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PHENOMENAL REPORT

A line-doubling illusion

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Abstract

We present a novel 'dazzle' illusion, in which a black/white negative bar embedded in a grating and viewed in near peripheral vision can look *doubled*, as if there were two bars lying side by side touching each other.

Keywords: *illusion*; *peripheral vision*; *phase reversal*; *edge*; *texture boundary*

To access the movies for this article, please visit the article landing page or read the html version of the article where all movies are embedded.

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In Movie 1, the vertical bar is like a strip of 'negative lens' that reverses the polarity of the background stripes. During direct fixation, the bar is seen veridically. But in near peripheral vision, say when one looks at the edge of the background, the bar looks doubled, like two bars lying side by side touching each other making three vertical edges (the middle one shared by the two bars. The illusion is depicted hypothetically in Fig. 1). This doubling of the bar can be seen in the stationary freeze frame of Movie 1, and it may be enhanced by running Movie 1. It can be seen during monocular viewing, and hence, it is not caused by binocular diplopia.

Next, we can look at the effect of bar width (Fig. 2). When the contrast-reversed bar is wider (Fig. 2 left), the contrast-reversing edges are now visible as two separate vertical columns and are joined by two horizontal strips along the top and bottom edges, making a salient thin frame around the entire wide bar. This frame may also be visible for some viewers in the dynamic version (Movie 2). However, there is no sense that the entire bar is doubled – along with the two horizontal edges, only two vertical edges are seen, not three as in Movie 1 (depicted in Fig. 1). The appearance of two bars (and three vertical edges) is limited to a range of bar widths similar to the width of one bar of the background.

Does contrast reversal or phase reversal cause the line doubling? The vertical bar in Movie 1 is a photographic negative of the grating on which it lies, with blacks and whites exchanged. But it is also phase shifted from the gratings by 180°. Is the contrast or the phase shift more important? Movie 1 confounds the two factors, but pinstripe and sawtooth gratings are asymmetrical and can separate the two. In Movie 3a, the vertical bar on the pinstriped grating is contrast reversed, whereas in Movie 3b, the bar is phase shifted by 180°. Similarly, in Movie 4a, the vertical bar on the ramp grating is contrast reversed, whereas in Movie 4b, the bar is phase shifted by 180°. In both cases, the phase shifted bar looks doubled but the contrast reversed bar does not. We conclude that spatial phase reversal, not contrast reversal, is responsible for perceptual doubling.

There have been many reports of distortions in peripheral vision. Motion appears too slow (Campbell & Maffei, 1979), faces and shapes can be distorted (Baldwin, Burleigh, Pepperell, & Ruta, 2016; Bowden, Whitaker, & Dunn, 2019), and crowding in the periphery can change the shapes of targets (Sayim & Wagemans, 2017). Rosenholtz

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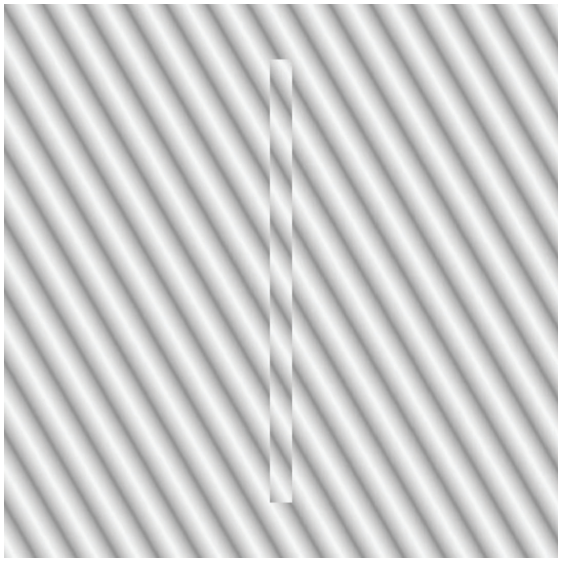


Movie 1. The line-doubling illusion. When viewed peripherally, the central vertical bar appears doubled, like two bars lying side by side (see Fig. 1 below). Doubling is visible when the movie is stopped but may be enhanced when it is running.

