Your Eyes Can Write

Our eyes perceive our surroundings, convey emotion and, some may say, that they can even speak, loud and clear. Now, with the help of an optical illusion, our eyes can also write.

Look at a white wall, and try to follow an imaginary moving speck with your eyes. Move from right to left... slowly! Go ahead and try! Not that easy, right? Your eyes make quick sudden thrusts, known as *saccadic movements*, jumping from one spot to another, apparently completely out of your control. If this is an unnerving experience, you will be happy to know that thanks to Jean Lorenceau from Université Pierre et Marie Curie, Paris, France, it is now possible to train your eyes to move smoothly along a white screen. What would this be useful for? Writing in cursive on a computer screen with the eyes, just as easily as when using a pen and paper, would be one possible future use.

When gazing at a sequence of changing static images, our eyes and brain perceive movement. This is an optical illusion, called *phi motion, and an important one at that, as it is central to the enter*tainment industry, from cinema to videogames. Phi motion relies on an intrinsic limitation of the human eye, the persistence of vision, where an image persists on the retina for a short amount of time after its trigger has disappeared.

Another related optical illusion occurs when the brightness of a moving object changes rapidly. In this case, our eyes move the opposite way and thus perceive the object as if it were moving in the opposite direction from that in which it actually is. This phenomenon is called *reverse phi motion* [1].

One day Lorenceau was performing an experiment on reverse phi motion. The experiment consisted in gazing at a field of flickering static dots that quickly changed brightness. He noticed that, when moving his eyes in a certain direction, the dots seemed to be moving in that same direction. He understood that this was the compound result of two effects. First, as he moved his eyes, the dots' relative motion was in the opposite direction, just as, if you move your eyes to the left, the image in front of you seems to move to the right. The second effect came as a result of reverse phi motion, as the rapid change in brightness made the dots appear to be moving in the opposite direction,

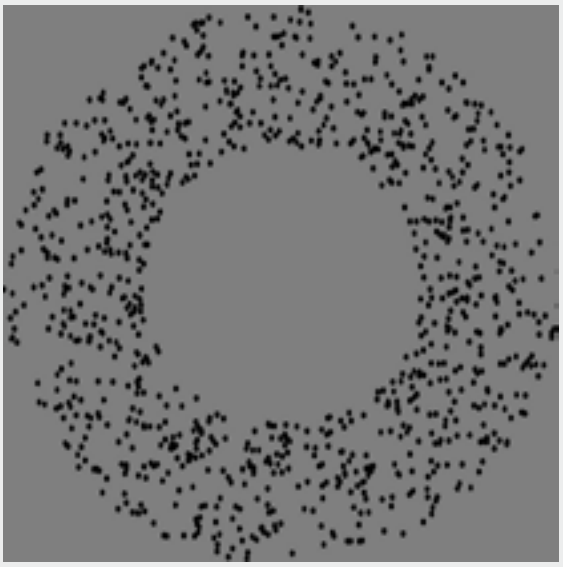

Figure 1: The *phi motion* optical illusion. When we gaze at a sequence of static images, our eyes get the impression of movement. This is the main principle behind movies and the videogames industry.

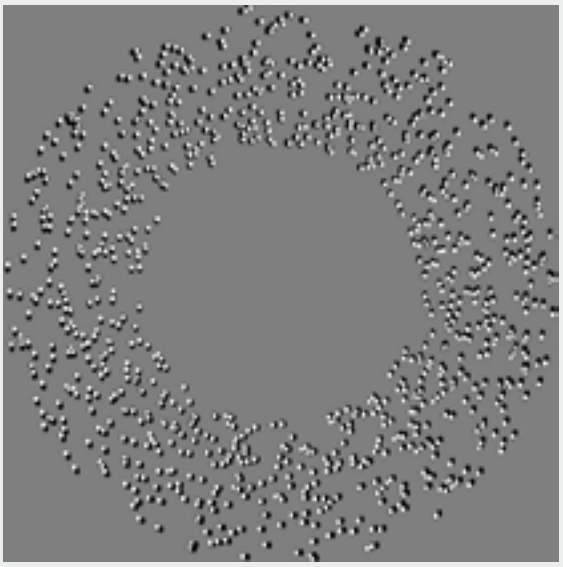

Figure 2: The *reverse phi motion* optical illusion. Rapid changes of brightness engender a sensation that an object is moving in a direction opposite to the one in which it is actually moving. When the circles change from black to white on alternate frames, they appear to be moving counterclockwise, while in reality they are actually moving clockwise, as you will notice if you focus (your attention) on one of them.

which, in its turn, was exactly the direction in which his eyes were moving.

Lorenceau understood that the apparent motion of the flickering dots in the direction of the movement of the eyes could be used to stabilize the motion of the eyes themselves, and to prevent the quick saccadic movements. He therefore built a device to train some volunteers to draw with their eyes just as they would draw with a pencil. This devise consists of a screen with flickering dots. After three 30-minute training sessions, the volunteers were able to control and perform smooth eye movements in any direction at will "as if surfing on a self-induced wave" of this reverse phi motion illusion, Lorenceau explains. And with a little further training they started to write letters and legible words with their eyes at a similar rate to writing by hand.

This new technology has a wide range of exciting potential applications. To patients suffering from locked-in syndrome, a condition in which complete paralysis of almost all voluntary muscles takes place, this technology could offer the possibility to communicate with others, draw figures and sign. The same goes for patients with tetraplegia, spinal cord injury and other limb movement deprivation diseases. Although other eye-writing devices currently exist, where users can make saccades towards predefined items displayed on the computer screen, these do not afford the patients or users the benefits of a personal and creative way of communicating.

The applications of an eye-writing device are not limited to the clinical field alone. According to Lorenceau, such device could also help children with dyslexia or attention deficits withoculomotor impairment to gain better control of their eye movements. Or even to improve motor skills in athletes, surgeons or artists, whose professional activities strongly rely on a faster, more precise control of how their eyes move. In addition, it could offer security systems a safer way of checking someone's true identity, as forging one's eye signature should prove far more complex than forging a handwritten one.

[1] S.M. Anstis, *Phi movement as a subtraction process*, Vision Res. **10**, 1411–1430 (1970).

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Jean Lorenceau, **Cursive Writing with Smooth Pursuit Eye Movements**, Current Biology **22**, 1506–1509 (2012).