Supporting Information

Pei *et al*. 10.1073/pnas.0800028105

SI Text

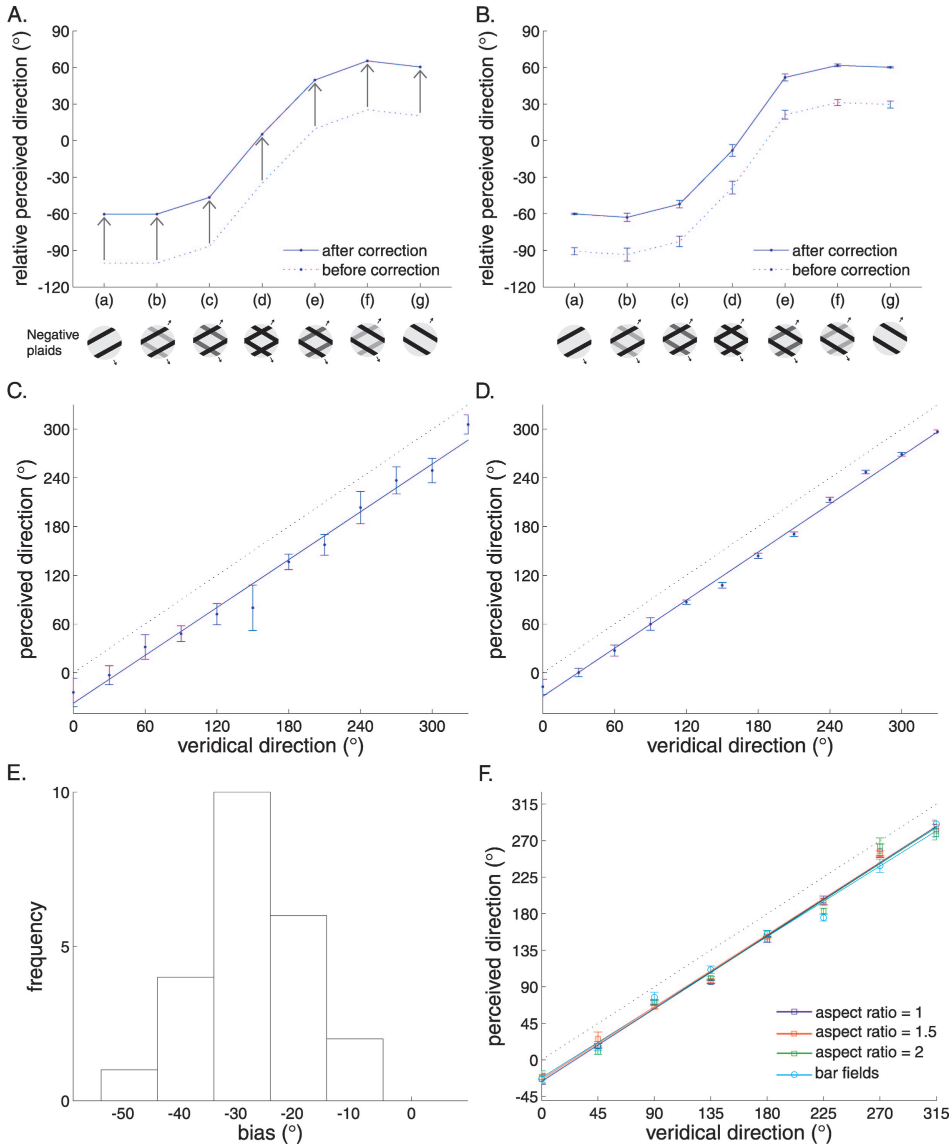

Fig. S1. (*A*) Data from a single subject in the negative plaid paradigm before and after correcting for the systematic bias. The correction consisted in shifting all of the responses by a constant amount, determined individually for each subject. (*B*) Data averaged across subjects from the negative plaid paradigm before and after correcting for the systematic bias. (*C*) Mean perceived direction of simple gratings as a function of their veridical direction for a single subject. The bias was constant across directions of motion as evidenced by the fact that the best fitting line (solid blue) is parallel to the unity line (dotted black). (*D*) Perceived direction of simple gratings, averaged across all subjects, as a function of their veridical direction. (*E*) Distribution of clockwise biases for both negative and positive plaids, for all subjects (mean ± SD: −28.6 ± 9.3°). (*F*) Mean perceived directions of the barber poles and of the bar fields as a function of their veridical direction of motion. The squares show data obtained from barber poles with aspect ratios of 1, 1.5, and 2 (blue, red, and green, respectively) when the orientation of the aperture was perpendicular to that of the grating. The cyan circles show the perceived directions of the bar fields when the direction of motion was perpendicular to the orientation of the bars. For all of these stimuli, the clockwise bias was constant as evidenced by a constant clockwise shift in subjects' judgments of direction. Furthermore, for the barber poles at all three aspect ratios, there was no significant interaction between direction of motion and the relative orientation of the aperture [repeated-measures ANOVA: $F(14,140) = 1.5$, $P > 0.1$], indicating that the clockwise bias was constant across experimental conditions in this paradigm. Similarly, for the bar fields, there was no significant interaction between direction of motion and the relative orientation of the bars [ANOVA: $F(14,140) = 1.4$, $P > 0.1$], indicating that the clockwise bias was constant across experimental conditions for this paradigm as well. For the barber poles, the clockwise bias (and the amount by which the each subject's judgments were shifted) was computed from subjects' responses when the aperture was perpendicular to the grating (i.e., when terminators and edges moved in the same direction). For the bar fields, the clockwise bias was computed from the responses to bars moving orthogonally to their orientation (again, when terminators and edges conveyed matching information about the direction of motion).

