Supplementary Table S1

<table>
<thead>
<tr>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
<th>Case 4</th>
<th>Case 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animal</td>
<td>M1</td>
<td>M1</td>
<td>M2</td>
<td>M3</td>
</tr>
<tr>
<td>Hemisphere (left or right)</td>
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<td>Right</td>
<td>Right</td>
<td>Right</td>
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<td>Anesthetized/awake exp.</td>
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<td>anesthetized</td>
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<tr>
<td>Total no. of exp. sessions</td>
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<td>8</td>
<td>1</td>
<td>1</td>
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<tr>
<td>No. of sessions DE maps observed</td>
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<td>3</td>
<td>1</td>
<td>1</td>
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<tr>
<td>Average signal/noise ratio</td>
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<td>11.8*</td>
<td>20.8</td>
<td>13.6</td>
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<td>Maps shown in Figures</td>
<td>Figures 1-2, 5-7, S1-S3, S5-S8</td>
<td>Figures 3, 7, S4, S5, S8</td>
<td>Figures 3, 7, S4, S5</td>
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<td>Quantification in Figures</td>
<td>Figures 3, 5-6, S3, S5-S9</td>
<td>Figures 3, 5-6, S3, S5-S9</td>
<td>Figures 3, S3, S5-S7, S9</td>
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</table>

Note: *: Average signal/noise ratio for 3 map-positive sessions: 14.3; for 5 map-negative sessions: 10.3.
#: Signal/noise ratio was calculated based on SVM maps.
Supplementary Figures

**Figure S1. Retinotopic mapping responses in V1, V2 and V4.**

A: Cortical response to a horizontal line (width: 0.1° length: 30-40°) viewed monocularly. Regions in V1 and V4 activated by this line are indicated by black and white arrows, respectively.

B: Similar to A, cortical responses to a vertical line. V1 activation also showed ocular dominance patterns due to monocular stimulation.

C: Illustration of 5 horizontal line conditions to which the responses are shown in D-H. Only one line was shown in each condition. The distance between two neighboring lines is 0.1°. The colors of the lines are for illustration purposes only.

D-H: V1 activation by the horizontal lines illustrated in C. Each panel is a subtraction map (stimulus condition minus blank condition) and is framed by the color illustrated in C. A systematic shift of V1 activation is observed. Note that the V4 activation region is outside of the field of view (to the left side of the window).

These mapping procedures were repeated for both eyes.

Scale bar in H: 5 mm, applies to A-B, D-H.
Figure S2. Eye alignment based on V1 retinotopic mapping.

A-C: Illustration of eye plotting stimuli. Horizontal dashed lines (width: 0.1°) are stimuli to elicit cortical responses. The gray squares represent approximate visual fields corresponding to the imaged V1 (not shown in imaging). The vertical gray lines represent X axis values already aligned (not shown in imaging). A: Stimulus condition for plotting the left-eye visual field. B & C: Two stimulus conditions for plotting the right-eye visual field (0.2° spatial offset between these two horizontal bars).

D-F: Monocular V1 activation (white arrows) to corresponding horizontal bars in A-C.

D'-F': The same maps as in D-F, overlaid with colors to indicate V1 activation.

G: Well overlapping of left-eye (from D’) and right-eye (from E’) responses to horizontal bars indicates that the two eyes were aligned on the Y axis. The same procedures were repeated for vertical line stimuli to align eyes on the X axis.

H: Offsets between the left-eye (from D’) and right-eye (from F’) responses indicate that the two eyes were not aligned on the Y axis.

I: When two eyes were well aligned (shown in G), a DE orientation map (45° vs. 135°) was obtained in area V4.

J: When two eyes were not aligned (shown in H), a DE orientation map was not observed in V4, even though all other stimulus parameters were the same as in panel I.

Scale bar in J: 5 mm.
Figure S3. Comparison of SVM maps and T-test maps.

A and B: Example DE orientation maps based on w-values from SVM calculation. B is a magnified view of a representative region in V4 (outlined in A).

C and D: Response profiles for areas V4 and V2, calculated based on SVM w-value maps of all cases. Curves for the example map shown in A are in color.

