

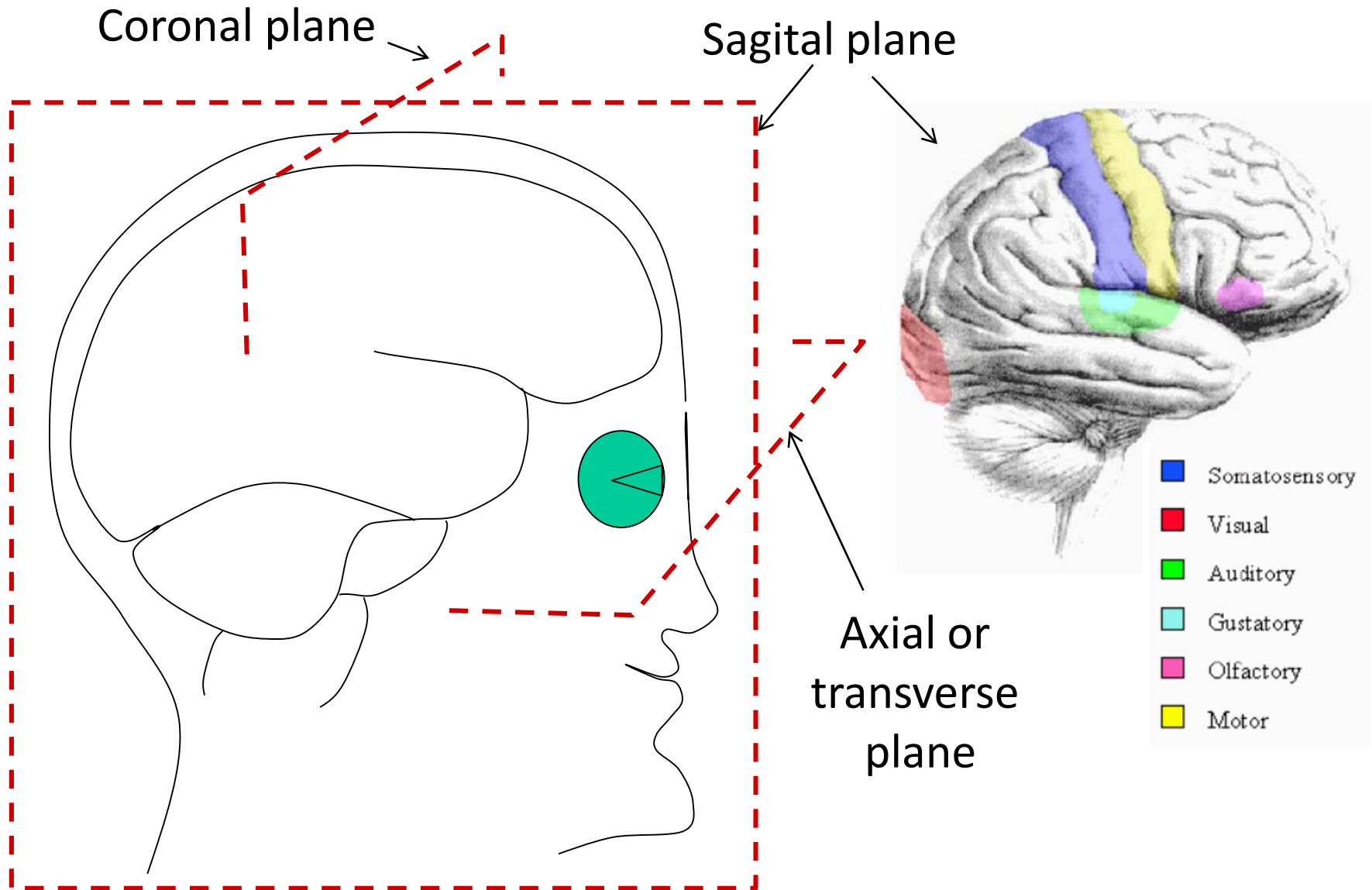


Perception and Action

1. Anatomic conventions & Lateralization
2. Perception & Action in the brain
3. Perception of biological motion
4. Conclusion

