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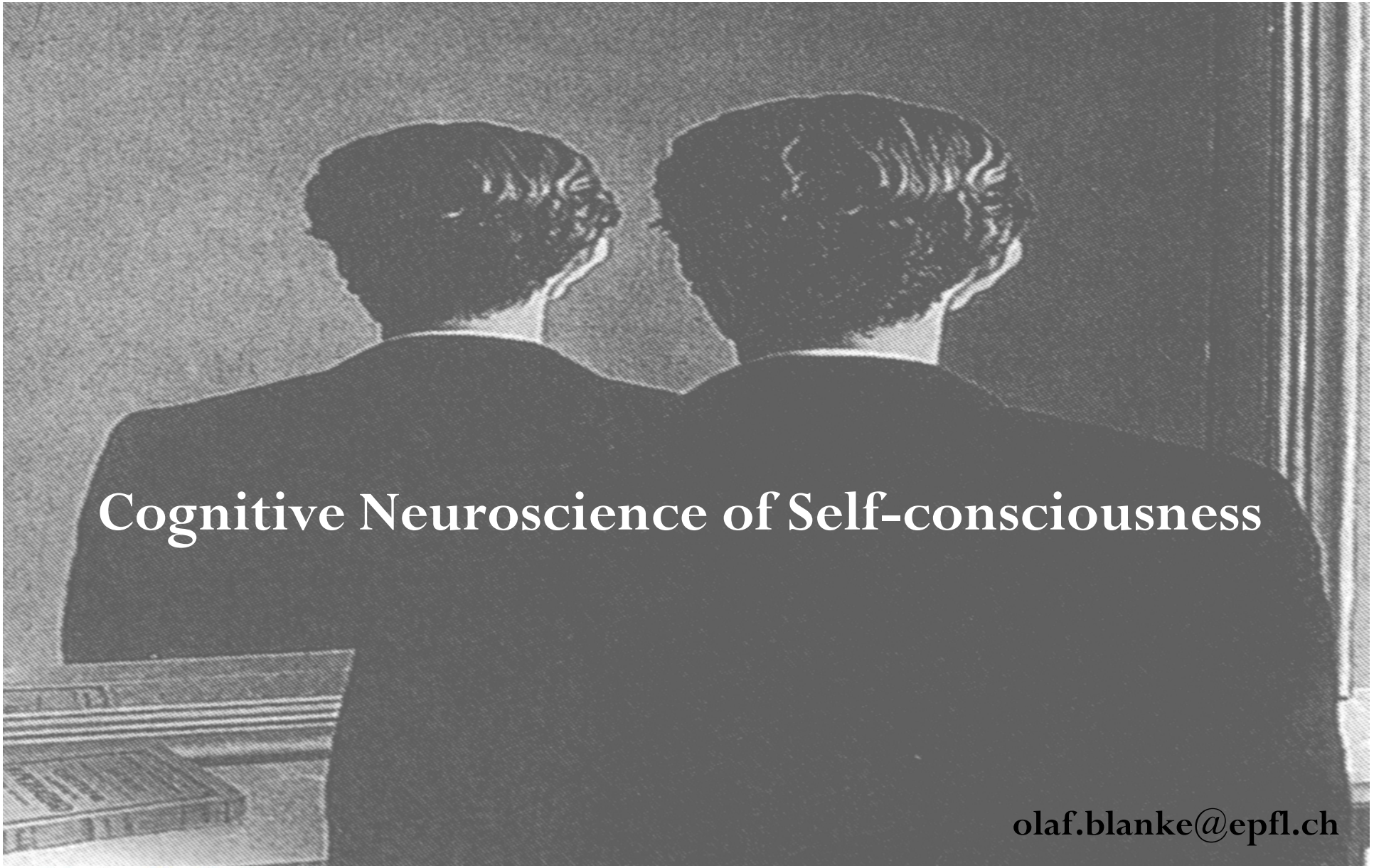

Cognitive Neuroscience of Self-consciousness

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Introduction

Neurology

Cognitive Science & Virtual Reality

Neuroimaging & Robotics

What is a Self ?

- The self seems to be directly available to a person through introspection
- „I“ seem to be in direct contact with the self
- „I“ am the self ; „I“ am someone
-The self seems to be the subject of perception, awareness, thinking, acting
-The self seems to be identical through time.
-The self seems to be different from other objects and other people.

-... long tradition in western thought (i.e. Sokratic self-knowledge; Aristoteles; ethics...), linked to soul/mind/ consciousness

What is a Self ? A fiction?

For my part, when I enter most intimately into what I call myself, I always tumble, on some particular perception or other, of heat or cold, light or shade, love or hatred, pain or pleasure. I can never catch myself at any time without a perception, and never can observe anything but the perception.

David Hume

→ The self (the introspective subject) is only a bundle of perceptions!
The self (or mind) is a « theater » that changes continously!

What is a Self ? A definition.

The self seems distinct from the environment and other humans and may be described as an entity to which certain mental events and actions are ascribed. [David & Kircher, 2003]

What is a Self ? Reflection ?

John Locke (1690)

In consciousness we find « a thinking intelligent Being, that has reason and reflection, and can consider itself as a self, the same thing in different times and places. »

Reflexive self:

Reflective self-consciousness is associated with self-recognition of one's image in the mirror, the proper use of the first-person pronoun, with attention of one's experiences, or other cognitive aspects of the self.

Pre-reflexive self:

Experiences happen for the experiencing subject generally in an immediate way and are generally felt as *my* experiences. This pre-reflective self-consciousness is present whenever I am living through or undergo an experience, i.e., whenever I am consciously perceiving the world, whenever I am thinking a thought, whenever I am feeling sad, happy, or I am in pain.

How have scientists defined the self?

How has the self been studied in psychology, neurology, and in neuroscience?

The Self

The 5 selves of Ulric Neisser

Ecological self: the self with respect to the physical environment: I am the person here in this place, engaged in this particular activity (optic flow and vection).

Interpersonal Self: also appears from earliest infancy (as the ecological self), is specified by species-specific signals of social and emotional rapport and communication: I am the person who is engaged, here, in this particular human interchange. (social self)

Extended self: is based primarily on our personal memories and anticipations: I am the person who had certain specific experiences, who regularly engages in certain specific and familiar routines. is based primarily on our personal memories and anticipations: I am the person who had certain specific experiences, who regularly engages in certain specific and familiar routines. related to language.

Conceptual Self: self as related to knowledge, language, concepts (not covered).

Private Self: appears when children first notice that some of their experiences are not directly shared with other people: I am, in principle, the only person who can feel this unique and particular pain.

(Neisser, 1987)

The many selves in Cognitive Neuroscience

- **Visual Recognition: Recognizing one's image in a mirror**

- **Memory: Autobiographical memory**

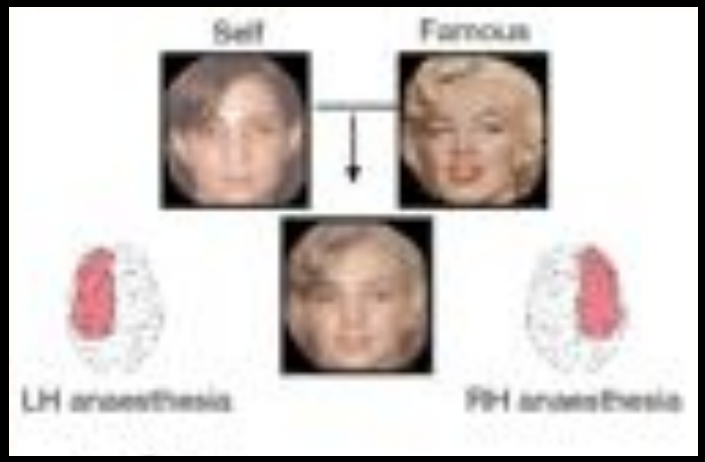
- **Thought: "Cogito ergo sum",**
  Ability to think "I" thoughts; ability to think of oneself as oneself, have a self concept (Baker, 2000)

- **Language:** first-person and self-reflexive pronouns (John touches him, John touches himself, I touch John; I touch myself,…
  self-narrative

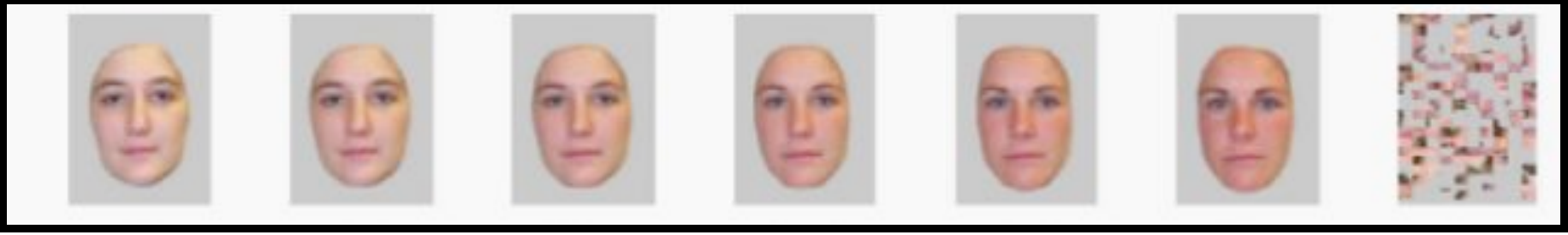
- **Agency/intentions/free will**

- **Social: ability to adapt the perspective of the other to oneself (Mead, 1962); capacity to discriminate self from other**

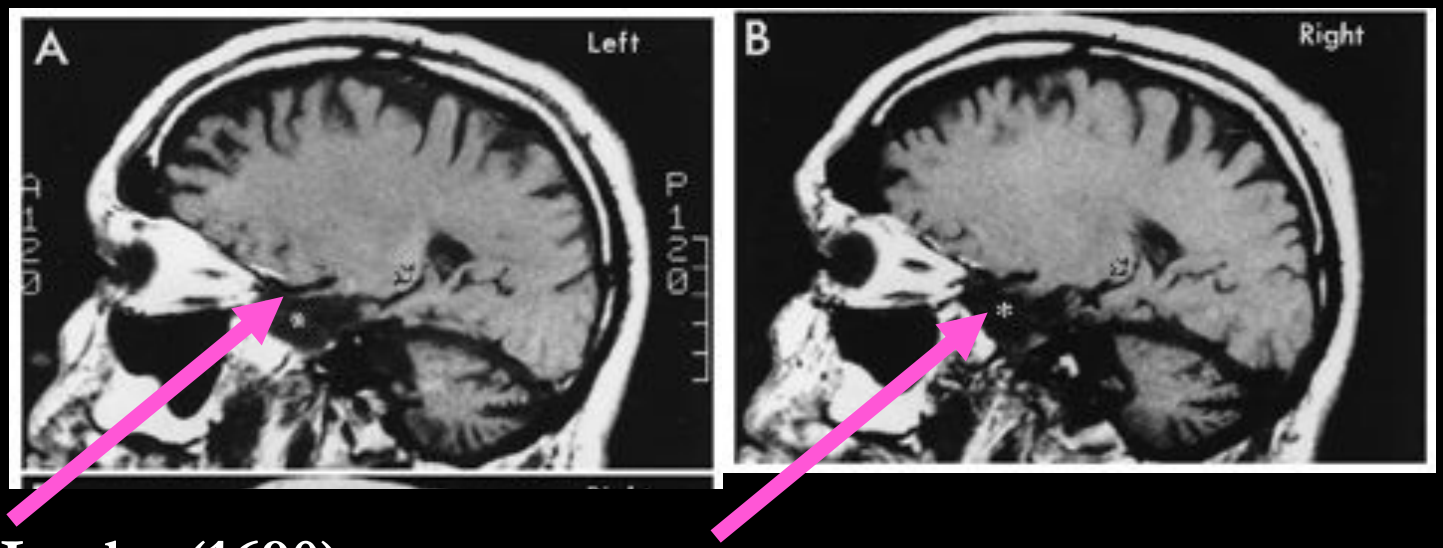
Facial Self Recognition: Cognitive



(Work by Gallup, Keenan, Iacoboni)



Autobiographical self: Memory
The neuropsychology of patient HM



John Locke (1690)

Memory is crucial for the unity of the self over time (we only maintain identity if we have normal autobiographical memory):

In consciousness we find « a thinking intelligent Being, that has reason and reflection, and can consider itself as a self, the same thing in differnt times and places. » (Corkin et al., 1997)

The bodily self

- **Visual Recognition: Recognizing one's image in a mirror**
- **Memory: Autobiographical memory**
- **Thought: "Cogito ergo sum"; Ability to think "I" thoughts; ability to think of oneself as oneself, have a self concept (Baker, 2000)**
- **Language: first-person pronouns, self-narrative**
- **Intentions and Free will**
- **Social: ability to adapt the perspective of the other to oneself; Capacity to discriminate self from other**
- **Bodily Self : multisensory and sensorimotor mechanisms (low-level self)**

The Bodily Self
as a low-level self

There are few things that are more intimate and that we identify with more closely than our body.

