A Perspective on 3-D Visual Illusions

What the Leaning Tower and related illusions reveal about how your brain reconstructs 3-D images.

By Stephen L. Macknik and Susana Martinez-Conde

The Leaning Tower of Pisa

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Slide Show: 3-D Illusions

This is the second article in a new Mind Matters series on the neuroscience behind visual illusions.

How could we have missed it? Hundreds, perhaps *thousands*, of visual scientists, psychologists, neuroscientists, visual artists, architects, engineers and biologists all missed it—until now. The "it" in question is the Leaning Tower Illusion, discovered by Frederick Kingdom, Ali Yoonessi, and Elena Gheorghiu of McGill University. In this illusion, two identical side-by-side images of the same tilted and receding object appear to be leaning at two different angles [*see slideshow*]. This incredible effect was first noticed just last year in images of the famed Leaning Tower of Pisa, but it also works with paired images of other tilted objects.

The Leaning Tower Illusion is one of the simplest visual tricks one can produce, but also one of the most profound to our understanding of depth perception. This fact is why vision scientists are shaking their heads in disbelief that they did not notice the illusion earlier. Kingdom and colleagues first announced the illusion at the 2007 Best Visual Illusion of the Year contest, where it won the First Prize. The annual contest, which we organized and which is hosted by the Neural Correlate Society, celebrates the ingenuity and creativity of the world's premier visual illusion creators, both artists and scientists. Contestants submit novel visual illusions (that is, unpublished, or published no earlier than the previous year). An international panel of impartial judges conducts the initial review, and narrows the dozens of submissions down to the Top Ten best entries. The Top Ten creators then compete in Naples, Florida, during a gala celebration, in which the audience chooses the Top Three winners. First, Second and Third prizes take home the coveted "Guido" (a 3-D illusion sculpture created by the renowned Italian sculptor, Guido Moretti).

View 3-D Illusions Slide Show

Mind Matters is edited by Jonah Lehrer the science writer behind the blog The Frontal Cortex *and the book* Proust Was a Neuroscientist.

ABOUT THE AUTHOR(S)

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More on the Leaning Tower Illusion

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Photo courtesy Thomas Haltner ENLARGE

BACK 2 of 5 NEXT

The Leaning Tower Illusion elucidates the way in which the visual system uses perspective to help reconstruct 3-D objects. We say "reconstruct" because the visual system has no direct access to three-dimensional information about the world. Our perception of depth results from neural calculations based on several rules. Such rules include: perspective (parallel lines appear to converge in the distance), stereopsis (our left and right eyes receive horizontally displaced images of the same object, resulting in the perception of depth), occlusion (objects near us occlude objects farther away), shading, chiaroscuro (the contrast of an object as a function of the position of the light source), and sfumato (the feeling of depth that one gets from the interplay of in- and out-of-focus elements in an image, as well as from the level of transparency of the atmosphere itself). The Leaning Tower Illusion shows that the brain also uses the convergence angle of two reclining objects as they recede into the distance to calculate the relative angle between them. Thus, two truly parallel towers, such as the Petronas Twin Towers in Kuala Lumpur, appear to converge in the distance as they recede. Two identical pictures of the Leaning Pisa Tower do not result in convergence as they recede, however. So your brain perceives the identical images as non-parallel and diverging.

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BACK 3 of 5 NEXT

Further analysis of similar images reveals subtleties in the way our visual system processes the perception of depth and perspective. For instance, the Leaning Tower Illusion also works with paired images of train tracks, violating the rules of perspective. It's hard to believe, but these are actually identical images of parallel train tracks. Although the angles are the same in both images, the brain perceives them as being quite different.

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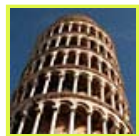



