Tango and mirror neurons : a neurological theory for an universal artistic genre

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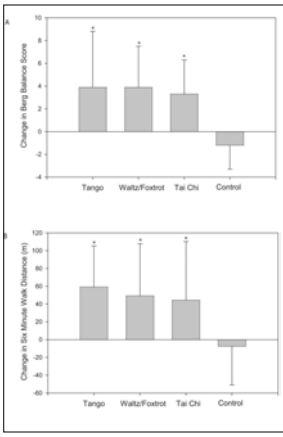
El 1er de octubre 2009, el UNESCO inscribió el Tango al patrimonio cultural de la humanidad

Tango & Parkinson's : the studies

- *Effects of Tango on functional mobility in Parkinson's disease : A preliminary Study*. Hackney ME, Kantorovich S, Levin R, Earhart GM. J Neurol Phys Ther. 2007 Dec; 31(4) : 173-9
- *Short duration, intensive tango dancing for Parkinson disease : an uncontrolled study*. Hackney ME, Earhart GM. 2009
- *Effects of dance on gait and balance in Parkinson's disease: a comparison of partnered and nonpartnered dance movement*. Hackney ME, Earhart GM. Neurorehabil Neural Repair. 2010 May;24(4):384-92.
- *Effects of dance on movement control in Parkinson's disease: a comparison of Argentine tango and American ballroom*. Hackney ME, Earhart GM. J Rehabil Med. 2009 May;41(6):475-81.



Doing the tango improves the aging brain

The salty moves of Argentine tango dancing can help the aging brain. McGill researchers have discovered that the fancy foot-work required to perform the tango bolsters brainpower and improves balance.

With Canada's growing aging population, this news is music to health professionals' ears. About one third of the elderly population in Canada experiences a fall each year and 40 percent of hospital admissions of this age group are due to fall-related injuries. Statistics show that 71 percent of seniors over the age of 65 live alone, and many spend more than seven hours a day without any social contact. This isolation, coupled with the normal aging process, can lead to cognitive decline.

This is where tango steps in. "Our findings suggest that tango may be better than walking for improving the execution of complex tasks and the ability to move within a restricted area without losing one's footing," says McGill University School of Physical and Occupational Therapy professor Patricia McKinley.

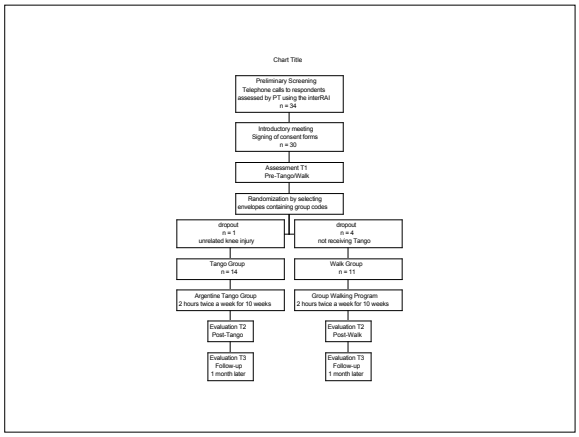
For the study, funded by the Drummond Foundation, researchers recruited 30 seniors from Cummings Jewish home centre, aged 62 to 90. All were healthy individuals who had experienced a fall within the last year and had developed a fear of falling. Half the group was assigned to take tango lessons and the other half to a walking group. Each group met for two hours twice a week for ten weeks at the Constance Lethbridge Rehabilitation Centre. The tango group showed more improvement in balance, posture and motor coordination, as well as cognitive gains, than the walking group. They also performed significantly better than the walking group at performing a complex cognitive task while walking, standing on one foot, or turning in confined spaces.

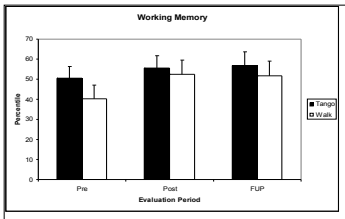
Memory testing, however, was inconclusive, perhaps because the sample size was not large enough, says McKinley.

"Tango dancing is an ideal leisure activity for this population," says McKinley. "It satisfies three basic requirements for exercise adherence: it's fun, it's a group activity, and it has a tangible goal that can be perceived not only by the dancer, but by his or her family and friends."

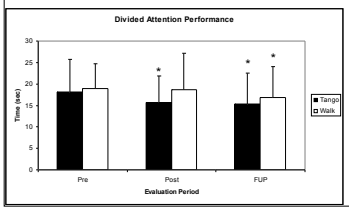
Source: McGill University

Jacobson AC, McKinley PA, Leroux A, Rainville C. Program No. 757.7 2005 Abstract Viewer/Itinerary Planner. Washington, DC: Society for Neuroscience; 2005. Argentine tango dancing as an effective means for improving cognition and complex task performance in at-risk elderly: a feasibility study.