E and F: DE orientation maps based on t-values from the t-test. The data are the same as for A and B. F is a magnified region in E (same area as B). Compared to SVM maps, t-maps contained stronger noise in the blood vessel regions.

G and H: Response profiles based on t-value maps. Both maps and response profiles show general similarity between two calculating methods, except that t-maps are more vulnerable to noise.

Scale bar in E: 5 mm, applies to A and E. Scale bar in F: 1 mm, applies to B and F.
Figure S4. Basic functional maps from Cases 2 and 3

A-D: Maps from Case 2. Stimulus and plotting conventions are the same as Case 1, shown in Figure 1B-E.
A: Surface blood vessel map
B: Ocular dominance map
C: 45° vs. 135° orientation map
D: Color vs. luminance map
E-H: Same as A-D, maps from Case 3.
Scale bar in D: 5 mm, applies to A-D. Scale bar in H: 5 mm, applies to E-H.
Figure S5. Similar domain locations for LE and DE orientation domains in V4.

A-C: Three 45° vs. 135° LE orientation maps obtained from Cases 1-3. These maps only show regions from area V4. Yellow and red dots mark the gravity centers of the 45° and 135° orientation domains, respectively. These gravity centers were identified based on the corresponding top 15% threshold maps. For some connected domains, they were manually separated based on information in stricter maps, i.e., top 5% threshold maps.

D-F: Corresponding DE orientation maps for the same 3 areas shown above. Yellow and red dots are transferred directly from the LE maps in A-C. It can be seen that these dots are mostly located within the corresponding domains of the same polarity, indicating that most orientation domains in the DE maps are in locations consistent with the LE ones. Some DE response patches (e.g., red arrow in D) are
off-center from the LE orientation domains, likely due to their low response strength, and are thus
easily influenced by imaging noise (see panels K-M).

G-I: These 3 panels were calculated based on panels A-F above. Open and filled circles are domain
centers for LE orientation domains and DE orientation domains, respectively. DE domain centers were
obtained in a similar way to the LE ones. Two sets of centers were paired using the nearest neighbor
algorithm and connected with a line to represent the center distance. Note that some open and filled
circles are overlapped.

J: The distribution of LE-DE domain offsets measured from their center distances (calculated from all
orientation domains in all cases). The dashed line indicates the average domain radius of V4 orientation
domains (266μm). In all pairs of LE-DE domains, 86% had center-to-center distances shorter than this
radius, indicating the overall overlap of these two types of domains.

K: Orientation response strength (average t-values) for LE and DE maps measured from the V4
orientation domains. The response strength of the DE map is about half that of the LE map (paired t-
test, p=0.0007).

L: An example of orientation-responsive domains obtained with LE and DE stimuli (top), and their
spatial overlap (bottom). Despite the overall similarity, there are some local differences.

M: The DE map strength averaged from the overlapping regions (e.g., dark gray in the bottom panel in
L) is significantly larger than those averaged from non-overlapping regions (e.g., light gray in the
bottom panel in L, paired t-test, p=0.0001). The results in K-M indicate that the spatial differences
between these two sets of domains were mainly due to the weak signals in the DE maps, which were
more vulnerable to the noise.

Error bar: SD. Scale bar in F: 1 mm, applies to A-I.
Figure S6. Map similarity between DE and LE orientation maps measured with a spatial correlation method.

A and B: Example DE and LE orientation maps from Case 1 (same maps as in Figure 2C and D).

C: Z-transferred spatial correlation values between DE and LE maps in V1, V2, and V4, averaged from all cases. V1s, V2s, and V4s indicate correlation values between shuffled DE maps and corresponding LE maps. These results are similar to the results obtained with the response profile method (Figure 3L): V4 and V2 show significant responses, but V1 does not (paired t-test, V1: p=0.63, V2: p=0.01, V4: p=0.0009). V4 has a much stronger response than V2 (paired t-test, p=0.002). It confirms that, spatially, the V4 DE orientation domains are significantly correlated with the corresponding LE orientation domains.

