

Figure S1. Distributions of saccade parameters, related to Figure 1. A) Example trajectory of bar fixation bouts showing initial anti-directional saccades opposite the motion of the bar, toward the stimulus, followed by continuous saccadic tracking in the direction of the bar. B) Saccade directions upon appearance of the bar within the field of view of fly. The majority of saccades are syn-directional (i.e. toward the bar). All data analyzed are prior to a bout of visual fixation to minimize inclusion of spontaneous saccades generated by ‘non-attentive’ flies. $n = 18$ flies, 60 trials. C) Saccade dynamics for bar fixation and spontaneous saccade. Top: histogram of saccade amplitude. Middle: duration vs. saccade amplitude. Bottom: Peak |angular velocity| vs. saccade amplitude. Bar fixation: 2,698 saccades from 10 animals. Spontaneous: 4,137 saccades from 23 animals. For bar fixation saccades, the trajectories of (D) Position angle, (E) angular velocity and (F) angular acceleration. The white line shows the means. Shaded areas are ± 1 STD. Lines represent individual saccades across all animals. Velocity and acceleration data were aligned about the peak angular velocity and acceleration of each saccade, respectively. $n = 2,968$ saccades from 10 animals. G) Bar fixation saccade torque for bar speeds of 38 (red), 78 (green), and 113 °s⁻¹ (blue). Bar fixation: 2,698 saccades from 10 animals.

