Saccadic eye movements evoked by optogenetic activation of primate V1

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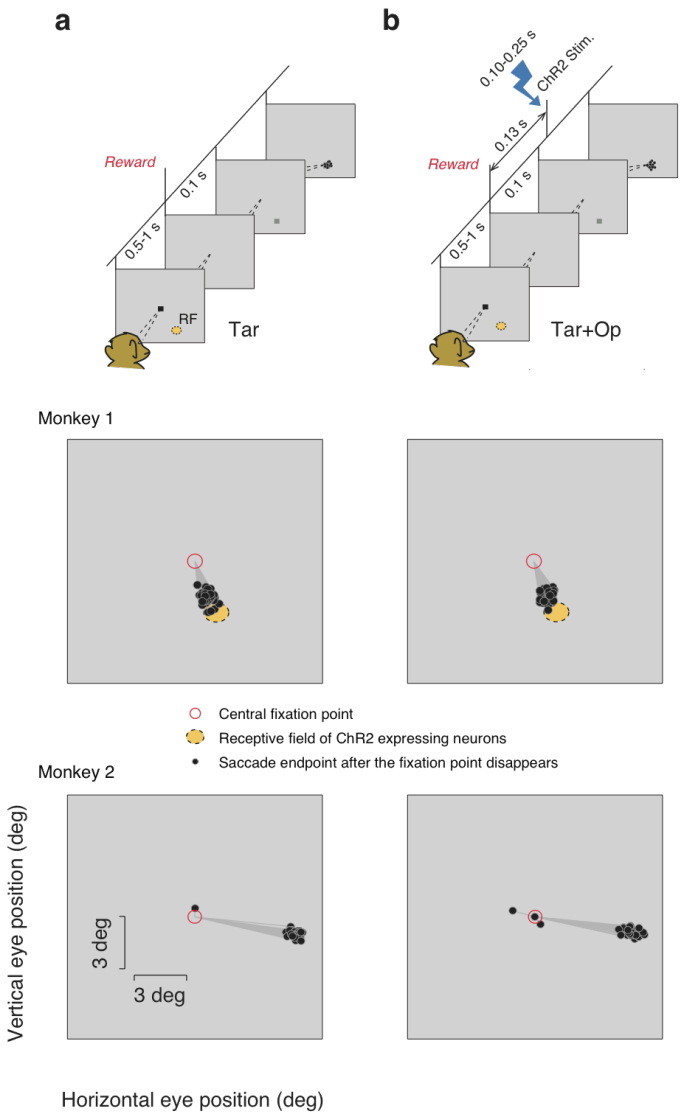

Figure S1. Task description and distributions of saccade endpoints in Tar trials. Schematics in (**a**) and (**b**) show task events for trials with and without optical stimulation ('Tar' and 'Tar+Op' respectively). For both Tar and Tar+Op trials, monkeys were required to maintain fixation for 0.5-1 sec on a central fixation point (FP, black square). After a fixed 0.1 sec after the disappearance of FP, a peripheral visual target (dark gray square) was presented. Monkeys had to make a saccade to the visual target within 0.3 sec after its onset to receive liquid reward. On Fix+Op trials (**b**), unbeknownst to the monkey, we applied optical stimulation 0.03 sec after the onset of the visual target (equivalent to 0.13 sec after the disappearance of FP). The optical stimulation consisted of light pulses that lasted a variable duration of 0.1 to 0.25 sec. The black circles on the topmost panel of (**a**) and (**b**) show depict the endpoints of saccades near the visual target, which was presented at the center of the receptive field (RF, orange) of ChR2-expressing neurons. The panels underneath the task schematics show the two monkeys' saccades toward the visual target in an example block of trials. In both trial types, the majority of saccades landed near the visual target.

