

Alain Berthoz Collège de France/CNRS Paris, France

Alain Berthoz is Honorary Professor at the College de France, member of the French Academy of sciences and the Academy of Technologies, the Academia Europae, American Academy of Arts and Sciences, and other Academies (Belgium, Bulgaria).

He is an Engineer, and is an expert in Biomechanics, Psychology and Neurophysiologist. He is a world known specialist of the physiology of multisensory integration, spatial orientation, the vestibular system, the oculomotor system, locomotion, and spatial memory. He is currently cooperating, within European Projects and with robotics groups in Japan for bio-inspired robotics and humanoids. He is the author of more than 300 papers in International

journals and the author of several books on these subject among which The Brain's Sense of movement, Harvard Univ Press (O. Jacob 1997), Emotion and Reason The cognitive foundations of decision making, Oxford Univ Press (O. Jacob 2000) and Simplexity Yale University Press (O. Jacob 2011).

The neuro-cognitive control and development of gait in health and disease. Recent findings

Locomotor trajectories are controlled by neurocognitive, anticipatory top-down mechanisms. I will review the following recent findings and theoretical views:

- a) Similar "simplex" laws subserve hand and locomotor trajectory formation. We have shown that goal oriented locomotor are very stereotyped due to optimization principles. We have also shown a hierarchical top-down organisation with an anticipation of the locomotor trajectory by gaze. In addition we have shown that the brain uses for both hand movement and locomotor trajectory formation combinations of several geometries (Euclidian, affine, equi-affine).
- b) Emotion does modify this organisation of gait.
- c) The generation of locomotor trajectories uses brain mechanisms underlying spatial memory and navigation. Several different brain subsystems are involved in the control of trajectories to near space, far space or environment space. In addition these brain mechanisms involve different networks for egocentric or allocentric coding of navigation including the hippocampus, parahippocampus, retrosplenial cortex, cerebellum. I will show recent fMRI and virtual reality experiment demonstrating lateralization. The left and right hippocampus are involved in respectively sequential egocentric and global allocentric control of navigation. I will also allude to the role of the vestibular system in navigation.
- d) New experimental paradigms, the "walking Corsi" and the "Magic carpet", " the "Walking Stroop" paradigms allow the study of cognitive strategies for the organisation of locomotor trajectory formation and visuo-spatial memory. We have used them to demonstrate the role of gaze in planning locomotor trajectories, and the development of locomotor trajectory formation in children and adolescents. I will also show some recent results concerning children patients with Cerebral Palsy, and aging persons with Mild Cognitive Disorders.
- e) I will also briefly show how these findings can inspire the design of Humanoid Robots.



Keir Pearson University of Alberta, Canada

Keir Pearson is a neurophysiologist who received his Bachelor of Engineering (Electrical) from the University of Tasmania and his PhD in Physiology from Oxford University. He is currently an Emeritus Professor in the Department of Physiology at the University of Alberta, Canada, and former Director of the University Centre for Neuroscience. He has held a Tier I Canada Research Chair in Movement Physiology and he is a Fellow of the Royal Society of Canada. His research program is focused on the nervous control of walking, with special interest in the role of vision and memory in guiding stepping movements.

Working memory for obstacle avoidance during walking

Stepping over an obstacle during walking usually relies on visual information about the location of the obstacle relative to the body. However, visual fixation of the obstacle is not necessary at the time the legs move to avoid the obstacle. For example, guadrupeds and humans often view the terrain two or three steps ahead of their current position, and store visual information about target locations in working memory to guide leg movements at a later time. In guadrupeds, a unique form of working memory is used to guide the hind legs over obstacles that have already been stepped over by the forelegs. This working memory is very long-lasting (many minutes) and incorporates precise information about the size and position of the obstacle relative to the hind legs. I will present data from electrophysiological and lesion studies that demonstrate that neuronal systems in the parietal cortex are necessary for establishing this memory and for representing the current position of the obstacle relative to the moving body. The lesion studies also indicate that these representations in the parietal cortex are used specifically to retain long-lasting memories (up to minutes) of obstacle location, and that short-lasting memories (up to a few seconds) are represented in other brain regions. I will present the hypothesis that remapping of obstacle location relative to the moving body depends in part on sequential activation of different populations of neurons in parietal cortex, with each population representing the specific location of the obstacle relative to the position of the legs. These and other observations will be discussed within the concept of a body schema, that is, how a representation of body geometry is used and updated to control motor commands as an animal interacts with the external world.



Marianne Dieterich Ludwig-Maximilians-University of Munich, Germany

Prof. Dr. med. Marianne Dieterich, is Head of the Department of Neurology, Ludwig-Maximilians-University, Klinikum Grosshadern, Germany. She is a former Research Fellow with the Primate Laboratory of the Vestibular Laboratory, Dept. of Neurology, Kantonsspital Zürich, Switzerland. She has also worked with the Alfried Krupp Hospital Essen, the Universities of Bochum and Essen, and Johannes Gutenberg-University Mainz, Germany.

In 2013 she was honored with the 'Designation of Corresponding Fellow of the American Neurological Association (FANA)' and in 2011 was awarded the 'Award of the German Society of Clinical Neurophysiology and Functional Imaging (DGKN) for outstanding teaching'.