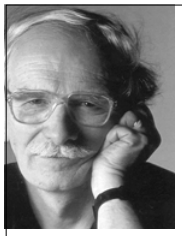
Significant improvement of working memory in both groups

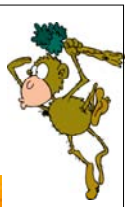


Significant and long-lasting improvement of divided attention in the "tango" group

How tango can improve brain function?

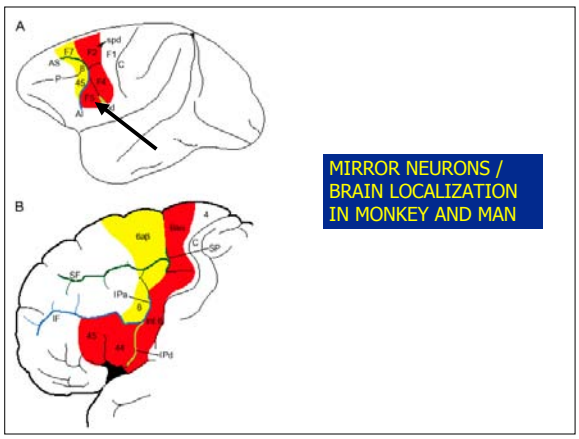
- Several explanations put forward :
  - Sensory-motor
- Multiple-direction walk training (forward, backward, side-walk).
- Favor initiating movement , trains impuse and energy trasfer
- Stimulates balance : dynamic posture and balance working both alone and partnered
  - Cognitive
- Trains dual-task situations : walking while avoiding obstacles, anticipate next figure, taking into account partner's movements and position.
- Largely based on rhythmically paced movements : need for intermodality/transcoding of information between different modalities
- Favors social/affective interplay with partners and between couples

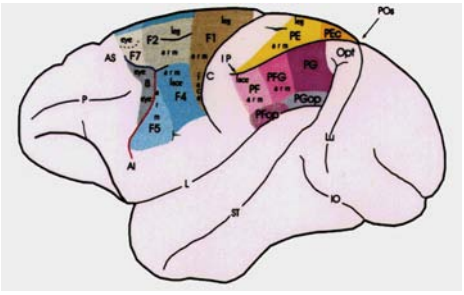




Giacomo Rizzolatti

Single neuron recording



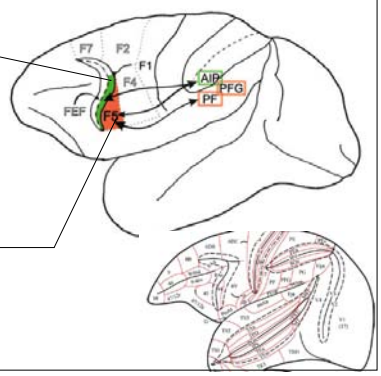


Premotor cortex : traditionally considered a homogenous field (Brodmann 6) ; actually composed of a mosaic of different areas with different functional properties and different connectivity

Posterior edge of arcuate sulcus
= canonical neurons

Among classical
= general purpose
motor neurons

F5 convexity
= mirror neurons



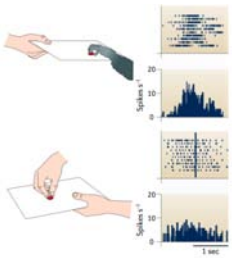
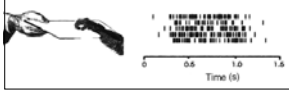


Figure 2 | **Mirror neurons in area F5.** The recordings show neural discharges of a mirror neuron in area F5 of the macaque inferior frontal cortex when the monkey grasps food (top) and when the monkey observes the experimenter grasping the food (bottom)[3]. Note that both tasks elicit strong neural responses in area F5. Modified, with permission, from REF. 115 © (2001) Macmillan Publishers Ltd.

Three situations provoking mirror neurons firing

a) Observing another monkey grasping the food

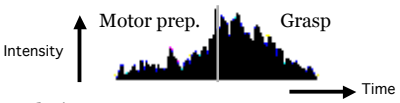
b) Observing a human doing so



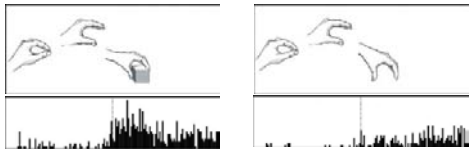
c) Animal itself grasps food

Testing action specificity

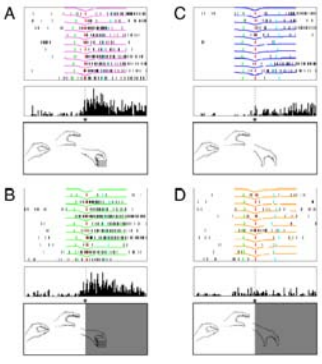
A class of cells in monkey ***MOTOR*** cortex:



Response during ***OBSERVATION***:



... same action specificity!