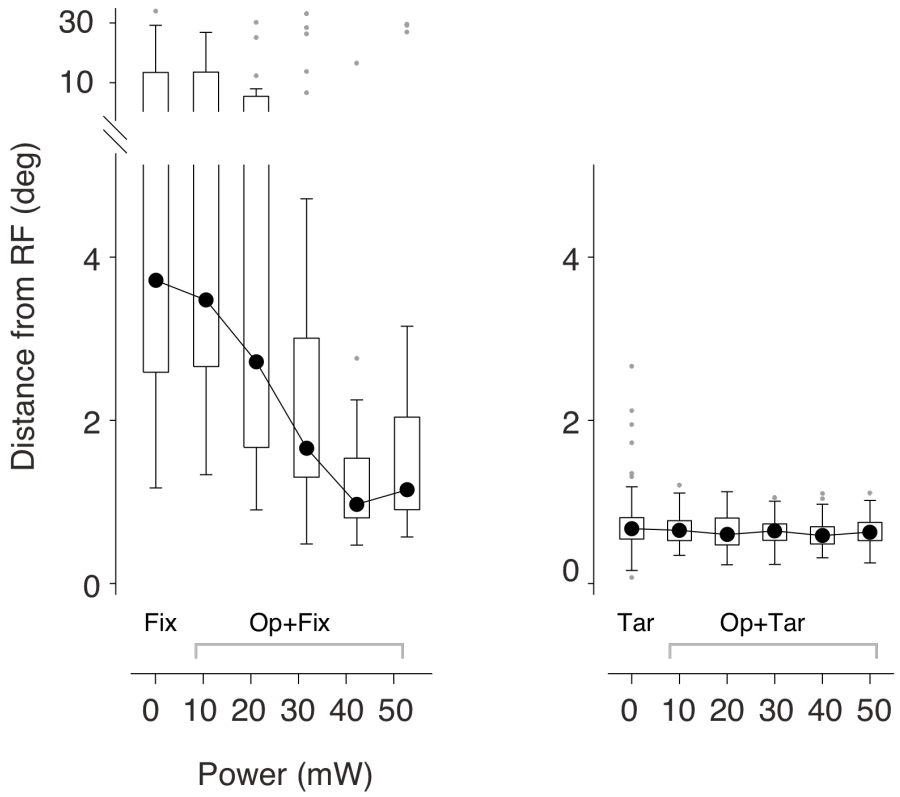

Figure S2. Behavioral effect as a function of laser power. On a subset of blocks, we varied the power of the laser in interleaved trials and quantified the magnitude of the behavioral effect by the average distance of saccade endpoints to the RF of stimulated neurons. (**a**) Box plot of this distance as a function of laser power across the Fix (leftmost column) and Fix+Op trials. As expected, the median distance of saccade endpoints to the RF reduces with laser power. (**b**) Results of the same analysis for the Tar and Tar+Op trials. In each box plot, the filled circle corresponds to the median, the surrounding box covers the range between 25 and 75 percentiles (Q1 and Q3, respectively), the whiskers extend from Q1-1.5*(Q3-Q1) at the bottom to Q3+1.5*(Q3-Q1) at the top, and the remaining "outliers" are plotted as small black dots.

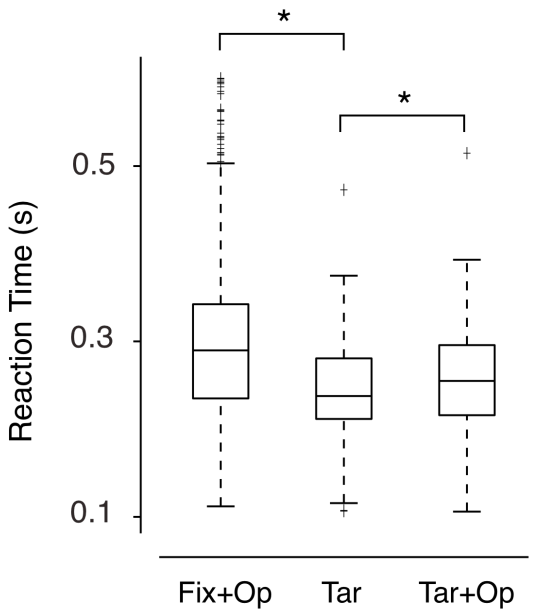

Figure S3. Reaction time. We quantified reaction time as the latency of the first saccade within a window of 0.1 to 0.6 sec after the disappearance of the fixation point. The box plot shows the statistics of the reaction times across the two monkeys for three trial types: Fix+Op, Tar and Tar+Op conditions. For the Fix+Op and Tar+Op conditions in which optical stimulation was applied, reaction times were significantly longer (Mann–Whitney; Tar versus Tar+Op: $p<1e-10$; Tar versus Fix+Op: $p<1e-4$). In each box plot, the horizontal line shows the median and plotting conventions are as in Fig. S2.

