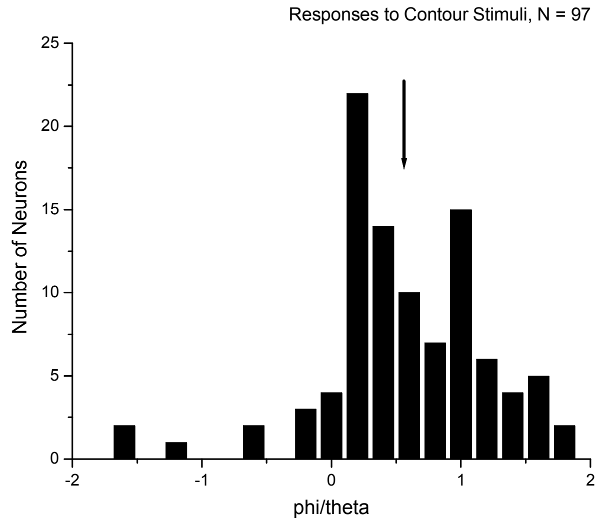
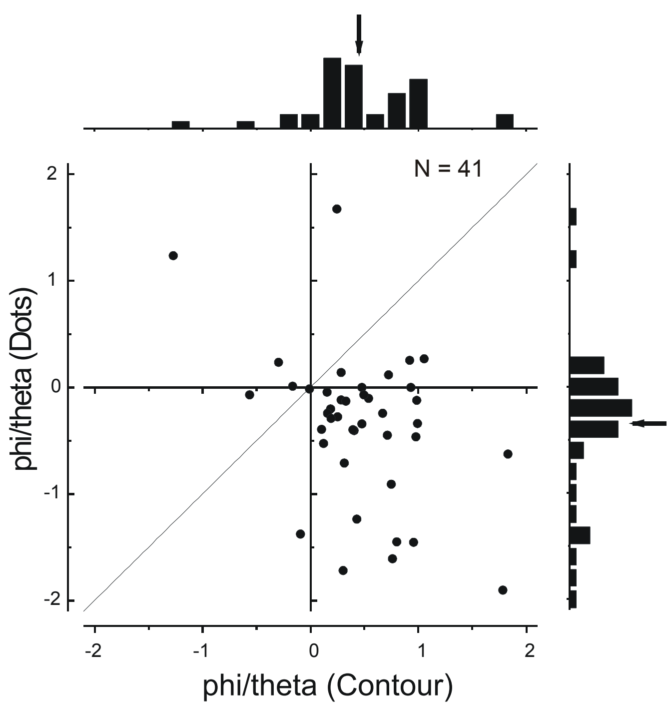
Supplementary Materials

S1. Angular shift of Contour Directional Preference

Based on our definition, the contextual modulation index (CMI, see Figure 2B and Experimental Procedures) yields a maximum of 1 when the Contour Directional Preference matches the Global Prediction. A CMI of 1 indicates that neuronal responses are accurately encoding the global motion information that is present in the surround. Deviations from a perfect match, whether in the direction of the Local Prediction or away from that prediction, thus represent less than perfect surround integration. Accordingly, the CMI decreases linearly as "phi" (i.e. the angular difference between the Contour Directional Preference and the Local Prediction) deviates from "theta" (the angular difference between the Local and Global Predictions). Our definition of the CMI avoids overestimation of the extent of integrative modulation but does not distinguish between under- and overshooting of the Contour Directional Preference relative to the Global Prediction. To show the distribution of this angular shift, we computed phi/theta across our neuronal sample. For the neurons tested with the contour stimuli ($N = 97$, the same data set as in Figure 2), the range of this index is from -1.67 to 1.83, with a significantly positive mean of 0.56 (Student t-test, $P << 0.0001$). **Supplementary Figure 1A** shows the distribution of phi/theta for all 97 neurons. We also computed phi/theta for the 41 neurons that were tested with both contour and dot stimuli (the same data set as in Figure 4). The mean value for contour stimuli was significantly greater than for dot stimuli (paired t-test, $P < 0.0001$). For contour stimuli, the average phi/theta was 0.45, which was significantly greater than zero (student t-test, $P < 0.0001$). The average phi/theta for dot stimuli was -0.35 and was significantly less than zero (student t-test, $P = 0.0015$). **Supplementary Figure 1B** shows a scatter plot of phi/theta values for these 41 neurons. The pattern of results found using the CMI as a measure of surround modulation therefore held using the simpler measure of phi/theta.