[références]

1. Anatomic conventions [W1]



1. Lateralization [W1]

Brain Laterality:

- 2 symmetric hemispheres
- **Lateralization** is the tendency for some neural functions or cognitive processes to be specialized to one side of the brain or the other.
- Such a specialization is not as strong as conveyed by popular psychology.
- Nevertheless, observations converge to state that:
 - the left hemisphere controls the right body side
 - the right hemisphere controls the left body side
 - special case: the eyesthe principle remains the same when considering the left and right *fields of view* instead of the retina as a whole
[lecture on stereo]





2 Perception & Action in the brain

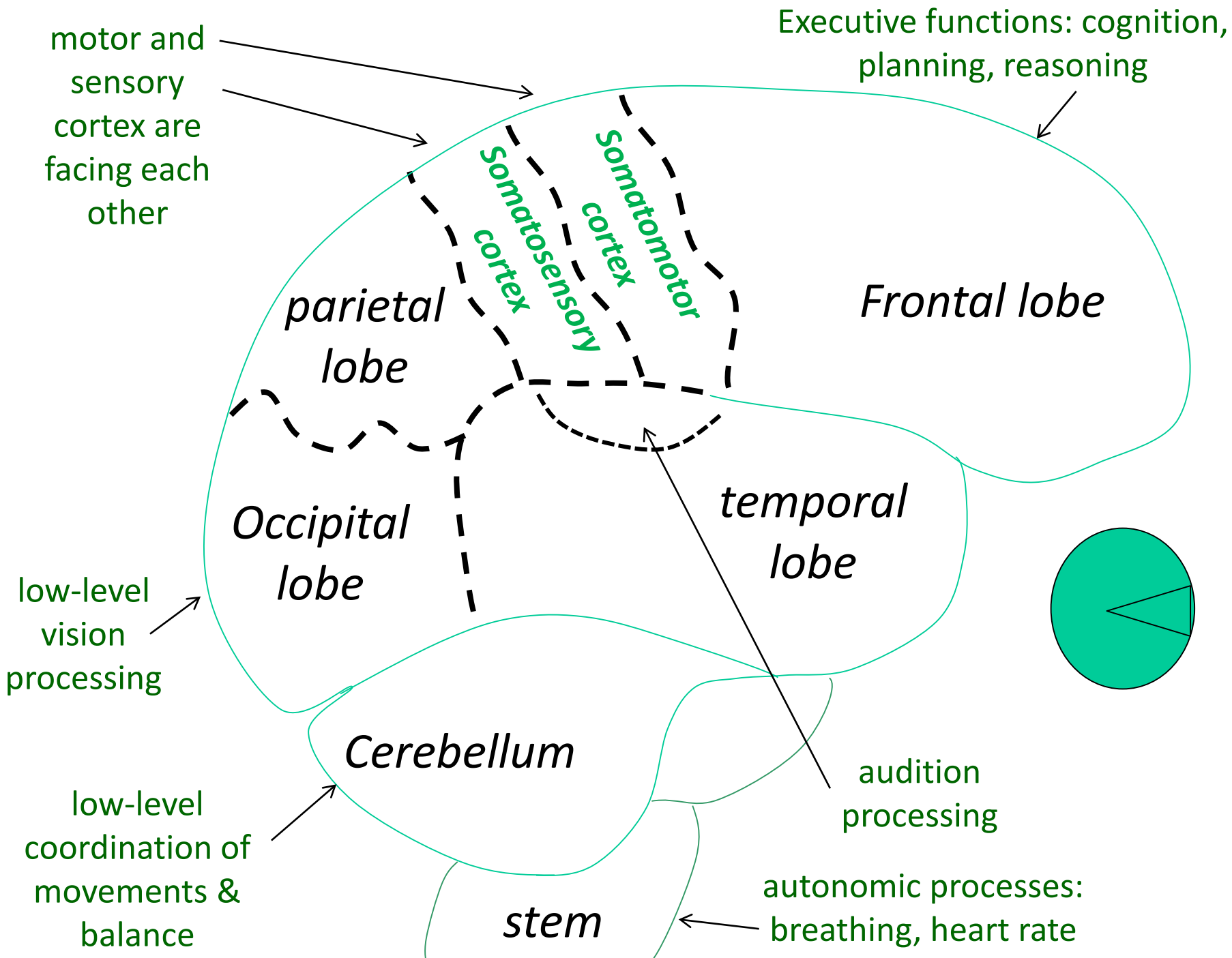
2.1 Perception-action mapping [W2]