Bodily experience is private (as the self). Only I experience my own bodily sensations.

Bodily experience is a background (as the self) rather than an intermittent foreground or percepts (i.e. auditory or visual signals).

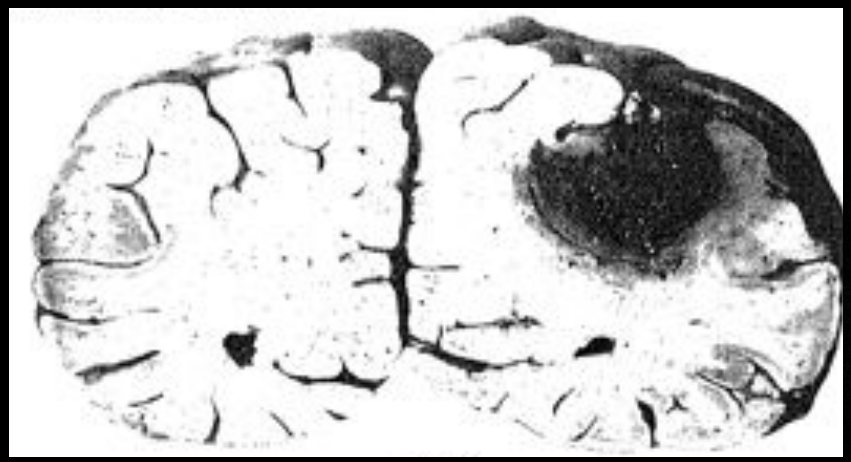
The bodily signals are constantly present (as the self).

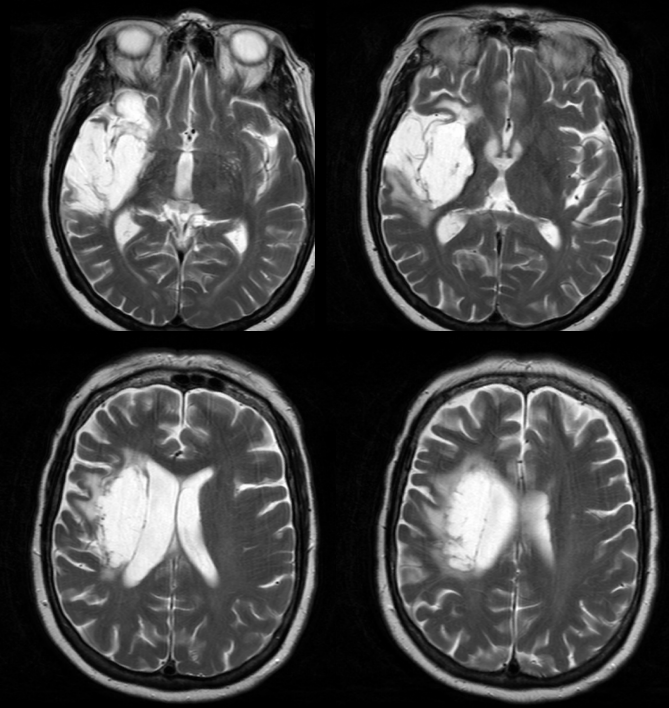
→ William James: « Whatever I may be thinking of, I am always at the same time more or less aware of myself, of my personal existence. »

Bodily Self

•Gibson/Neisser/Bermudez/Gallagher/...
→Ecological Psychology, Cogniitve Psychology, Philosophy…)

•Head/Schilder/Menningher-Lerchenthal/ Lhermite/Hécean/… (Damasio)
→ Neurology of the Body schema





[Pötzl, 1924]

Bodily self (consciousness) without a body

Phantom limbs

The physical body is NOT necessary for the experience of the bodily self.

Melzack proposed "that the brain generates the experience of the body and that sensory inputs merely modulate our bodily experience."

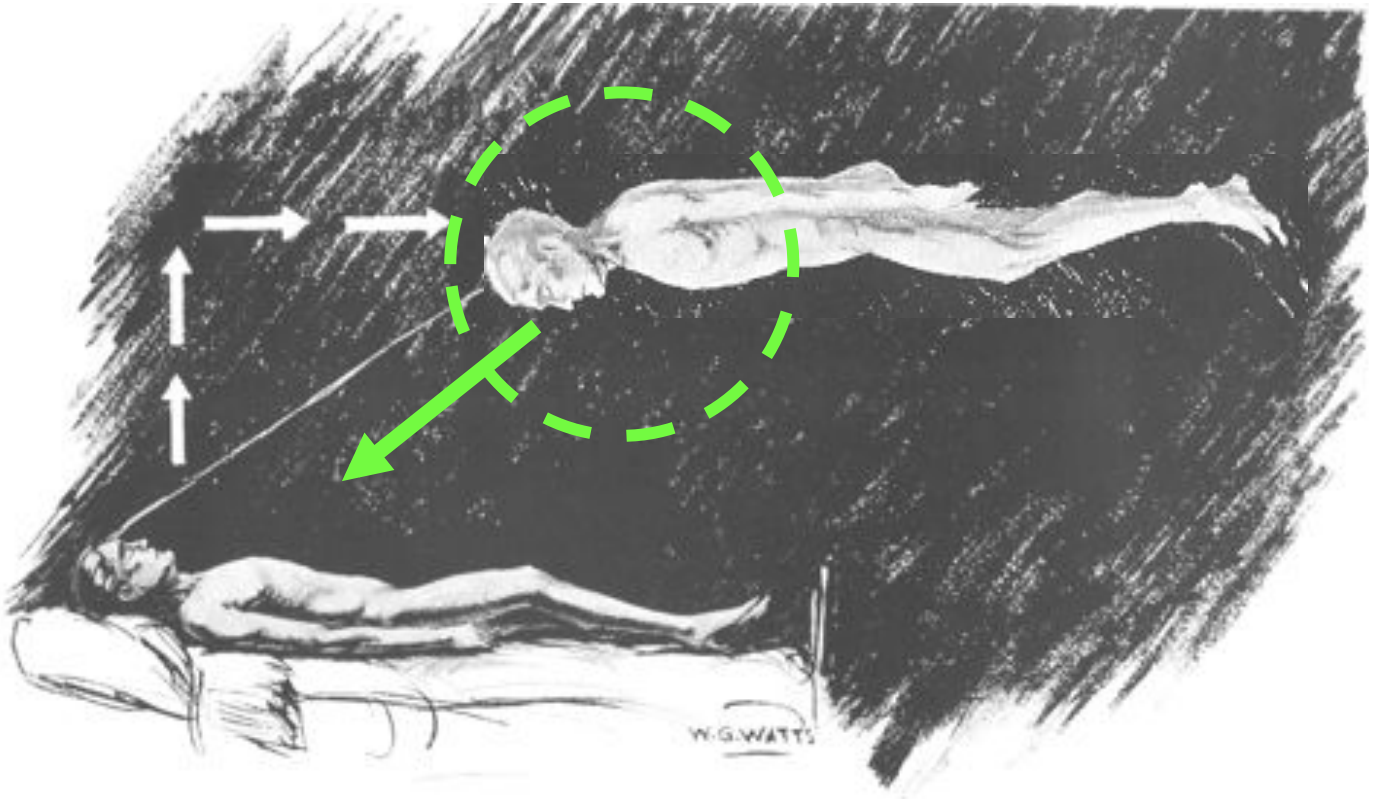
Phantom limbs and real limbs are "produced by the same brain processes that underlie the experience of the body when it is intact"

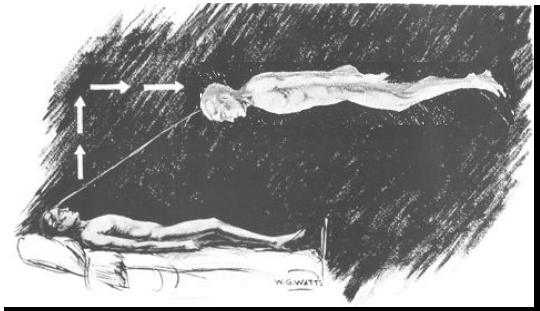
[Halligan, 2002; Melzack, Brain 1990; Brugger et al., Cogn Neuropsychiatr 2000]

Bodily self for the entire body ?

Are there phantom bodies and phantom selves?

