NEUROSCIENCES SEMINAR

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"BODY CONSCIOUSNESS: BRAIN MECHANISMS OF REPRESENTATION OF THE SELF AND OTHERS"

Soria, 9 al 13 de julio de 2007
Convento de la Merced
Sede de la Fundación Duques de Soria
Santo Tomé, 6
Soria

What functional imaging can tell us about the body representation

H. Henrik Ehrsson

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The perception of one's own body is a fundamental aspect of self consciousness. This talk will discuss what functional imaging can tell us about the central representation of one's own body. Functional magnetic resonance imaging (fMRI) and position emission tomography (PET) measures changes in the oxygenation of the blood (fMRI) or changes in blood flow (PET) as indexes of synaptic activity in large populations of neurons. Functional imaging critically depend on the design of the experiment where the goal is to relate activity to a specific function, process or mechanism. In my talk I will first describe the advantages and disadvantages of these techniques, and explore how they can be used to address different questions relating to the body representation. Secondly I will illustrate the use of these techniques to study the central representation of one's own body by reviewing some of my recent experiments on this topic (see below).

These include experiments were we aimed to identify the cortical representation of limb movement (kinesthesia). The sense of limb movement is of particular interest in this respect because proprioceptive signals are always originating from the own body. Kinesthetic illusion can be induced by vibrating the tendon of a muscle (Goodwin et al., 1972; Naito et al., 1999). The vibration of a muscle tendon excites the muscle spindle afferents signaling that the vibrated muscles are stretched although the limb remains immobile. Converging evidence from many studies suggest that the motor areas including the primary motor cortex participates in somatic perception of one's own limb movement (Naito et al., 1999; Naito et al., 2002).

The perception of the size of body parts is another important aspect of the body representation. Changes in the perceived size of body parts can be induced by tendon vibration where the vibrated limb is in direct contact with another limb ("Pinocchio illusion"; Lackner, 1988). We found that activity in the cortices lining the left postcentral sulcus and the anterior part of the intraparietal sulcus reflected the illusion of a body part changing size, and that this activity was correlated with the reported degree of shrinking. These results suggest that the perceived changes in the size and shape of body parts are mediated by hierarchically higher-order somatosensory areas in the parietal cortex.

Finally, I will review recent studies that have manipulated the feeling of ownership of a seen limb (Ehrsson et al., 2004, 2005, 2007). These experiments used the so called rubber hand illusion (Botvinick and Cohen, 1998) where brushing of a seen rubber hand in synchrony with brushing the hidden real hand induces the illusion that the rubber hand senses the touch and that it is part of one's own body. These studies suggest that integration of visual, tactile and propriocetive information in multisensory areas is the mechanism of ownership (Supported by Wellcome Trust and Human Frontier Science Program).

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Lecturer and Title of Lecture: Prof. Pietro Pietrini

Perception of the environment in the congenitally blind: new insights on the functional organization of phenomenic consciousness in the human brain

Lecture Summary:

The lecture will review and discuss the results of the studies conducted in sighted and congenitally blind individuals using novel methodologies for the functional exploration of the brain, including positron emission tomography (PET), functional magnetic resonance imaging (fMRI), magnetoencephalography (MEG) and transcranial magnetic stimultaion (TMS) to investigate the brain mechanisms underlying phenomenic consciousness in the human brain. The study of the blind brain has allowed to shed some new light on how our brain perceives and makes sense of the external world. Scientifical advances and their implications will be discussed.

Résumé:

How can blind individuals with no visual experience interact effectively with the surrounding environment, such as handling tools or walking safely across a house or a street? How does their brain process dynamic tactile information that changes in-time and in-space to provide cues for object recognition or spatial localization? By using functional magnetic resonance imaging (fMRI), a technique that allows to measure brain activity, we looked at how the human brain responds while blind-folded sighted and congenitally blind adults were asked to recognize with their hands different objects, localize items in the space, or detect the direction of moving stimuli. During these different tasks of tactile perception and recognition, sighted and blind individuals showed similar patterns of brain activation. These activated networks overlapped with those brain areas, identified as visual extrastriate cortex, that sighted individuals recruit while they perform visually the same tasks of object recognition, movement perception or spatial localization. These results indicate that these brain regions show *supramodal* features, i.e. they respond to the sensorial information of the stimuli (such as object form, spatial localization, movement direction) independently from the sensory modality - vision or touch - that conveys the information to the brain. Furthermore, the findings from the congenitally-blind individuals indicate that activations in visual extrastriate cortex during tactile tasks cannot be merely attributed to visual imagery, and that visual experience is not necessary to develop these cortical representations that are used during both visual and tactile perception. Thus, the cerebral representations of object form, or motion and spatial features in the extrastriate cortical areas may not be considered to be strictly visual but, rather, to have more abstract characteristics. These results may contribute to explain how individuals who have had no visual experience are able to become aware and interact effectively with their external world and may provide novel and stimulating insight for the development of rehabilitation and educational programs for sensory-deprived individuals.

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Ricciardi E, Vanello N, Sani L, Scilingo EP, Landini L, Guazzelli M, Haxby JV, Pietrini P. The effect of visual experience on the development of functional architecture in hMT+. **Cereb Cortex**, 2007 Mar 19; [Epub ahead of print].

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Vecchi T, Cattaneo Z, Monegato M, Pece A, Cornoldi C, Pietrini P. Why Cyclops could not compete with Ulysses: monocular vision and mental images. **Neuroreport**, 17:723-6, 2006.

SEMINAR: NEUROSCIENCE (Soria, 9th - 13th July 2007)

Lecturer: Nicholas P. Holmes

Title of Lecture: "Hands: Location, recognition, & self-defence"

Lecture Summary:

The hands are the tactile and motor 'fovea' of space perception and action. The first part of my talk addresses how the brain determines the position of our hands in space, by calculating a weighted sum of visual and proprioceptive information. I show, with experiments using mirrors and dummy hands, that the visual information used in this weighted sum is very sensitive to hand posture, but insensitive to hand ownership & identity: The felt position of our hands is significantly influenced by nearby and c10sely aligned fake hands. In the next section, I present several experiments conducted with healthy and with brain-damaged participants, showing that visually recognising our own hands is a difficult perceptual task, and is subject to strong attribution biases: We are far more likely to misattribute pictures of our own hands to someone else, than another's hands to ourselves. Finally, I will present the results of transcranial magnetic stimulation experiments concerning the representation of handdposition with respect to nearby objects. When our hands are 'threatened' by rapidly approaching objects, excitabiJity in the hand area of the motor cortex is suppressed. This suppression may indicate either the programming of alternative avoidance responses, or else of a 'freezing' response. Together, this research documents a number of experimental approaches to study the representation of hand position and hand ownership. The results show that relatively conscious perceptual mechanisms of hand-recognition are conservative and unlikely to be fooled by fake or foreign hands. By contrast, relatively unconscious mechanisms of action planning are strongly affected by fake hands, so long as their position and posture is plausible.

Résumé:

1996-2000, BSc in Psychology and Neuroscience, University of

Manchester, UK

2001-2002, MSc in Neuroscience, University of Oxford, UK 2002-2005, DPhil in Neuroscience, University of Oxford, UK

2005-2007, Science Research Fellowship, The Royal Commission for the Exhibition of 1851, Imperial College London, UK, and Espace et Action, INSERM U534/864, Bron, France

2007 -2008, Lady Davis Fellowship, Hebrew University of Jerusalem, Israel

Multisensory Contributions to the representation of the body in space

Prof. Charles Spence

Department of Experimental Psychology, University of Oxford, UK

In order to determine precisely the location of a tactile stimulus presented to the hand it is necessary to know not only which part of the body has been stimulated, but also where that part of the body lies in space. This involves the multisensory integration of visual, tactile, proprioceptive, and even auditory cues regarding limb position. In recent years, researchers have become increasingly interested in the question of how these various sensory cues are weighted and integrated in order to enable people to localize tactile stimuli, as well as to give rise to the 'felt' position of our limbs, and ultimately the multisensory representation of peripersonal space. I will highlight recent research on this topic using the crossmodal congruency task. The crossmodal (and intramodal) congruency task has been used to investigate a number of questions related to the representation of space in both normal participants and brain-damaged patients. I will detail the major findings from this research, and highlight areas of convergence with other cognitive neuroscience disciplines. I will also review the most recent research from my laboratory using the crossmodal congruency task to investigate how the brain represents the position of the body when the limbs are seen only indirectly via either mirror reflection, video feedback, or even when viewing static pictures of specific body parts.