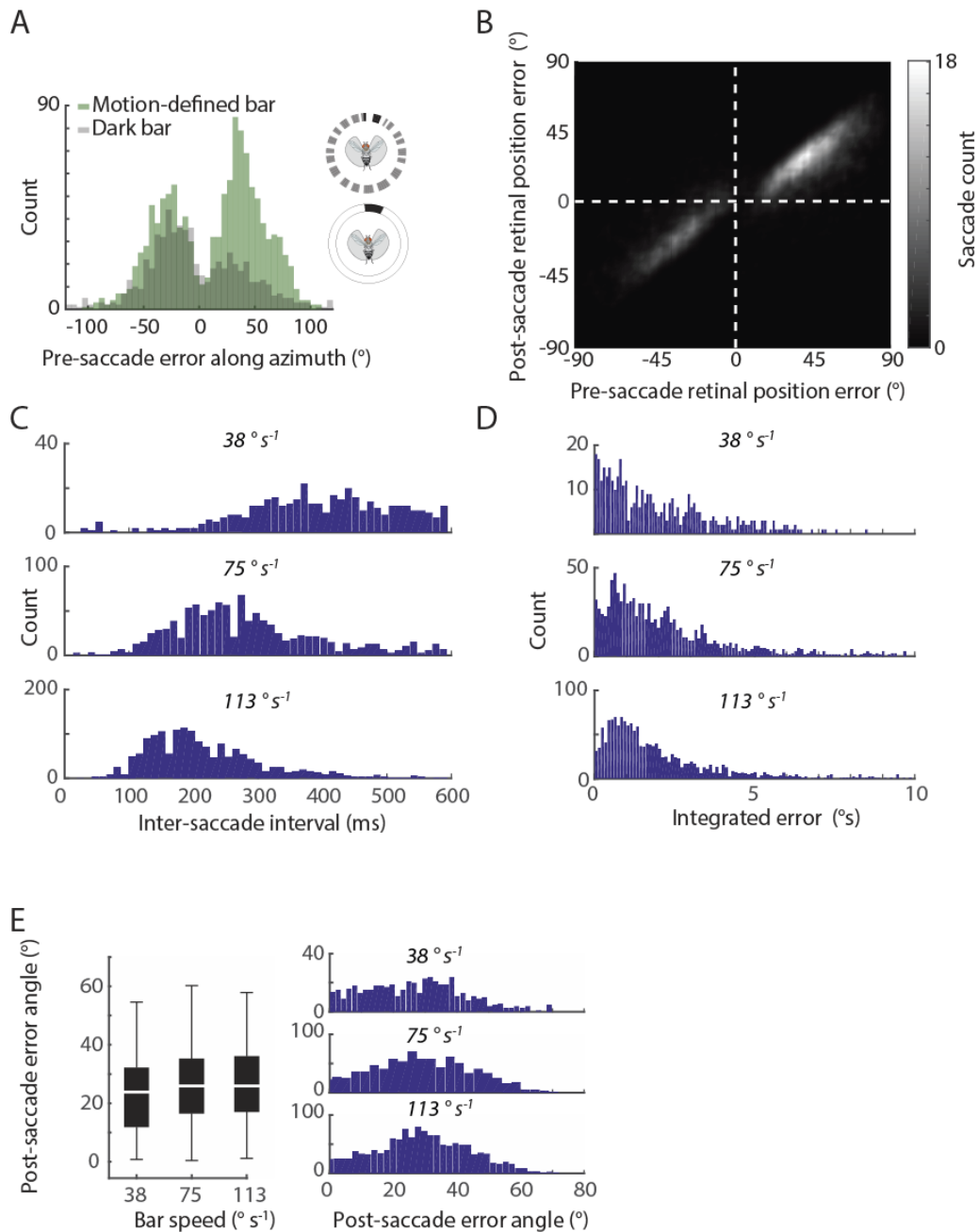


Figure S2. Distribution of pre and post-saccade error, related to Figure 2. A) Pre-saccade error along the azimuth for a motion-defined bar on a randomly-textured panorama and a dark bar on a uniform panorama. $n = 12$ animals with balanced experimental design. 112 trials, 1,815 bar fixation saccades total. B) Distribution of pre- and post-saccade position error angles for bar-fixation saccades. C,D) Histogram of inter-saccade intervals and integrated error for all speeds. E) Box plot and histograms depicting the distributions of end-of-saccade error angle for all bar speeds. Error is between fly visual midline and bar center. B–E: 2,698 saccades from 10 animals, 181 trials.

