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The Motion Aftereffect Illusion

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# The Motion Aftereffect

This paper will discuss the motion aftereffect, also known as “the waterfall effect.” This paper will go over the illusion and variants of the illusion, then go through the history of the illusion, and the debate over who first described the illusion. The paper will also go through the technical details of the theories as to why the illusion occurs, and the implications of the illusion on everyday life.

# What is the illusion?

The motion aftereffect illusion (MAE) is an illusion where the subject will look at some movement, and then when the subject looks away (usually at a stationary object), the object appears to be moving in the opposite direction of the original movement. For example, if one were to look at a waterfall for a few moments, then look at a rock next to it, it may appear that the rock is moving upwards, in the opposite movement of the falling water. Mather, Pavan, Campana, & Casco put this succinctly by stating “After prolonged adaptation to a visual scene moving in a certain direction, observation of a stationary scene evokes an experience of motion in the opposite direction” (2008, p. 481). It used to be considered that the effect only occurs after several seconds of fixation on the moving object, however this was shown to be incorrect, and the adaptation period can actually be much shorter than this. Glasser, Tsui, Pack, & Tadin showed in 2011 that they could “demonstrate objectively that 25 ms of motion adaptation is sufficient to generate a motion aftereffect, an illusory sensation of movement experienced when a moving stimulus is replaced by a stationary pattern. This rapid adaptation occurs regardless of whether the adapting motion is perceived” (p. 1). There are variations of the motion aftereffect as well.

Whereas the motion aftereffect is often referred to as the “waterfall effect,” it is often considered that the effect only occurs when a viewer looks at something moving in a single direction, however this can occur in any direction that is continuous, such as spirals. The spiral aftereffect is one such variation of the motion aftereffect, except instead the stationary object viewed after appearing to go in the opposite direction (circularly), they instead appear to expand or shrink. For instance, if the spiral is viewed as such that it appears to be moving inward, the spiral aftereffect will make objects appear to be growing bigger, and if the spiral appears to be moving outward, then the aftereffect will make objects appear to be getting smaller. There is some debate over the history of the topic though, with two different parties considered to have first referenced the effect, multiple millennia ago.

# History behind the illusion

It is often considered that Aristotle (ca. 384-322 B.C) was the first to mention the illusion, however this is debatable since he gave no indication of the direction of motion, so it is not clear whether he was referring to the motion aftereffect or another illusion. Aristotle said, “When persons turn away from looking at object in motion, e.g., rivers, and especially those which flow very rapidly, they find that the visual stimulations still present themselves, for the things really at rest are then seen moving” (Aristotle, trans. 1931, p. 459b). The next person to give mention of the motion aftereffect in text was Lucretius, who is considered to have been the first to actually refer to the illusion by some (Verstraten, 1996), since whereas Aristotle simply said that “the visual stimulations still present themselves,” Lucretius gave more specific details about the direction of motion,

When our spirited horse has stuck fast in the middle of a river, and we have looked down upon the swift waters of the stream, while the horse stands there a force seems to carry his body sideways and pushing it violently against the stream, and, wherever we turn our eyes, all seems to be rushing and flowing in the same way as we are. (Lucretius, trans. 1975, p. 309)

In layperson terms, this means that after one looks at running water for a prolonged period of time, when looking at the land next to the river, it appears to be moving in the opposite direction. The motion aftereffect generally went unnoticed for a long period after this, without much writing toward the illusion until the 19th century.

Robert Addams (ca. 1800-1875) rediscovered the motion aftereffect and was the first to relate it to the water running down a waterfall. This was later picked up by Thompson (1880), who coined the term “waterfall illusion” (Wade & Heller, 2003).

Joseph Plateau rediscovered the motion aftereffect around the same period as Addams, except he was the first to discover the effect with regard to spirals (1849), with an object that became known as the Plateau spiral (Wade & Heller, 2003). Plateau’s experiments were critical to the evolving theory as to why the illusion occurred, as prior to this it had been thought that the cause of the illusion was involuntary eye movement (Purkinje, 1820; Addams, 1834; Wade & Heller, 2003). Plateau’s experiments proved that this could not be the case as the visual motion perceived from the spiral aftereffect causes objects to become bigger and/or smaller, which is impossible with unconscious eye movement alone (Wade & Heller, 2003).

Wohlgemuth (1911), experimented the motion aftereffect in dozens of ways, putting the research much further ahead than it had been before. This was later described as “the most thorough of all investigations on this subject” (Flügel, 1954, p. 25). Wohlgemuth discovered in the early 20th century according to Wade, Thompson, & Morgan (2014) that for the motion aftereffect (MAE), “an MAE can be produced in each eye independently, and what is seen with two eyes is a combination of the two monocular adaptations; adaptation of one eye transfers to the other; MAEs can be produced by a wide range of speeds, and by stroboscopic as well as real motion; following adaptation motion can be seen with the eyes closed” (p. 230). The latter means that there is a certain motion aftereffect storage, which has also been investigated (Spigel, 1960). Wade et al. (2014) also mentioned that Wohlgemuth discovered that the motion aftereffect “strength increases with spatiotemporal frequency and is related to the velocity of the adapting motion” (p. 230), and that the motion aftereffect does not require attention (p. 231). It has also recently been found that humans can even retrieve the motion aftereffect from still images representing movement, depending on what direction the movement *appears* to be in (Winawer, Huk, & Boroditsky, 2008). The current theories of why the motion aftereffect illusion occurs were also created more recently.

# Why does this illusion occur?

It is “a widely accepted explanation of it in terms of changes in the response of cortical direction-selective neurons” (Mather et al., 2008, p. 481). It is considered that there are certain cells within one’s visual cortex that prefer a particular direction, or a particular orientation, and since there are different cells that prefer different directions, they are constantly competing against one another to fire in the way that they all prefer. When a subject fixates on some movement travelling in a certain direction, some of the cells prefer this direction, and they start winning the competition against the other cells. After a while looking at the movement, these cells become worn out from winning against the other cells, so when the movement is removed from sight, for instance when the subject looks at a different object without motion, the cells are worn out from adapting to the motion and cannot compete against the other cells. This means the other cells that prefer a different direction start beating the cells that are worn out, creating an imbalance in the opposite direction, which means that the subject appears to see the new object moving in the opposite direction (Anstis, Verstraten, & Mather, 1998; Chris, 2008).

# Implications for everyday perception

Since it has been shown that the motion aftereffect can occur after very short stimulation (Glasser et al., 2011), and that it is thought that humans have cells within the visual cortex that are constantly competing with each other, this implies that one may never really know how to judge speed accurately purely with the human eye. If one were to look at one moving object, and then at another object moving within a different direction, it may be judged to be moving faster than it actually is, and if one were to look at a slower moving object in the same direction as the original, the backwards illusion may make the object appear to be moving slower than it actually is. Similarly, this implies that it may be difficult to determine if humans can accurately determine if an object is even moving or not, at least when around other moving objects, but humans must have become adapted to this feeling to be able to effectively ignore it and come up with some illusion to ourselves of what appears to be still or not, it is simply that this may be exacerbated by fixation on certain continuous movement.

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