Think your gaze is steady? Think again. (And thank your wobbly eyes for sight)

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Try to focus on one thing, and your eyes will keep moving around very slightly, even if you think you're holding them still. Such movements are called "fixational eye movements" (FEMs). Scientists have been trying to determine if these errors enhance our ability to see or impede it by being an inherent error in the motor system.

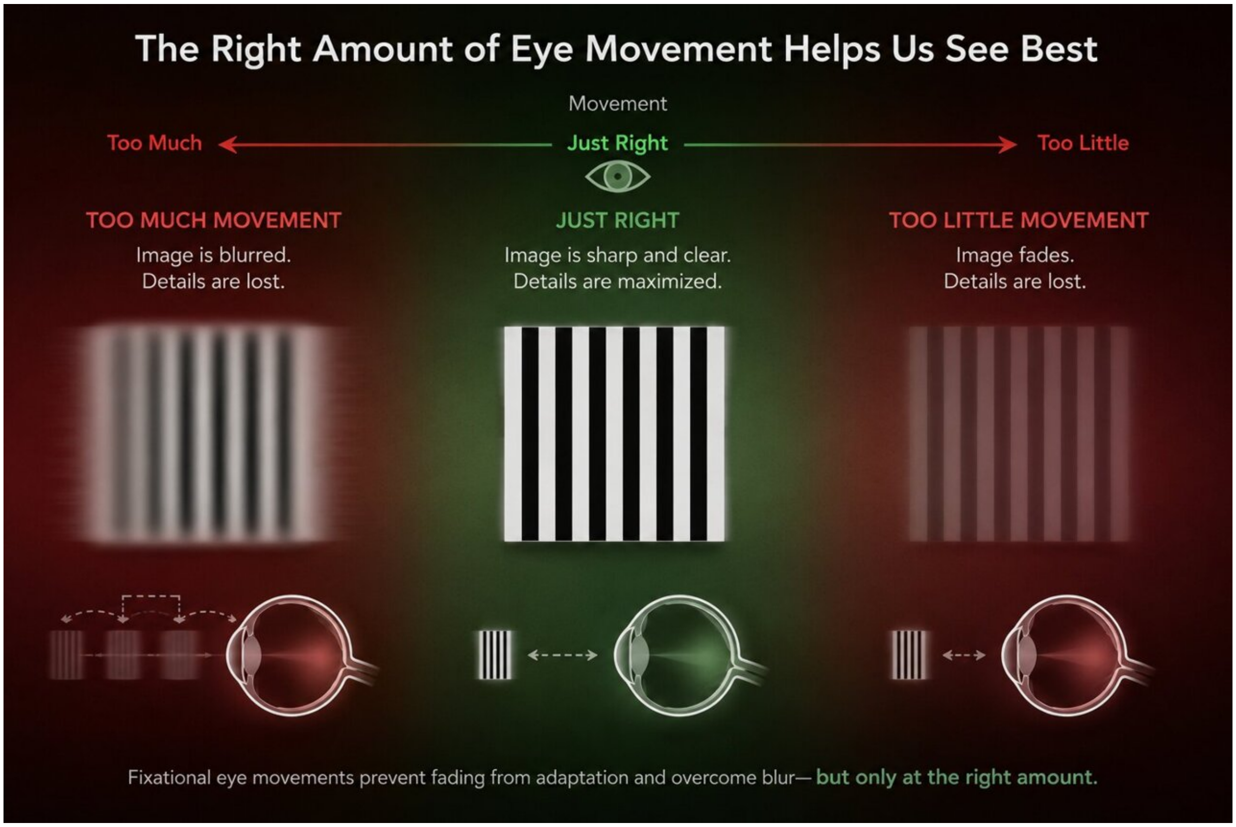
However, a new study presents an alternative explanation that suggests the human gesture is not entirely random at all. By developing an advanced mathematical model of the earliest stages of the visual system, scientists have learned more about the complex interplay between this and our perception of the outside world. It seems that most of the time, our "jitters" actually serve an important purpose.

Tiny twitches, big effects

A recent paper published in *Physical Review Research* offers a novel explanation. The purpose of this paper was to show how drift-like eye movements contribute to the information extracted during vision. For this purpose, an analytical mathematical model of the early vision system was constructed that incorporates the retina response, adaptation, eye blur, and noise.

Their analysis shows a delicate balance between drift and image. Minor drifts of the eyes can, depending on different circumstances, help vision, interfere with vision, or not have a significant effect. The effects of fixational eye movements can be positive or negative, but not always.

For instance, FEMs may help or hinder the detection of particular stimuli, which depend on the exposure duration and spatial properties of the images in question. "Our results show that the effect of fixational eye movements is highly dependent on the dimensionless parameters that define their temporal characteristics and their interaction with the spatiotemporal features of the visual stimulus."



An illustration showing how tiny fixational eye movements affect vision. Too much motion blurs fine details, too little causes images to fade through neural adaptation, while a "just right" amount keeps patterns sharp and stable on the retina. Image generated with AI tools for illustrative purposes.

It also explains several mysteries. One study on the physiology of the retina showed that, unexpectedly, the introduction of small jittery movements improved the ability to decode the retina's signals, leading the authors to conclude that "fixational eye drifts enhance the precision of the retinal representation." This model provides an explanation for why this happens sometimes. The jitter diffuses the spatial detail in time, allowing for easier neuronal processing. However, there are instances when too much or too little drift will blur the image, which is supported by findings in other studies.

When too little or too much motion backfires

The key insight is that our eyes' tiny drifts convert spatial details into a flickering signal. The retina is highly sensitive to changes over time, but it also "blurs" very fine detail (the optics of the eye are not perfect). The new explanation shows that moderate drift speeds produce an optimal mix: they move the image just enough to fight adaptation without washing out detail. In fact, by plugging in human visual system estimates, researchers found that measured rates of natural ocular drift lie near this sweet spot.

As they note, "Measured rates of fixational ocular drift are tuned to provide maximum benefit given the presence of optical blur—an indication that once again a biological process is operating near a limit imposed by physical principles." In other words, our involuntary eye shakes are surprisingly close to the ideal amount for our optics and neurons.

What does this look like? Imagine looking at a finely striped pattern. Without any drift, the stripes would fade from view. A gentle drift motion makes them shimmer on the retina, keeping them visible. But if the drift speed were much faster, the stripes might blur into gray.

The researchers showed that across the range of everyday visual stimuli, one can find regimes where FEMs help vision and others where they hurt. This explains why classic measures of human contrast sensitivity (how well we see patterns of different fineness) seem hard to reconcile: the so-called band-pass shape of our sensitivity might emerge from precisely this balance of eye motion, blur, and adaptation. The study even revisits classic fixation experiments (like Barlow's stabilized image experiments) and shows their results fall out naturally once you account for these interactions. In short, tiny eye movements knit together the spatial and temporal facets of vision in unexpected ways.

Tuned by blur

The work also hints at practical applications. If tiny eye drifts are closely matched to the blur in human vision, then changes in those movements could affect how clearly people see. That could eventually matter for visual prosthetics, eye-tracking displays, or even machine-vision systems that mimic the human eye's constant motion.

But the deeper takeaway is harder to ignore. The tiny jitters we never notice may not be flaws at all. They appear remarkably well-tuned to the limits of physics and biology.

So when you find yourself gazing at an object that does not move, keep in mind that your eyes are actually in constant motion, and this may be one explanation for why everything is so clear to us.

More information: Alexander J. H. Houston et al, Information, movement, and adaptation in human vision, *Physical Review Research* (2026). DOI: 10.1103/l4qd-5s7d