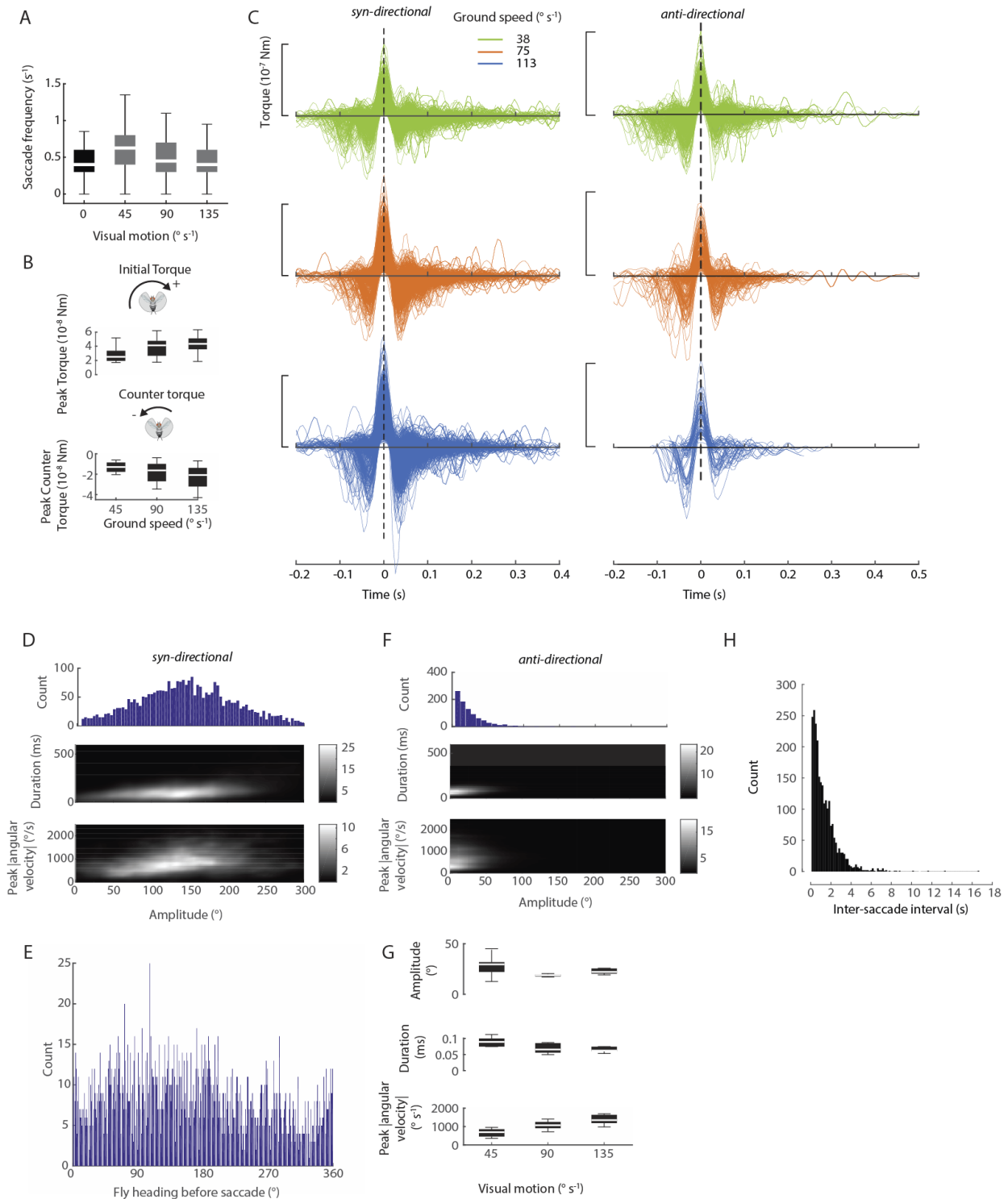


Figure S3. Syn- versus anti-directional saccades, related to Figure 3. A) Saccade frequency for ground motion at speeds of 35, 90 and 135 $^{\circ} \text{s}^{-1}$ and no motion ($0 \text{ }^{\circ} \text{s}^{-1}$). B) Peak torque and counter torque for ground motion speeds of 35, 90 and 135 $^{\circ} \text{s}^{-1}$. C) Torque signals for ground motion speeds of 35 (red), 90 (green) and 135 $^{\circ} \text{s}^{-1}$ (blue) for syn-directional tracking saccades (left column), and anti-directional saccades (right column). D) Saccades in the same direction as bar motion. All speeds pooled. E) Distribution of fly heading prior to syn-directional saccade during optomotor stabilization across all speeds. F) Dynamics for saccades in the direction opposite to the stimulus. All speeds were pooled. G) Anti-directional saccade dynamics for motion speeds of 35, 90 and 135 $^{\circ} \text{s}^{-1}$. H) Distribution of syn-directional, inter-saccade intervals with all speeds pooled. For A–H $n = 10$ flies, 451 trials, 2232 saccades. For G–I, $n = 10$ animals, 451 trials, 670 saccades.

