Body pitch and movement distort perception, find researchers

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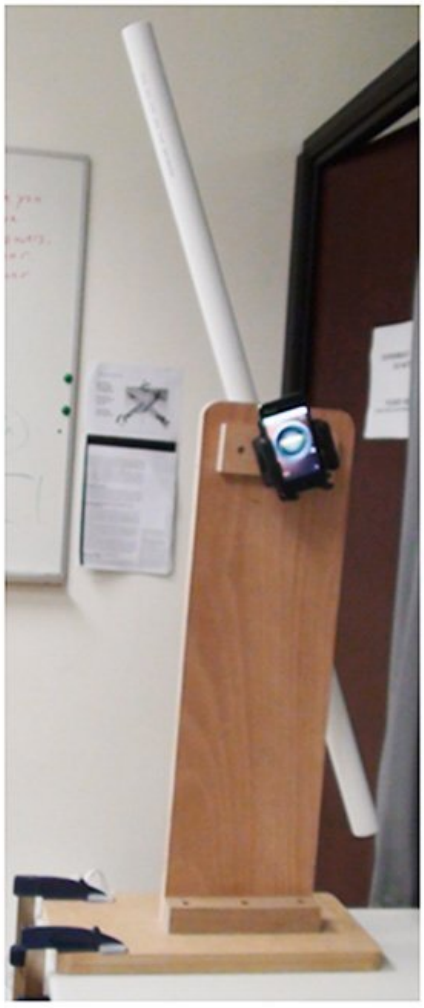
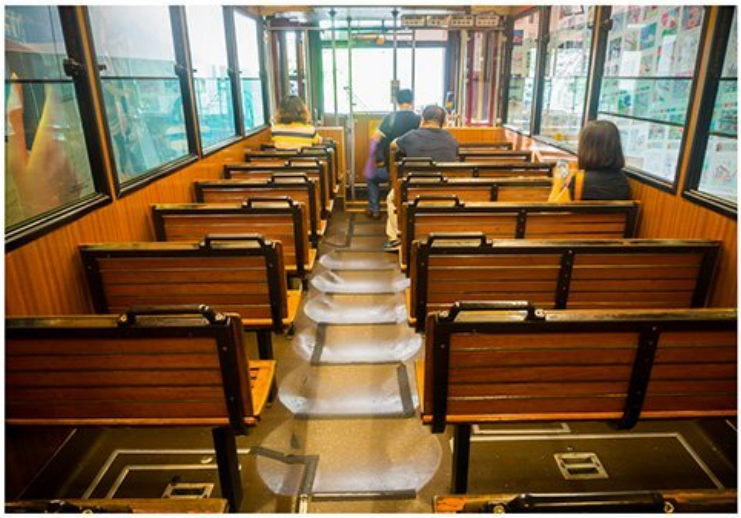




The experiments were conducted on the famous Hong Kong Peak Tram. The device for measuring the SHV included a gravity-neutral plastic rod and wooden stand. During the experiment, observers set the rod to match their subjective vertical in the pitch plane. An iPhone installed with an app to read out the tilt

was attached to the other end of the axle so the rod and digital device rotated in unison. The digital device was calibrated at the beginning of each experimental session using a plumb line and regularly re-checked throughout the experiment to ensure its accuracy. Credit: Chia-huei Tseng

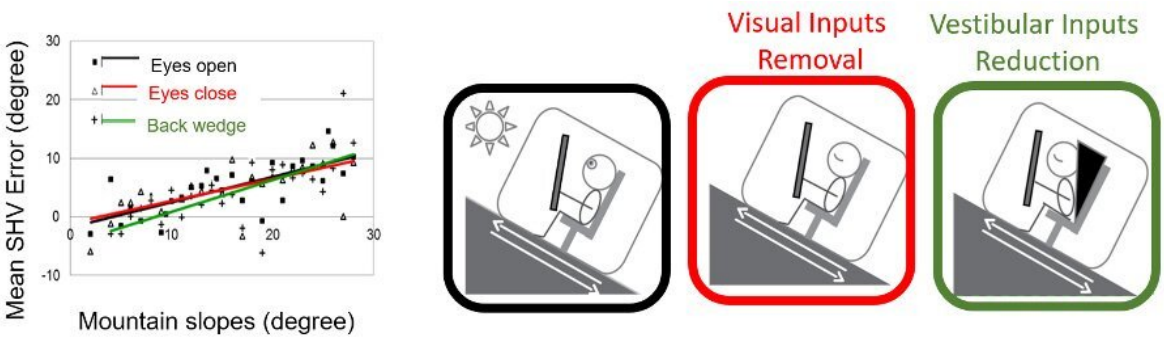
Our ability to perceive what is truly vertical is crucial. Without it, we would struggle to perform simple tasks such as holding a cup of coffee without spilling it and maintaining appropriate body posture.

