Supplementary Information for

Evidence for an Attentional Priority Map
in Inferotemporal Cortex

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This PDF file includes:

> Supplementary text
> Figures S1 to S2
> Table S1
> Legends for Movies S1 to S3

Other supplementary materials for this manuscript include the following:

> Movies S1 to S3

Supplementary Information Text

Behavioral Analysis of micro-stimulation experiment.

We analyzed the effects of electrical stimulation at 29 PITd sites during a total of 4531 trials. The main behavioral outcomes of a trial were hit (saccade to the saccade target indicated by the prolonged motion event of the target surface), selection error (saccade to the saccade target indicated by the prolonged motion event of the distractor surface), discrimination error (saccade to a saccade target neither indicated by target nor by distractor), and a detection error (a failure to respond to the prolonged motion event). The overall distribution of reaction times (SI Appendix, Fig. S2), shows a low response rate after the prolonged motion event (PME) onset until about 300ms, when it slowly rises to peak just below 500ms after PME onset and then fall off within little more than a hundred milliseconds. Because of the distribution of reaction times, we defined two more behavioral categories, which we called fast responses. These are the ones that occur until the 300ms bin, i.e. faster than 320ms. It is important to note that these responses are not direct effects of electrical stimulation, which started before the PME onset (see Methods), nor saccades to the receptive field of stimulation, but saccades to one of the eight saccade targets. We differentiated fast hits and fast error. We coded these six behavioral outcomes as 1 for 'missed detection', 2 for 'discrimination error', 3 for 'selection error', and 4 for 'fast error response', 5 for 'fast hit', and 6 for 'hit'.

Electrical stimulation shortened reaction times significantly ($p \ll 0.01$, Wilcoxon signed rank test) for hits (median reduction from 490ms to 470ms) and selection errors (490ms to 480ms), but not for the other behavioral categories. To analyze how electrical stimulation affected the quality of behavioral outcomes, we used logistic regression analysis (performed with Statistica 13.02, Dell). The hit condition served as the reference. In addition to the behavioral outcome, we coded each trial according to whether attention was cued inside or outside the receptive field (0/1), whether electrical stimulation was applied or not (0/1), the post-stimulus time during which the behaviorally relevant translation event occurred (in 100ms bins).

The table S1 in SI appendix shows the results of the multinomial regression analysis for results presented in Fig. 6B and 6C and for the effect of time (Fig. 6D and 6E). The significant (at $p < 0.01$) effects of stimulation are as follows: electrical stimulation ('stim') decreased the fraction of missed detection events, an effect that was stronger when attention ('att') was cued into the RF ('att*stim' interaction). Stimulation had no significant effect on the fraction of discrimination errors. Stimulation significantly increased the number of selection errors, which also depended on the attention condition and, importantly, on the interaction of attention condition and stimulation (i.e. a selective increase of selection errors when attention was cued outside the RF *and* electrical stimulation was applied). Electrical stimulation also significantly enhanced the rate of fast responses, most of which were reporting the wrong motion direction. The

effectiveness of electrical stimulation decreased with time, and this effect was significant for all behavioral outcomes with the exception of fast response error rate.

Out of 29 stimulation sites, 25 were effective to alter behavior.