Functional imaging of vestibular disorders with implications for rehabilitation

The last 15 years have brought new insights into the vestibular system thanks to lesion studies and functional imaging of the human brain. The latter technology was at first applied only to healthy subjects but now it is being more often used with patients who have diseases localized to the vestibular system, so-called vestibular disorders. The groundwork for such investigations was provided by neurophysiological and tracer animal studies in the 1970s to the 1990s. These studies located several areas in the cerebral cortex, especially in the temporo-parietal cortex, that formed a sort of network. All of these areas showed multisensory reactions, not only to postural stimuli but also to stimuli of the visual and sensory systems. The center of this network was located in the parieto-insular vestibular cortex, the PIVC. Today, owing primarily to the findings of functional imaging studies, we know that such a network also exists in the human temporo-parietal cortex of both hemispheres. Moreover, this human network has a number of particular features. For example, the "activation" of the network in healthy subjects is not equally distributed in the two halves of the brain; while the right hemisphere is predominant in right-handers, the left hemisphere is predominant in left-handers. The side stimulated also plays a role: activation is more strongly pronounced in that half of the brain that is on the same side as the stimulated ear. In addition to such activations we know there are simultaneous "deactivations" that are localized in the visual and somatosensory cortices of both brain halves during vestibular stimulation. A complementary activation-deactivation pattern was observed during visual stimulation: activations in the occipital and parietal visual areas occurred simultaneously with deactivations in the multisensory vestibular cortex. These observations led to the hypothesis of the existence of a reciprocal inhibitory interaction between the two sensory systems of the cortex, i.e., between the visual and the vestibular systems. The data from brain activation studies of the vestibular system in healthy subjects can now be compared with the data of patients with various peripheral and central vestibular disorders in the acute stage of disease and lateron during compensation. Such comparisons promise to deepen our understanding of these syndromes, will have implications for rehabilitation and thus will speed the development of new therapies for these disorders.



Stephen Robinovitch Simon Fraser University, Canada

Stephen Robinovitch, Ph.D., is a Professor and Canada Research Chair at Simon Fraser University in Vancouver, Canada. His research focuses on the cause and prevention of falls and fall-related injuries in older adults, and incorporates biomechanics, neurophysiology, and clinical research methods. He currently leads a program in "Technology for Injury Prevention in Seniors" (www.sfu.ca/TIPS), involving long-term care facilities who participate as "real life" laboratories for capturing objective evidence of falls (through video and wearable sensors), and exploring the clinical effectiveness of engineering interventions such as wearable hip protectors and compliant flooring for preventing fall-related injuries.

Protective responses in older adults for avoiding injury during falls

Over 30% of older adults living independently, and 60% of those in long-term care (LTC) fall at least once each year. Any fall from standing onto a firm surface has the potential to cause life-threatening brain injury, and carries 20 times the energy required to fracture the elderly proximal femur. It is therefore not surprising that falls are the number one cause of injuries, including 95% of hip fractures and 60% of traumatic brain injuries, in older adults. Indeed, a more perplexing issue is the observation that most falls in older adults are benign events: only 10-15% result in some form of injury, and only 1-2% cause hip fracture or head injury. Understanding the factors that separate injurious and non-injurious falls is essential to developing improved approaches to fall injury prevention. In this talk, I will review evidence of the crucial role of "safe landing responses" for avoiding injury during falls, derived from laboratory experiments and field studies involving video capture of real-life falls in LTC. I will also discuss how these responses are altered through the lifespan, and how they may be enhanced through interventions. Specific topics to be discussed include: (1) "Factor of risk" for injury: the energy management problem of falls; (2) Lessons from epidemiology on falling behaviours: effect of age, functional status, and wearable hip protectors on injury patterns during falls; (3) Video-captured evidence of strategies by older adults for avoiding impact to the head and hip, and reducing impact velocity during falls; (4) The effect of disease and functional status on fall severity in older adults. The talk should be of interest to both researchers and care providers interested in the prevention of fall-related injuries in older adults.



Jeffrey Hausdorff Tel-Aviv Sourasky Medical Center, Sackler School of Medicine, Israel

Dr. Jeffrey M. Hausdorff is the Director of the Laboratory for the Analysis of Gait and Neurodynamics at Tel-Aviv Sourasky Medical Center, Professor at the Sackler School of Medicine and Sakol School of Neuroscience, and Lecturer in Medicine at Harvard Medical School. With a background in biomedical engineering and a strong interest in wearable computing, Dr. Hausdorff studies gait and postural control, fractal physiology, gait variability, motor control, and brain function. Recent investigations focus on imaging and the genetics of gait alterations, the potential of virtual reality to improve motor-cognitive interactions, and new methods for assessing and minimizing fall risk.

What happens when body-fixed sensors meet Parkinsonian gait? A look back to the future

For about two decades now, researchers have been studying the walking pattern of patients with Parkinson's disease using body-fixed sensors. The understanding of gait dynamics in Parkinson's disease evolved over this period. It has been shown that certain features of the stride-to-stride fluctuations in gait are related to disease severity and that some properties respond to dopamine and other therapeutic interventions. Associations between measures of gait dynamics and specific aspects of cognitive function have also been uncovered. Insights into the perplexing and debilitating episodic phenomenon known as freezing of gait have been achieved, along with intriguing observations on the relationship between genetic mutations common in Parkinson's disease and specific alterations in gait dynamics.

In parallel, the sensors and algorithms that have been used to evaluate gait dynamics in Parkinson's disease and related disorders have also evolved. Today, the traditional clinical examination of Parkinson's disease can be augmented by instrumenting clinical tests like the Timed Up and Go with small, easy-to-use body-fixed sensors. The combination of these inertial measurement units and new technology like wireless functional near infrared spectroscopy (fNIRS) and virtual reality also hold promise for providing a new window into the control and treatment of gait dynamics. At the same time, the clinical exam is expanding outside the walls of the clinic. The assessment of gait dynamics during community ambulation will further enhance our understanding of both the continuous and the episodic gait disturbances in Parkinson's disease, the disabling motor response fluctuations, and fall risk.

This lecture will take us on a brief tour of some of the advances made over the past twenty years in Parkinson's disease and related populations and speculate about where we are headed toward in the future.