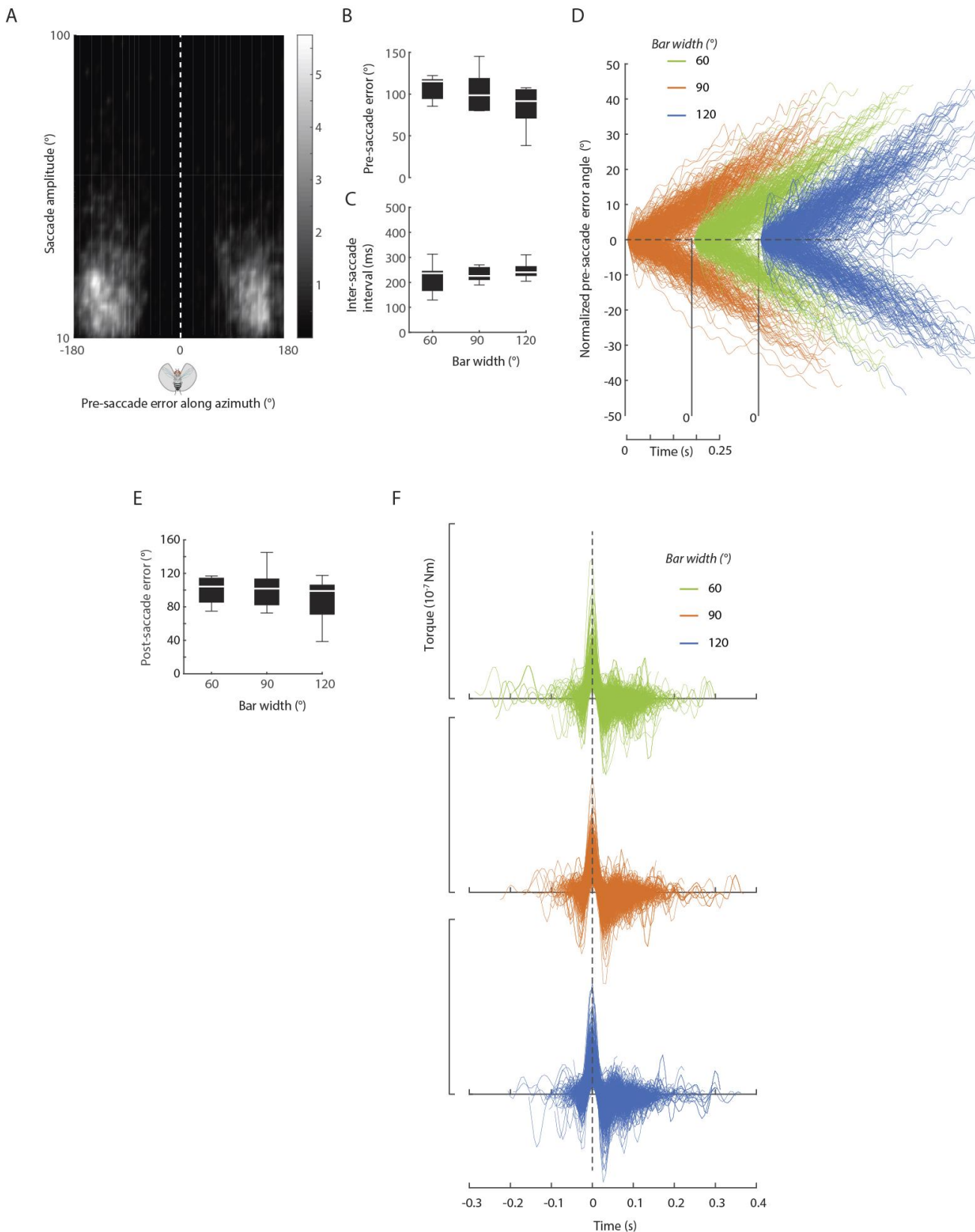


Figure S4. Saccade dynamics against different width bar, related to Figure 4. A) Distribution of saccade-triggered error angles vs. amplitude along the visual azimuth during bouts of visual fixation pooled for bar width of 60, 90 and 120°. The error angle is calculated between the flies' heading and the bar center. Color bar indicates the number of saccades. Error is between visual midline and bar center. B) Pre-saccade error for bar width of 60, 90 and 120°. Error is between visual midline and bar center. C) Inter-saccade intervals (ISIs) for bar width of 60, 90 and 120°. D) Trajectory of normalized pre-saccade error angle for bar width of 60 (red), 90 (green) and 120° (blue). E) Post-saccade error angle for bar width of 60, 90 and 120°. Error is between visual midline and bar center. F) Torque signals for bar width of 60, 90 and 120°. $n = 10$ animals, 10,067 saccades.