We quantified the effect of time on electrical stimulation by fitting an exponential function to the curves shown in Fig. 6D and 6E using the MATLAB Curve Fitting Toolbox. The decay constants were determined as 706ms for the decay of electrical stimulation effectiveness on the hit rate, when attention was cued into the RF, and 765ms when attention was cued outside the RF. The decay of missed detection errors without electrical stimulation with attention cued into the RF was 610ms. And the decay of electrical stimulation effectiveness on the generation of selection error rates, when attention was cued outside the RF, was 985ms.
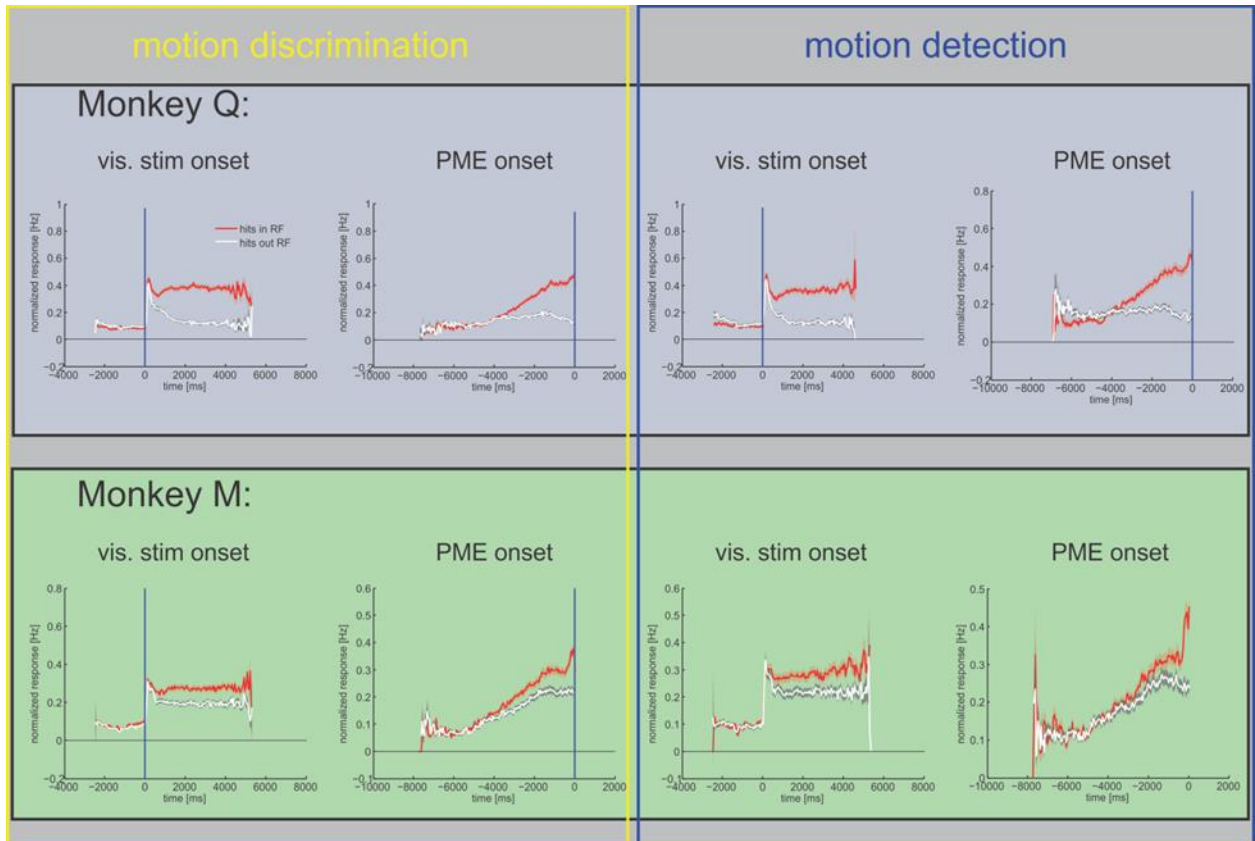
Fig. S1. Attentional Activity Modulation for each subject individually: Population PSTHs for each monkey separately (top and bottom) and for the motion discrimination task and for the motion detection task (left and right), respectively. Left (yellow box): Average population PSTHs triggered to visual stimulus onset (left) and triggered to the PME (right) for monkey Q (upper row) and monkey M (lower row). Only successful completed trials are considered. Because trial durations differed widely, stimulus-onset triggered PSTHS (left) grow more noisy towards the end, as fewer trials are available for analysis. Both monkeys show substantial attentional modulation throughout the course of the trial (left). Attentional modulation is stronger in monkey Q than in monkey M. This is largely due to the different degrees of modulation of the distractor stimulus. The attentional modulation grows stronger, on successfully completed trials, with increasing proximity to the behaviorally relevant translation, the prolonged motion event (PME). Right (blue box) shows PSTHs for each monkey separately for the motion detection task. Same format as for the motion discrimination task. The same pattern of results appears in both subjects. Interestingly, towards the very end of the trial (right column), just prior to response selection, activity for the attended surface surges sharply, more so than in the motion discrimination task. Since responses are onto targets outside the RF in the discrimination task, but into the RF in the detection task, this difference in tasks indicates an overt attentional component in PITd.
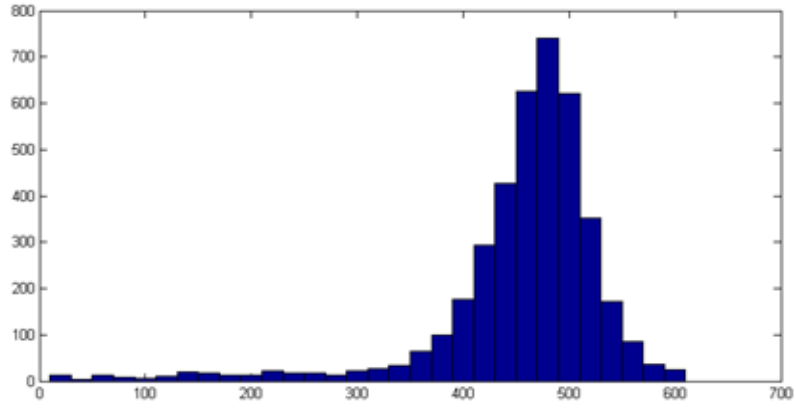
Fig. S2. Distribution of reaction times (IN MS) after prolonged motion event (PME) onset (, not electrical stimulation onset, see Methods). Shown is the number of trials as a function of reaction time in milliseconds with 20ms bins.

