Supplementary material for Perge et al.

Rotation of preferred directions in our simulations introduced a centrifugal distortion of cursor movements in the opposite direction from the rotation (Fig. 5D). These results were not intuitive, and thus deserve additional explanation. Let us consider a simulation with only two decoded neurons (A and B) with preferred directions A=90deg (up) and B=0deg (right). If firing rates are normalized and mean-subtracted prior to decoding, let us assume that a firing rate of ‘1’ from neuron A would instruct the decoder to move the cursor ‘up’, while ‘-1’ would signal the decoder to move it ‘down’. Firing rate of ‘1’ in neuron B would signal rightward movement, while ‘-1’ would signal leftward movement. During normal operation with the intention to move up, the firing rates would be A=1 and B=0. The firing rates and the decoded movement directions are summarized in table X.

Table 3. Firing rates of two hypothetical neurons and the decoded movement direction

Normalized firing rate		Decoded direction
Neuron A	Neuron B	
1	0	‘up’
-1	0	‘down’
0	1	‘right’
0	-1	‘left’

Now let us imagine that the preferred directions of both neurons rotate 90deg clockwise (A=0deg and B = -90deg), and both the subject and the decoder remain unaware of the change. When the user attempts another upward movement, the firing rates of the neurons now with the new preferred directions would be A=0 and B=-1. Since the decoder still assumes that the neurons signal movement direction according to their former preferred directions, this combination of firing rates [0,-1] would correspond to movement to the left (see table), i.e. 90deg counterclockwise from the intended direction. Similarly, movement to the right would evoke new neural responses A=1 and B= 0 which would be interpreted by the decoder as moving ‘up’. Again, this would result a 90deg counterclockwise deviation from the intended direction. As a summary, clockwise rotation of the preferred directions with a decoder that is unaware of these changes introduces a rotational bias to the counterclockwise direction.