A (Full vision)

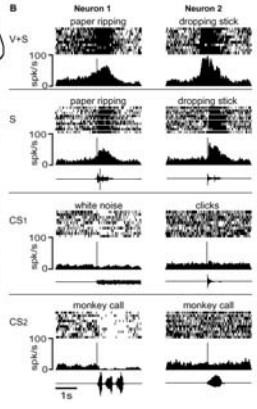
B (Hidden)

C (Mimicking)

D (HiddenMimicking)

2 AUGUST 2002 VOL 297 SCIENCE www.sciencemag.org

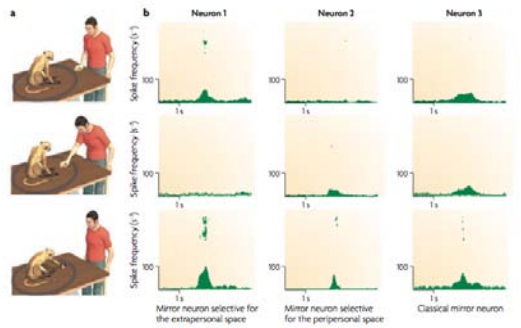
Fig. 1. (A) Lateral view of macaque brain with the location of area F5, shaded in gray. Major sulci: a, arcuate; c, central; ip, intraparietal; s, sylvian sulcus. (B) Two examples of neurons responding to the sound of actions. Rastergrams are shown together with spike density functions. Text above each rastergram describes the sound or action used to test the neuron. Vertical lines indicate the time when the sound occurred. Traces under the spike density functions in S and in CS conditions are oscillograms of the sounds used to test the neurons. Only 1 of the 10 different instances of the sounds is shown.



Hearing Sounds, Understanding Actions: Action Representation in Mirror Neurons

Evelyne Kohler,[1] Christian Keysers,[1] M. Alessandra Umiltà,[1] Leonardo Fogassi,[2] Vittorio Gallese,[1] Giacomo Rizzolatti[1]*

Cagiano et al., Science, 2009



Mirror neuron responses in the monkey during observation of actions executed in the peripersonal and extrapersonal space : space selectivity

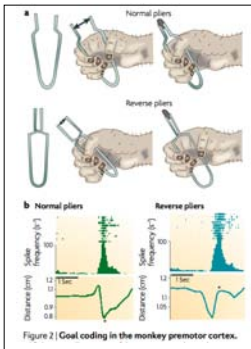


Figure 2 | **Goal coding in the monkey premotor cortex.**

Using reversed pliers allowed to show that F5 activates for a specific position of pliers, and not a specific position of the hand : activation occurs during the same grasping phase, the movement being either extension or flexion

Area F5 neurones code the goal of action and not only the action itself

Umiltà, M. A. et al. How pliers become fingers in the monkey motor system. Proc. Natl Acad. Sci. USA 105, 2209-2213 (2008).

Summary 1 : prefrontal mirror neurons in monkey

There exists in the inferior prefrontal cortex of the macaque monkey very peculiar neurons named : "mirror neurons"

They fire not only when animals perform a motor action, but also when observing a congener or a human performing the same action

- A part of mirror neurons are organized in a functionally specific manner, i.e. one neuron being specialized for a specific type of action (other neurons are less specialized).
- They are not specifically visual neurons, because they only activate when gesture possesses a specific goal.

•Action goal rather than action itself is encoded by some mirror neurons

•Finally, their activity is supramodal, since they also activate whenever the animal listens to the action "noise".

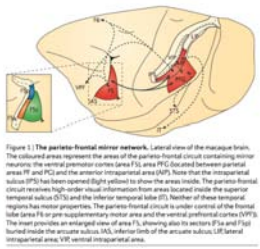
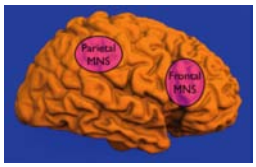
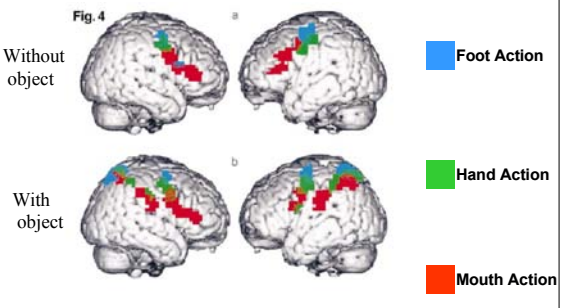


Figure 1 | **The parieto-frontal mirror network.** Lateral view of the macaque brain.



