

# Mind-grasping gravity

Victor Smetacek

Imagine yourself standing at the edge of a precipice, looking down at its foot, and then crouching at the same place on all fours. The difference between the two sensations is the difference between being human and being a quadruped. Clearly, latent anxiety is inherent in the precarious, human mode of bipedalism, which balances a vertical vertebral column on straight legs, with no tail for support.

Balance is so central to every activity, both of the body and the mind, that it is simply taken for granted. It is imbalance (disturbance, perturbation) that captures attention, be it fear of falling, the mental struggle to balance an equation, or the moral urge to right an injustice. As the concept of balance applies smoothly across the entire range of human endeavour, it would be parsimonious to assume a direct connection between the concrete and the abstract, on the basis of compatible neural hardware in the brain. Is the mind's balance, and hence its functioning, derived from that of the body?

Aristotle did not list balance as one of the explicit senses, although it is based on sensory organs. In contrast, Eastern philosophy is explicitly balance-based. Balance is to gravity as vision is to light, or hearing to sound; but whereas light and sound fields vary, Earth's gravitational field is constant.

Because sense organs perceive only gradients, the sensorimotor system

senses the gravitational field with great precision when the body moves.

Three independent organ systems enable the body to maintain balance. To experience how they interact with and compensate for each other, stand close to a wall, on one leg, with your arms dangling, and then shut your eyes; repeat the experiment but touch the wall lightly with a fingertip beforehand. Clearly, we rely on vestibular, visual and somatosensory systems to get our bearings in relation to gravity.

The vestibular organs of the inner ear sense gravity directly, but also as a deviation from the vertical and as self-motion. Balance and momentum signalled by this complex system are manifested in the body's centre of mass — the lower gut — as experienced on heaving ships and rollercoasters. These sensations can also be evoked, as in nightmares.

The eyes also sense and appreciate balance and mass. We enjoy watching dancers, athletes and acrobats (but also clowns), and the mass and symmetry of monumental buildings (or leaning towers) fill us with awe (or other emotions). Beauty, symmetry and balance evidently go hand in hand — there is more to the eye of the beholder than just vision.

The somatosensory system comprises a variety of receptors in the skin, muscles and skeleton which sense gravity as pressure and weight. Body awareness (proprioception) is part of this system. Although the arms are decoupled from locomotion, hand-held tools such as a cane (equivalent to touching the wall) or an acrobat's balancing rod significantly enhance the body's ability to balance.

Each sensory system provides independent, but integrated, coordinates for the body (including the hands) to orientate itself. Research on the vestibular cortex is in its infancy, but its multiple representation, its intimate interaction with visual and sensorimotor cortices and its right-hemispheric dominance distinguish it from other sensory systems. Recent studies indicate that the vestibular system is involved in self-perception and cognition. The human cerebellum, a central organ of balance and also of fine motor skills, contains five times as many neurons as the cerebrum but has received much less attention. Additional functions are only now coming to light.

As balance is central to every directed movement, evolving fine motor skills is synonymous with fine-tuning the sense of balance. Human evolution can be characterized as stages in differentiation and refinement of our balancing abilities. Our lineage first learned to balance bodies on feet, then tools in hands, and most recently,

## Balance

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instruments and aircraft with eyes.

Refining balancing ability improved tool production and use, but also resulted in a form of perception that is linked to the hands and decoupled from the body. Whereas whole-body proprioception and personal viewpoint (the body's sense of balance) is subjective and private, the hands weighing different objects as the pans of a balance (say one big stone in the left, and two small ones in the right) create a demonstrable, verifiable quality (the balance between objects) that can be judged externally and objectively. With this 'disembodied' sense of balance, the principles of constancy and equivalence (the basis of common-sense logic) could be grasped, understood and communicated, in successive stages of evolution. Eventually, measuring rods, pendulums, levers and balances, which are mechanical projections of the body, could be transformed into abstract projections within the mind, unified by an innate understanding of gravity.

Just as there is a mind's eye and a mind's ear, there must also be a mind's gravity, based on each sensory system either on its own or in concert. This is the mind's space-time coordinating system, in which mass, balance and momentum — the substrates of science — are sensed. Archimedes, Newton and Einstein, among a host of others, have shown that there is more to insight than just vision or words.

The bipedal apes striding across the savannah with head held high evolved a very different proprioception and world view to their slouching cousins. Our ancestors dared to challenge gravity by standing up to it and we continue to do so, with our bodies and tools, minds and machines, balancing our way onwards and upwards, both literally and figuratively. ■

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### FURTHER READING

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