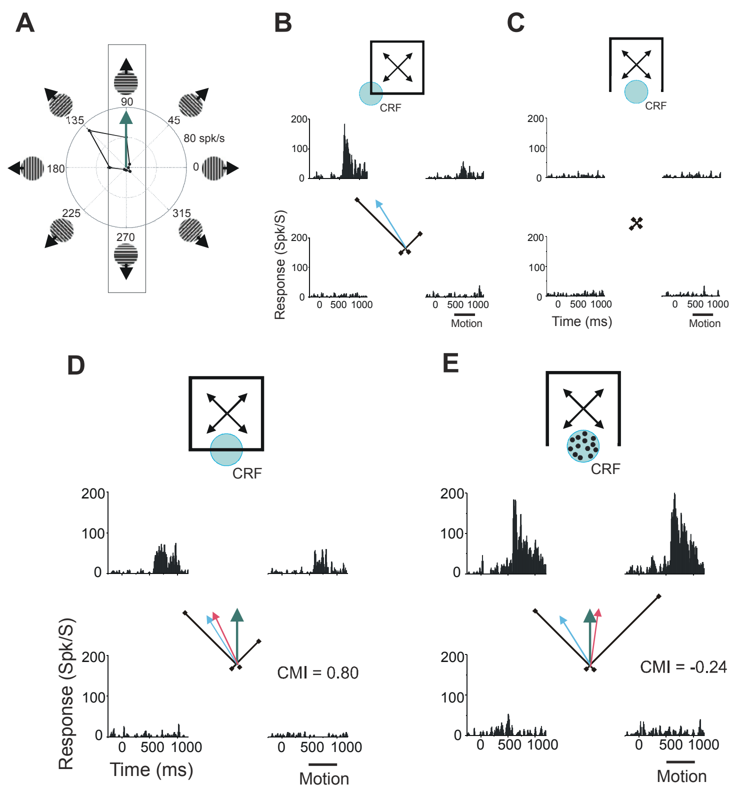
Supplementary Figure 1A. Distribution of phi/theta obtained with contour stimuli (N = 97). The range of the index value is from -1.67 to 1.83. The mean value is 0.56 (indicated by the arrow), which is significantly positive.



Supplementary Figure 1B. Phi/theta obtained with contour and dot stimuli (N = 41). The mean value for contour response was 0.45, which is significantly positive. The mean value for dot response was -0.35, which is significantly negative and significantly smaller than that obtained with the contour stimuli.

S2. An additional example neuron

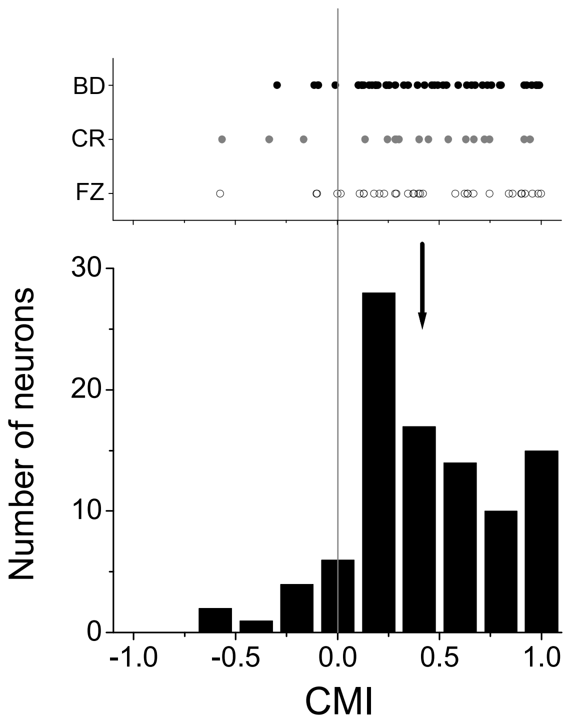
Supplementary Figure 2 shows an example of neuronal responses to the various stimuli used in our study. For contour stimuli, the CMI of this neuron was 0.80 indicating integrative surround modulation: the Contour Directional Preference (red arrow) was biased away from the Local Prediction (green arrow) towards the Global Prediction (blue arrow). When presented with dot stimuli, however, surround modulation switched from integrative to antagonistic: responses were smaller when the surround features moved up and to the left (the preferred direction for CRF stimuli) than when they moved up and to the right; the resultant CMI was -0.24.