SEMINAR: NEUROSCIENCE (Soria, 9th – 13th July 2007)

Lecturer and Title of Lecture:

Dorothée Legrand

Bodily self-consciousness: neuroscientific results in light of philosophical considerations.

Lecture Summary:

Self-recognition is by and large considered as the landmark of self-consciousness. In particular, recent cognitive sciences intend to investigate subtle forms of bodily self-consciousness, beyond limitations of explicit measures of self-recognition (verbal reports). For that, they introduce various implicit measures (behavioural and neurophysiological states). Here, I intend to bypass limitations of these two standard approaches. Indeed, both explicit and implicit forms of self-recognition involve a reflexive stance that cannot account for the specificity of bodily self-consciousness. In the light of considerations issued from phenomenological and clinical research, I will describe a pre-reflexive form of self-consciousness that constitutes bodily experience in its core by avoiding any explicit or implicit reflexive stance on the bodily subject. Even though this fundamental form of self-consciousness remains neglected in cognitive sciences, I will argue that both theoretical and scientific studies of consciousness would particularly benefit from considering pre-reflexive self-consciousness at the empirical level. Several methodologies and techniques are appropriate to do so and will be discussed. Such operationalization of the notion of pre-reflective self-consciousness in functional and empirical terms will allow a reconsideration of the role of sensorimotor integrative processes in grounding bodily self-consciousness.

SEMINAR: NEUROSCIENCE (Soria, 9th – 13th July 2007)

Lecturer and Title of Lecture:
Leonardo Fogassi
The mirror neuron system: how cognitive functions emerge from motor organization

Lecture Summary:

The neurophysiological studies of the last two decades have provided evidence that the motor cortex is not simply involved in movement programming and execution, but plays a main role in coding the goal of motor acts. This endows the motor cortex with a storage of motor representations that can be addressed by different types of sensory input through dedicated parieto-premotor circuits. This sensory input can be related to objects, space or biological stimuli. The matching between sensory input and motor representation allows the creation of different types of cognitive abilities. An example of the outcome of these matching mechanisms is represented by the properties of mirror neurons, found in both the ventral premotor and the inferior parietal cortex of the monkey, that respond during both action observation and action execution. It has been hypothesized that the mirror neuron system, largely described also in humans, underpins action understanding. Further recent data indicate that the mirror neuron system may also have an important role in understanding action intention and that its mechanism can be at the basis of other important functions such as imitation, language, and emotion understanding. This evidence suggests that the organization of the motor system allows the emergence of cognitive functions.

SEMINAR: NEUROSCIENCE (Soria, 9th – 13th July 2007)

Lecturer and Title of Lecture:
Salvatore M Aglioti, Department of Psychology, University of Rome "La Sapienza"

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Lecture 1: THE SENSORIMOTOR SIDE OF EMPATHY FOR PAIN

Lecture 2: NEURAL UNDERPINNINGS OF EXCELLENCE IN SPORT

Lecture Summary:

Lecture 1: THE SENSORIMOTOR SIDE OF EMPATHY FOR PAIN

I will present experimental investigations of phenomena and neural mechanisms underlying the human capability to empathize with other individuals. Special attention will be paid to the neural activity induced by observation and imagination of others' pain. Indeed, although pain has long been considered inherently private, recent neuroimaging and neurophysiologic studies hint at the social implications of this experience. I will present TMS, SEP, LEP and fMRI studies on a form of rudimentary empathy for pain, called sensorimotor contagion, elicited by mere observation of potentially very hurtful stimuli delivered to specific body parts of a stranger model. I will show that representing others' pain brings about the activation of neural structures largely overlapping with those activated during the experience of pain on oneself and that neural structures involved in both emotional and sensorimotor processing may be recruited during empathy for pain. Finally, I will discuss the possible adaptive functions of empathy for pain.