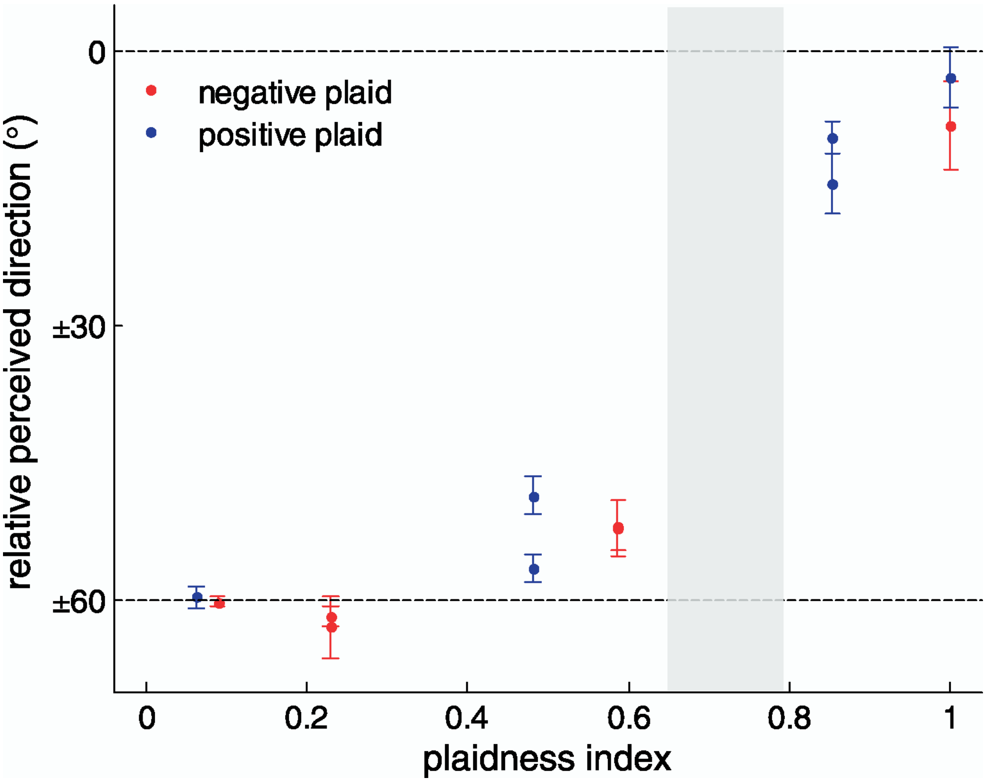

Fig. S2. The plaidness index (*PI*) gauges the similarity between the strain profile produced by a given pattern and the strain profile produced by a plaid (see below for the method for computing PI). A *PI* of 1 indicates identity between the two profiles; a *PI* of 0 indicates that the profile is identical to that produced by a simple grating. When the strain profile of the stimulus is nearly identical to the strain profile of a plaid (above a threshold *PI* indicated by the gray shaded area), pattern motion is perceived (0°); otherwise, component motion is perceived. The relationship between *PI* and perceived direction is eliminated when the analysis is carried out using the stimulus indentation profiles (data not shown). To compute plaidness index (*PI*), we first estimate, using a continuum mechanical model (1), the strain at the approximate depth of the receptor sheet (500 μm) for each position on the array (sampled at a resolution of 500 μm). Each strain profile is expressed as a vector, each element of which is the strain at a given position within the 1 cm^2 of stimulated skin; the vector is normalized to unit length. The *PI* for each plaid stimulus is defined as $PI = \cos^{-1}(S_{grating} \times S_{plaid}) - \cos^{-1}(S \times S_{plaid})$ where S is the normalized strain vector for a given stimulus, and S_{plaid} and $S_{grating}$ are the normalized strain vectors for a plaid and a simple grating, respectively. The *PI* is then normalized to take on values between 0 and 1: *PI* is 0 when S is identical to $S_{grating}$ and *PI* is 1 when S is identical to S_{plaid}.