Somato (from greek *soma*) : body

Somatosensory system: all *bodily sensations*, i.e. *tactile* (all skin sensors), *proprioceptive* (joint , tendon, muscles and other sensors related to posture and movement of the body) or *internal organ sensations*.

The vestibular system (sense of balance) is considered independently from the somatosensory system

Somatomotor system: all *voluntary control of body* movements (can be unconscious as in exertion of a skill). Opposed to *autonomic control* of breathing, heart rate....



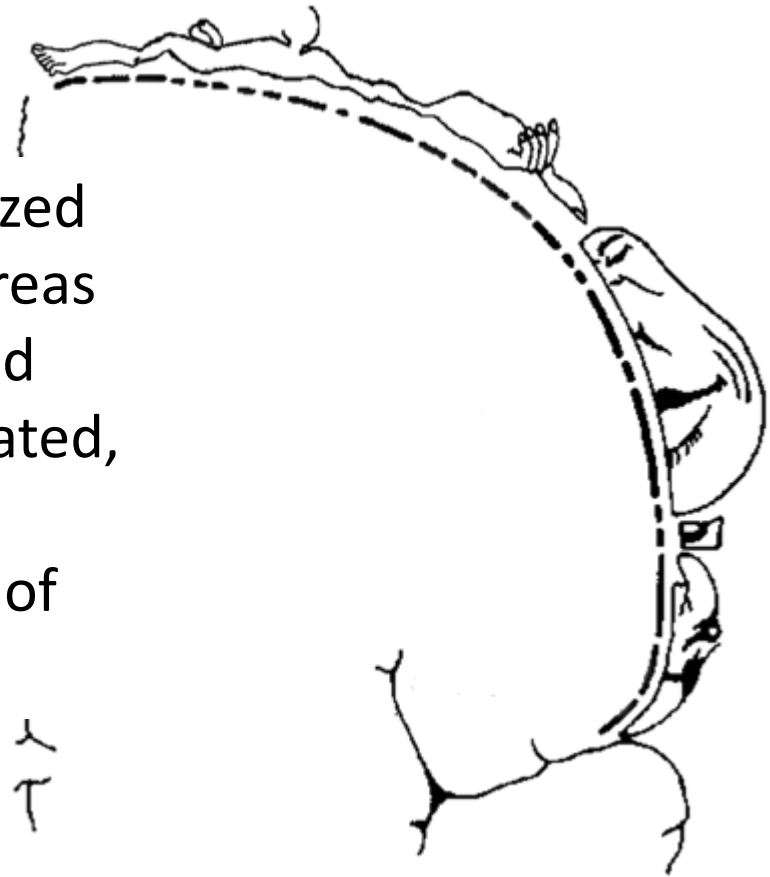
2.2 Homonculus [W. Penfield 1960s]

The somatosensory cortex is characterized by a point-to-point mapping of body areas to specialized neurons that are activated only when those body areas are stimulated,

e.g. each finger maps to its own region of neurons.

Two cortical Homonculi identified by W. Penfield in Montreal in the 60s:

A neural area in the **sensory homonculus** is **proportional to the density of sensors**, not to the body surface.