Lecture 2: **NEURAL UNDERPINNINGS OF EXCELLENCE IN SPORT**

Although it is held that professional athletes have better sensory and motor skills than novices, little is known about the neural underpinnings of these superior abilities. I will present: i) psychophysical evidence that professional basketball players predict the outcome of free shots at a basket observed on a video earlier and more accurately than novices will be provided; ii) neurophysiological evidence that the accuracy in judging the fate of free throw shots paralleled the increase of motor system excitability assessed by means of the modern, non-invasive neurophysiological technique of transcranial magnetic stimulation. This effect was specifically related to the domain of expertise, since it was absent during observation of soccer kicks. Thus, excellence in sport and other complex cognitive and motor tasks may depend on the fine tuning of a neural mechanism for linking action observation and execution.

SEMINAR: NEUROSCIENCE (Soria, 9th – 13th July 2007)

Lecturer and Title of Lecture: Computing with Neural Ensembles
Miguel Nicolelis

Lecture Summary:

In this talk, I will review a series of recent experiments demonstrating the possibility of using real-time computational models to investigate how ensembles of neurons encode motor information. These experiments have revealed that brain-machine interfaces can be used not only to study fundamental aspects of neural ensemble physiology, but they can also serve as an experimental paradigm aimed at testing the design of modern neuroprosthetic devices. I will also describe evidence indicating that continuous operation of a closed-loop brain machine interface, which utilizes a robotic arm as its main actuator, can induce significant changes in the physiological properties of neurons located in multiple motor and sensory cortical areas. This raises the hypothesis of whether the properties of a robot arm, or any other tool, can be assimilated by neuronal representations as if they were simple extensions of the subject's own body.

Title:
"The bodily self: functional and neural signatures of body-ownership"

Manos Tsakiris, Department of Psychology & Institute of Cognitive Neuroscience, University College London, 17 Queen Square, WC1N 3AR, London, UK, Email: e.tsakiris@ucl.ac.uk

Abstract

We constantly feel, see and move our body, and have no doubt that it is our own. "Body ownership" refers to the special perceptual status of one's own body, the sense that bodily sensations are unique to one's self. This sense of 'body-ownership' is a basic form of self-consciousness. Correct demarcation of the physical body's boundaries seems to be essential for goal-directed action, for our sense of who we are and for our successful interaction with other agents.

In a series of experiments, we studied the functional and neural signatures of body-ownership by controlling whether an external object was accepted as part of the body or not. Watching a rubber hand being touched synchronously as one's own unseen hand gives the experience that the rubber hand is part of one's body. Asynchronous stimulation serves as a control. A behavioural proxy of the 'Rubber Hand Illusion' (RHI) is a drift in the perceived position of one's own hand towards the rubber hand.

A series of experiments showed that ownership of one's body is based on the integration of multisensory signals such as touch, vision and proprioception. However, body-ownership is modulated by other factors which imply an internal representation of the body, over and above current bodily sensation. Representations of the anatomical and functional structure of the body (e.g. morphological characteristics, body-part identity and posture) modulate body-awareness by providing the background conditions against which new multisensory percepts are assimilated. Consistent psychophysical results suggest that body-ownership arises as an interaction between multisensory perception and representations of the body's permanent structure: current sensory integration is modulated by top-down processes reflecting a pre-existing model of the postural and visual features of one's body.

This functional interaction has identifiable neural signatures in the right hemisphere. The brain processes that produce incorporation depend both on current sensory integration and also on top-down processes reflecting a pre-existing reference of the postural and visual features of one's own body. The right temporo-parietal junction modulates the assimilation of novel multisensory signals to this pre-existing reference model of one's body. The effect of multisensory integration and recalibration of hand position, namely the experience of body-ownership of the rubber hand, is correlated with activity in the right posterior insula. These structures may form a network that plays a fundamental role in linking current sensory stimuli to one's own body, and thus also in self-consciousness self-consciousness.