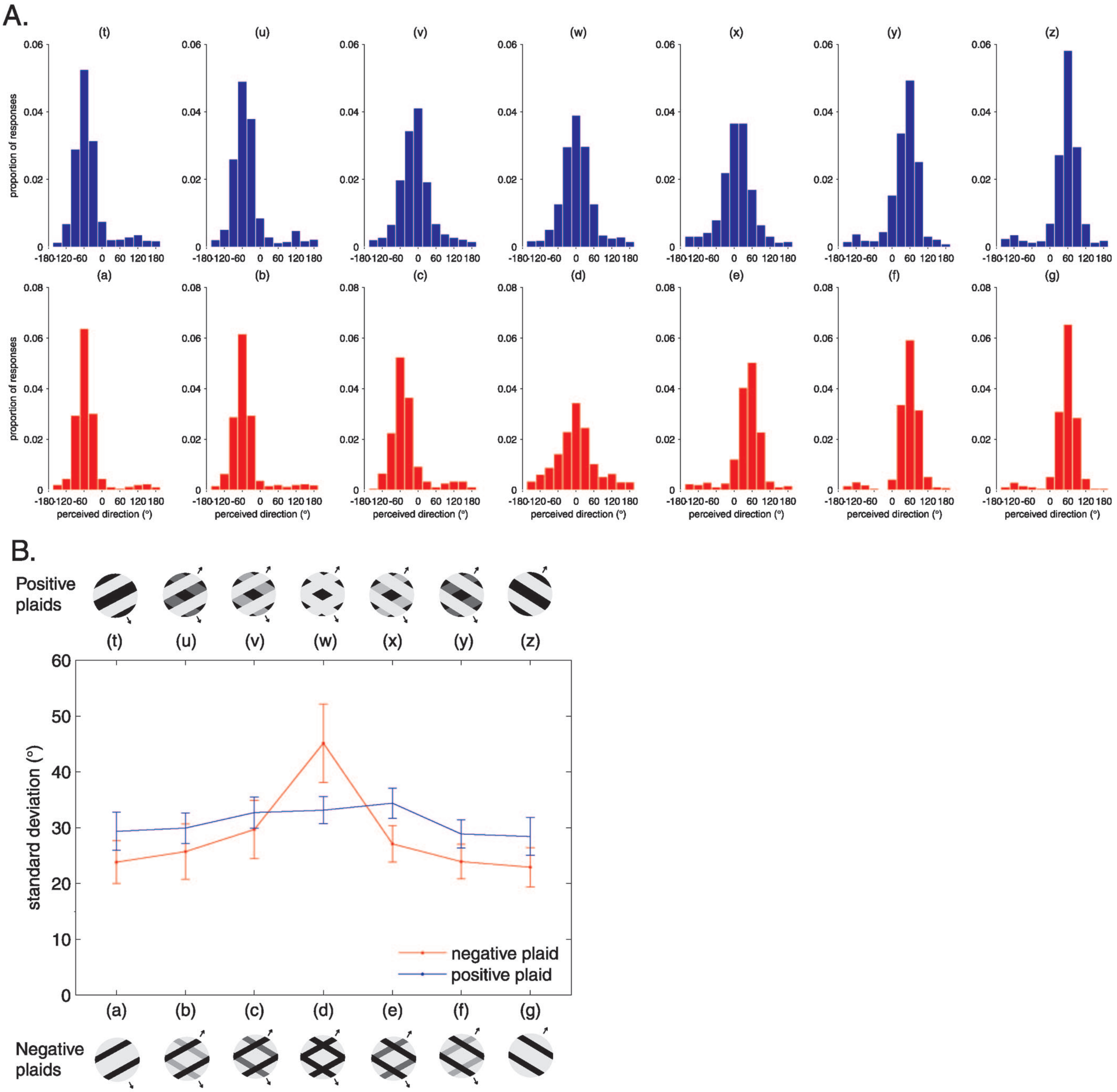

Fig. S3. (*A*) Distributions of responses, pooled across subjects, evoked by each stimulus in the plaid paradigm. All of the stimuli yielded essentially unimodal distributions of perceived directions. There was a slight tendency for subjects to perceive the direction opposite to the modal perceived direction, which may reflect a failure to correctly solve the correspondence problem. (*B*) The SD of the distributions of perceived direction for gratings and plaids. For the simple gratings (a,g or t,z), the mean SDs were 28.9° and 23.4° for positive and negative plaids, respectively. For negative plaids, the SD peaked in condition d, in which pattern motion is perceived. The SD did not vary much in the positive plaid condition but was slightly higher in the pattern motion conditions. The increase of the SD when pattern motion is perceived suggests that the uncertainty in perceived direction is higher in these conditions than in the component motion conditions.