Slice in the coronal plane
Revised proposition of
Somatosensory cortex
[Kell et al 2005, Jneuro]



Mrs H. P. Cantlie artist view of the sensory homonculus identified by Wilder Penfield

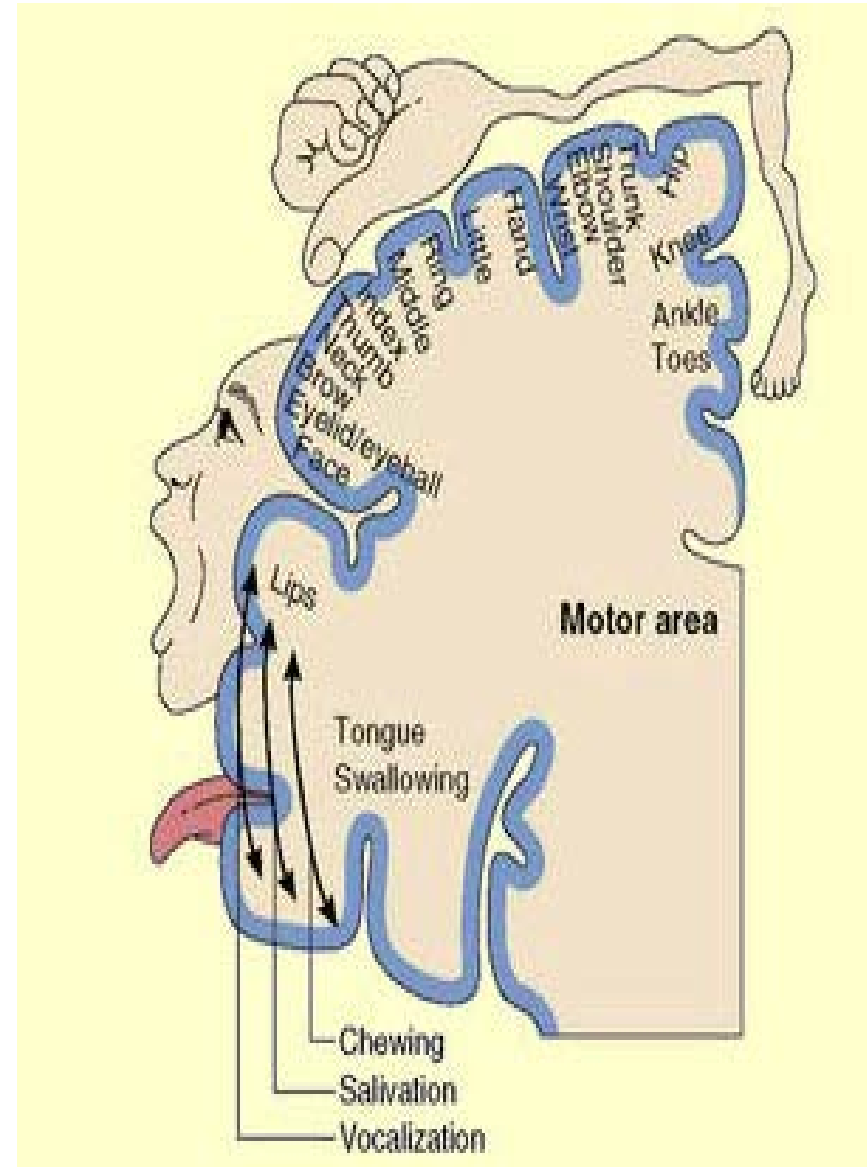
2.3 Homonculus [W. Penfield 1960s] (2)

Likewise, the **motor homonculus** characterizes the mapping of motor neurons to the muscle control system.

Muscles involved in **fine motor skills** (manual tasks) are controlled by **large neural areas**,

Small neural areas for muscles involved in a regular motion pattern.

Ex: locomotion is mostly encoded in the spine and tuned in the cerebellum.



Coronal plane slice [<http://thebrain.mcgill.ca>]

2.4 Body scheme [W3]

This concept integrates the knowledge of somatotopic maps into higher-order representations to describe « **organized models of ourselves** ».