In humans, as in monkey, there exists a system of mirror neurons involving a restricted set of cortical areas in two specific locations : ventral pre-motor and parietal

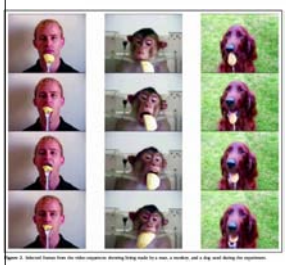
Somatotopy of Action Observation

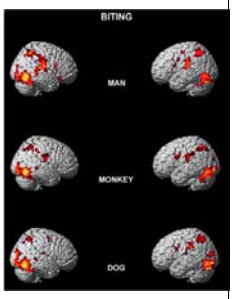


Observing transitive (b) et intransitive (a) actions **Buccino et al. Eur J Neurosci 2001**

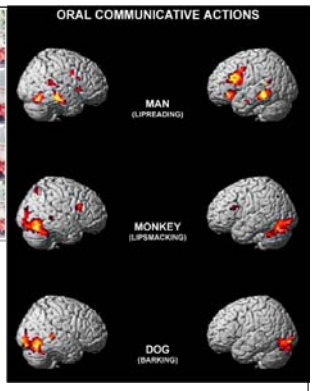
Neural Circuits Involved in the Recognition of Actions Performed by Nonconspecifics: An fMRI Study

Giovanni Buccino[1], Fausta Lui[2], Nicola Canessa[1], Ilaria Patteri[1], Giovanna Lagravinese[1], Francesca Benuzzi[2], Carlo A. Porro[3], and Giacomo Rizzolatti[1]



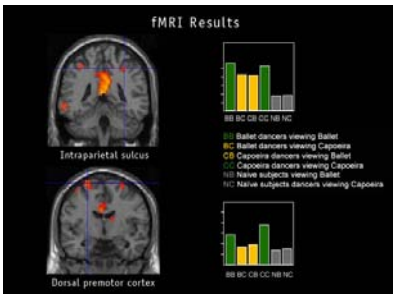


Observing the action of biting, whatever the species, activates IPL & IFG



Observing communicating actions activates inferior frontal cortex (left) for observation of a human or a monkey but not for a dog barking

Daniel Glaser
University College London



Daniel Glaser
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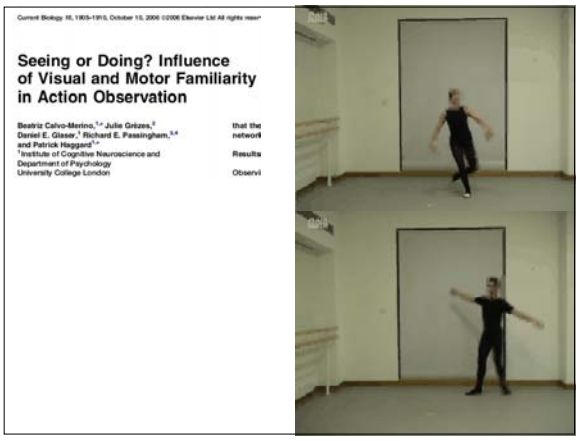
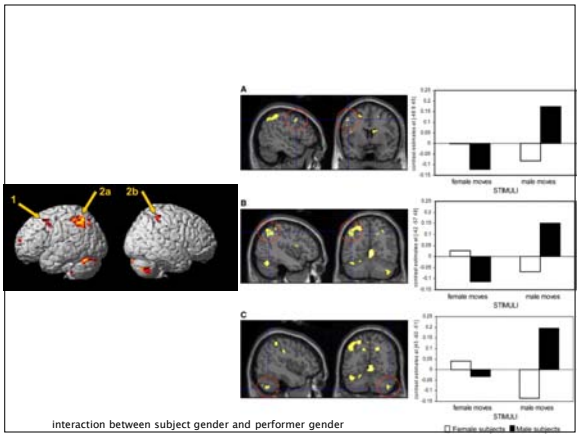
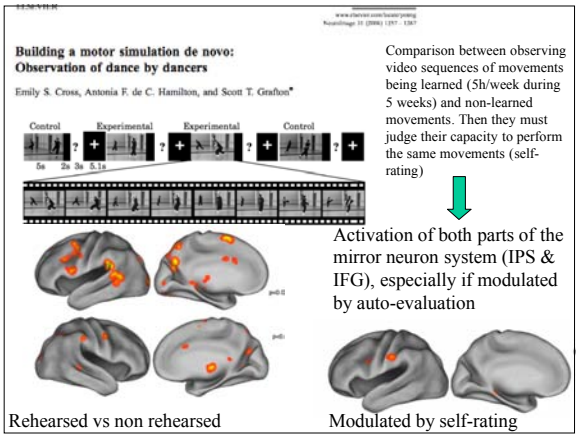