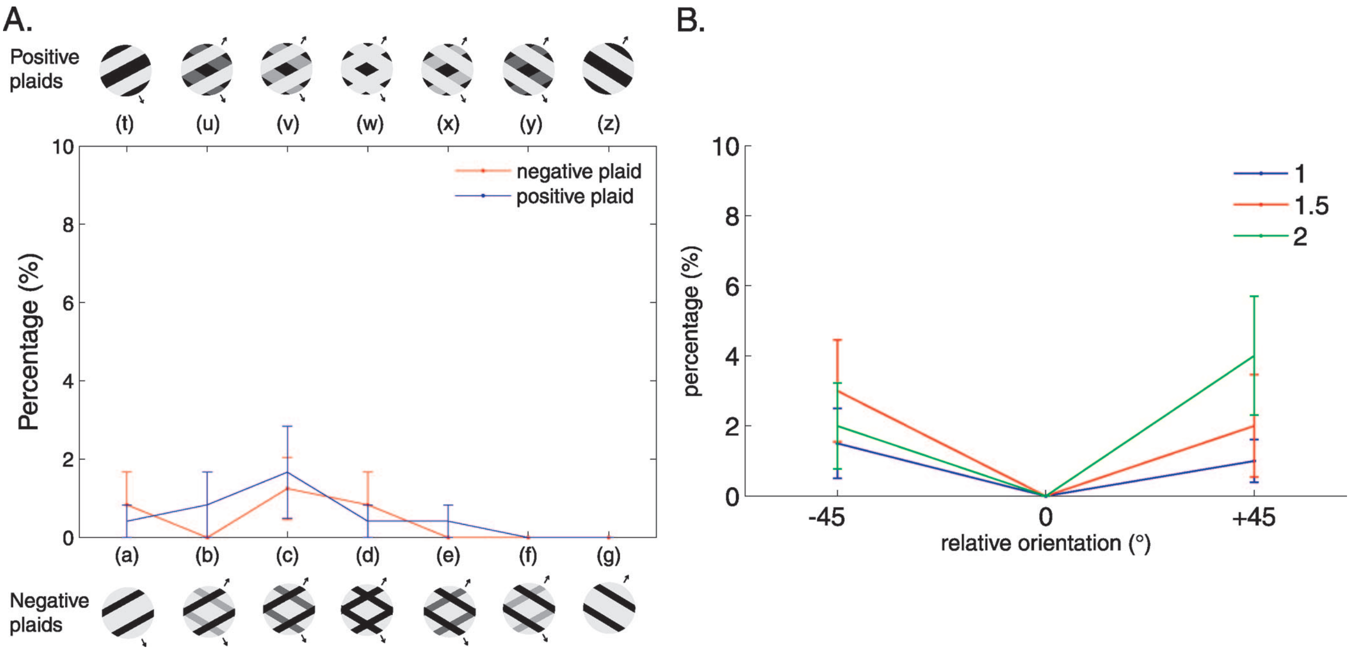

Fig. S4. (*A*) Four subjects (two males and two females) participated in a control experiment in which they were presented with plaid patterns and could select multiple perceived directions of motion after each stimulus presentation. The probability of perceiving two simultaneous component motions, highest when both components were of comparable magnitude, was always $<5\%$, suggesting that subjects perceived only a single direction of motion, that of the plaid, on the overwhelming majority of trials. (*B*) The same control experiment was carried out using barber poles (with five subjects: three males and two females). In $<5\%$ of trials, subjects perceived multiple directions of motion. Even on trials on which subjects did perceived multiple directions, responses were unimodally distributed (data not shown), suggesting that bistability is rare and qualitatively different from its visual counterpart (2).

