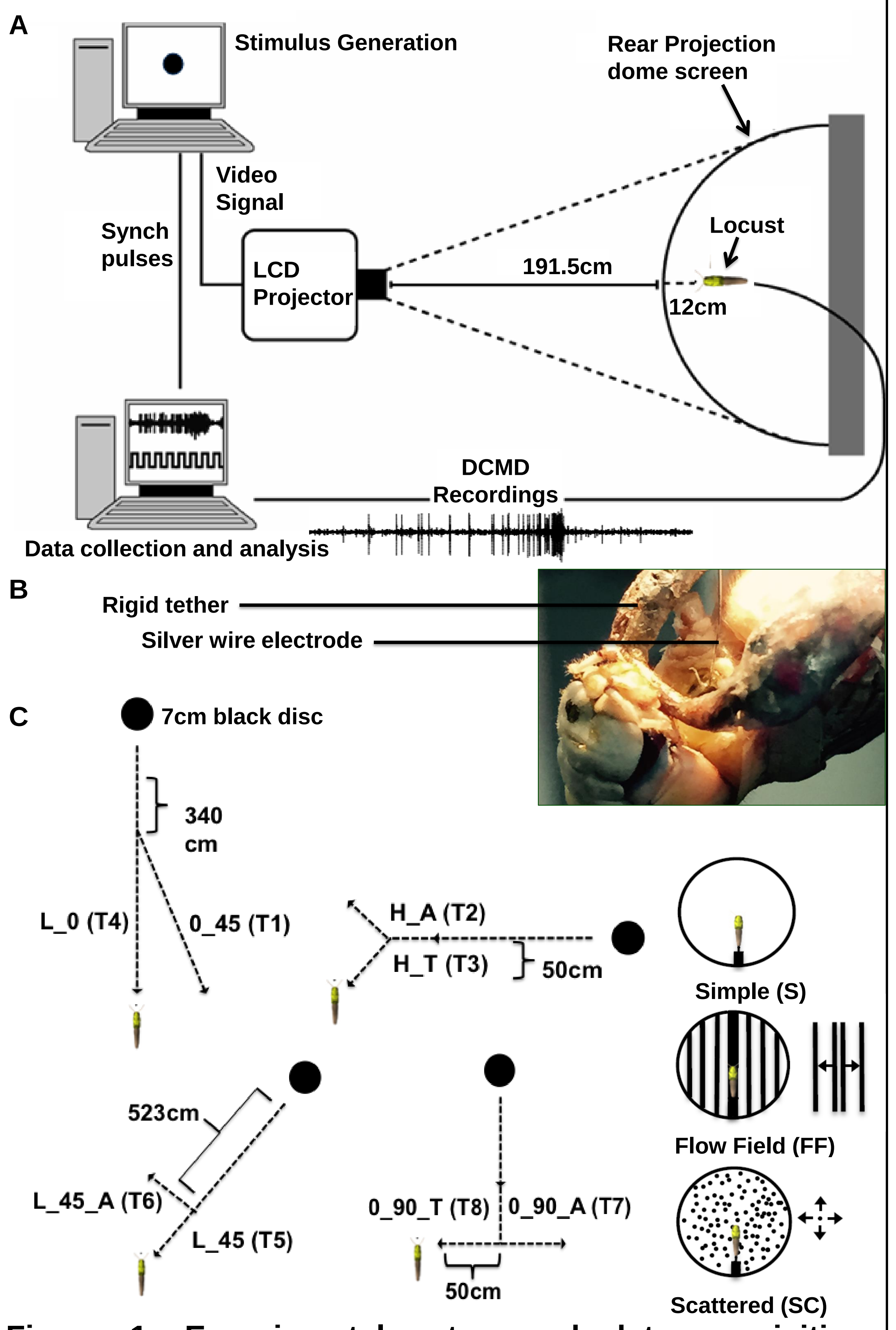


Figure 1: Experimental setup and data acquisition. *Locusta migratoria* (n=20) were placed within a rear projection dome (A). A patch of ventral cervical cuticle was excised to expose the underlying pair of ventral nerve cord connectives. Neural recordings were obtained with a silver hook electrode (B). Locusts were exposed to a randomized set of 8 trajectories presented within 3 different visual backgrounds (C).

3. THE EFFECT OF BACKGROUND

Regardless of stimulus background, the DCMD generated a characteristic rapid rise to peak firing rate in response to a looming object. More spikes were evoked depending on background SC,S>FF. The moving backgrounds resulted in delayed peak firing, as well as shorter rise phases and longer fall phases consistent with previous findings[3]. This indicates that the locust remains sensitive to looming in the presence of moving visual backgrounds.