Supplementary Figure 2. An example of adaptive surround modulation in area MT. A. Directional tuning measured with drifting gratings. The Local Prediction is indicated by the green arrow. B. Responses to one corner of the square shown as PSTHs and vectors. The Global Prediction is indicated with the blue arrow. C. No statistically significant responses were evoked in the "control conditions". D**.** Responses to one contour of an intact square shown as PSTHs and vectors. The Contour Directional Preference (red arrow) was biased away from the Local Prediction (green arrow) *toward* the Global Prediction (blue arrow). Modulation was thus integrative. E. Responses of the same neuron to dots moving either upward or downward within the CRF. The surround stimulus moved in one of the four oblique directions. The Contour Directional Preference (red arrow) was biased away from the Local Prediction (green arrow) and *away* from the Global Prediction (blue arrow). Modulation was thus antagonistic. The direction of the mean response vector is repelled from the Global Prediction.

S3. Results obtained from different monkey subjects are not significantly different.

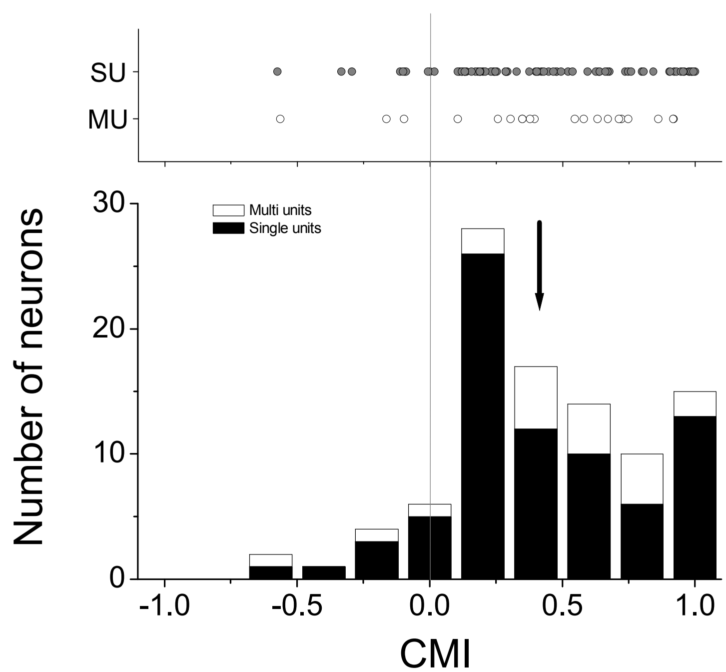
CMIs of responses to contour stimuli (total N = 97) from each monkey (BD, CR and FZ) are shown as scatter plots in **Supplementary Figure 3.** The mean contour CMIs for all monkey subjects were significantly positive (student t-test, $P < 0.01$) and there was no significant difference in the contour CMIs for any monkey pair (paired t-test, $P > 0.05$). Two monkeys (BD and CR) were tested with both contour and dot stimuli. Both monkeys yielded dot CMIs that were negative (and not significantly different from each other) and significantly smaller than those to the contour stimuli (paired t-test, $P < 0.01$).



Supplementary Figure 3. CMIs obtained with contour stimuli (total N = 97) for each monkey. Scatter plots show data from the three monkey subjects BD, CR and FZ.

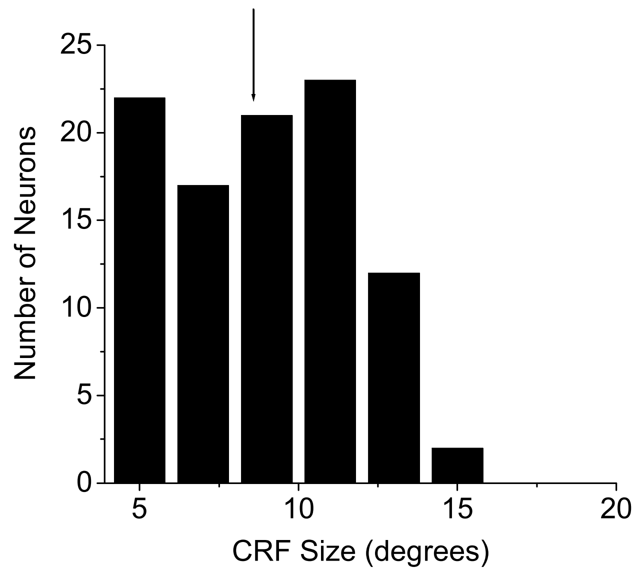
S4. Single- and multi-units yielded similar results.

