

Figure S1. Columnar-scale orientation discriminability as a function of spatial-frequency for the two monkeys separately (Related to Figure 1G) (A) Results from monkey BA (B) Results from monkey AP. Same format as **Figure 1G**. Responses from both monkeys show a large and significant drop in discriminability of low SF gratings relative to medium SF gratings. This drop is significantly larger than the drop in detectability of low SF gratings relative to medium SF gratings (see **Figure S3**). The two monkeys differ in their responses to high SF gratings. Monkey AP is less sensitive to high SF both in orientation discrimination and in detectability (**Figure S3**). Additional tests suggest that this monkey is mildly myopic, which degraded his neural and behavioral responses to high SF gratings but not to medium and low SF gratings (data not shown).

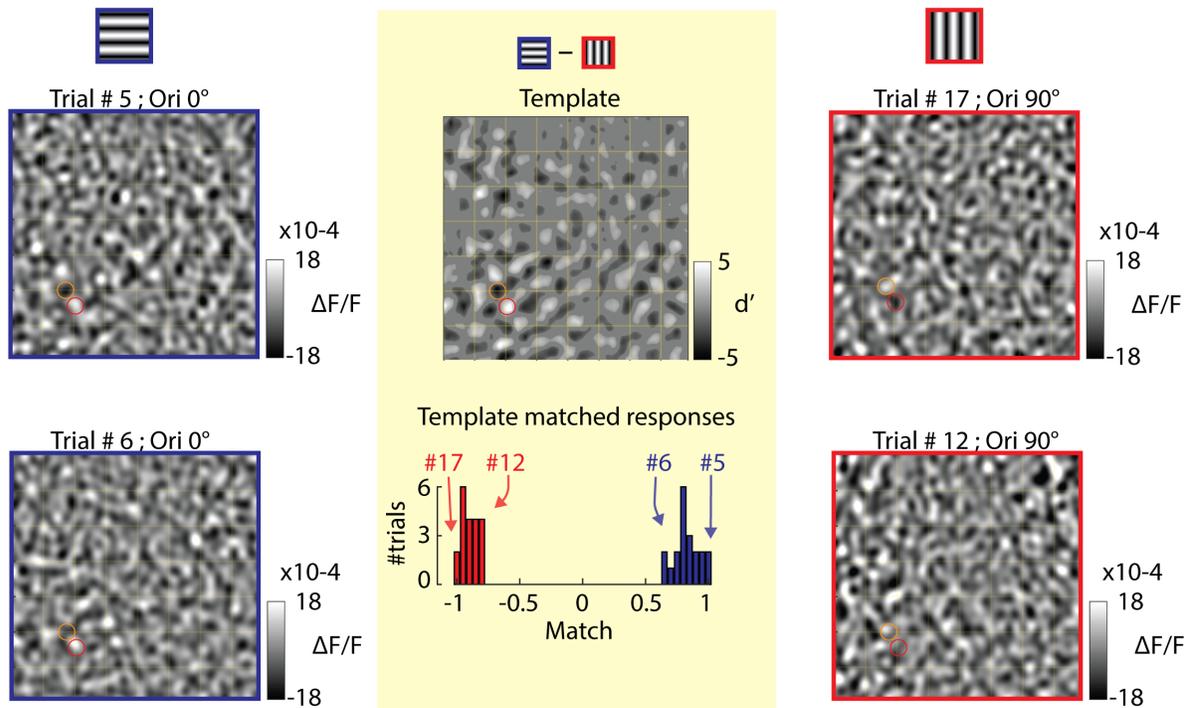


Figure S2. Example of single-trial columnar responses to orthogonal grating stimuli (Related to STAR Methods). The central panel shows a reproduction of the example columnar decoder/template (d' map) from Figure 1D for 2 cpd stimuli (d' values between -1 and 1 were set to 0). The histogram below shows the single-trial template-matched responses (pooled over space and normalized) to horizontal (blue) and vertical (red) gratings, in the same example experiment (see Methods). The two panels on the left and the two panels on the right show examples of the columnar responses in single trials respectively for horizontal and vertical gratings (see arrows indicating the corresponding position in the templated-matched histogram). The two small circles, in red and orange, in the template and trials images, indicate the position of two example columns presenting a clear orientation selective activation.