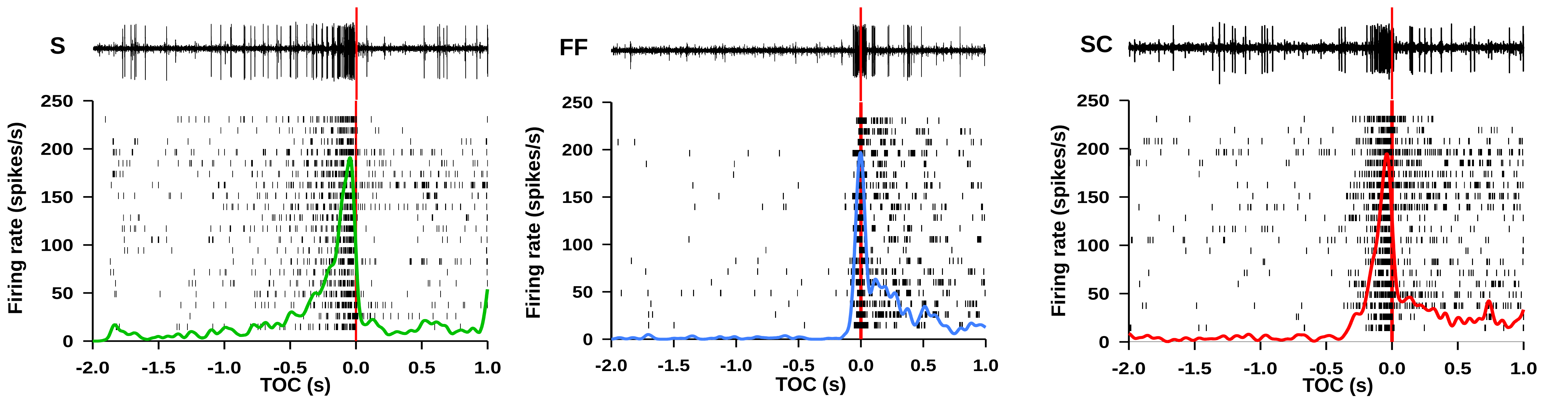


Figure 2: Mean DCMD perievent raster figures for a looming stimulus approaching at a 45° angle relative to the eye (L_45). Each graph shows the corresponding raster plot of spike times (black vertical lines) and the mean DCMD firing rate [S (green), FF (blue), SC (red)] from each individual animal (n=20). The red vertical line represents the projected time of collision (TOC).