Out-of-body experience





Out-of-body experience: Phantom body as self

Extracorporeal Self-location

I am localized outside my body

Extracorporal first-person perspective

I perceive the world (and my body) from a disembodied perspective

Self-identification

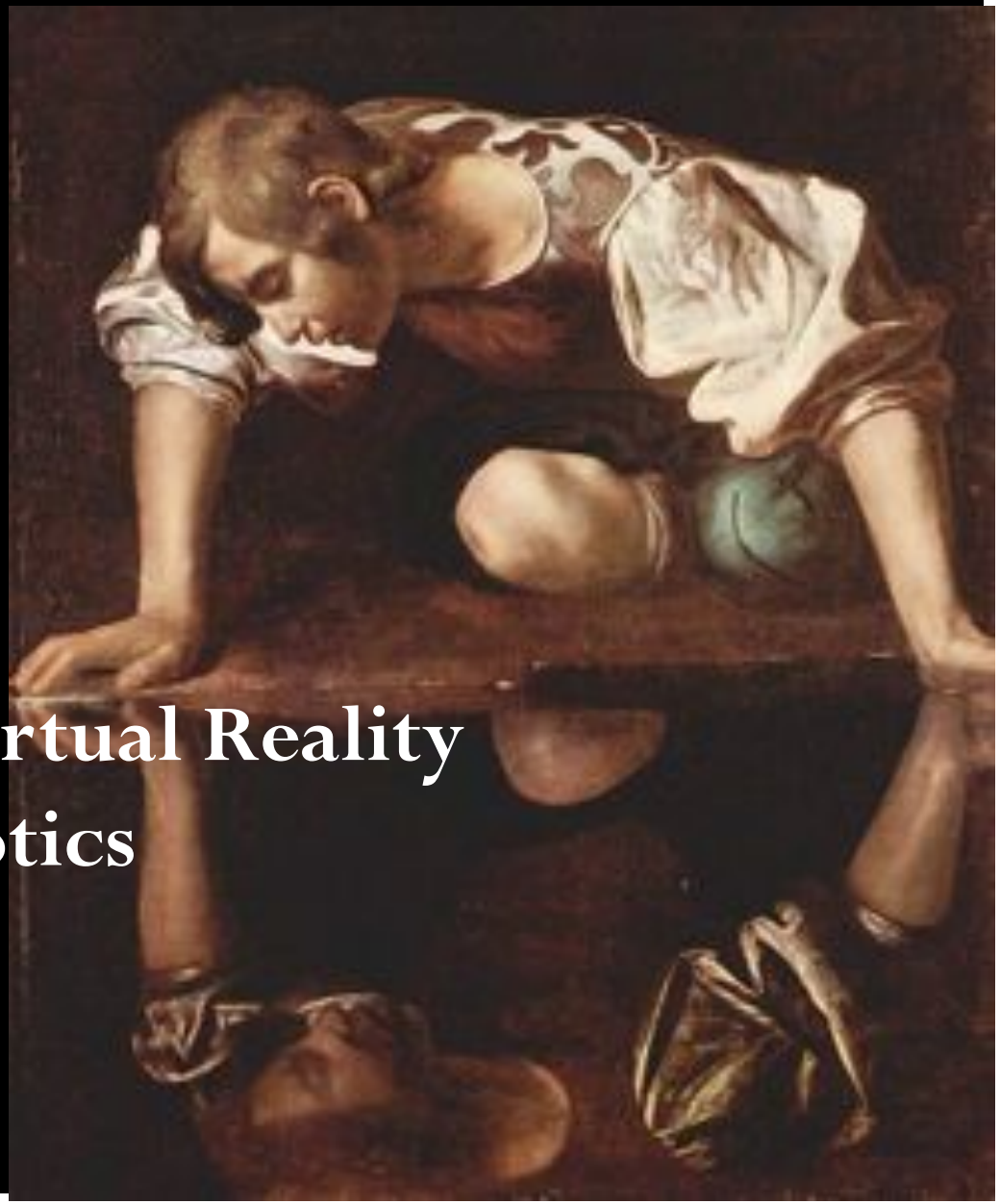
I identify with the elevated body

1

Neurology

Cognitive Science & Virtual Reality

Neuroimaging & Robotics

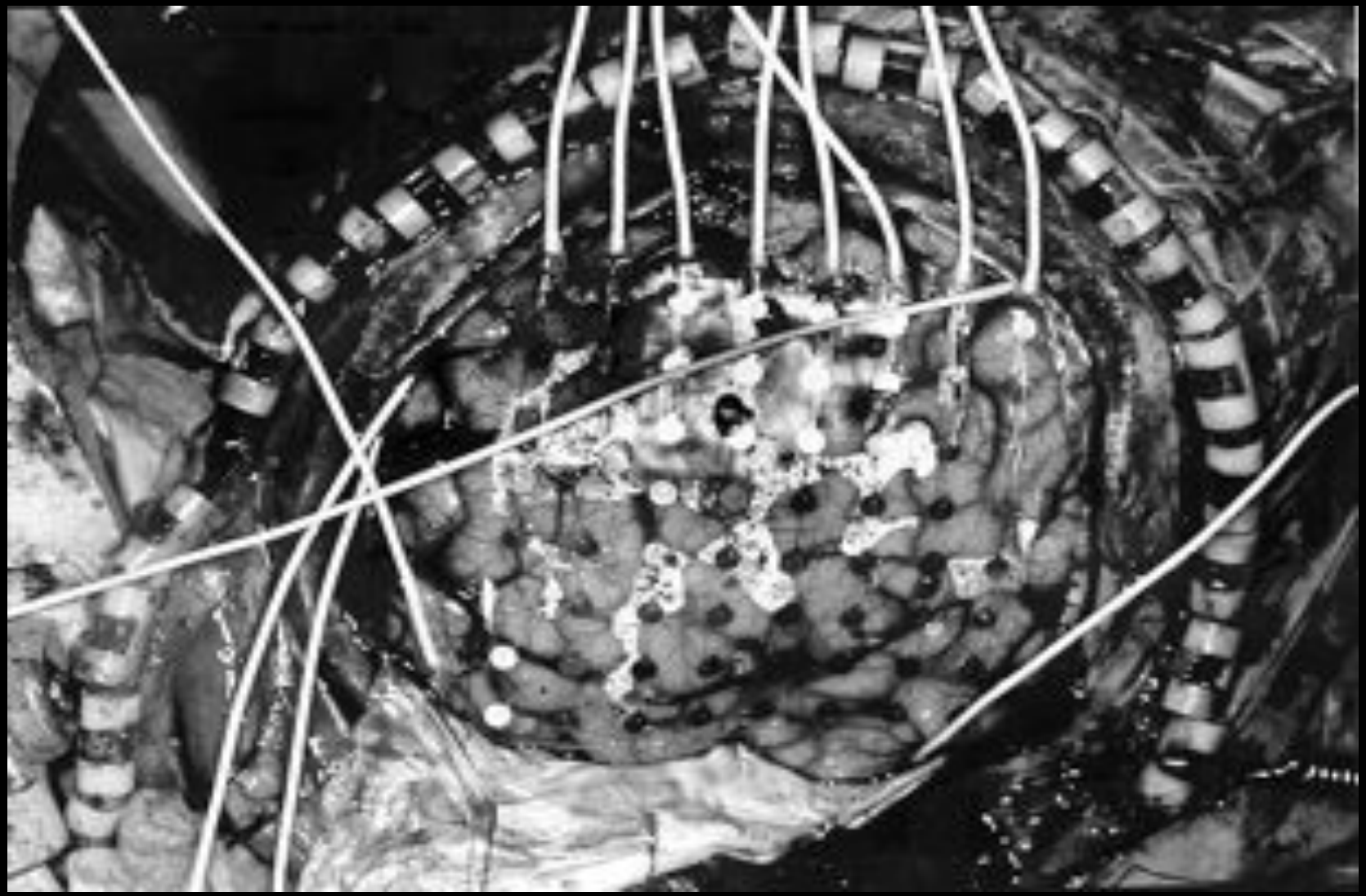


OBE induced by a complex partial seizure

- 21 years old, right-handed woman, pharmacy apprentice
- pharmacoresistant epilepsy since 14 years
- frequent complex partial seizures without secondary generalization

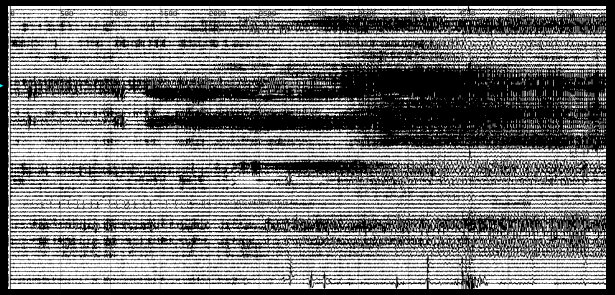
"The patient was lying in bed and awakened from sleep, and the first thing she remembered was "the feeling of being at the ceiling of the room". She "had the impression that I was dreaming that I would float above [under the ceiling] of the room". The patient also saw herself in bed (in front view) and gave the description that "the bed was seen from above"… The scene was in color, and was visually clear and realistic".

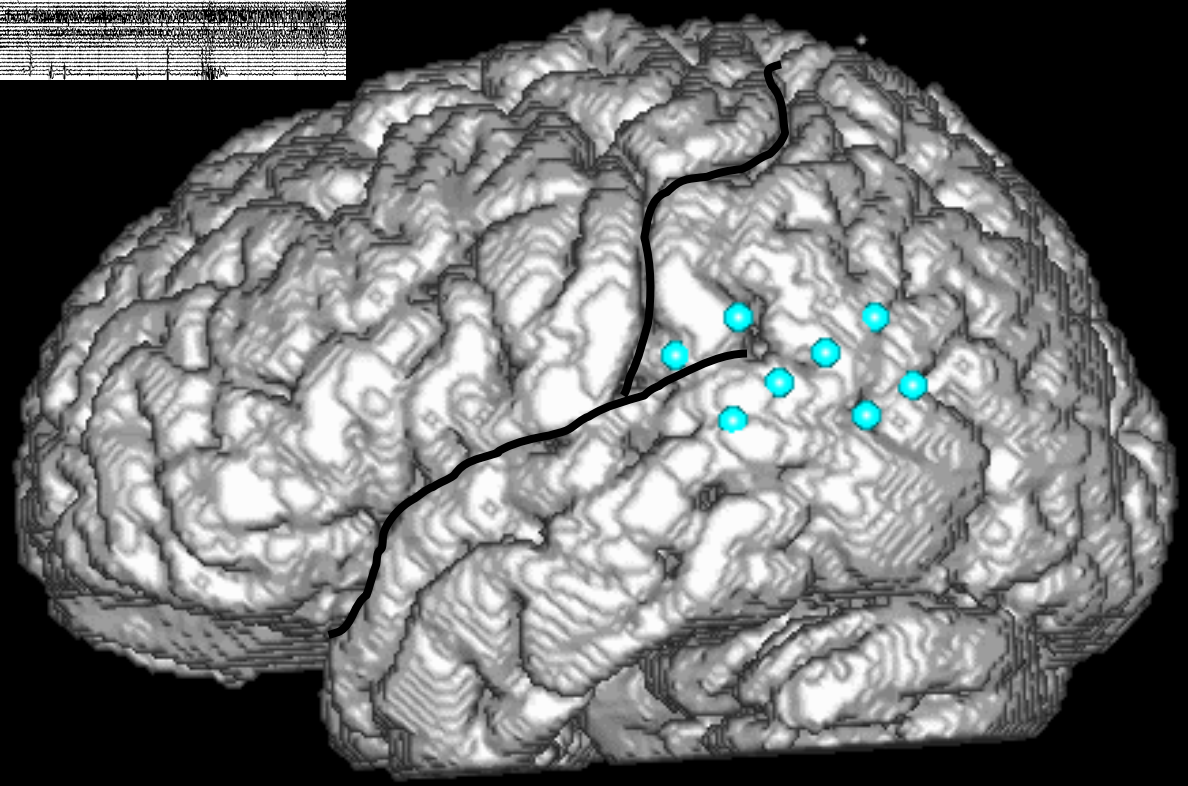
OBE induced by a complex partial seizure



OBE induced by complex partial seizure

Intracranial EEG
[seizure onset]

