Scientists show how the brain's estimate of Newton's laws affects perceived object stability

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The next time you are in Pisa, try looking at its tower from a different perspective. Newton's laws of motion predict that an object will fall when its centre-of-mass lies beyond its base of support. But how does your brain know whether the tower will fall or not?

Scientists from the Max Planck Institute for Biological Cybernetics in Tubingen, Germany recently reported in the journal PLoS ONE that although the physical laws governing object stability are reasonably well represented by the brain, you are a better judge of how objects fall when you are upright than when you lay on your side.

"The force of gravity is not sensed directly," says Michael Barnett-Cowan, a Canadian postdoctoral neuroscientist and Project Leader for motion perception at the Max Planck Institute. "It is the indirect effects of gravity that are detected."

In the mid 19th century, Hermann Aubert tilted to one side and observed a vertical line as being tilted towards him. "Since Aubert we now know that the brain combines visual and vestibular information to determine gravity's direction relative to an internal representation of our body's orientation," Barnett-Cowan explains. "We wondered whether objects are perceived as stable relative to this biased perceived direction of gravity rather than gravity's true direction."

Equipping observers with laptops, testing them upright and on their sides, and comparing the participants' judgment of object stability and vertical line estimates, Barnett-Cowan and colleagues found evidence that our perception of the likelihood that an object will fall is relative to this biased perceived direction of gravity rather than gravity's true direction.

A vase set at its critical angle where it is equally likely to right itself or fall off of the table. Copyright: Martin Breidt, Roland Fleming, Manish Singh; MPI für Biologische Kybernetik, Tübingen.

"We might expect the brain to depend primarily on visual heuristics and assumptions about an object when assessing whether it will fall or not," says Roland Fleming, now an assistant professor of psychology at the University of Giessen. "Surprisingly, however, we find that observers' judgments of object stability are biased towards the tilt of the body."

These findings have important implications for existing theories of how humans perceive the physical stability of objects. "Since the work of Jean Piaget it has been known that children and adults have difficulty in solving problems involving the physical laws which govern equilibrium, but in everyday life we seem to be quite good at estimating object stability," says Manish Singh, associate professor of psychology at Rutgers University. "Our results suggest that solving such problems may depend on integrating multisensory information."

"This is another fine example suggesting that in order for the brain to accurately represent objects in the world, it combines information from multiple sensory organs that individually do not provide an accurate representation of the physical world," adds Heinrich Bülthoff, Director of the Max Planck Institute for Biological Cybernetics.

We spend most of our time engaging in the world with an upright posture. "Here visual, vestibular and body sense cues are aligned and the brain can make use of this redundant information to maintain optimal perception and action, particularly when information from one sense is poor or lost," says Barnett-Cowan, who plans to assess perceived object stability in microgravity environments and in patients such as those with Parkinson's disease and muscular dystrophy.

So how should one look at the leaning tower of Pisa differently to make it appear more stable? "Pisa's tower may appear more stable than it is if you lay in the same direction of its lean," points out Barnett-Cowan. "Lay in the opposite direction, and it may appear even more likely to fall."

More information: Barnett-Cowan M, Fleming RW, Singh M, Bülthoff HH (2011) Perceived object stability depends on multisensory estimates of gravity. *PLoS ONE*, dx.plos.org/10.1371/journal.pone.0019289

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