4. RESPONSE PROFILES TO DIFFERENT TRAJECTORIES

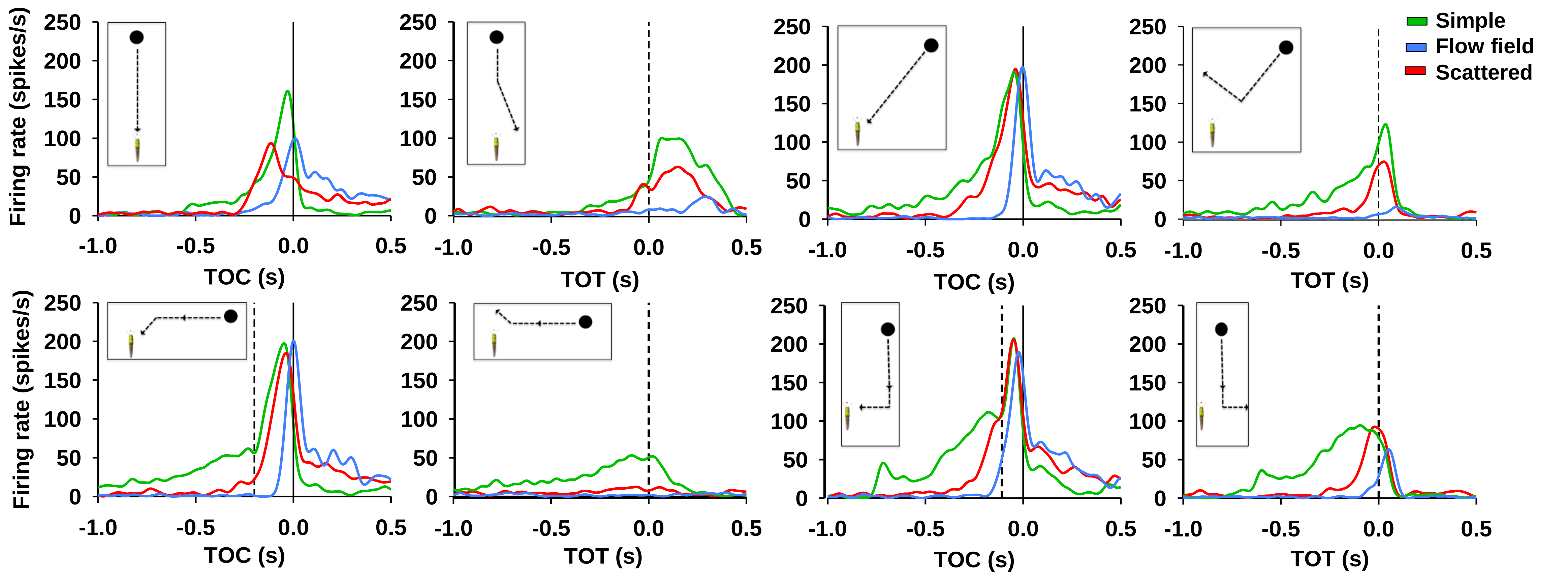


Figure 3: Mean DCMD responses to a 7cm black disc travelling along 8 unique trajectories. Peristimulus time histograms (PSTHs) of the DCMD show responses to the different categories of object motion. Trajectories are aligned to either time of collision (TOC-black vertical line) or time of transition (TOT-dotted black vertical line). Within each trajectory, responses in each visual background are displayed using different coloured lines: Simple (green), Flow field (blue), Scattered (red).

5. TRANSITIONS TOWARD AND AWAY FROM LOOMING

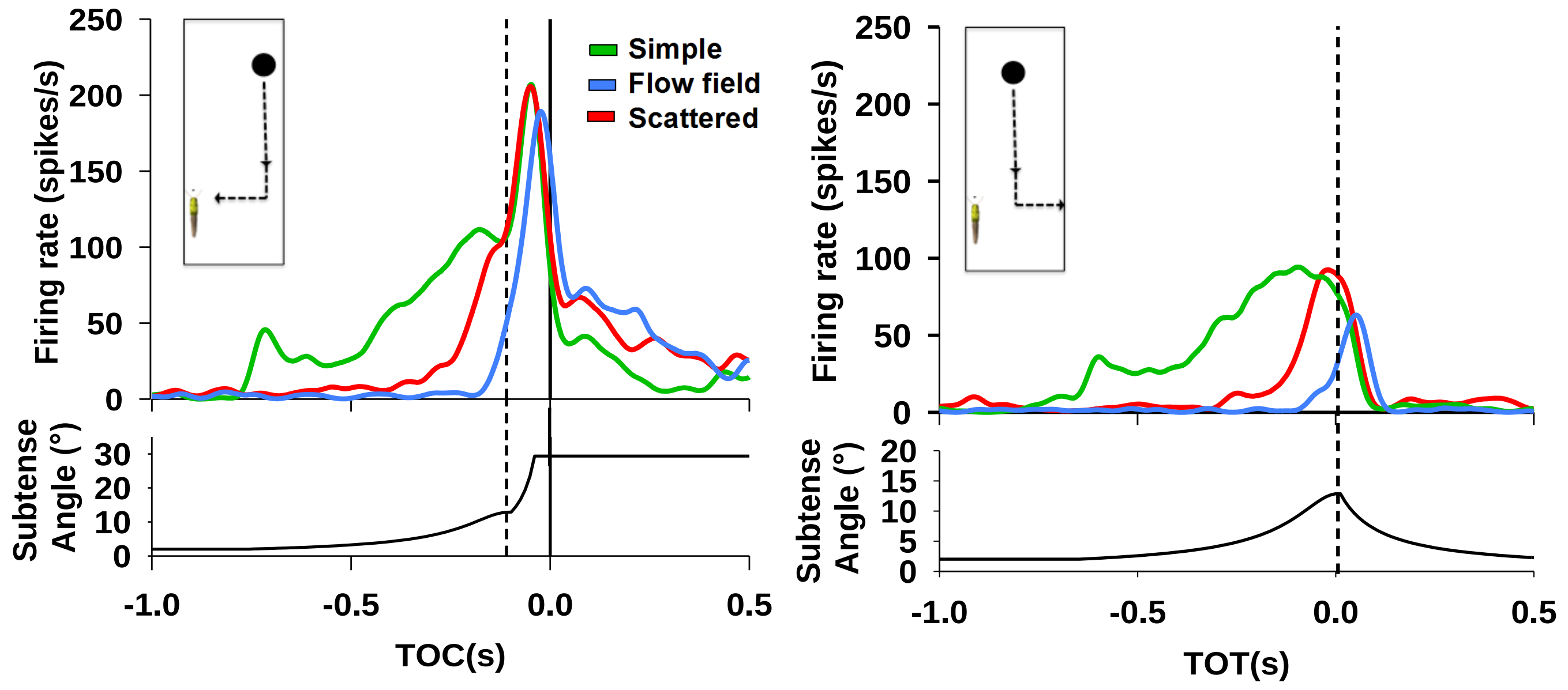
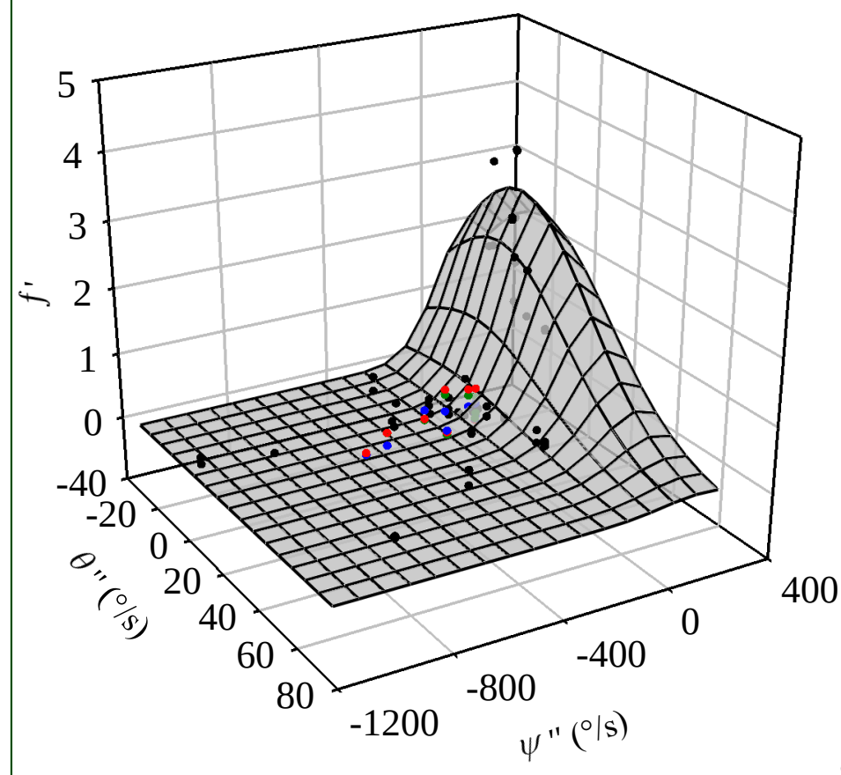