Seeing or Doing? Influence of Visual and Motor Familiarity in Action Observation

Beatriz Calvo-Merino,[1,*] Julie Grèzes,[2] Daniel E. Glaser,[1] Richard E. Passingham,[3,4] and Patrick Haggard[1,*]
[1]Institute of Cognitive Neuroscience and Department of Psychology University College London





Building a motor simulation de novo: Observation of dance by dancers

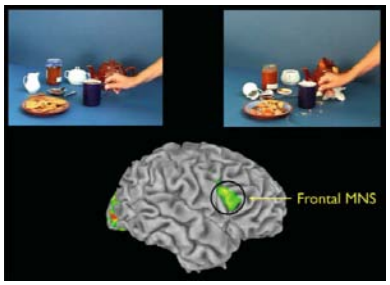
Emily S. Cross, Antonia F. de C. Hamilton, and Scott T. Grafton*

Comparison between observing video sequences of movements being learned (5h/week during 5 weeks) and non-learned movements. Then they must judge their capacity to perform the same movements (self-rating)

Activation of both parts of the mirror neuron system (IPS & IFG), especially if modulated by auto-evaluation

Rehearsed vs non rehearsed

Modulated by self-rating



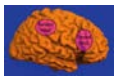
Mirror neurons differently encode the same gesture in two different contexts

Summary 2: human mirror neurons

•A mirror neuron system probably exists in man just as in monkeys

•This system probably mainly involves the inferior parietal cortex and the inferior frontal cortex (Broca's area)

•The activation elicited from observation of actions follows a somatotopic organization

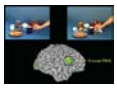


- Such activation is notably only present for actions belonging to the personal repertoire of the observer
- Just as for monkey, this system seems to be sensitive to the goal of movement, thus being probably involved in recognizing intentions

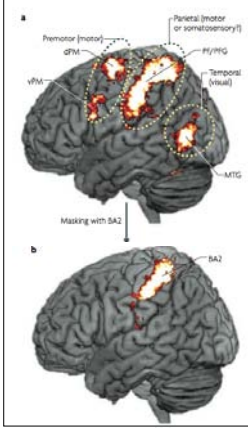
•In spite of some debate about the reality of mirror neurons in humans it seems now highly probable that certain regions of the human cortex possess the two characteristics of mirror neurons

–both activated in action execution and observation (invariance)

–specific to a given action (selectivity)



•However, there is now mounting evidence that human mirror system is **much more extensive than previously thought**



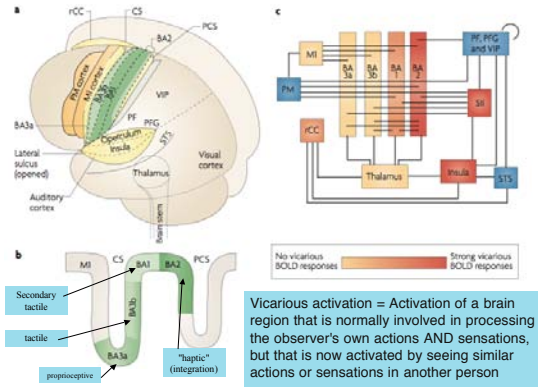
Shared voxels in both action observation and action execution:

-dorsal premotor cortex (dPM) and ventral premotor cortex (vPM), which are involved in motor control;

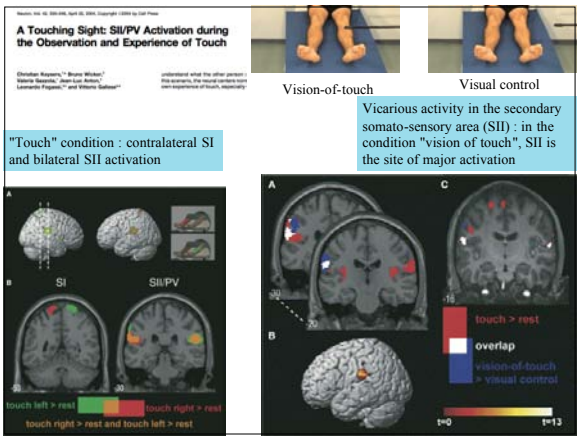
- posterior mid-temporal gyrus (MTG), which is involved in visual perception;

-and a large cluster encompassing multiple regions of the parietal lobe

much of the parietal shared voxels actually fall into BA2, the association somatosensory cortex. This indicates that activity in this part of the cluster probably represents **vicarious haptic** activity instead of vicarious motor activity.