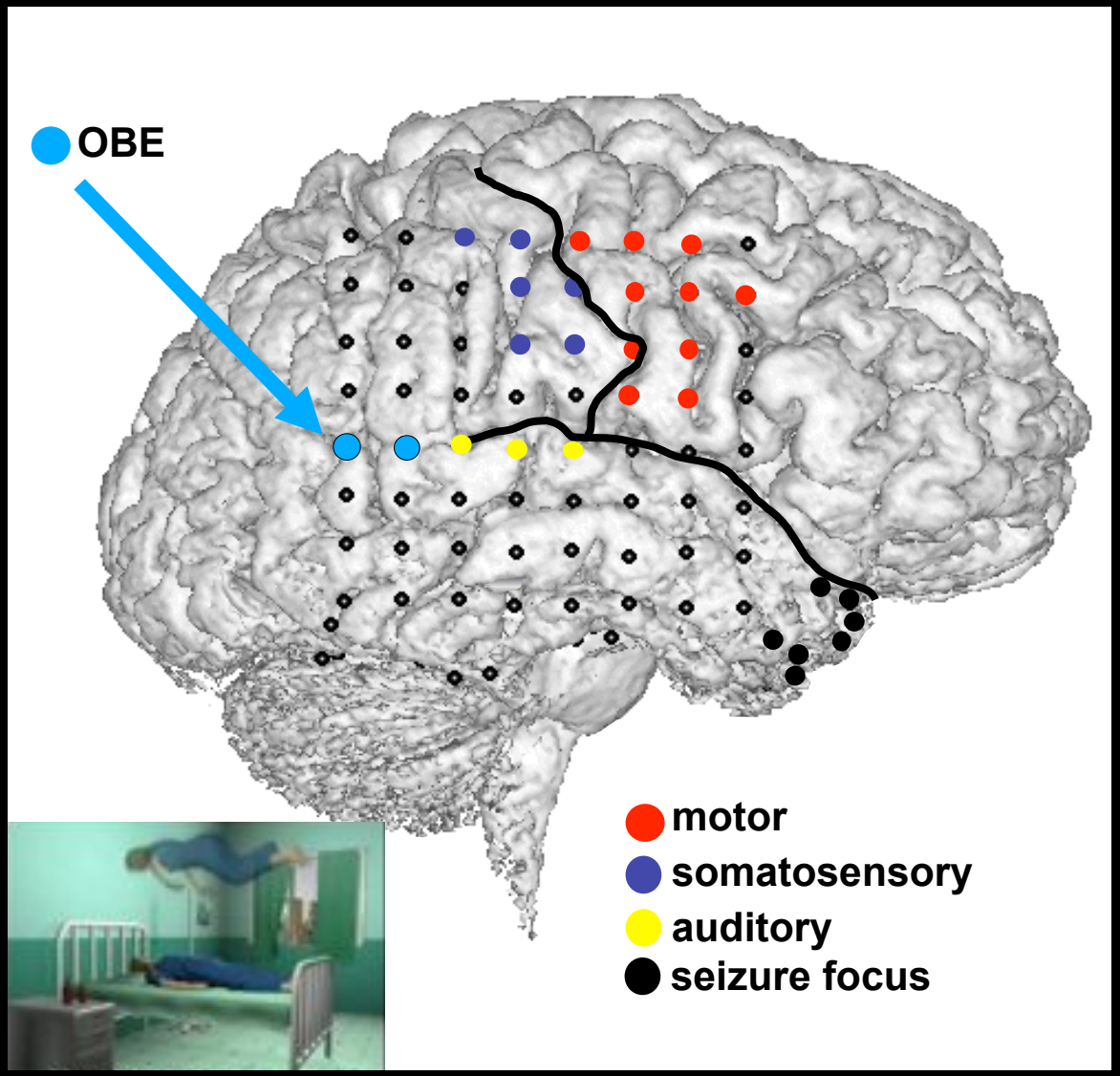




[Blanke et al., Brain 2004]

Stimulation induced out-of-body experience

with abnormal self-location, perspective, self-identification



Falling (2.5-3.0 mA)

OBE (3.5 mA)

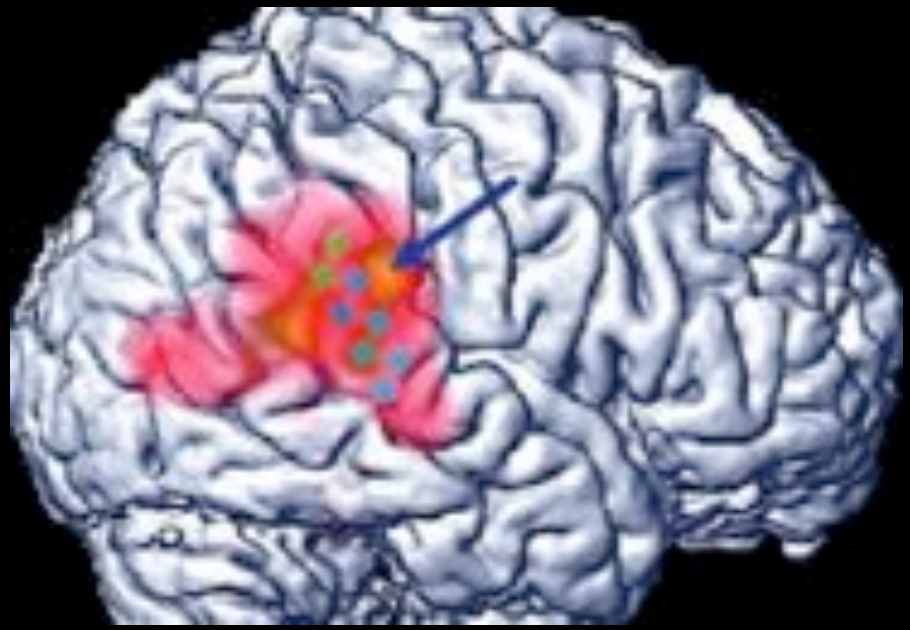
Visual body part illusions (3.5-5 mA)

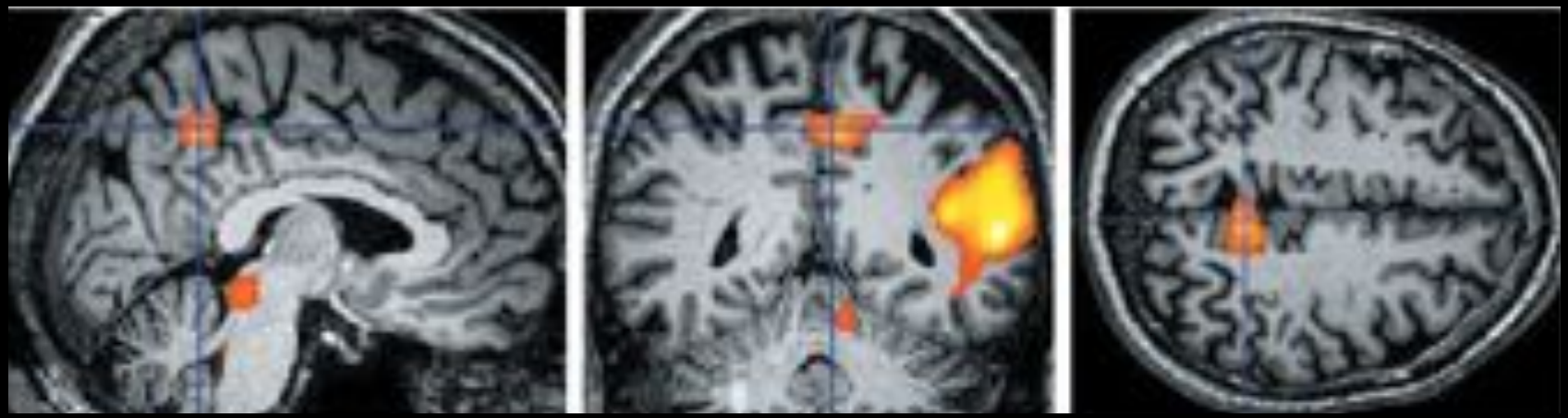
Kinesthetic illusions (3.5-5 mA)

[Blanke et al., Nature 2002]

Stimulation induced out-of-body experience

with abnormal self-location, perspective, self-identification

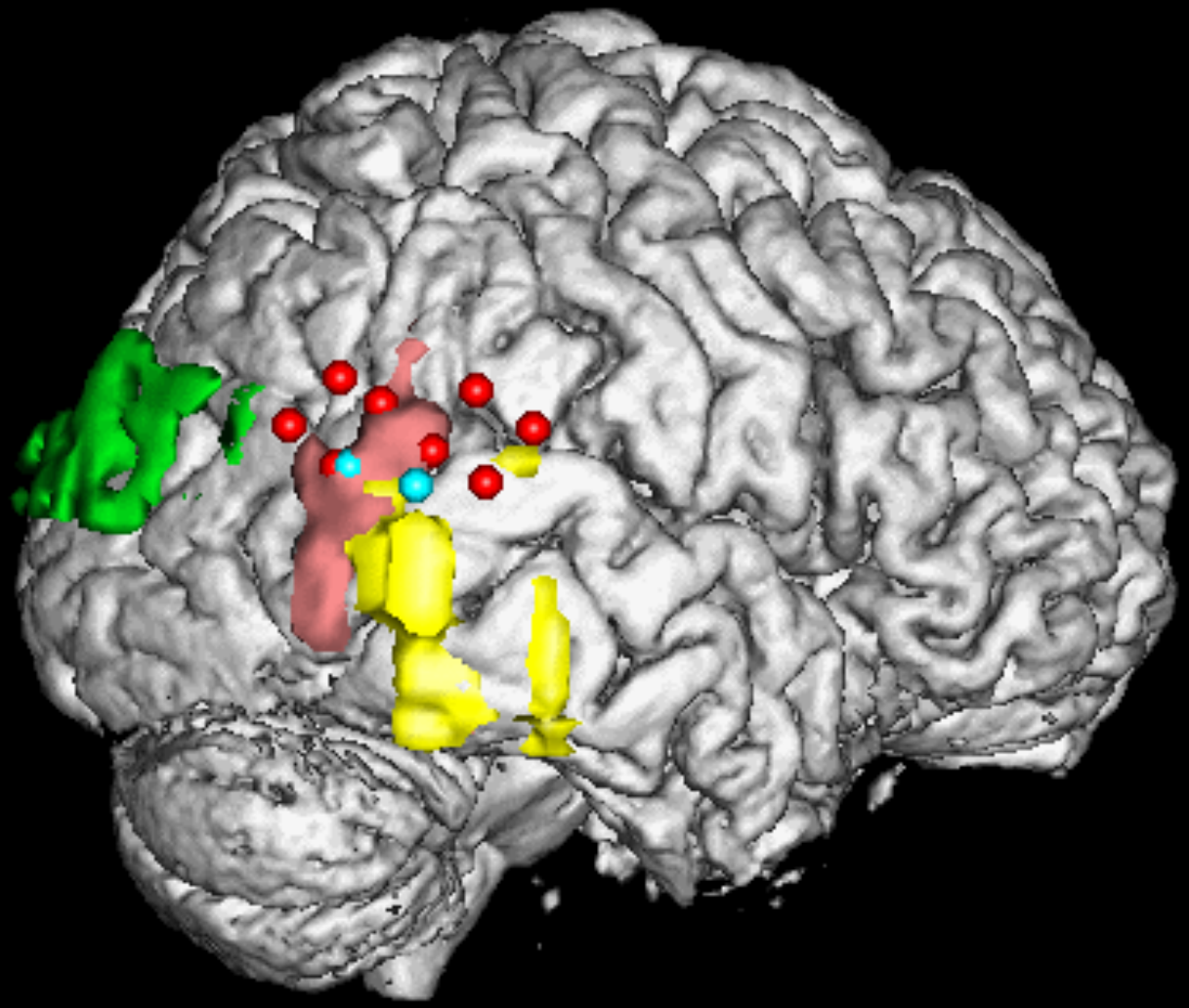




[de Ridder et al., 2007]