Figure 4: PSTHs illustrating mean DCMD responses to trajectories that transition towards (0_90_T) and away from looming (0_90_A) within three background types. The corresponding visual subtense angle during stimulus approach is located below each response profile, which are aligned to either time of collision (TOC) or time of transition (TOT) as indicated. The DCMD retains the ability to respond to transitions toward and away from looming irrespective of background type.

6. COMPUTATIONAL MODEL

McMillian and Gray (2012) described expansion parameters and changes in firing rate in response to transition changes in a 2D Gaussian equation. The most current version is illustrated below. The 2D Gaussian model was fitted based on the data illustrated in Fig. 5.



$$f' = 3.0e^{-0.5\left[\left(\frac{\theta'' + 6.6}{-32.3}\right)^2 + \left(\frac{\psi'' + 157.7}{136.1}\right)^2\right]}$$

Figure 5: Three-dimensional scatterplot representing data collected from previous work[1,2,3]. Each data point represents the correlation between the change in mean DCMD firing rate (f') with subtense angular acceleration (θ'') and rotational acceleration of the leading edge (ψ'') of a disc for different trajectories.

7. SUMMARY

- Complexity of visual backgrounds affects DCMD responses.
- Trajectory type had a profound impact on TOT and TOC associated trajectories.
- Increasing background complexity resulted in shorter rise and longer fall phases, reduced firing rates and changes in spike number.
- Generally, peak firing rate was lower in a FF background, consistent with previous findings[3].
- Peak timing relative to TOT was variable and overall, lower peak amplitudes were observed in both FF and SC backgrounds for transitions away.
- Trajectories with a transition to looming did not clearly show the localized decrease in firing rate as a result of transition as previously shown [1,2,3].
- Our stimuli were presented at a high velocity (300 cm/s) and transitions occurred in considerably close proximity to the animal, which could have potentially affected the response profile.
- Data will be used to test the ability of the LGMD/DCMD pathway to convey information regarding the unique expansion parameters of a moving visual stimulus (Fig. 5), irrespective of background complexity[1,2,3].

8. REFERENCES

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