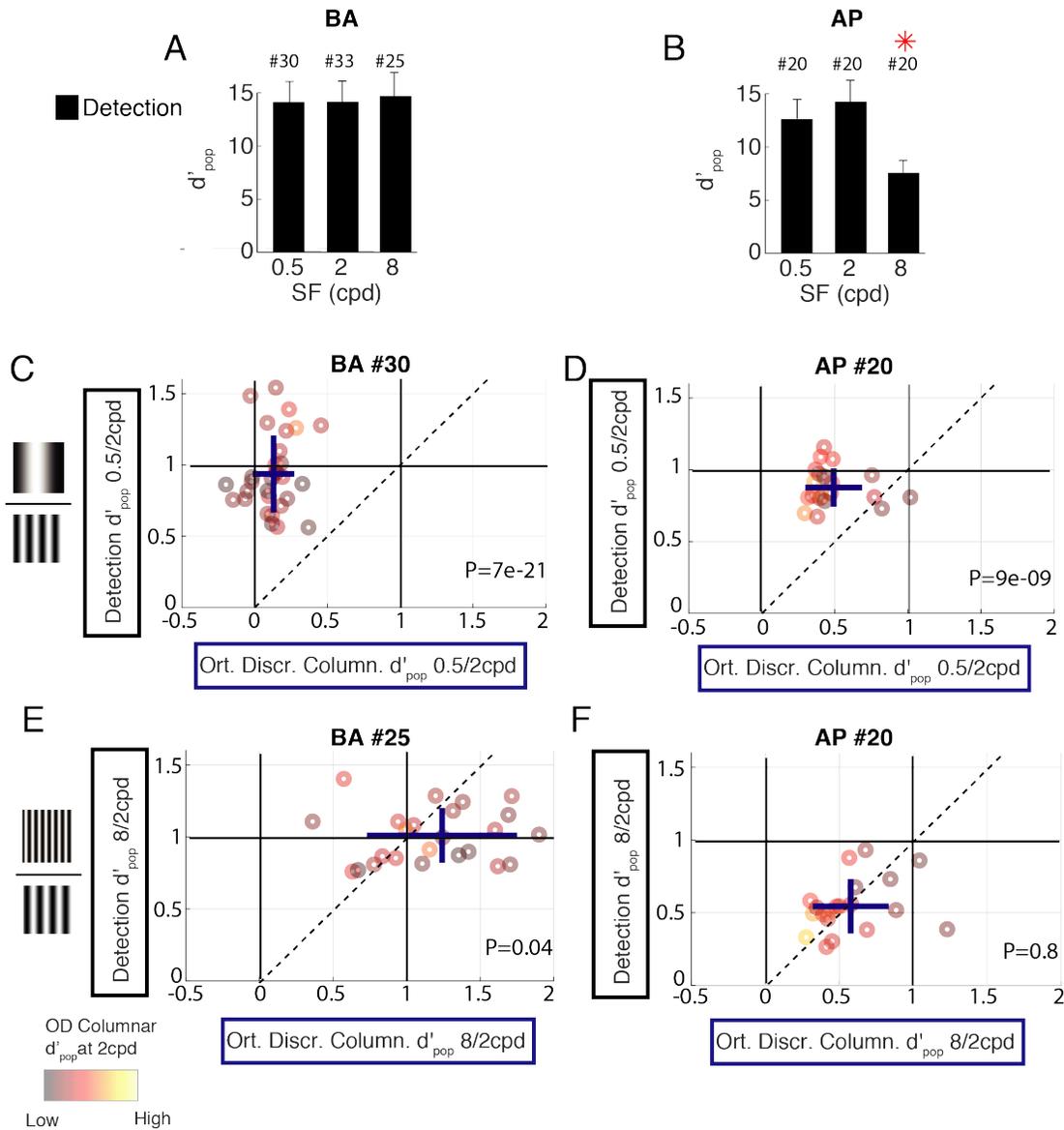


Figure S3. Detectability of responses to grating stimuli as a function of stimulus spatial frequency and relation between detection and columnar-scale orientation sensitivity at low and high spatial frequencies (Related to Figure 2B). (A) Average discriminability across sessions from monkey BA alone, between responses to gratings vs. blank, at the three different stimulus SFs. Same format as **Figure 2B**. (B) Results from monkey AP alone, same format than A. (C,D) Scatter plot across sessions of the ratio of detection d'_{pop} at 0.5 over at 2 cpd plotted against the same ratio for columnar-scale orientation discrimination d'_{pop} . Marker color represents the relative value of columnar-scale orientation discrimination d'_{pop} at 2cpd. Blue cross represents the mean and standard deviation across sessions. p-value on bottom right indicates significance of paired *t*-test between the two ratios across sessions. The relative drop in detection sensitivity at 0.5cpd vs. at 2cpd is significantly smaller than the relative drop in in orientation discrimination sensitivity. **C** – data from Monkey BA. **D** – data form monkey AP. (E,F) Same as C, D but for 8cpd vs. 2cpd. Ort. Discr. Column. – orientation discrimination columnar.

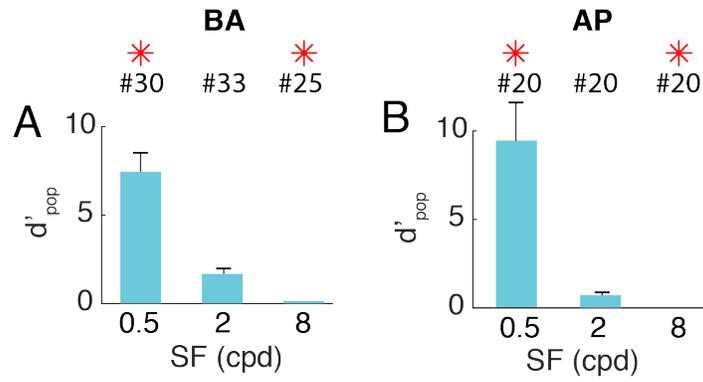


Figure S4 (Related to Figure 4B). Orientation discriminability based on luminance-retinotopic responses as a function of spatial-frequency for the two monkeys separately. (A) Results from monkey BA. (B) Results from monkey AP. Same format as Figure 4B.