Results from single- and multi-unit recordings were very similar. For contour stimuli (N = 97), the mean CMI for the 77 single-units was 0.41, which was significantly positive (student t-test, $P \ll 0.0001$). The mean CMI for the 20 multi-units was 0.43, which was also significantly positive (student t-test, $P < 0.0001$) (see **Supplementary Figure 4**). For neurons tested with both contour and dot stimuli (N = 41), contour CMIs were significantly positive and CMIs of the dot responses were significantly negative for both single- and multi-unit recordings (student t-test, $P < 0.05$).



Supplementary Figure 4. Contour stimuli CMIs for single- (N = 77) and multi-units (N = 20) recordings. For both single- (first row of the scatter plot and filled columns of the histogram) and multi-units (second row of the scatter plot and open columns of the histogram), mean CMIs are significantly positive and are not significantly different from each other.

S5. The distribution of CRF sizes



Supplementary Figure 5. The distribution of the CRF sizes in our neuronal sample (N = 97). The mean CRF size was 8.6º± 2.8º (std). Due to the size of the gratings used to map the CRFs (5ºx5º), our size estimates were conservatively large with the minimum size being 5º (see Methods) . For most neurons in our sample, these initial estimates indicated that only one contour of the contour stimulus passed through the CRF and hence that none of the control stimulus (which also constituted the surround portion of our dot stimuli) would intrude into the CRF. This was confirmed by examining responses to the control stimuli: no neurons with significant control stimulus responses were included in the analyses presented in this paper.

S6. No significant correlations between surround modulation and other neuronal parameters

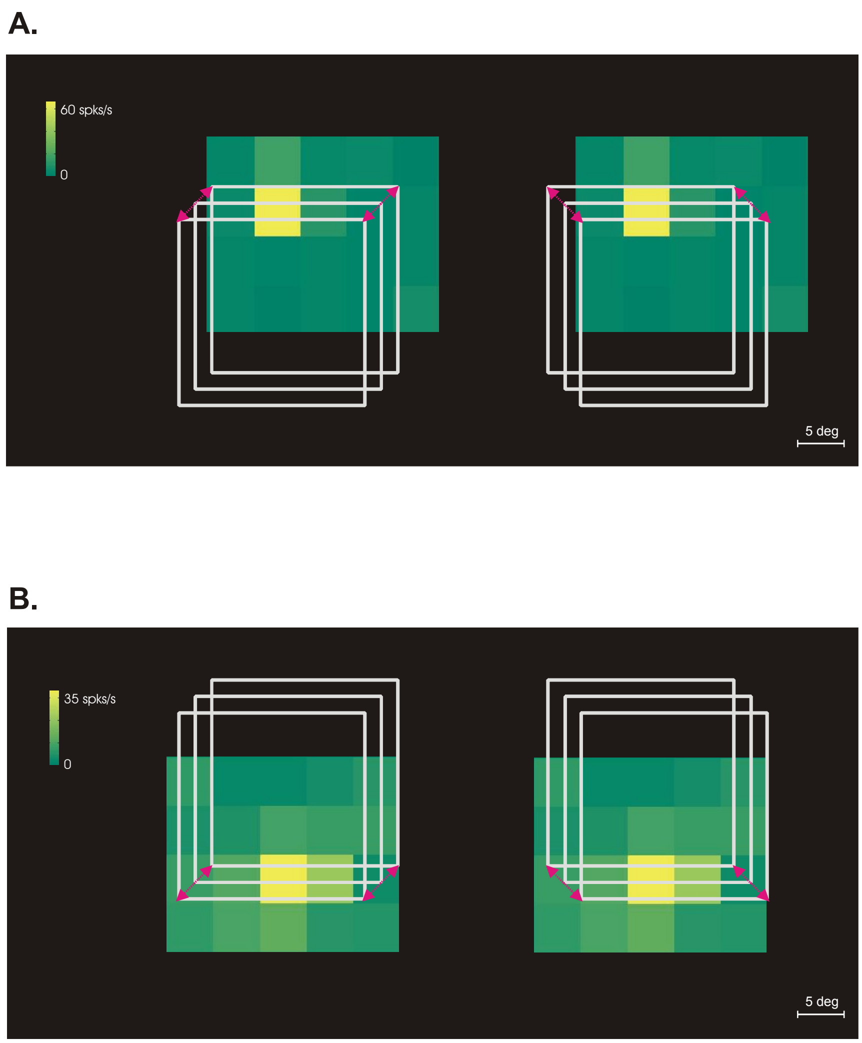
We found no significant correlation between the CMI (for contour and dot stimuli) and any of the following neuronal parameters: CRF size, CRF eccentricity and directional selectivity (as quantified by the Directional Selectivity Index or DSI, see Experimental Procedures). CRF eccentricity was defined as the distance from the fixation point to the center of the CRF (see Experimental Procedures for description of how the CRF center was determined). **Supplementary Table 1** lists correlations and P values.