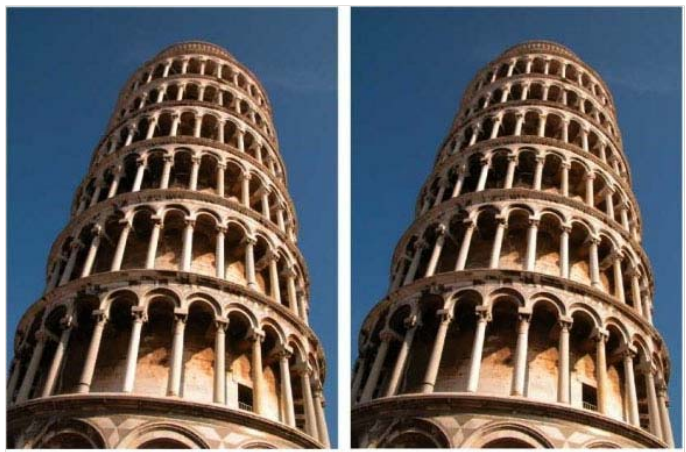

ENLARGE

1 of 5 NEXT

In the Leaning Tower Illusion, discovered by Frederick Kingdom, Ali Yoonessi, and Elena Gheorghiu of McGill University, two identical side-by-side images of the same tilted and receding object appear to be leaning at two different angles. This incredible effect was first noticed just last year in images of the famed Leaning Tower of Pisa, but it also works with paired images of other tilted objects.

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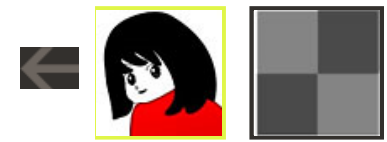

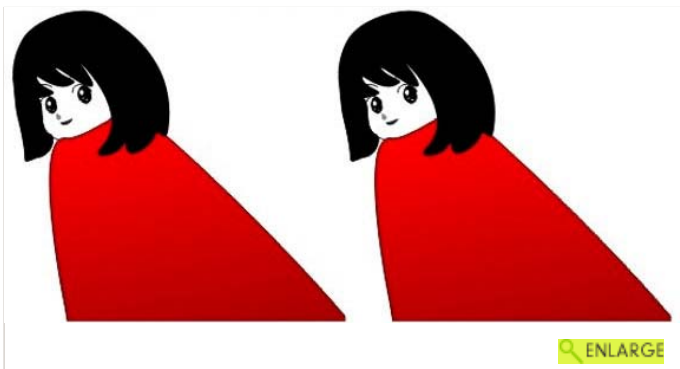

BACK 4 of 5 NEXT

However, the illusion does not occur when viewing two leaning Japanese manga girls, even though the two cartoon images are tilted. The reason is that the cartoon girls do not appear to recede in depth, so our brain does not expect that they would converge into the distance. This phenomenon demonstrates that the brain only applies its depth perception tool-kit in specific situations.

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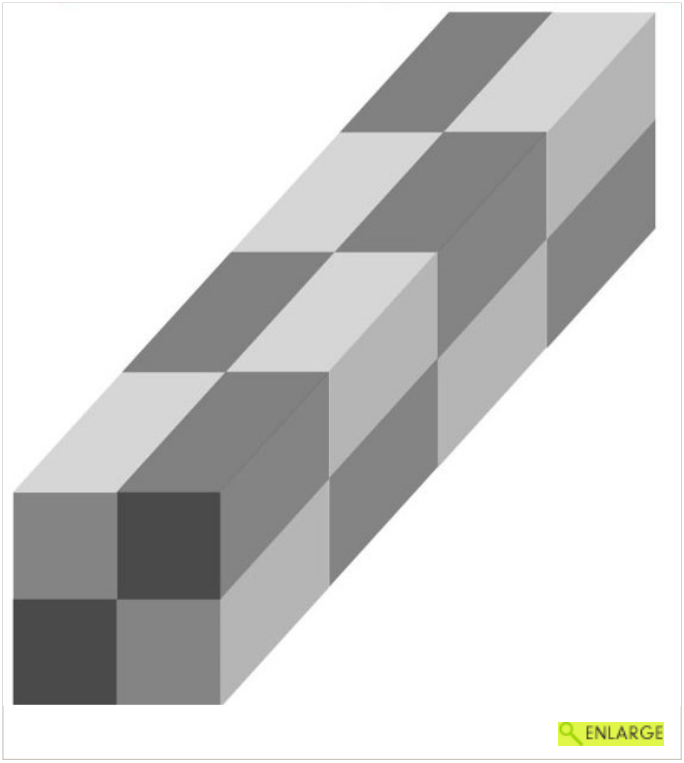

The leaning tower illusion is such a fundamental feature of our visual system that it works even if one draws a 3-D solid object as it recedes into the distance. The parallel lines give the illusion of diverging in the distance. That is, the box appears wider at the back than it does at the front, when it fact the back and front are precisely the same width on the retina.