Foot-eye coordination: How our vision changes in rhythm with our walking

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For the first time, neuroscientists have established a link between shifts in our visual perception and the cadence of our steps while walking.

The research, published in *Nature Communications*, shows that the brain processes vision in a rhythmic manner, rising and falling in sensitivity in a cycle that corresponds to the rhythm of our steps. When swinging from one step to the next, human perception is good and reactions fast.

During footfall, however, our vision is not as sharp and reactions are slowed.

Lead author Dr. Matthew Davidson from the School of Psychology at the University of Sydney said, "This work reveals a previously unknown relationship between perception and movement. It bridges a gap between experimental psychology and our natural, everyday behavior."

The study also confirms our understanding of the visual brain sensing the environment in a strobe-like way; our perception takes regular samples of the world before stitching them together to create our seamless experience.

However, the new finding that reveals shifts in our visual perception has important implications for understanding human behavior, including how we interact with our environment and make decisions.

The work was conducted by Dr. Matthew Davidson with colleagues Professor David Alais and Professor Frans Verstraten in the School of Psychology, University of Sydney.

Dr. Davidson said, "We are consciously aware of a seamless stream of vision but this is deceptive. I use the analogy of a duck swimming on a pond. Beneath the smooth motion on the surface there is a lot cycling activity beneath."

This study extends earlier work from the same lab showing that perception of vision and sound is cyclic, with our brain taking around

eight samples per second.

Professor Alais said, "The critical new finding in this study is that these oscillations in the brain's sampling of the world slow down when walking to match the step cycle.

"Humans take about two steps per second when walking and generally keep to a consistent rhythm. The reported oscillations in visual sensitivity also occur at about two cycles per second and are locked to the step cycle. In some participants, these rhythmic oscillations occur at four cycles per second but these were also locked to the step cycle."

This work is the first time that visual perception has been finely and continuously sampled during walking. Without virtual reality headsets and motion tracking it would not be possible.

Dr. Davidson said, "Thanks to VR technology we have discovered that our vision moves through a good and a bad phase on every step."

It is unclear why our brain's perceptual processes are so closely linked to walking.

Professor Alais said, "One possible explanation is that vision becomes secondary to motor control while your foot is grounded and the next step is planned. Once you are in the swing phase between footfalls, the brain switches back to prioritizing perceptual sampling of the world, creating an ongoing perceptual rhythm that harmonizes with your step rate."

The findings open questions that the research team will pursue in further studies. For example, does perception of sound and touch also modulate as we walk? And what about neural activity?

The research team plans to follow up on these questions to further

understand the implications.

Dr. Davidson said, "An obvious question is whether these oscillations in perception are more pronounced in the elderly given difficulties with balance and coordination as we age.

"It also raises the exciting possibility that we could develop cheap and easy diagnostic tests using VR headsets, or use this information to develop tests for early onset of neuro-muscular disorders or some psychiatric illnesses, which can manifest in abnormal gaits."

He said it could also be applied to further research in sports science to see if the findings could be applied to optimize decision-making and reaction times in athletes.

Underlying all this research remains a persistent mystery. If the world is sampled by our brains rhythmic pulses, why is our conscious perception so seamlessly smooth?

Professor Verstraten said, "This was once a question for philosophers, but with access to technology neuroscientists have been able to shed light on how the gaps get filled in. The current view is that the brain is a predictive machine that actively constructs perception and predicts what ought to be there and fills in the blanks. But clearly, we need more research to deepen our understanding."

Methods

Researchers tracked the walking of 45 subjects walking back and forth along a 10-meter path in a virtual environment. During each walk (lasting about 9 seconds), subjects were required to respond to between zero and eight random visual stimuli. The same stimuli were also presented in stationary trials. Eye and head movement was tracked along

with gait and walking information.

Of the 45 subjects, insufficient data was collected for seven subjects. In the datasets for 38 subjects, reduced perception at footfall was recorded 83 percent of the time.

The behavioral data generated in this study have been deposited in a public database under accession code.

More information: Walking modulates visual detection performance according to stride-cycle phase, *Nature Communications* (2024). DOI: 10.1038/s41467-024-45780-4

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