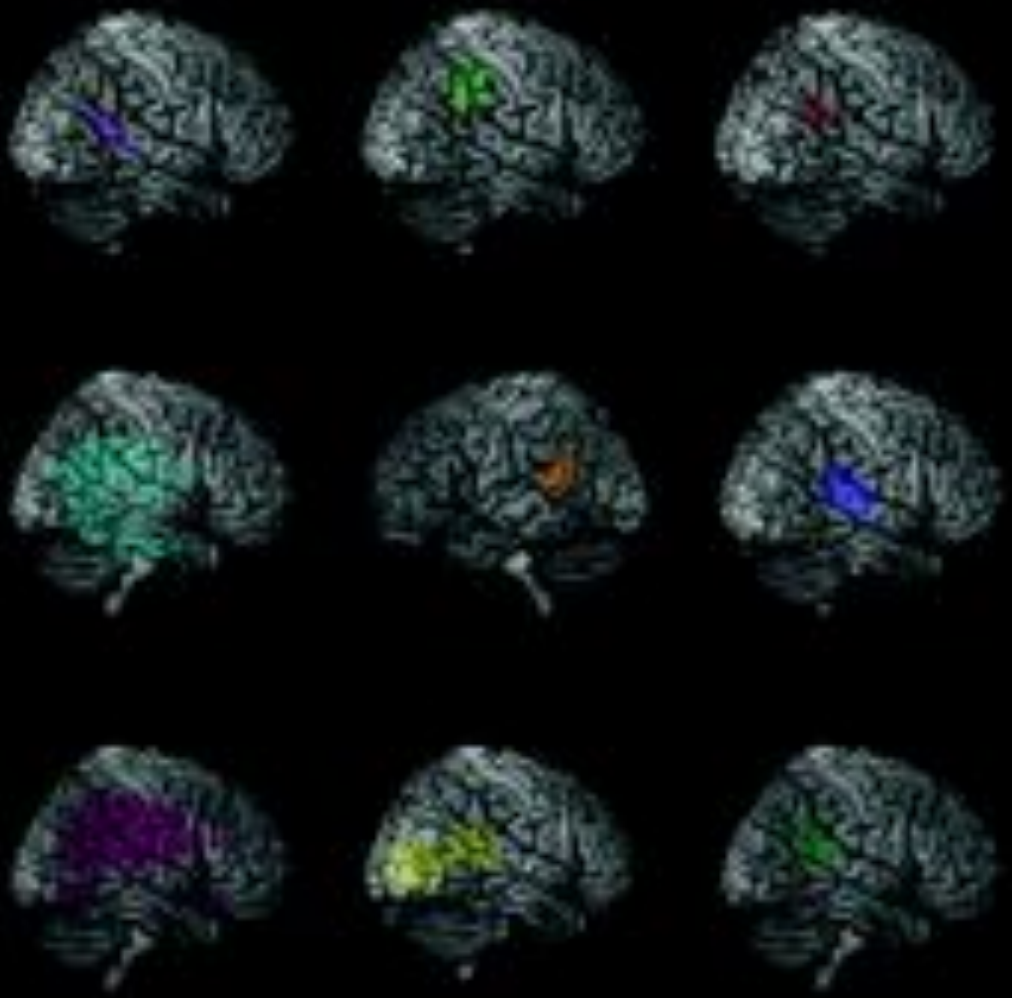
Out-of-body experience

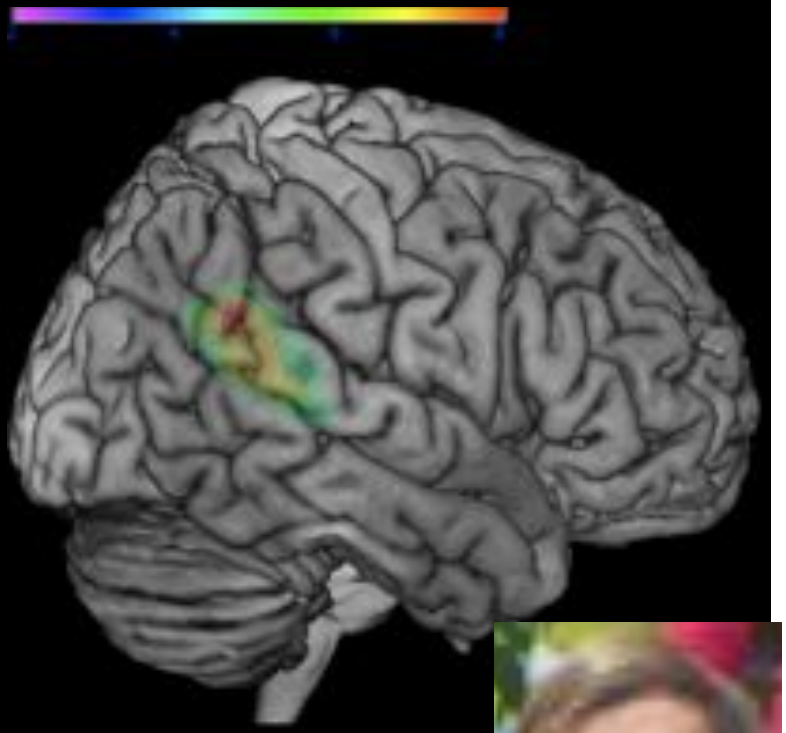
Brain damage in 5 patients with disembodiment



[Blanke et al., Brain 2004]

9 patients with OBEs… (MRI)

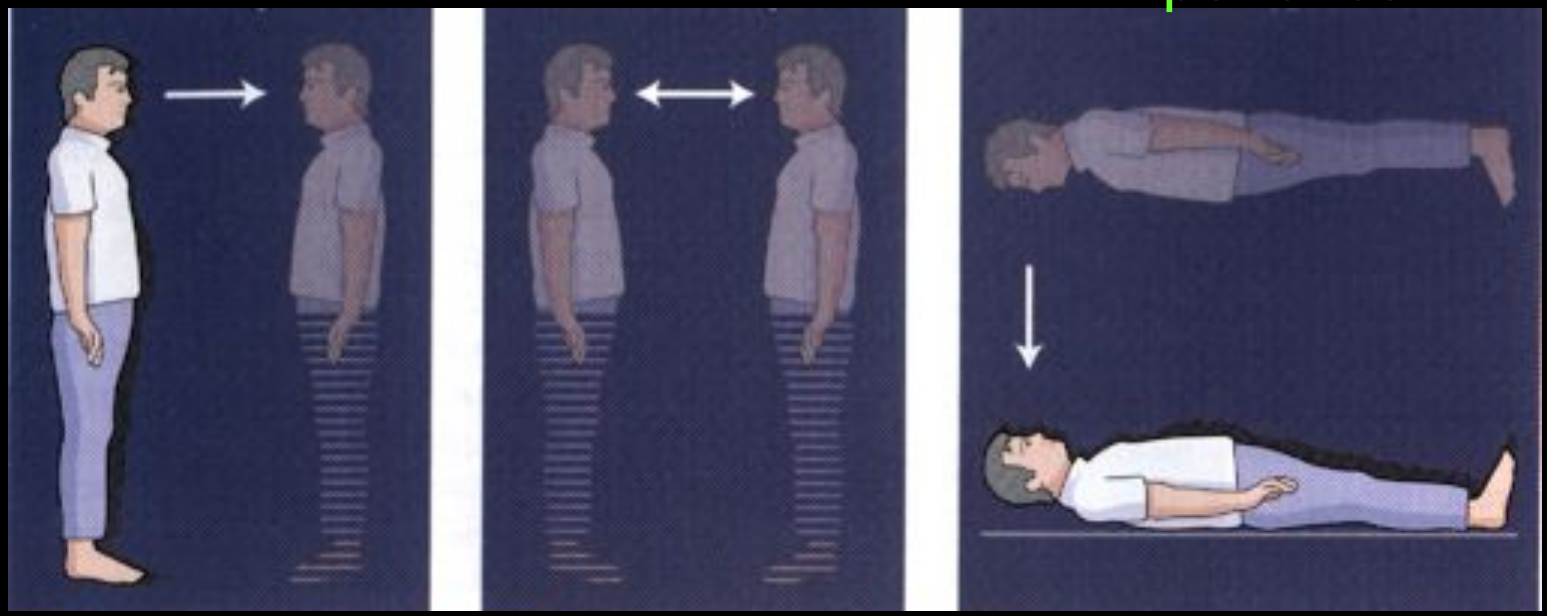




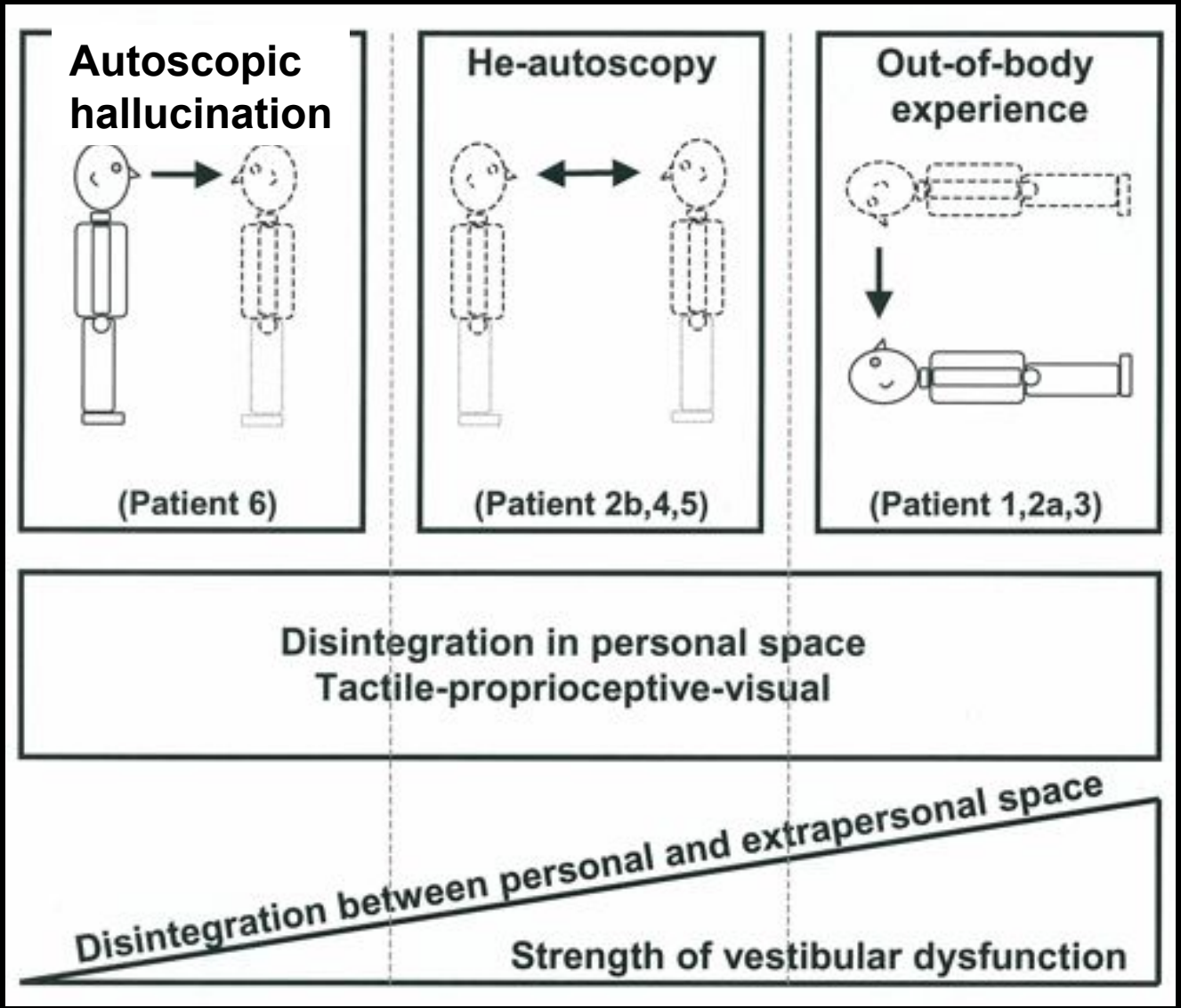
[Heydrich et al.]

