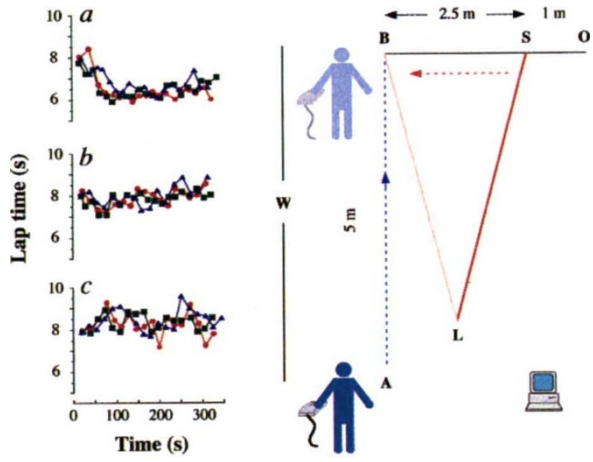
Visual illusion from running

SIR — We have observed a striking visual illusion. When walking on solid ground after more than 10 minutes of fast jogging or running on a treadmill exercise machine, people experience a sensation, lasting 2–3 minutes, of apparently moving at a markedly accelerated pace, as when walking on the passenger-transporting devices (travelators) often found in airports.

We and 14 other subjects (total age range 23–73 years), seven of whom were naive to the expected effect, reported the sensation of accelerated self-motion in comparing their experiences when walking in stationary surroundings before and immediately after treadmill running. In separate experiments, subjects were instructed to maintain a constant 'visual speed' while repeatedly walking a 5-metre course, and were seen to accelerate their pace as the illusion gradually vanished with successive laps (see figure).

We made the following additional observations. First, the effect is strongest after treadmill running with eyes open; we also observed a weak effect after treadmill running while blindfolded, running outdoors, or exercising on a stationary bicycle. Second, occluding peripheral visual information during treadmill running by looking through a restrictive visor reduces the strength of the effect. Third, we observed the illusion when moving forwards, backwards or sideways only after movement on the treadmill in the corresponding manner. Fourth, running with the treadmill close to a textured wall on one side leads to a stronger effect when walking next to a wall on the same side compared with the other side. Fifth, long-term experience of exercise on treadmills reduces the strength of the effect. Sixth, there is no reduction in strength after running with head and elbows stabilized on a shelf mounted above the treadmill. Seventh, active movement is necessary to observe the effect — subjects report no effect when pushed on a wheelchair instead of walking. And finally, the effect is most compelling when walking on the treadmill itself after it has stopped.

We think the first four observations show that the illusion is primarily generated by vision, and results from activity-dependent discrepancies between the observed and expected peripheral optic flow of locomotion. From the fifth observation we conclude that repeated exposure to the adapting conditions reduces these discrepancies. In the sixth, the up-and-down visual motion that normally accompanies running was reduced or eliminated, together with corresponding vestibular signals; we conclude that these are not important for the adaptation. The seventh observation suggests at first that signals initiating active motion are necessary, but their role could be taken by the proprioceptive and efference copy signals actually accompanying locomotion. From the final test we conclude that re-exposure to more of the adventitious sensory signals accompanying the main adapting stimulus heightens the effect.



Left, quantifying the treadmill visual motion illusion. Successive lap times are plotted as a function of elapsed time for three male subjects (aged 24, 28 and 34 years) who were instructed to maintain a constant 'visual speed' while repeatedly walking a 5-m course. A gradually accelerating walking pace is evident as the illusion decays after running (20 min at 10 km per h) on a treadmill (*a*), but not after running outdoors (*b*), or after a control period without prior treadmill activity (*c*). Right, the test setup. The first lap in each trial was designed to ensure that all subjects started walking at the same pace. A red laser point-source emanating from L was swept at a speed of 8 s per 2.5 m across the wall facing the subject, from O to B. When the spot of light was at S, the subject began walking from A to B, alongside wall W, adjusting his pace so as to meet the spot at B. After the first lap, the spot disappeared at S, at which point the subject would begin each lap. The subject timed the laps by pressing a button at start and finish on the hand-held mouse.

Two related after-effects have recently been reported. In one study[1], blindfolded subjects who had jogged for 60 seconds on a treadmill inadvertently advanced when asked to jog in place, still blindfolded, on solid ground. In the other study[2], subjects walked for 8 minutes on a treadmill which itself was pulled along by a tractor at different speeds; they were then shown a target and asked to walk to it blindfolded on solid ground. When the tractor speed was lower than the treadmill-walking speed, the subjects overshot the target, and when it was higher they undershot it. In these experiments, subjects made biased movement in atypical self-motion situations without any visual input during the test period. Our illusion shows that disturbing the normal relation between self-induced motion and the expected sensory input leads subjects to experience altered motion and misjudge its extent even in normal locomotion with eyes always open.

We believe that all these phenomena are related to those Helmholtz explained as unconscious inference[3], and involve recalibration of the mechanisms estimating associations between sensory messages. Changes in these associations are often of vital importance, for they signal changes in the causal net within which we live. One way to detect them sensitively would be to adjust the representational variables continuously, so that they are decorrelated[4]; in the illusion described here, this achieves the same end for variables representing self-motion inputs from two or more sensory modalities as automatic gain control does for a single sensory variable (for example, in light adaptation). Adaptation after-effects, including those discussed here, would then be the outcome of adjustments made during a period of novel sensory experience.

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