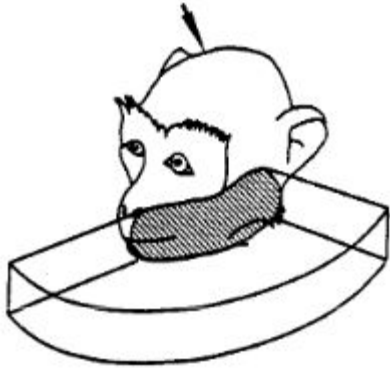
It consists of two schema:

- **registration of posture and movement**
- **localization of stimulated locations on the body surface**

Properties [HW 2005]:

- **Spatial encoding** : the body scheme represents both the position and configuration of the body as a 3D object in space [exercise FST]
- **Plasticity** : adjust to body growth, skill training, accident recovery

2.5 Body sheme & adaptive extra-personal space



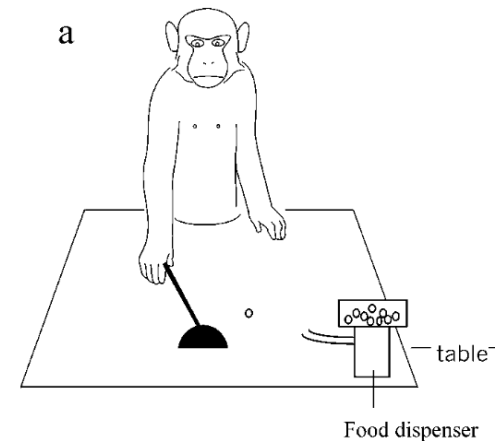
A model of the Extrapersonal space is possible with bimodal visual-tactile neurons [GG1996]:

Some proximity neurons becomes active both when an object is brought close to the body and when the object touches the body.

Iriki et al [O2001] [F2007] have shown that a tool is integrated in the monkey body sheme after a short duration training (30 min).

The tool becomes an extension of the body

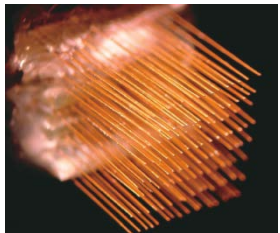
The Proximity neurons become active when an object is brought close to the tool, in the same way as when it is brought close to the body.



The use of a tool modifies the "body image" in the brain [O2001] [F2007]

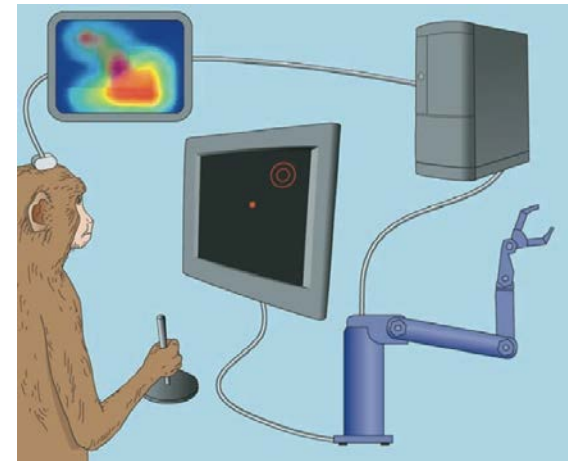
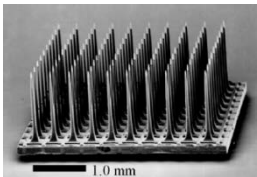
2.6 Long term Plasticity

Brain plasticity is much more important than initially thought. The body schema is the result of a dynamic equilibrium permanently updated through everyday activities with a large range of time scales: from short (tool integration) to long (skill training over years).



Miguel Nicolelis et al [N12] have instrumented a monkey brain with microelectrodes.

After some (weeks of) training of an arm + robot task, the monkey notices that controlling its arm is not necessary for controlling the robot.