Self-identification → abnormal
Self-location → abnormal
First-person perspective → abnormal

Out-of-body Experience

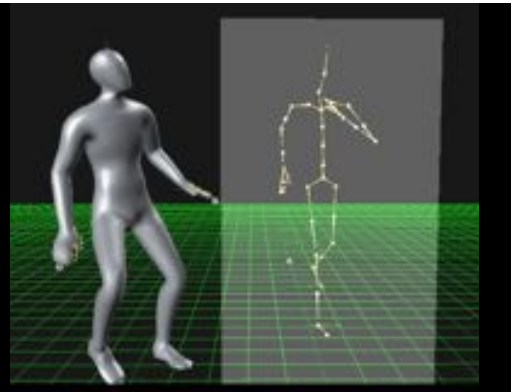


Multisensory disintegration in OBEs



[Blanke et al., Brain 2004]
Lopez & Blanke, 2007]

Conclusion



•OBE: phantom body and phantom
•self (abormal self-location, self-identification, 1PP)
→ disorder of the spatiality of bodily self-consciousness

•Disintegration in bodily space (tactile, proprioceptive, visual information)
•Disintegration between extrapersonal (visual) and personal space (vestibular) by vestibular dysfunction

•Interference with processing in right temporo-parietal cortex and damage is distinct from other related conditions

2

Neurology

Cognitive Science & Virtual reality

Neuroimaging & Robotics

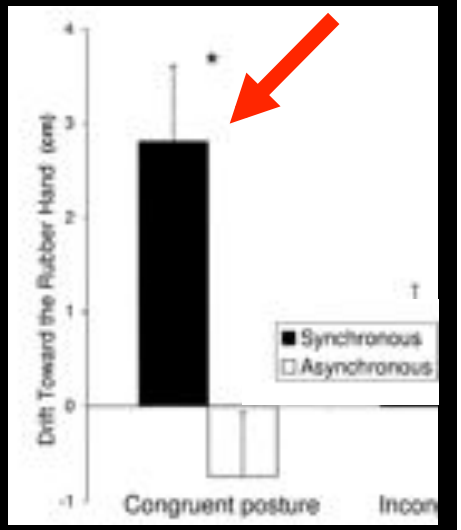
A fake arm feels like my arm and is associated with abnormal arm localization

~The rubber hand illusion~

[Botvinick and Cohen, Nature 1998]

A fake arm feels like my arm and is associated with abnormal arm localization

~The rubber hand illusion~

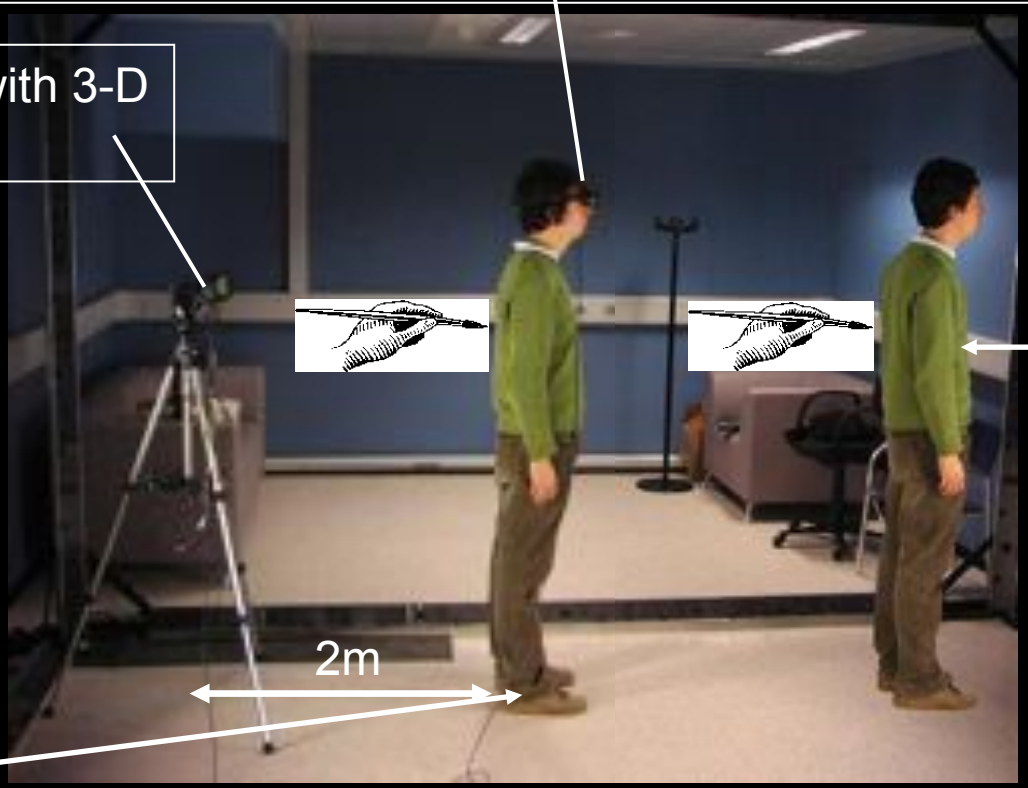


« I feel the touch where I see the touch »
« The fake hand feels like my real hand »

[Botvinick and Cohen, Nature 1998]

[demo on youtube]

Projecting the bodily self to a fake body

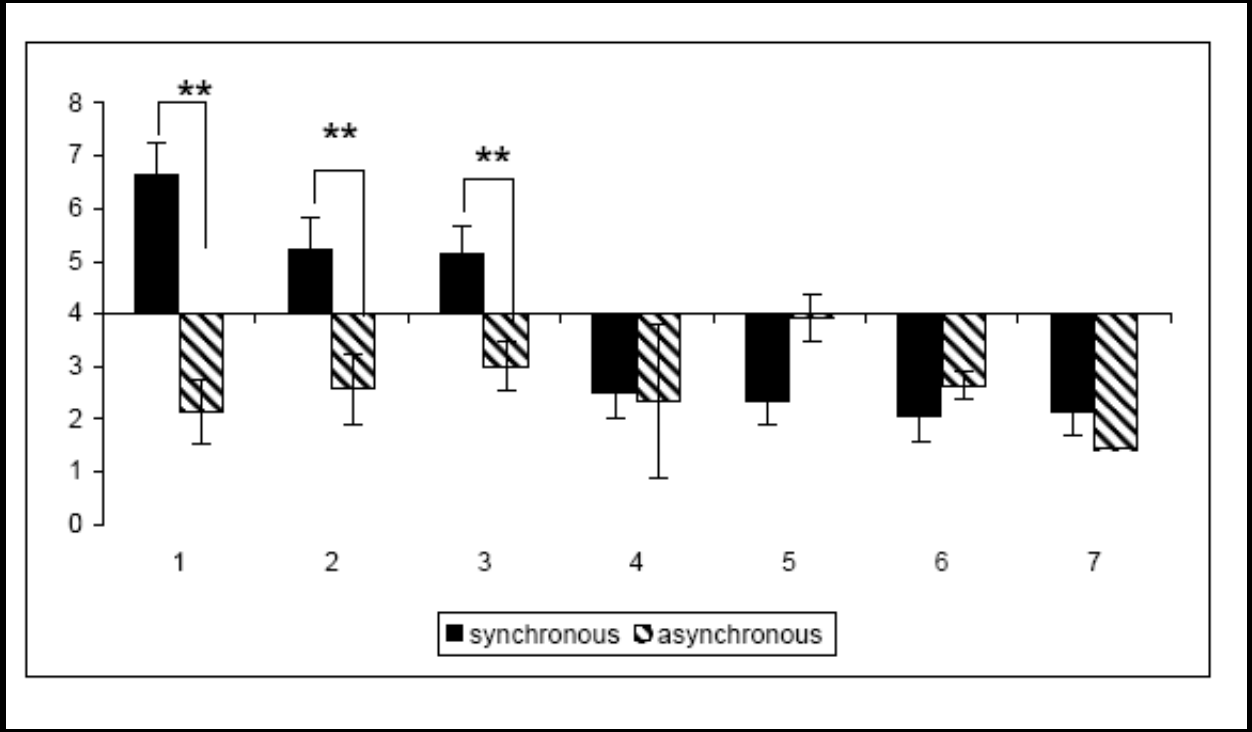


[Lenggenhager et al., Science 2007]

Measuring self-identification

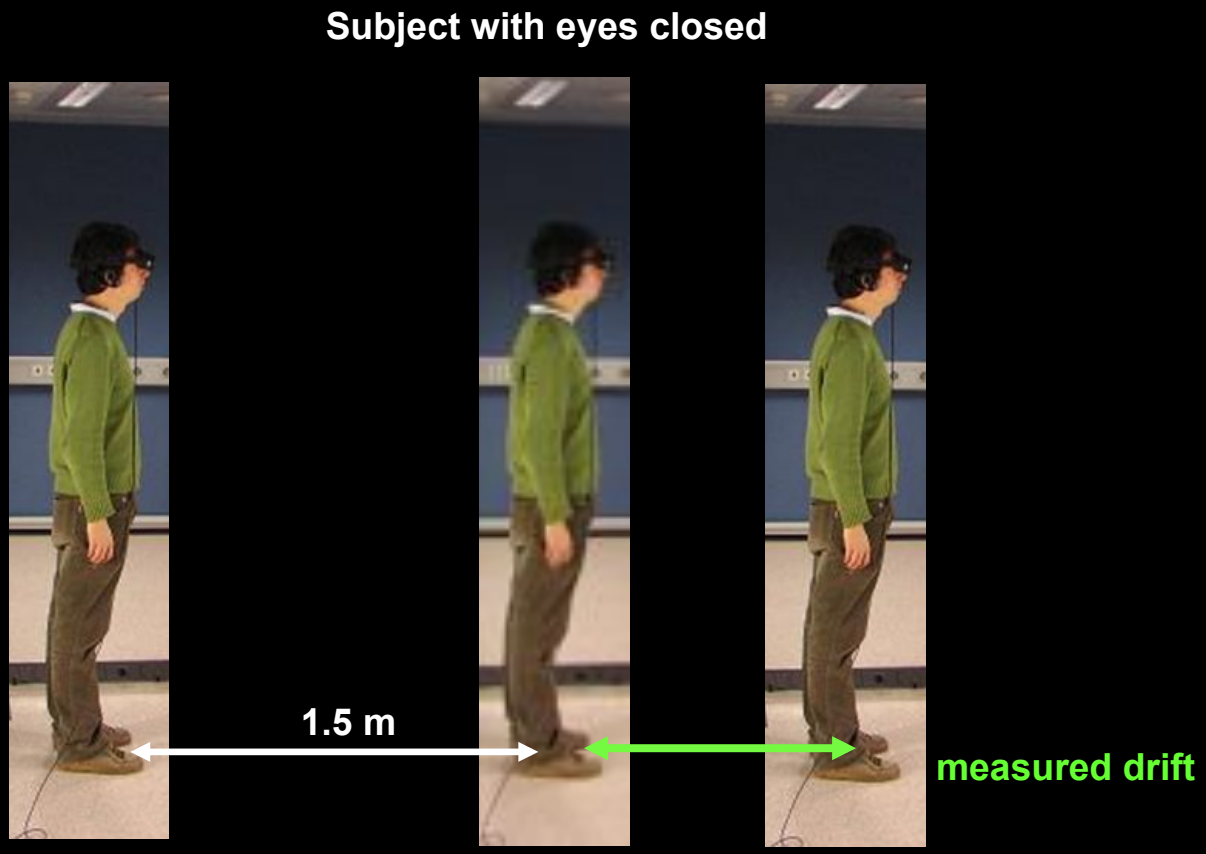
1. I seemed as if I were feeling the touch of the paintbrush in the location where I saw the virtual body touched.
2. It seemed as tough the touch I felt was caused by the paintbrush touching the virtual body.
3. I felt as if the virtual body was my real body.
4. It felt as if my real body was drifting towards the front (towards the virtual body)
5. It seemed as if I might have more than one body.
6. It seemed as if the touch I was feeling came from somewhere between my real and my virtual body
7. It seemed (visually) as if the virtual body was drifting backwards (towards my body)