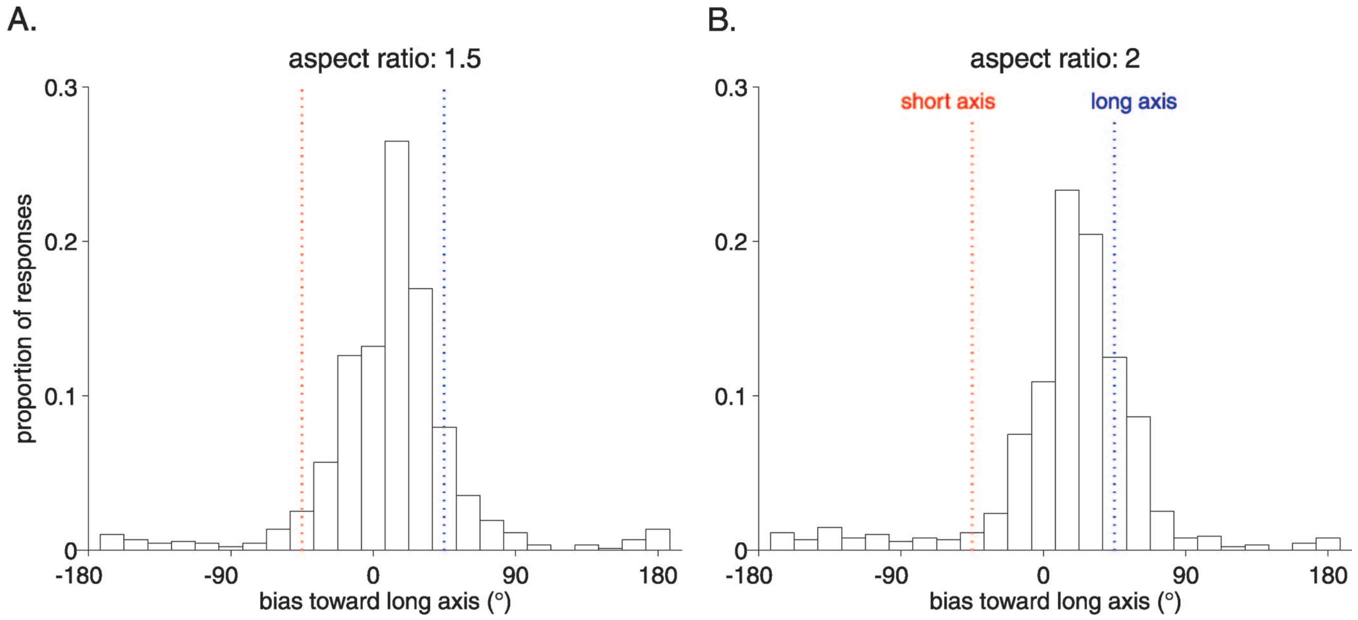

Fig. S5. Distribution of responses elicited by barber pole stimuli. The red and blue dotted lines denote the directions of motion of the terminators along the short and long axes of the aperture, respectively; 0° denotes the direction of motion orthogonal to the orientation of the gratings. Both distributions are unimodal and shifted rightward (toward the direction of motion of the terminators along the long axis of the aperture). The distribution of responses elicited by barber poles of aspect ratio 2 (*B*) is shifted to a greater degree than the distribution of responses elicited by barber poles of aspect ratio 1.5 (*A*). The unimodality of the distributions suggests that motion percepts were stable across the stimulus period (also see Fig. S4).