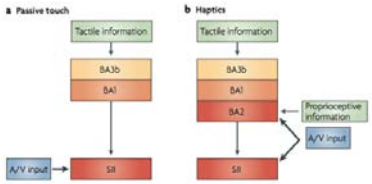


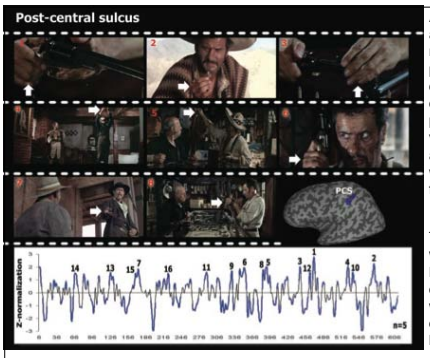
Vicarious activation = Activation of a brain region that is normally involved in processing the observer's own actions AND sensations, but that is now activated by seeing similar actions or sensations in another person



"Touch" condition : contralateral SI and bilateral SII activation

Vicarious activity in the secondary somato-sensory area (SII) : in the condition "vision of touch", SII is the site of major activation





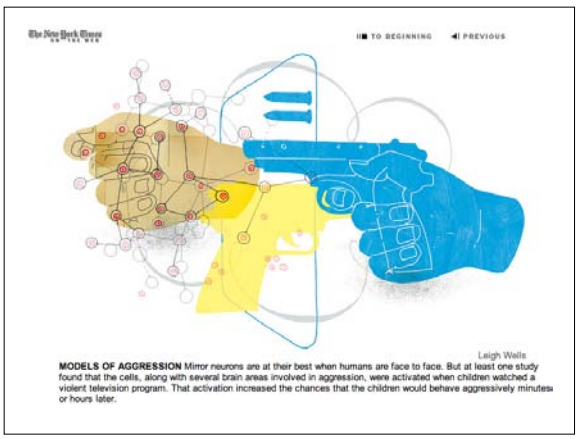
Averaged time course of the mid-postcentral sulcus region

A common theme across all frames, revealed without any prior experimental design, is the usage of hands for performance of various motor tasks, as denoted by the white arrow in each frame.

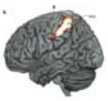
This parietal area, which projects on BA2, might be the site of vicarious activity when viewing haptic components of the hand action

Intersubject Synchronization of Cortical Activity During Natural Vision

12 MARCH 2004 VOL 303 SCIENCE www.sciencemag.org



Third summary : sharing somatosensory sensations

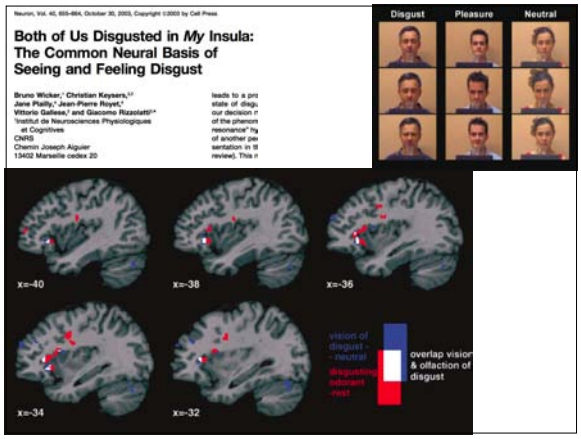


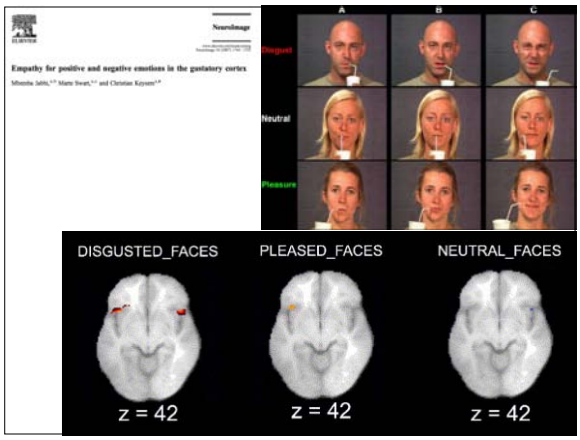
- BA2 might be particularly involved in vicarious representation of the haptic combination of tactile and proprioceptive signals that would arise if the participant manipulated the object in the observed way

•the more motor expertise people have, the more they activate BA2 when observing actions related to their field of expertise

•Together, these considerations propose a functional complementarity in vicarious somatosensory activity, with BA2 relating to the "sharing" of the haptic aspects of actions and SII activity to the sharing of passive touch.