Self-identification. The virtual body feels like my body

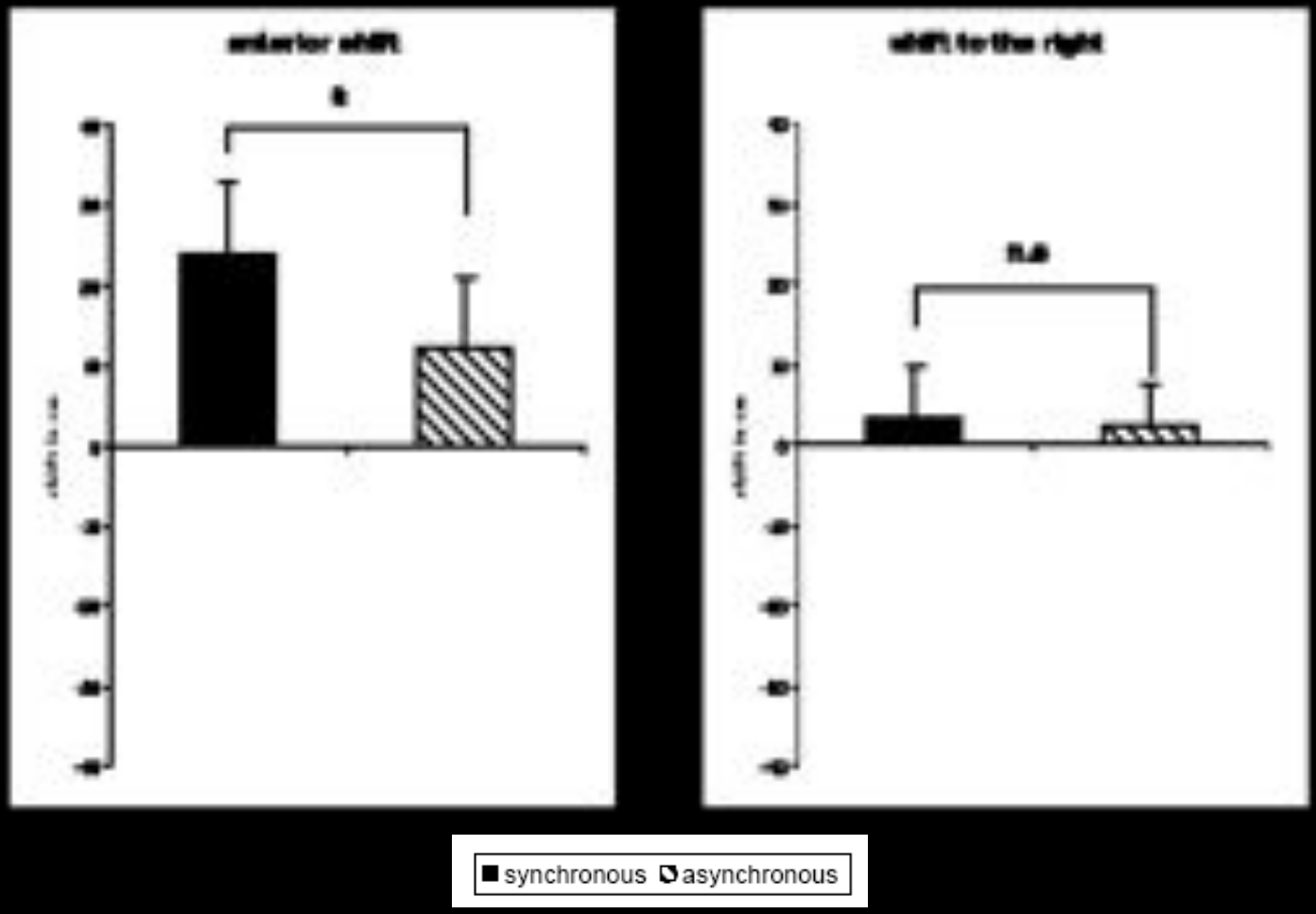


[Lenggenhager et al., Science 2007]

Measuring self-location

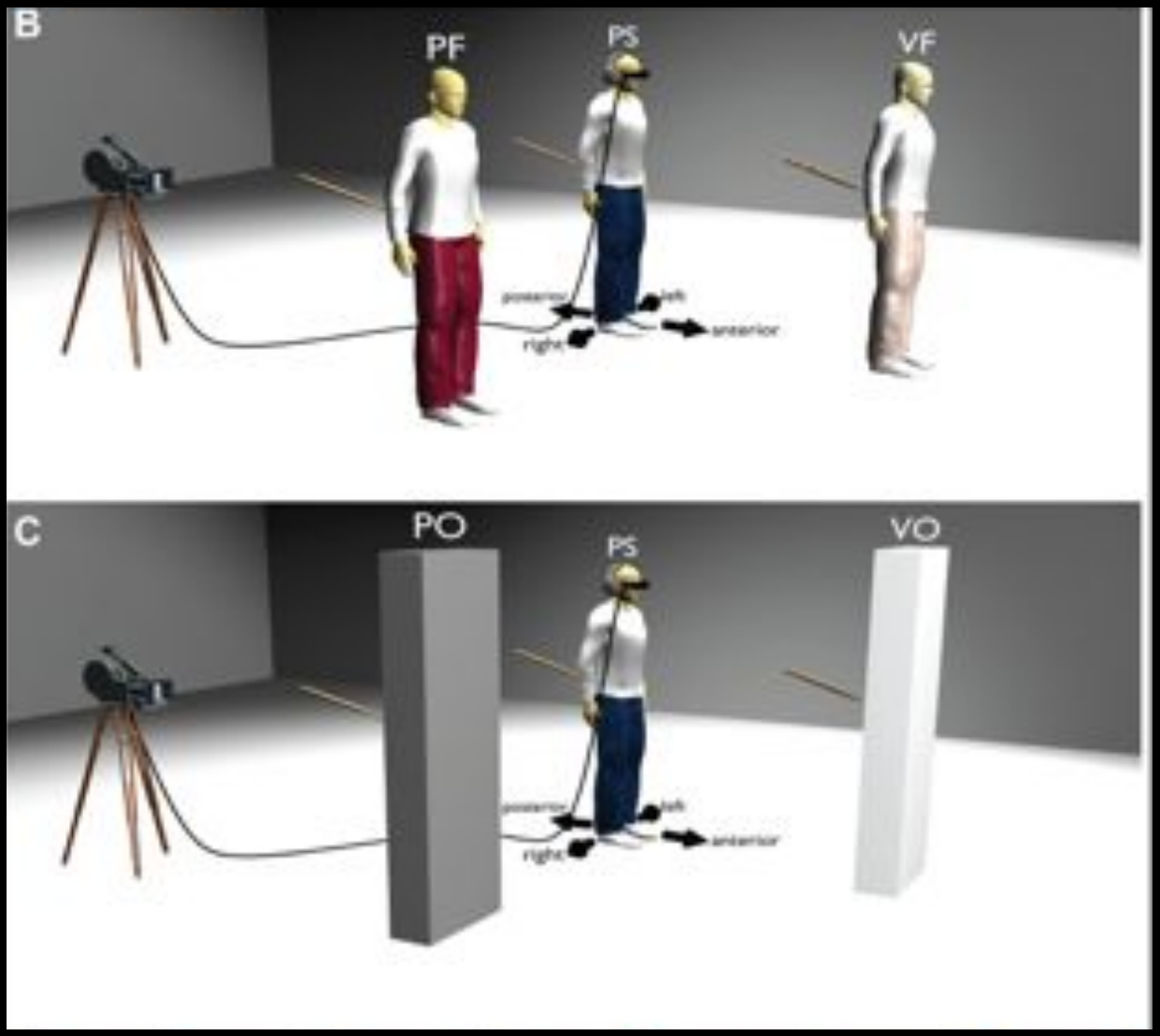


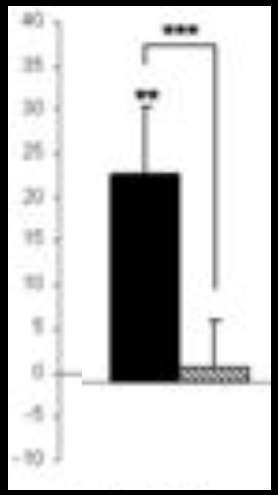
Self-location is shifted in the direction towards the virtual body

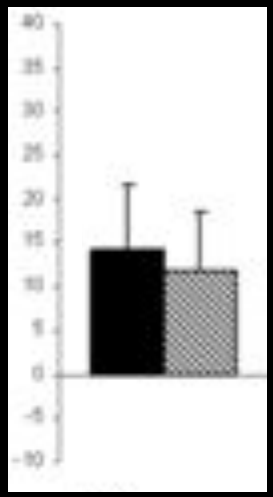


[Lenggenhager et al., 2007]

Further experimental manipulations of self-location and self-identification







Study 2 [Lenggenhager et al., Science 2007]

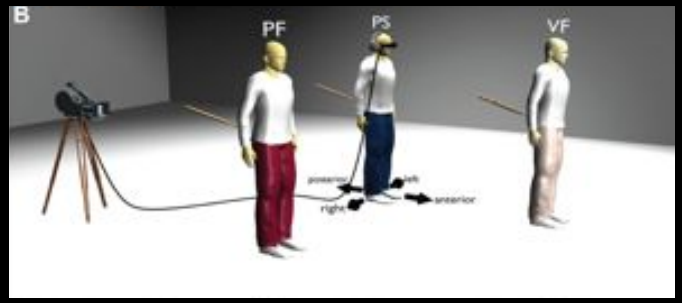
Conclusions

•Humans systematically experience a virtual body as their own (ownership) when visually presented in their anterior extrapersonal space & stroked synchronously

•Participants also mislocalized their body to a position outside their body (not due to motor or attention bias)

•Self location and ownership (self-identification) for the full body rely on visual-somatosensory mechanisms

•We can use video-projection & virtual reality technology to study global bodily self-consciousness and our "inside body experience"



Recent work on bodily self-consciousness

Tactile body representations (crossmodal congruency effect)
→ Aspell et al., Plos One 2009

Supine position, elevation, and vestibular sensations → Lenggenhager et al., Cons & Cogn 2009

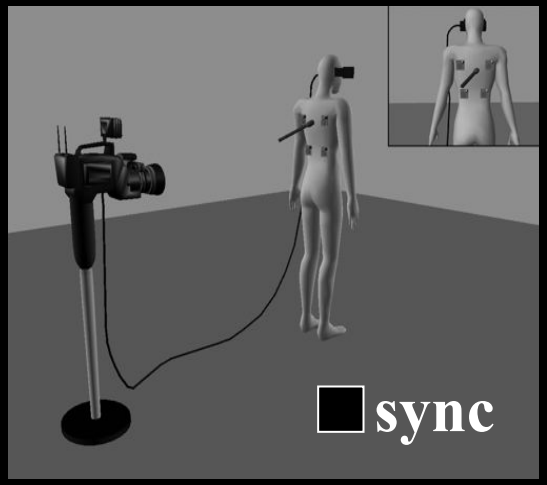
Pain reduction → Haensel et al., in revision