Application potential for paralyzed persons (ex Pittsburg monkey)

<http://www.youtube.com/watch?v=wxlgdOIT2cY>

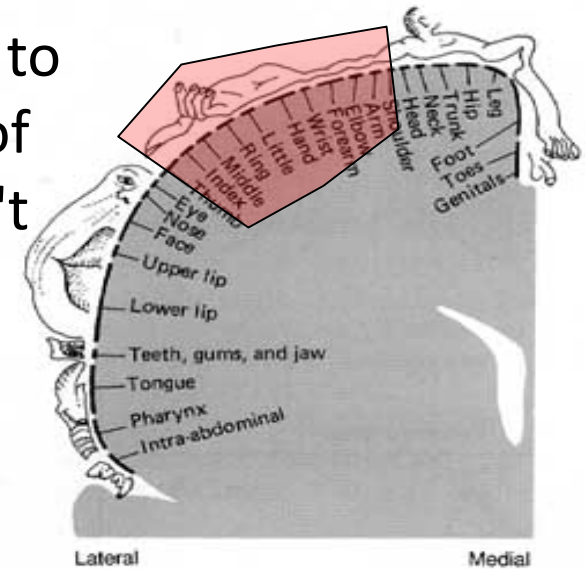
2.7 Body scheme Pathology: Phantom Limb Pain

The loss of a body part (amputation) may lead to intense phantom pains (e.g. strong sensation of closing hand) because the body scheme couldn't adapt to the sudden change.

Various remapping have been observed.

ex: after arm loss, a patient felt finger tips on the face

A Sensory homunculus

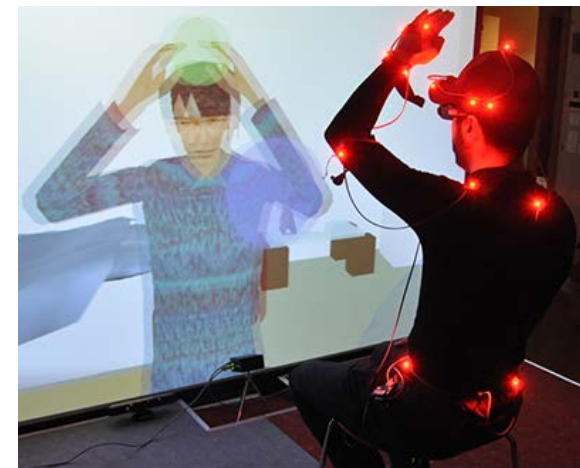


Ramachandran has proposed a mirror-box therapy to visually fool the brain about a restoration of the missing limb.

<http://endthepainproject.org/>



Alternatives of the box are being explored with Virtual Reality setups (more expensive & yet to be clinically validated)



2.8 Body scheme activation

The body scheme is actively and continuously updated when :

- Performing an action
- Thinking about performing that action (mental visualization)
- Perceiving **somebody else** performing that action (through *mirror neuron* [RS 2008]).

Simply viewing someone performing an action with efforts even induces heart and breath variations [PJ 2000].



2.8 Body scheme activation

Example : *Silent Speech* [Kapur et al., 2018]= speaking in one's head activates the neural activation of «internal speech articulators», allowing its detection with electrodes.

-> 92% correct for 20 words (10 users, 0.4s latency, some hours of training).