Error bar: SD. Scale bar in B: 5 mm, applies to A and B.
Figure S7. Resilience of DE responses in V4 for different stimulus parameters.

To test the resilience of the DE orientation maps, we varied several stimulus parameters and evaluated the patterns of DE orientation domains and their orientation selectivity. All maps shown here are DE orientation maps obtained from a representative case (Case 1), while response profile quantifications are from both example maps (brown) and other cases (gray). The DE stimuli were similar to the ones shown earlier except one in which one of the following parameters was modulated in each row. In each map, the lower-right corners show the magnified views of the representative V4 regions.

A and B: Horizontal vs. vertical DE orientation maps obtained with DE stimuli in which RD were coherently drifting along either the 135° (A) or 45° (B) axes.

C: Response profiles for V4 DE orientation maps in A and B (brown) and other cases (gray). Values were obtained from the corresponding t-maps. All curves are plotted relative to the stimulus orientation (X-axis). Significant responses are marked with a “*” as below.

D and E: DE orientation maps obtained with DE stimuli made with different signs of absolute disparities (D: 0 and -0.2°; E: 0 and 0.2°).

F: Response profiles for DE orientation maps in D and E.
G and H: DE orientation maps obtained with different magnitudes of relative disparity (G: 0.2°, H: 0.4°).
I: Response profiles for DE orientation maps in G and H (brown) and other cases (gray).
J-L: DE orientation maps obtained with different DE spatial frequencies (J: 0.8, K: 1.2 and L: 1.6 cycles/degree).
M: Response profiles for DE orientation maps in J-L (brown) and other cases (gray). Note that only one curve (dotted gray) is not significant.
In all parameter modulations, the orientation response patterns in V4 were consistent across different parameters and peaked at the stimulus orientation.
Scale bar in L: 5 mm, applies to all orientation maps.
Figure S8. Replication of DE orientation maps.

A-C: DE orientation maps of the same cortical regions in Case 1 obtained from three different experiment sessions (A&B: 40 days apart, B&C: 70 days apart). The experiment procedures and stimulus settings were the same. The lower-right corners show the magnified views of a V4 region. The similarity between these maps indicates that the DE orientation map is stable over time and is thus an intrinsic feature of the area.

D: Response profiles for the V4 orientation responses shown in A-C.

E-G: Similar to A-C, three DE orientation maps were obtained from Case 2 in 3 different sessions (D&E: 30 days apart, B&C: 70 days apart).

H: Response profiles for the V4 orientation responses shown in E-G.

I-K: In 5 out of 8 sessions in Case 2, no obvious DE orientation maps were observed due to the low signal-noise ratio. Three of them are shown here. Note that the response in V4 is mainly flat and that there are no other patterns in the corresponding V4 regions.

L: Response profiles from these three experimental sessions also show no orientation-specific responses in these maps. Note that all curves were individually normalized to 1.

Scale bar in C: 5 mm, applies to A-C. Scale bar in K: 5 mm, applies to E-K.
Figure S9. Summary of V4 DE orientation responses to different types of control stimuli.

Based on the response profiles in Figures 5 (negative controls), 6 (anti-correlated DE) and S7 (modulation of stimulus parameters), we calculated two values from each of the curves: orientation offset (peak orientation minus stimulus orientation), and amplitude ratio (response amplitude divided by average amplitude of shuffled controls). In this scatter plot, open symbols represent response strength significantly larger than 95% of the shuffled controls, and filled symbols represent response strength within 95% of the shuffled controls. All except one (arrow indicated) of the response profiles from parameter modulation tests have response strength significantly larger than the shuffled controls. All negative controls and anti-correlated DE have response strength not significantly different from the shuffled controls.
**Supplementary movie S1**

This movie illustrates the main DE stimulus used in this study. These two 10×10° RD patches were presented on two sides of the CRT monitor and viewed by the left and right eyes, respectively. After these two patches were converged by prisms, vertical strips at 2 depth surfaces can be observed. RDs were made to move to elicit a stronger cortical response to these DEs. Note that there are no monocular orientation cues in either of these two RD patches.