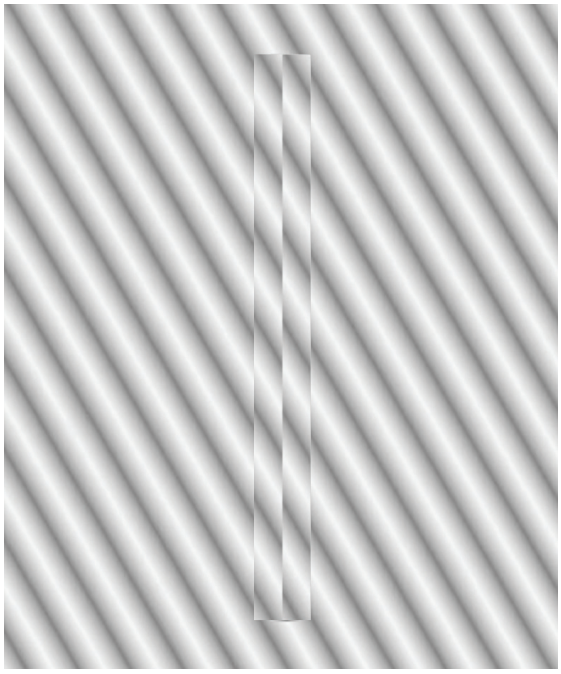


Fig. 1. Here we use physical doubling to mimic, in direct view, the doubling seen with peripheral viewing in Movie 1.

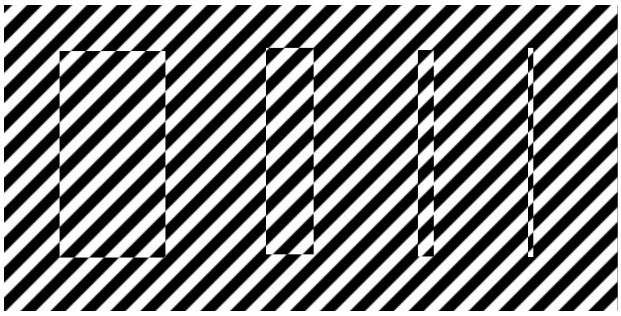
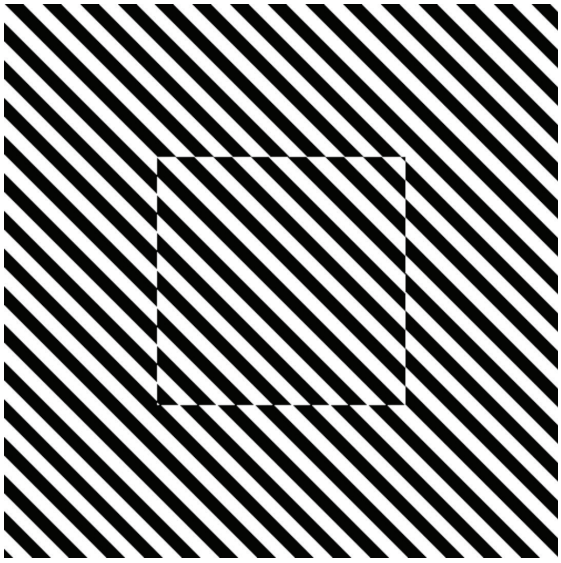


Fig. 2. The vertical contours are widely spaced on the left, closer together on the right. Line doubling is most evident on the third bar from the left whose width is similar to the width of the grating's bars. In the widest bar on the left, the two edges are clearly seen while viewing it peripherally, giving an impression of two vertical strips without any impression that the whole bar is doubled.