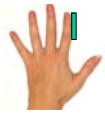
Keysers et al., Nature Neuroscience, june 2010



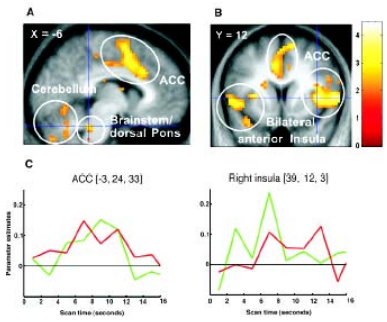


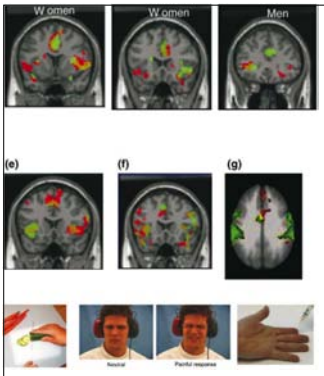
"Feeling" someone else's pain...

Own pain:



Significant other's pain:

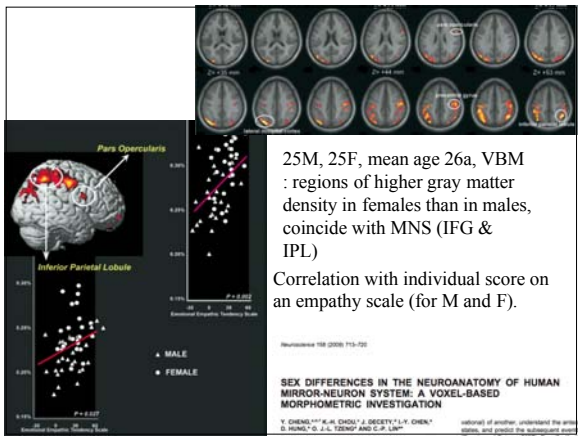




Oneself pain

Other's

Singer, T. et al. (2004) Empathy for pain involves the affective but not sensory components of pain. Science 303, 1157ڿ1162



25M, 25F, mean age 26a, VBM : regions of higher gray matter density in females than in males, coincide with MNS (IFG & IPL)

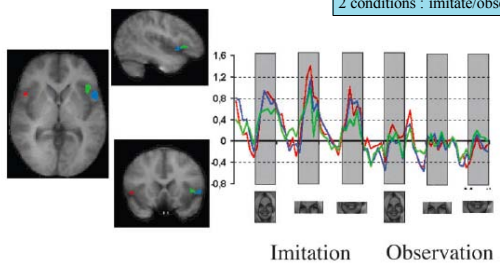
Correlation with individual score on an empathy scale (for M and F).

SEX DIFFERENCES IN THE NEUROANATOMY OF HUMAN MIRROR-NEURON SYSTEM: A VOXEL-BASED MORPHOMETRIC INVESTIGATION

Neural mechanisms of empathy in humans: A relay from neural systems for imitation to limbic areas

Presentation of photographs of human faces representing 6 types of emotions (total face, mouth or eyes)

2 conditions : imitate/observe



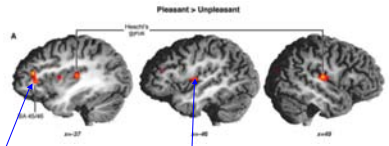
Imitation and observation activate in common a network including premotor cortex and insula

Imitation >observation for right insula and IFG bilat.

Investigating Emotion With Music: An fMRI Study

Stefan Koelsch, Thomas Fritz, D. Yves v. Cramon, Karsten Müller, and Angela D. Friederici

Comparison of active listening of pleasant and non-pleasant (electronically manipulated) musical extracts with fMRI: activation Heschl, ant-sup Insula and BA 45/46 (Broca).

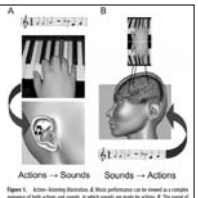


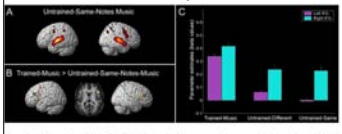
" **IFG activations** appear to reflect processes of music-syntactic analysis and working memory operations"

"widespread interconnections with both premotor cortex and limbic structures render it likely that the **anterior superior insula** plays a role in the activation of the Rolandic operculum during the emotional perception of the musical stimuli."