Effect	Level of Effect	Level of Response	Column	Estimate	Standard Error	Wald Stat.	Lower CL 95.0%	Upper CL 95.0%	p
	Multinomial Regression Analysis (n=29 stimulation sites)								
Intercept 1	MISSED DETECTION	1	1	-0.402	0.1703	5.56	-0.735	-0.068	0.018353
att	1	1	2	0.062	0.0525	1.40	-0.041	0.165	0.237116
stim	1	1	3	-0.581	0.0525	**122.49**	-0.684	-0.479	**0.000000**
att*stim	1	1	4	-0.195	0.0526	**13.80**	-0.298	-0.092	**0.000203**
time		1	5	-0.038	0.0042	**83.27**	-0.046	-0.030	**0.000000**
Intercept 2	DISCRIMINATION ERROR	2	6	-1.525	0.3682	17.15	-2.247	-0.803	0.000035
att	1	2	7	0.042	0.1010	0.17	-0.156	0.240	0.679163
stim	1	2	8	-0.068	0.1010	0.45	-0.266	0.130	0.503259
att*stim	1	2	9	-0.078	0.1010	0.60	-0.276	0.120	0.441780
time		2	10	-0.050	0.0096	**27.37**	-0.069	-0.031	**0.000000**
Intercept 3	SELECTION ERROR	3	11	-0.033	0.2909	0.01	-0.603	0.537	0.910255
att	1	3	12	-0.539	0.0995	**29.40**	-0.734	-0.344	**0.000000**
stim	1	3	13	0.508	0.0995	**26.06**	0.313	0.703	**0.000000**
att*stim	1	3	14	-0.458	0.0995	**21.20**	-0.653	-0.263	**0.000004**
time		3	15	-0.085	0.0080	**110.29**	-0.101	-0.069	**0.000000**
Intercept 4	FAST RESPONSE ERROR	4	16	-4.147	0.4117	101.47	-4.94	-3.340	0.000000
att	1	4	17	0.123	0.1318	0.88	-0.135	0.382	0.348888
stim	1	4	18	0.756	0.1318	**32.95**	0.498	1.015	**0.000000**
att*stim	1	4	19	0.125	0.1318	0.90	-0.133	0.384	0.341868
time		4	20	0.008	0.0089	0.75	-0.010	0.025	0.386103
Intercept 5	FAST RESPONSE HIT	5	21	-5.512	0.5425	103.25	-6.575	-4.449	0.000000
att	1	5	22	0.265	0.1377	3.72	-0.004	0.535	0.0538

									26
stim	1	5	23	0.340	0.1377	6.11	0.070	0.610	**0.0134 46**
att*stim	1	5	24	0.228	0.1378	2.73	-0.042	0.498	0.0981 79
time		5	25	0.032	0.0112	8.22	0.010	0.054	**0.0041 46**

Table S1. Results of the multinomial regression analysis.

Movie S1. This movie illustrates the spatial layout and the temporal sequence of a trial of the attentive motion-discrimination paradigm. Stimulus events are slowed down for clarity. The basic spatial layout consists of the central fixation point (FP), which has to be foveated throughout the trial, the bar cue (to the left of the fixation spot) indicating which of the two random dot surfaces, one to the left, the other to the right of the FP, is to be attended, two random dot surfaces, and eight saccade targets in the periphery. The saccade targets are positioned at equidistant locations from the FP. The random dot surfaces undergo rapid random changes in motion transition, which are interrupted, at a point in time unpredictable by the subject, by a prolonged motion event (PME). In the example in this movie the distracter PME on the right occurs prior to the target PME. Since the target's PME direction is towards the upper right, a saccade to that location would need to be made for successful completion of the trial.

Movie S2. This movie shows live video taken during the first PITd recording while the subject was successfully performing six trials of the attentive motion discrimination task. The top shows the control monitor on which the hand-mapped receptive field (RF) is marked on a transparent plastic sheet on top of a control monitor that shows the stimuli as the subject was seeing them. The activity of the simultaneously recorded multi-unit activity can be heard. At the bottom, the average PSTHs for the two attention conditions are shown, light red for 'attend into RF', and grey for 'attend away from RF'. The instantaneous firing rates (causally smoothed with half Gaussian) are plotted online in red and white (for 'attend into RF' and 'attend away from RF' conditions, respectively). At the end of the trial, the outcome ('Hit') is indicated and in case of a successful completion, the sound of the solenoid controlling juice reward can be heard opening and closing as a click. The first trial is an 'attend in RF' condition (red) – the bar cue is to the left of the fixation spot. The following three trials are 'attend away from RF' conditions, and the final two trials again, 'attend into RF' conditions.

Movie S3. This movie shows the same live recording as S2, but an error trial. All conditions and conventions are as in S2. The cue is placed to the right of the fixation spot, thus the subject's task was to pay attention to the right random dot surface ('attend away from RF' condition, white). Yet activity is as high as it would be, on average, when attention is paid into the RF. And the subject is responding to the prolonged motion event on the distractor surface, thus completing the trial as an error.