A new view on moving

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The brain's sense of movement

by Alain Berthoz

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Co-ordinated movement in time and space is at the core of animal life, so it is certainly worthwhile summing up and explaining our current knowledge about the neurophysiology of moving. Alain Berthoz, Director of the Laboratory of Physiology of Perception and Action at the College de France, has recently written an extensive treatise on this topic. The reader who just expects a detailed description of how movements are controlled by the brain will be surprised by the wide scope of biological, physiological and philosophical problems that Berthoz comes up with. Indeed, it becomes clear throughout the book that our current knowledge of the hardware of sensory and motor systems may be enough to create artificial movements in robots—an aspect also touched upon in the book—but it is certainly not enough to grasp the full depth of this important aspect of animal life.

Without detailed knowledge about how vertebrates perceive their environment, further ideas would be futile. Consequently, Berthoz explains the neurophysiological machinery in great detail when it is necessary to do so. His book starts by describing how nervous systems explore the world and how animals control their movements. In the beginning is the idea that perception is not just an interpretation

of sensory messages but an internal simulation of action, which means that perception and action are strongly intertwined. And as every moving body must ultimately follow the laws of mechanics, the brain had to invent strategies to solve complex mechanical calculations in an economical way. However, according to the author, neurobiology and neuropsychology have widely neglected this fact and have rather focused on the connectivities within the brain. Berthoz claims that a new neuroethology of natural movement is needed—an approach that would also have to include the emotions, which movements express or arouse.

But before the author includes emotions as the climax of his line of reasoning, he first explains the necessary neuronal hardware in terms of structure and function. Thalamo-cortical circuits oscillating at 40 Hz that account for perceptual coherence play a key role by linking numerous multisensory perceptions into larger entities. As sight and hearing are two sensory modalities that act in parallel, it is not surprising to find that visual and hearing neurones come together in the superior colliculus. Another important aspect of co-ordinated and goal-directed movement is the spatial memory, in which the hippocampus plays a key role. A whole chapter 'A memory for predicting' is devoted to the different ideas and hypotheses on the actual functions of the hippocampus related to memory and movement.

Basic conditions for complex movements are synergies—the orchestrated activation of single-motor components. Here, Berthoz points out that, despite all the sophisticated modelling and other tools, good old morphology and anatomy remain important for analysing synergies and thus the building blocks of action. Those circuits in the brain that are responsible for selecting, activating and co-ordinating synergies have to internalise the basic laws of geometry and kinematics. This has interesting consequences for our perception, mainly that natural movements constrain what we perceive, which quite often is different from the physical reality. Consequently, Berthoz regards illusions as solutions and not as errors and he analyses them in a whole chapter. He makes clear that illusions are the best possible hypothesis the brain can offer when dealing with conflicting information.

The structure and function of the sensory systems on which the brain's sense of movement depends are explained in a way

that allows the reader to follow the route from the periphery to central circuits step by step, particularly the information processing of visual input. Here, Berthoz asks for a complete revision of the word 'sense', based on perceptual functions and including the biological goals. Indeed, a new classification would be more useful for neurobiology. I can strongly support this view and I am glad that the fields of 'sensory ecology' and 'neurobiological ecology' that ask for the study of both proximate and ultimate 'reasons' of sensory systems and central circuits, have found a further supporter in Alain Berthoz.

The last chapter, 'Architects have forgotten the pleasure of movement', will not please a lot of representatives of this profession. Berthoz criticises modern architecture as a 'tragedy for our brains, its emotions, and the pleasure it takes in movements', invoking the notion that 'perception is inseparable from action'. Starting with von Uexküll's analysis of the importance of the *Umwelt*—the environment—for an organism and how each organism is adapted through evolution to its *Umwelt*, Alain Berthoz makes the criticism that straight lines and rectangles condemn our brains to idling and boredom.

This entertaining book excellently presents the known facts and links them to new insights and aspects. When introducing important hypotheses, Berthoz also gives a glimpse of the history of these ideas. But the most striking aspect of the book is the message that understanding the brain's sense of movement is of great relevance today. Mankind is getting ready to leave our planet—as indicated by the cover of the book—and the hard- and software of our bodies is not made for this new challenge. It is therefore essential to understand and to be able to predict how humans will move and orient themselves under conditions of zero gravity or acceleration. But also for those of us who stay behind, a better knowledge about the complex relations between action, perception and emotion will help to improve the environment we create for ourselves on earth.

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