Novel Approaches to Image Multisensory Body Self-Perception

Chair: Henrik Ehrsson, *Department of Neuroscience, Retzius väg 8, Stockholm, Sweden*

This symposium brings together four leading experts that use a combination of novel imaging and behavioral approaches to study the multisensory mechanisms of body perception. Dr. Amedi uses multi frequency fMRI spectral analysis and fMRI adaptation approaches to map multiple somatotopical representations of the body in the parietal and frontal lobes activated by imagination, illusions and physical multisensory stimulation. Dr. Beauchamp uses TMS and model based fMRI to identify parietal mechanisms for the integration of visual and tactile signals. Dr. Ehrsson uses MRI-compatible virtual reality technology to create novel illusions of owning entire artificial bodies to characterize the multisensory mechanisms of body self-perception. Finally, Dr. Serino uses a combination of behavioral, TMS and fMRI experiments to study the integration of multisensory information between self and others. The topic of this symposium is timely as body-self perception has recently become a hot topic in cognitive neuroscience, and a number of state-of-the-art imaging analysis tools have recently been employed in this area.

Learning Objectives: Having completed this symposium, participants will be able to:
1. Understand the multisensory mechanisms of body self-perception; and
2. Learn about novel analysis approaches to map multiple body representations in the cortex.

A Brain Full of Body Maps: Cortical Mapping of the Somatosensory, Visual, Motor and Mental Imagery Representations of Our Body Scheme using fMRI

Amir Amedi, *Dept. of Physiology - Faculty of Medicine & Program of Cognitive Science, The Hebrew University of Jerusalem Ein Karem, Jerusalem*

In this talk I will cover cutting-edge brain imaging techniques for mapping the multiple topographical representations of one's own body. I will also present data depicting the organization of imagination, illusions and physical multisensory stimulation of the body. In the somatosensory domain, the sensory homunculus which was demonstrated so vividly by Penfield's seminal work has been a focus for extensive research. However, the vast majority of the studies focused on distinct areas of the body surface, especially the hands or the face. Using advanced analysis of the dynamic of BOLD response we managed to reveal in high resolution and for the first time the whole-body homunculus. Additional mirror-symmetry homunculi were revealed both medially and laterally to SI, suggesting that topographical mapping might be a more common fundamental characteristic also of associative and multisensory cortices. Furthermore, the relationship between the neural basis of perception and mental imagery was studied extensively in the visual system (i. e. our mind's "eye") but not in the somatosensory system in relation to our body (i. e. the mind “body” scheme). As in other sensory modalities, we found areas around the post central sulcus which showed highly significant activation for both tactile perception and tactile imagery of the body. However, in contrast to visual and auditory imagery, we found several brain areas in the posterior parietal cortex and in the occipito-parietal cortex which showed robust activation for mental imagery of the body, but no or negligible activation to perception of the same body part. These brain areas showed broad topographical mappings similar to the representation in the somatotopic human homunculus, but with greater variability between subjects. Finally we also present data from multisensory (visual-tactile) convergence body maps and motor body maps which were found in the cortex, basal ganglia and cerebellum. I will suggest that the brain is full of topographical maps, which can serve as preliminary road maps to help us understand how the human brain represents the many aspects of our body scheme.

Reliability-Weighted Multisensory Integration

Michael S. Beauchamp, *Department of Neurobiology and Anatomy, University of Texas Health Science Center at Houston, Houston, TX, USA*

Different sensory modalities provide independent information about the world around us and its relationship to our bodies. While this extra information can improve the accuracy of our judgments, using it comes with an added challenge: from moment to moment, the reliability of different sensory modalities can change. For instance, in order to determine if an insect has landed on one's arm on a windy day, the visual modality will be more reliable; making the same judgment in a dark room, the somatosensory or auditory modalities would be more reliable. Using BOLD fMRI and behavioral experiments on two different combinations of modalities--visual-somatosensory, and visual-auditory--I will show that the brain weights different modalities by modulating the effective connectivity between early sensory cortex and multisensory areas in the intraparietal sulcus and superior temporal sulcus, mirroring the reliability weighting observed behaviorally.

Illusion of Owning an Entire Artificial Body Reveals the Multisensory Mechanism of Body Self-Perception
Henrik Ehrsson, *Department of Neuroscience, Retzius väg 8, Stockholm, Sweden*

Why do we experience a particular body as our own? This question, discussed in philosophy and psychology for centuries, has recently become experimentally accessible in cognitive neuroscience. Here we use a 'body-swap' illusion where people experience an artificial body as their own body, in combination with brain imaging and behavioural experiments to identify the brain mechanisms of ownership of an entire body. Our results show that integration of visual and somatic signals in body-centred reference frames in the intraparietal cortex and ventral premotor cortex is a key mechanism, presumably by producing a coherent multisensory percept of one's own body in near-personal space. Interestingly, ownership was also associated with an amplification of the signal in the extrastriate body area, probably reflecting a modulatory effect from the multisensory areas upon this non-primary visual area. Taken together these results provide a mechanistic multisensory explanation for how we come to experience that we own our body.

Sharing Visuo-Tactile Experience Between Self and Other
Andrea Serino, *Dipartimento di Psicologia, ALMA MATER STUDIORUM – Università di Bologna, Bologna, Italy*

Observing a body being touched modulates the perception of tactile stimuli on one's own body. We developed a new experimental paradigm to measure this effect, termed Visual Remapping of Touch (VRT). Subjects perform a tactile discrimination task for around threshold stimuli delivered to their face, while observing the image of a face being touched, or just approached, by fingers. Visual information boosts tactile perception when the observed face iss touched, but not when only approached. The strength of this effect varies systematically as a function of the similarity between the observed and the observer's face, being highest for viewing the one's own face. F-MRI data show that tactile and visual information related to touch is integrated in the ventral intraparietal area, whereas visuo-tactile information specifically related to the self is processed in the ventral premotor cortex. These neural signals then transfer to the somatosensory areas, modulating tactile perception.