Movie 2. Wide bar contrast reversed. The bar is defined by the contrast reversal revealed at its edges. Here with a very wide bar and a moving texture of an oblique square wave, no doubling is seen. Instead, some viewers may see a salient edge, making a frame around the entire bar.

et al. (e.g., Rosenholtz, Yu, & Keshvari, 2019) have described how compression processes in the periphery can produce distortions and 'mongrels', odd shaped percepts created from the effects of compression. Our new report of doubling seems too organized to fall into these types of degraded perception. Nevertheless, it is possible that the compression transformations operating in the periphery act on the particular stimuli we use here to produce a

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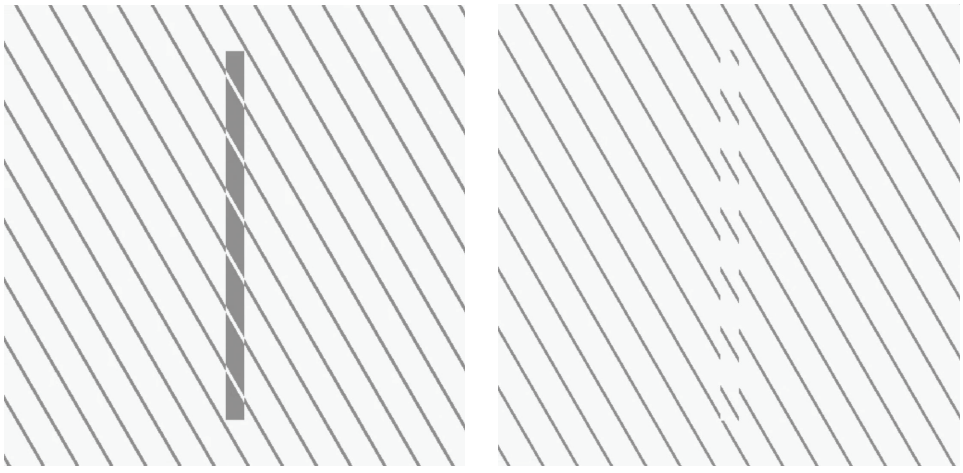
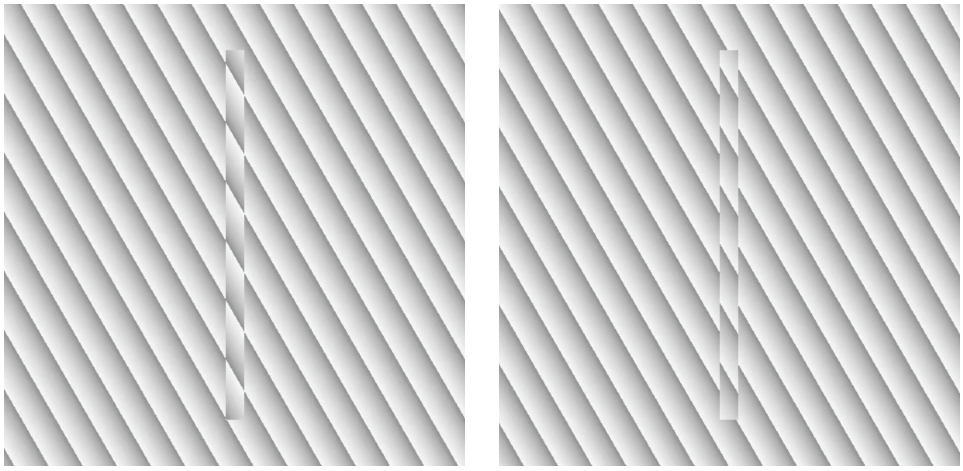


a b

Movie 3. Pinstripe gratings. (a) The vertical bar is reversed in luminance from the background grating and shows no doubling. (b) The vertical bar has a 180° shift in spatial phase compared to the background and does show doubling.



a b

Movie 4. Ramp grating. (a) The vertical bar is reversed in contrast from the background grating and shows no doubling. (b) The vertical bar has a 180° shift in spatial phase compared to the background and does show doubling.

shifted copy, implying that the phase-shifted patterns are a class of eigen pattern for these transformations.

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