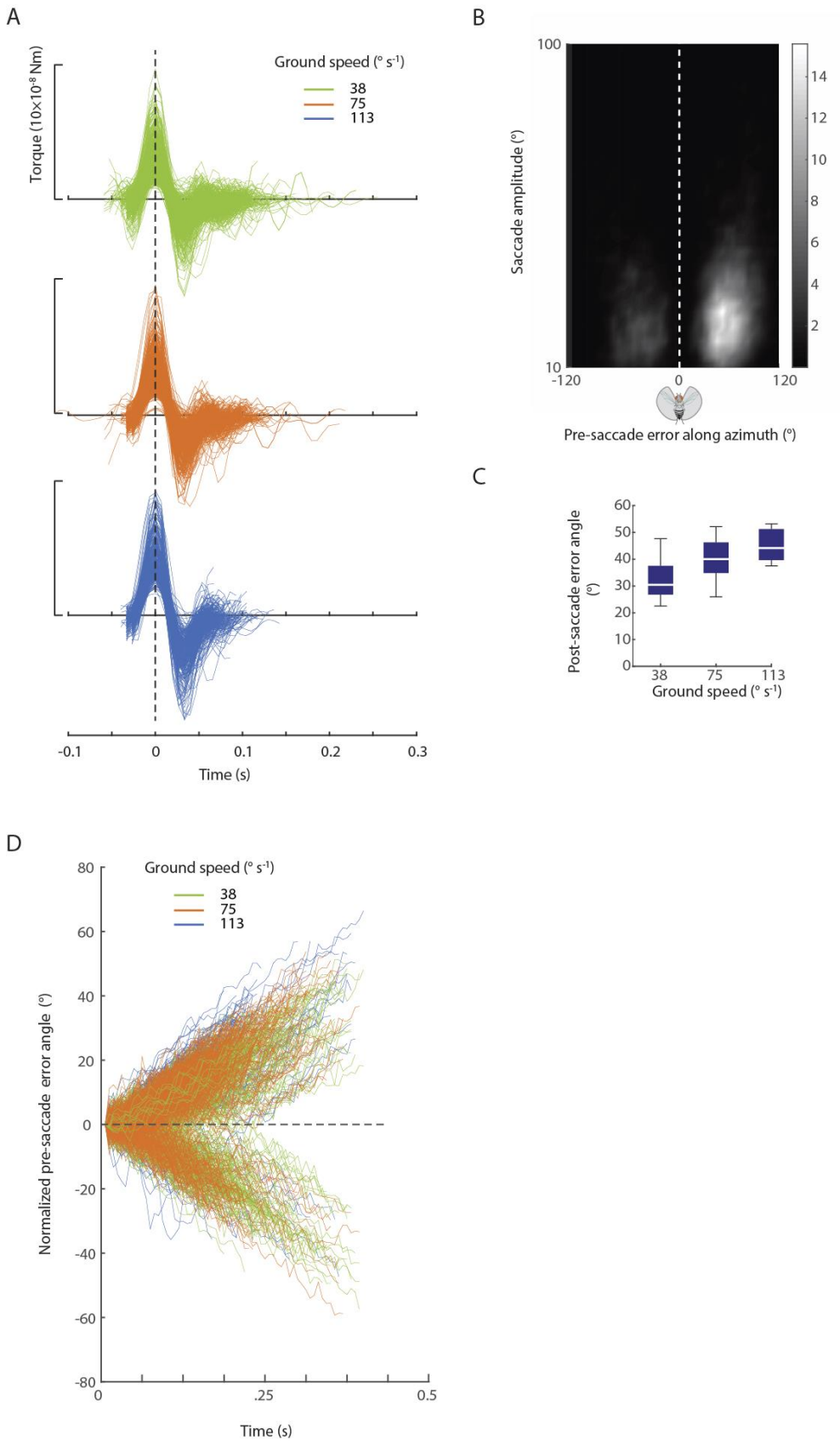


Figure S5. Saccades against varying ground speed, related to Figure 5. A) Bar fixation saccade torque for ground speed of 38 (red), 78 (green), and $113 \text{ }^{\circ} \text{s}^{-1}$ (blue). Bar counter-rotates at $113 \text{ }^{\circ} \text{s}^{-1}$. B) Distribution of saccade-triggered error angles vs. amplitude along the visual azimuth during bouts of visual fixation. The error angle is calculated between the flies' heading and the bar center. Color bar indicates the number of saccades. C) Post-saccade error for ground speed of 38, 78, and $113 \text{ }^{\circ} \text{s}^{-1}$. Error