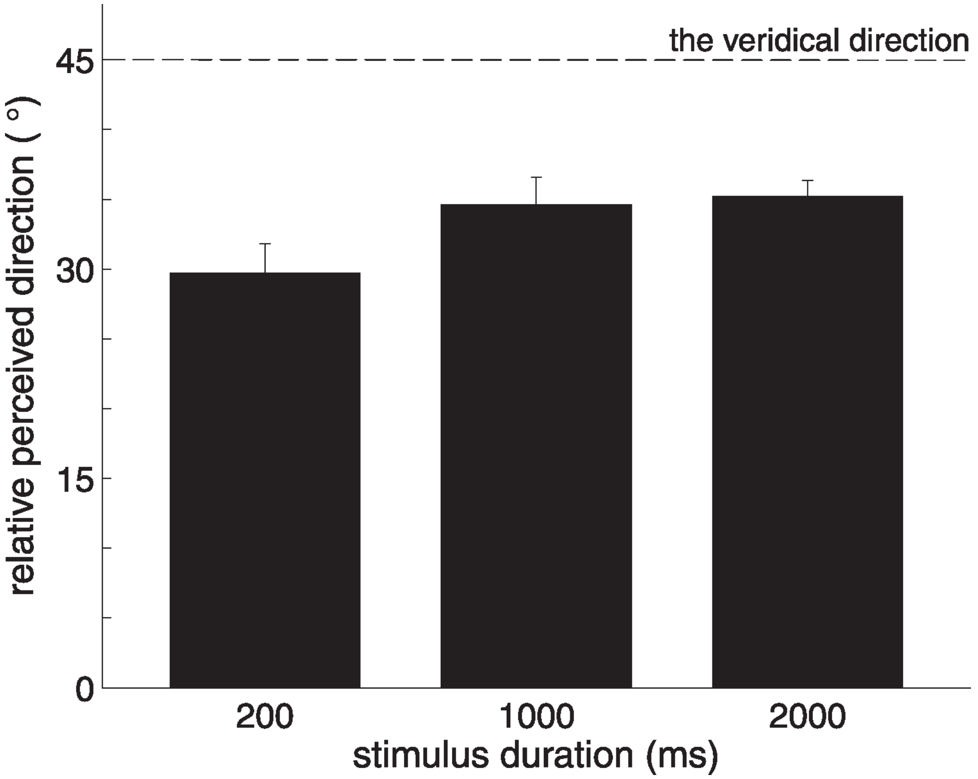

Fig. S6. Perceived direction of the bar fields relative to their orientation for short and long stimulus durations. The stimuli were identical to those presented in the bar field experiment, the results of which are shown in Fig. 4 *A* and *B*, except that longer stimulus durations were used. Even at the longest stimulus durations (2,000 ms), the percept of direction was significantly biased toward the direction perpendicular to the bars' orientation (*t* test, $P < 0.001$). Five subjects (three males and two females) participated in this control experiment.