Now, an international team of scientists from Japan, Canada and Germany have discovered a new situation from our everyday environment where this ability is compromised—when our body pitches (body pitch) and moves at the same time (body motion).

The scientists' observations, which were published in the journal *Multisensory Research*, were based on real-world scenarios, revealing factors long overlooked by past laboratory studies.

"Unlike typical studies of this kind, which happen in well-controlled laboratories, our team traveled to Hong Kong to conduct field research on the world-renowned Peak Tram," said Dr. Chia-huei Tseng, who led the research and is associate professor at Tohoku University's Research Institute of Electrical Communication (RIEC). "We performed experiments on hundreds of commuters making their way up Hong Kong's highest hill, Victoria Peak."

Although body pitch and body motion have been studied in previous studies, the phenomena were isolated. This study combined both aspects to determine a new situation where verticality becomes distorted.



The participants' SHV error measured on the Hong Kong Peak Tram increased linearly with the mountain slopes (black line). When participants' eyes are closed (visual influence removal), the bias persists (red line). When the vestibula system information is altered with a back wedge (vestibular influence removal), the bias stays (green line). Credit: Chia-huei Tseng

The team enlisted the help of an architect to build a device that participants could hold to indicate their perceived verticality (i.e., subjective haptic vertical or SHV).

In most laboratory setting, humans are capable of perceiving SHV with an error of less than 1 degree. However, when measurements were taken on the moving Peak Tram, a misjudgment of 10 degrees was observed, something never previously reported.

To investigate the possible sources of errors, the researchers devised additional experiments. First, they had participants close their eyes to rule out visual influences. Then, to eliminate the effects of the vestibular system—the sensory system that creates a sense of balance and spatial orientation—they inserted a back wedge between the participants and their chairs. None of these alternations had much bearing on diminishing the SHV error, ruling out visual and vestibular systems as the primary

cause.

Participants' SHV error measured on the dental chair with a small (~6 degree) or a big (~ 26 degrees) inclination. Unlike the observations on the Hong Kong Peak, participants can accurately tell the subjective vertical regardless of the body pitch. Credit: Chia-huei Tseng

The team then turned their attention to motion. They re-created a motion-free seating inclination with a dental chair. Changing the body pitch alone did not create any SHV error.

Additionally, they ran their tests on Hong Kong's Ding Ding Tram, which runs at similar speeds to the Peak Tram but on a relatively flat surface. In both situations, no bias was detected.

Psychology Professor Kenzo Sakurai from Tohoku Gakuin University, an expert on self-motion and co-author of the study, points out what a major discovery their findings are. "The failure to accurately sense our body orientation relative to gravity may result in inappropriate movements or falls, as well as impair daily functions such as walking, climbing a staircase, and carrying a tray. In specialized tasks such as driving a car or piloting a plane, this failure could be disastrous."

The participants' SHV error measured on a flat surface tram in Hong Kong. Unlike the observations on the Peak Tram, participants can accurately determine the subjective vertical. Credit: Chia-huei Tseng

Dr. Tseng thinks that their study demonstrates a great example of scientific inquiry generalizing the actual world we live in. "On top of its pure scientific contribution, this study challenges the misconception that research is limited to scientific cubicles indoors. In this case, the natural environment provided a well-designed puzzle for scientists to solve."

With international travel restriction gradually lifting, the paper's authors encourage those to take a ride on Hong Kong's Peak Tram to feel this fascinating perceptual phenomenon. But maybe wait until after the ride to get your coffee.

More information: Chia-Huei Tseng et al, Body Pitch Together With Translational Body Motion Biases the Subjective Haptic Vertical, *Multisensory Research* (2022). DOI: 10.1163/22134808-bja10086, brill.com/view/journals/msr/ao … 2134808-bja10086.xml

Provided by Tohoku University