Action Representation of Sound: Audiomotor Recognition Network While Listening to Newly Acquired Actions

Non-musicians trained to play simple melodies : activation of (mainly left) IFG when listening to learned melodies (compared to same notes unlearned)

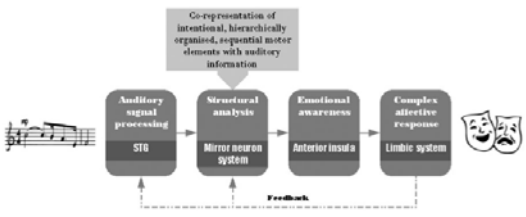




Our findings thus support the view that Broca's area is presumably a central region ("hub") of the mirror neuron network (Iacoboni et al., 1999; Nishitani and Hari, 2000; Hamzei et al., 2003; Rizzolatti and Craighero, 2004; Nelissen et al., 2005), demonstrating here its multifunctional role in action listening.

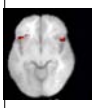
Music and mirror neurons: from motion to 'e'motion

István Molnár-Szakács and Katie Overy



"The shared recruitment of this neural mechanism in both the sender and the perceiver of the musical message allows for co-representation and sharing of the musical experience."

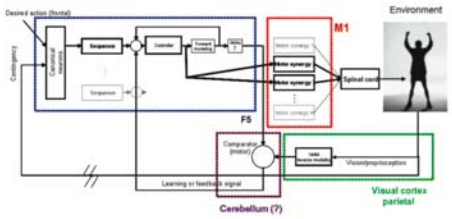
Last summary



One of the most convincing demonstrations of the existence of mirror neurons in the human brain is provided by the remarkable property of insular neurons to "feel" someone else affects, as a true basis of human empathy.

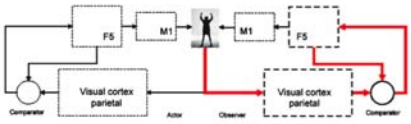
•The most recent works show that parts of the mirror neuron system, including the IFG, are closely related to the degree to which a given individual can empathizise with others, opening the way to important, multiple potential applications to understanding the richness and diversity of human mind.

•Major involvement of the mirror neuron system in learning music and musical execution plausibly rely on the multimodal nature of mirror neurons, but also probably on the affective component of the system.



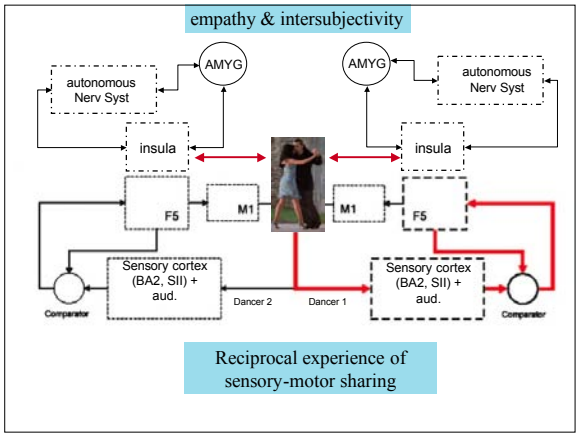
A model of area F5 and the mirror-neurons system

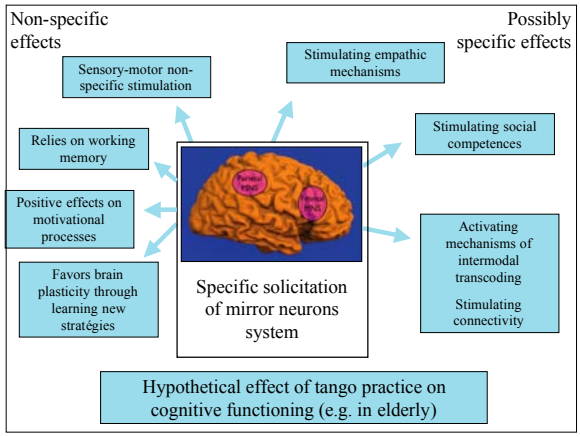
L. Craighero et al. Progress in Brain Research, 164:39-59, 2007



Danced tango : from sensory-motor simulation to intersubjectivity

- Perception (comprehension) of movement
- Perception of intention
- Sharing of proprioceptive sensation
- Temporal simultaneity of movement
- Auditory-motor association (music-dance)
- Affective resonance of music/dance connection
- Affective resonance of "close embrace" position





En homenaje al pueblo
quien inventó este genero
universal, un arte mayor y
intemporal, a lo mejor un
nuevo tema en neurociencias