is between visual midline and bar center. D) Trajectory of normalized pre-saccade error angle for ground speed of 38 (red), 78 (green), and $113 \text{ }^{\circ} \text{s}^{-1}$ (blue). 1,361 saccades from 10 animals.

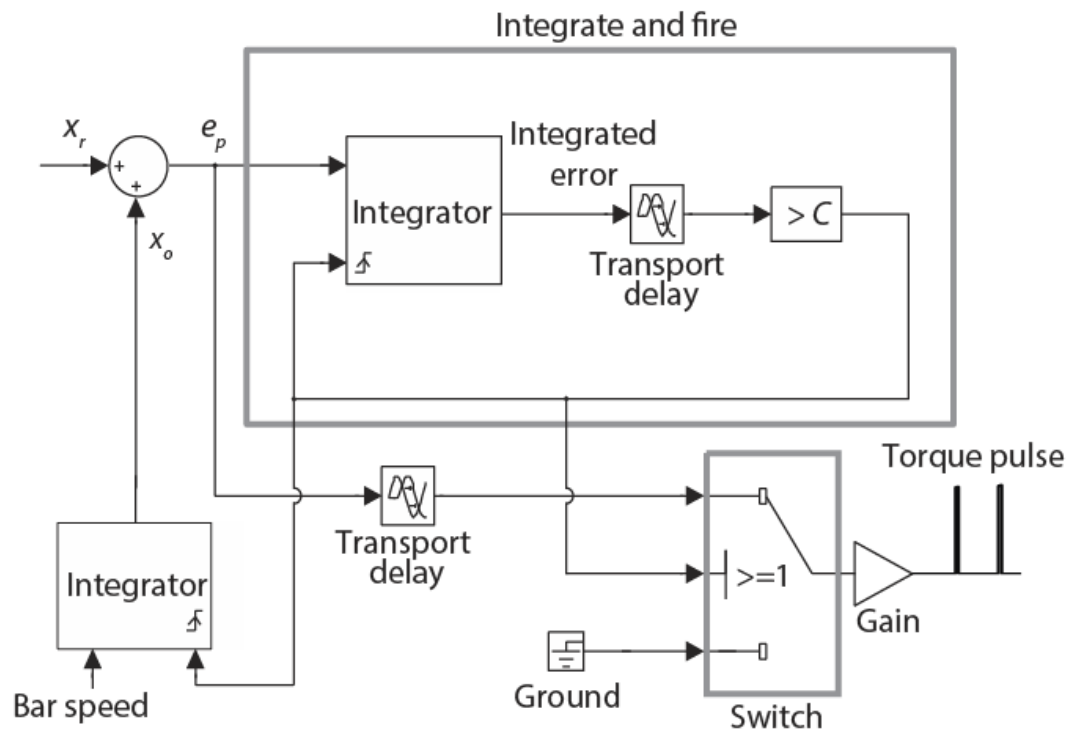


Figure S6. Open loop tracking model, related to Figure 6. Open-loop visual tracking model simulated with Simulink (Matlab). x_r : reference position; e_p : position error; x_o : bar position. When the integrated error of e_p exceeds a threshold C , a command signal is sent to a switch that allows the error e_p to flow for a set transport delay.