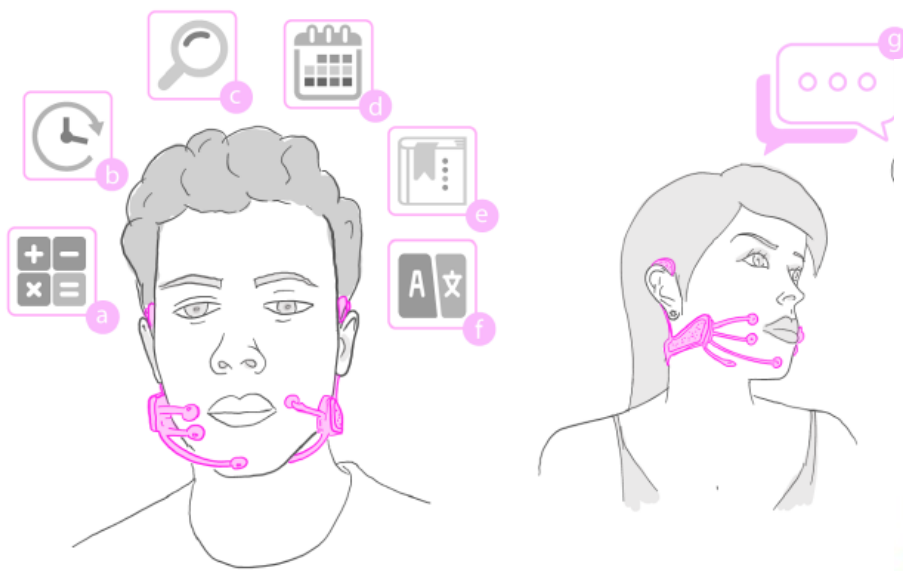


Figure 3. Rendering of the AlterEgo wearable (Top). Front view of the user wearing the device (Bottom).

Figure 1. Alterego seeks to make computing a natural extension of the user's own cognition by enabling a *silent, discreet and seamless* conversation with machines and people, in likeness to the user talking to her own self.

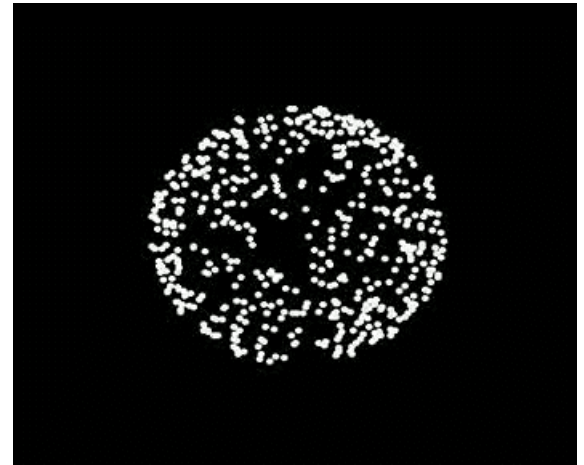
Arnav Kapur, Shreyas Kapur, and Pattie Maes. 2018. AlterEgo: A Personalized Wearable Silent Speech Interface. In 23rd International Conference on Intelligent User Interfaces (IUI '18). ACM, New York, NY, USA, 43-53. DOI: <https://doi.org/10.1145/3172944.3172977>

3. Perception of biological motion

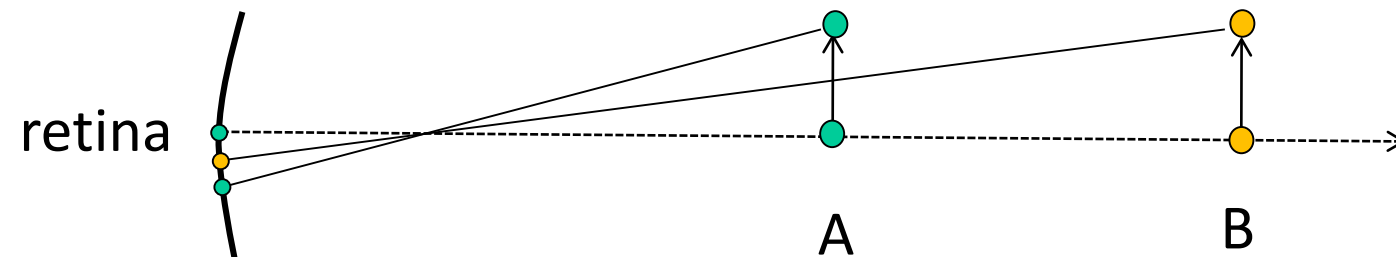
3.1 3D shape from rigid body movement

A 3D shape can be conveyed solely from the motion information owing to the *motion parallax*:

- for 2 entities with the same size, located at different depths and moving perpendicularly to the view axis, the closer one moves more on the retina than distant one.