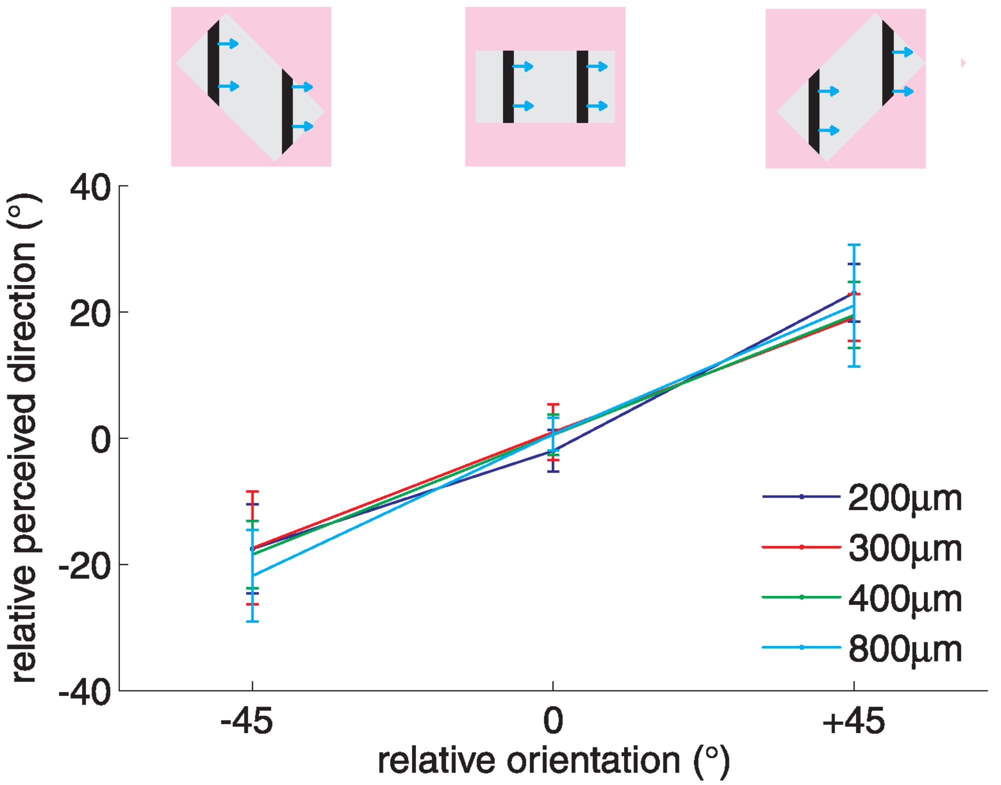

Fig. S7. The effect of aperture depth context on the perception of the barber pole. The amplitude of the aperture frame (pink shaded area) was 300 μm, and its aspect ratio was 2 to 1 (see *Experimental Procedures*). The perceived direction was not affected by the depth of the aperture [repeated-measures ANOVA: $F(3,18) = 0.32$, $P > 0.05$]. Six subjects (three males and three females) participated in this experiment.

1. Sripati AP, Bensmaia SJ, Johnson KO (2006) A continuum mechanical model of mechanoreceptive afferent responses to indented spatial patterns. *J Neurophysiol* 95:3852–3864.
2. Castet E, Charton B, Dufour A (1999) The extrinsic/intrinsic classification of two-dimensional motion signals with barber-pole stimuli. *Vision Res* 39:915–932.