Correlated Parameters	**Pearson's r**	**P value**
Contour CMI and CRF size	-0.07	0.52
Dot CMI and CRF size	0.06	0.73
Contour CMI and CRF eccentricity	-0.015	0.88
Dot CMI and CRF eccentricity	0.09	0.59
Contour CMI and DSI	-0.013	0.90
Dot CMI and DSI	-0.13	0.41

Supplementary Table 1. Correlations between neuronal parameters and CMIs for contour (N = 97) and dot (N = 41) stimuli.

S7. Receptive field map and stimulus path

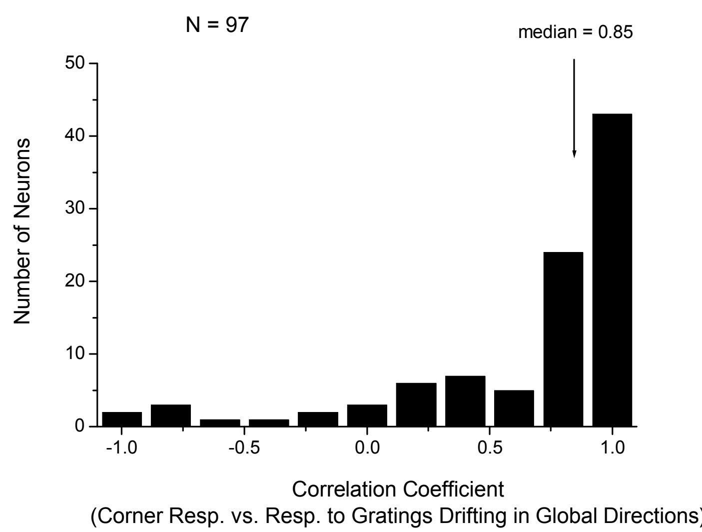
To illustrate the path of our visual stimuli relative to the CRF, we have superimposed the path of the contour stimulus (i.e. a square) on raw CRF maps obtained with drifting gratings. **Supplementary Figures 7A** and 7**B** illustrate this relationship for the example neurons illustrated in Figure 3 (main text) and in Supplementary Figure 2, respectively. Except for the contour centered within the CRF, the paths of the dot and control stimuli are identical to that of the contour stimulus.



Supplementary Figure 7. **A** and **B** show receptive field maps of the two example neurons shown in Figure 3 and Supplementary Figure 2, respectively, overlaid with the paths of contour stimuli moving in the four global directions.

S8. Global Prediction based on responses to drifting gratings

In our analyses, the "Global Prediction" served as the reference point for surround integration. For the results presented in the main text, the Global Prediction was based on responses to corner stimuli. We found similar results, however, when we constructed the Global Prediction based on responses to drifting gratings moving in the four "global" directions. This is not surprising as the directional selectivity observed with the two stimulus types (corner and grating stimuli) was very similar. For our population of 97 MT neurons, the median correlation coefficient between responses to gratings and responses to corners moving in the four "global directions" was 0.85 (**Supplementary Figure 8**). As was found using corner responses to generate the Global Prediction, we found that surround modulation under contour conditions was predominately integrative when grating responses were used to generate the Global Prediction (mean CMI = 0.30, student t-test, P<<0.0001). Similarly, we found that surround modulation was predominately antagonistic under dot conditions when the Global Prediction was based on grating rather than corner responses (mean CMI = -0.17, student t-test, P = 0.003).



Supplementary Figure 8. Correlation coefficients between responses of individual neurons to corners and to gratings drifting in the four global directions (N = 97). Corner and grating responses are highly correlated with a median of 0.85 (indicated by the arrow).