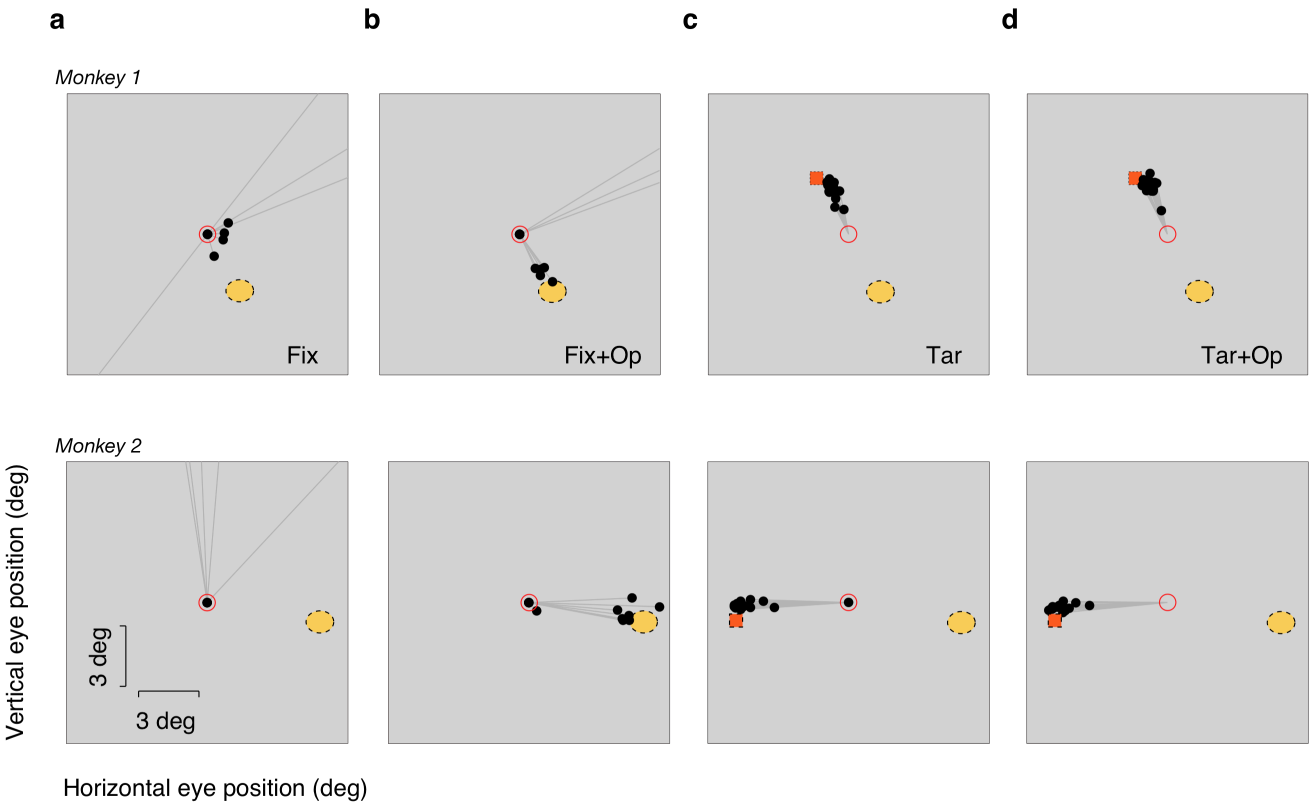

Figure S4. Control experiment. In the control experiment, the target (red square) was presented in the hemifield opposite the RF of the optically stimulated ChR2-expressing neurons. Panels (**a**) to (**d**) show endpoints (black dots) of saccades made after the disappearance of the fixation point (FP, red circle) in the four experimental conditions. (**a**) In the Fix condition, saccade endpoints (black dots) were broadly distributed. (**b**) In the Fix+Op condition, saccade endpoints were concentrated near the RF of the stimulated neurons (orange) even though no target was shown in these trials. (**c**) In the Tar condition, saccade endpoints were directed toward the visual target (red square), which was opposite the RF of the optically stimulated neurons. (**d**) In the Tar+Op condition, similar to the Tar condition, saccades were directed at the visual target. Results for the two monkeys appear in separate rows.