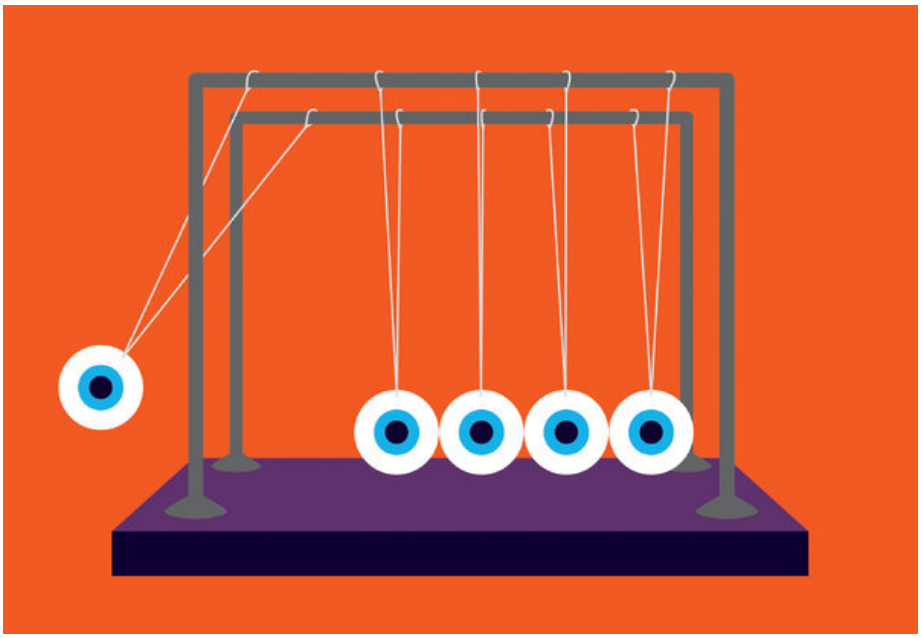
GRAY MATTER

Vision Is All About Change



Post Typography

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YOUR eyes are the sharks of the human body: they never stop moving.

In the past minute alone, your eyes made as many as 240 quick movements called “saccades” (French for “jolts”). In your waking hours today, you will very likely make some 200,000 of them, give or take a few thousand. When you sleep, your eyes keep moving — though in different ways and at varying speeds, depending on the stage of sleep.

A portion of our eye movements we do consciously and are at least aware of on some level: when we follow a moving bird or plane across the sky with our gaze, for instance. But most of these tiny back-and-forths and ups-and-downs — split-second moves that would make the Flying Karamazov Brothers weep with jealousy — are unconscious and nearly imperceptible to us. Our brain suppresses the feeling of our eye jumps, to avoid the sensation that the world is constantly quaking.

Even when we think our gazes are petrified, in fact, we are still making eye motions, including tiny saccades called “microsaccades” — between 60 and 120 of them per minute. Just as we don’t notice most of our breathing, we are almost wholly unaware of this frenetic, nonstop ocular activity.

Without it, though, we couldn't see a thing.

Humans are hardly unique in this way. Every known visual system depends on movement: we see things either because they move or because our eyes do.

Some of the earliest clues to this came more than two centuries ago. Erasmus Darwin, a grandfather of Charles Darwin, observed in 1794 that staring at a small piece of scarlet silk on white paper for a long time — thereby minimizing (though not stopping) his eye movements — made it grow fainter in color, until it seemed to vanish.

In the early 1950s researchers used technology to counteract eye movements by mounting a tiny slide projector onto a contact lens affixed to the observer's eye with a suction device. This retinal stabilization technique forces the image to remain still with respect to the eye, even when the eye continues to move. The images, in these experiments, fade away perceptually, because of the lack of neural stimulation.

Some two decades later, the neuroscientist John K. Stevens, at the University of Pennsylvania, underwent the injection of a paralytic drug that obliterated nearly all of his bodily motion, including that of his eyes (he was artificially ventilated during the experiment). An arterial tourniquet prevented blood flow to, and therefore paralysis of, one of his arms, allowing him to communicate with his colleagues by flexing his hand. He found that without eye movements, "image fading became a real problem."

We see the same result with certain rare diseases that lead to complete ocular paralysis. One woman afflicted with extraocular muscular fibrosis has never made eye movements. She can read and even perform some complex daily activities (like making herself a cup of tea) — but only because she has learned to make saccade-like motions with her head. The head movements provide her brain with the jerky motion it needs to gather information from the environment.

What may be most surprising is that large eye motions and miniature eye jolts help us see the world in similar ways — largely at the same time.

Scientists had long believed that we used two types of oculomotor behavior to sample the visual world, alternating between big saccades to scan our surroundings and tiny ones to fix our gaze on a location of interest. Explore, fixate, repeat, all day, every day.

It seemed to make intuitive sense that we would have one brain system for exploring the environment and another for focusing on specific objects. But it turns out that exploration and gaze-fixation are not all that different processes in the brain.

Three colleagues and I recently published a study in the Proceedings of the National Academy of Sciences in which volunteers were asked to view images of all sizes, from the massive to the minute, while we measured their eye movements. We found that people's eyes scanned the scenes with the same general strategy in all cases, whether the images were huge or tiny, or even when they were fixing their gaze.

The findings suggest that exploration and fixation are not fundamentally different behaviors after all, but rather two ends of the same visual scanning continuum. They also imply that the same brain systems control our eye movements when we explore and when we fixate — an insight that may ultimately offer clues to understanding oculomotor dysfunction in neurological diseases, like Parkinson's, that affect eye movements.

On a more personal level, I've often found a bit of inspiration from the biological fact that vision is all about change. If the world stands still, we must manufacture our own motion to perceive it — which would mean that the well-cited spiritual advice, "be the change you wish to see in the world," often misattributed to Mohandas K. Gandhi, has a sound scientific basis as well.

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