G. Marther
shape from movement



3.2 Point light display of biological movements

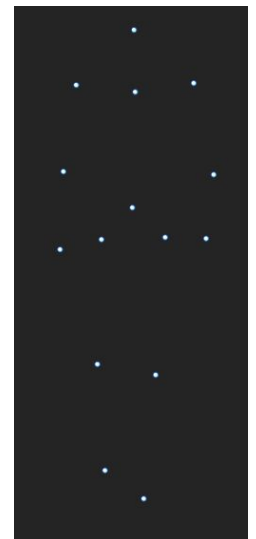
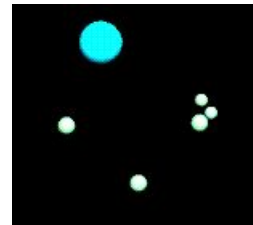
The discovery of the mirror neurons by Rizzolatti et al. in 1995 confirms the intuitions from Johansson about human high sensitivity to the perception of biological motion [J 1973].

200ms are sufficient to detect a human motion

Many motion attributes can be detected in addition to the action itself :

<http://www.biomotionlab.ca/Demos/BMLwalker.html>

Franck Pollick (Univ. Glasgow, Dept. Psychology) study on knocking styles [P 2001]



3.3 Neural path of human movement processing

In 1997 Jeannerod used some point light display to show that the neural path of the visual processing differ significantly depending on the nature of the observed movement :

- **without human character** : activity only in the visual cortex
- **with human character**:
 - **without meaning**, e.g. *sign language*
 - **fast dorsal pragmatic** stream: emphasis on spatial understanding
 - **with meaning**, .e.g. a *pantomime* of a known action
 - ventral *semantic* stream

Note: an accelerated human movement loses its human character and is only processed in the visual cortex.

4. Conclusion

Human viewers have high expectations regarding the animation quality of human beings and other living entities they view in the real world.

A movement that does not respect the human dynamics (e.g. too fast or discontinuous) may be disregarded as being performed by a human-like character

Can induce a Break in Presence (BIP)

Or a Break in Embodiment (BIE) if it is about an avatar

Other requirements on the plausibility of Virtual Humans will be studied in a future lecture.

[References]



- [B 2008] D. Badre, Cognitive control, hierarchy, and the rostro-caudal organization of the frontal lobes, Trends in Cognitive Sciences, Volume 12, Issue 5, 193-200, 1 May 2008
- [HW 2005] Haggard P & Wolpert DM (2005), Disorders of body scheme, in "Higher-Order Motor Disorders", Ed. Freund, Jeannerod, Hallett & Leiguarda, Oxford University press
- [N12] Beyond Boundaries , Times Books 2011
- [O2001] Shigeru Obayashi, Tetsuya Suhara, Koichi Kawabe, Takashi Okauchi, Jun Maeda, Yoshihide Akine, Hirotaka Onoe, Atsushi Iriki, Functional Brain Mapping of Monkey Tool Use, NeuroImage, Volume 14, Issue 4, October 2001, Pages 853-861
- [P 2001] Pollick FE, Paterson HM, Bruderlin A, Sanford AJ., Perceiving affect from arm movement., Cognition 82 (2001)
- [PJ 2000] Paccalin, C., Jeannerod, M.:Changes in breathing during observation of effortfull actions. Brain Research, 862, 194--200 (2000)
- [RS 2008] Rizzolatti, G, Sinigaglia, C. Mirrors in the Brain. How We Share our Actions and Emotions. Oxford University Press 2008
- [TRV 2006] Traité de Réalité Virtuelle, Ed. P. Fuch, vol 1, chap 11 Eds A. Berthoz & J.L. Vercher
- <http://lecerveau.mcgill.ca/>
- http://www.lifesci.sussex.ac.uk/home/George_Mather/Motion/index.html
- <http://www.michaelbach.de/ot/index.html>
- [W1] http://en.wikipedia.org/wiki/Anatomical_terms_of_location: sagital, coronal, axial, dorsal, ventral...
http://en.wikipedia.org/wiki/Lateralization_of_brain_function
- [W2] http://en.wikipedia.org/wiki/somatosensory_system: body senses mapping in the brain
- [W3] http://en.wikipedia.org/wiki/Body_schema : body spatial encoding