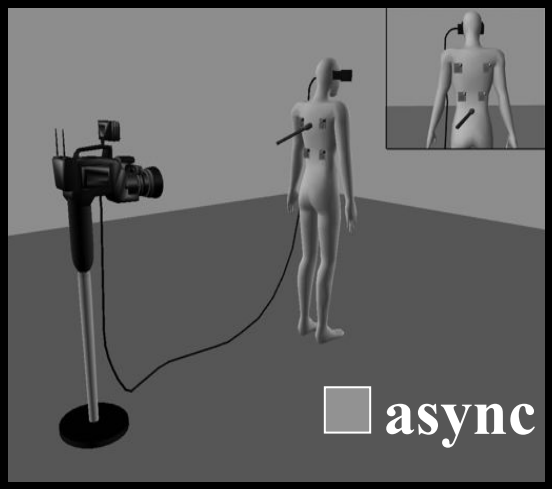
Audio-tactile mechanisms in bodily self-consciousness
→Aspell et al., 2010

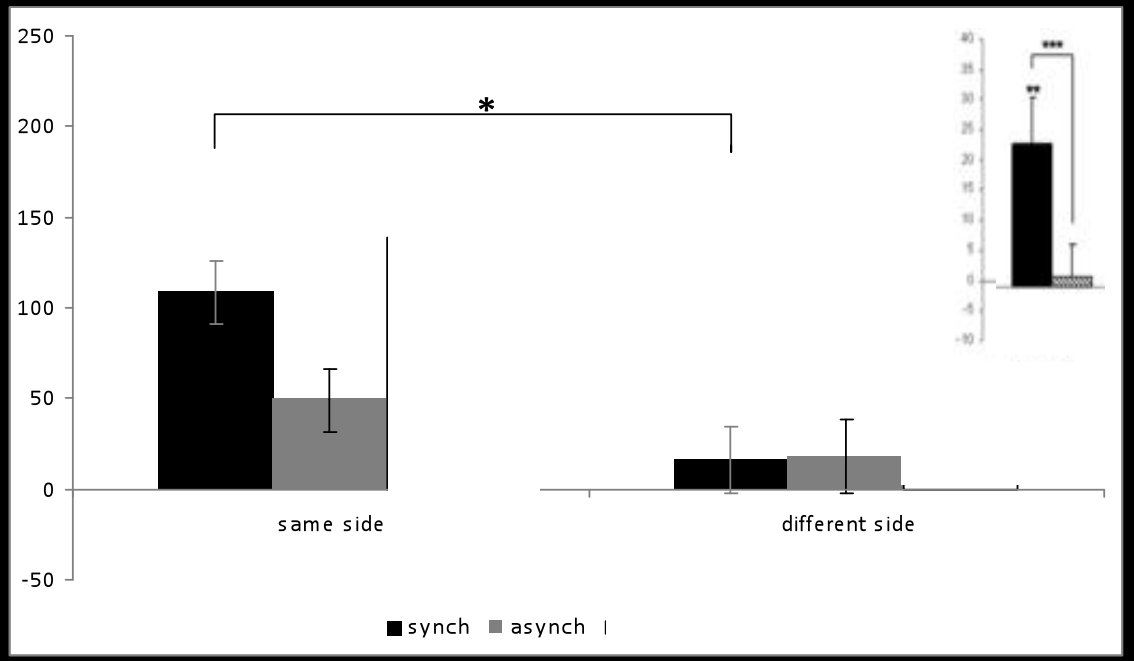
Prioprioceptive signals alters bodily self-consciousness → Palluel et al., in revision

Visuo-motor mechanisms during locomotion
→ Kannape et al., Neuropsychologia 2010

Self-identification and self-location modulates how you perceive touch !

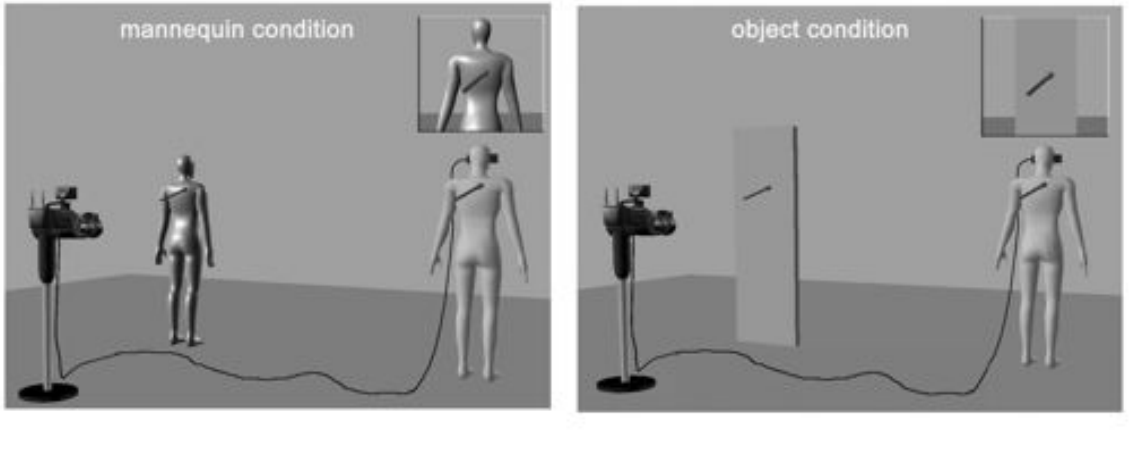




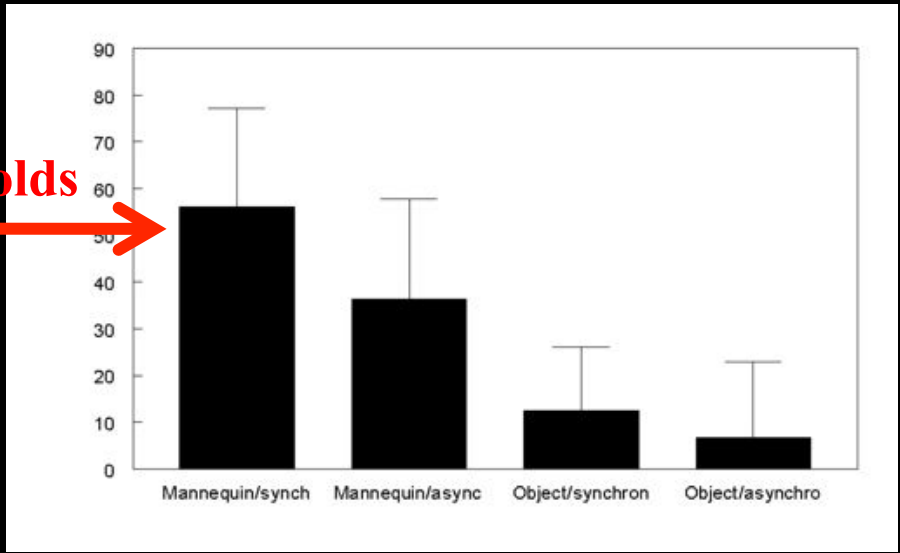


[Aspell et al., 2009]

Bodily self as an analgesic: Self-identification and self-location modulates how you perceive pain !



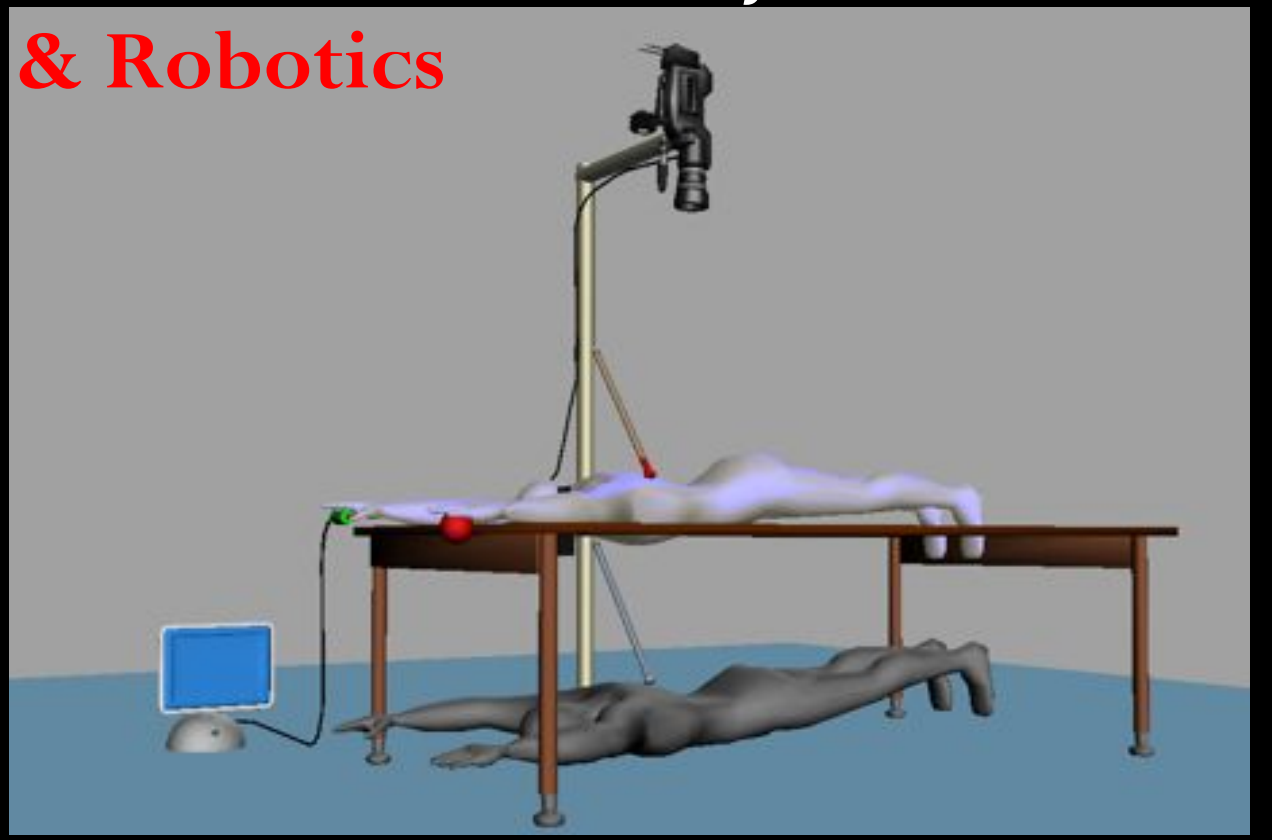
Increase in pain thresholds



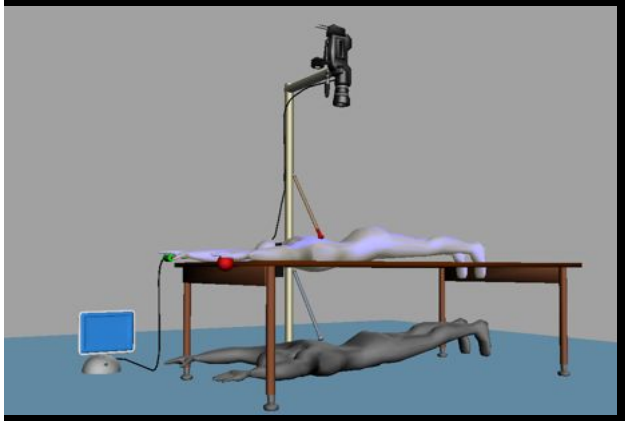
[Haensel et al., in revision]

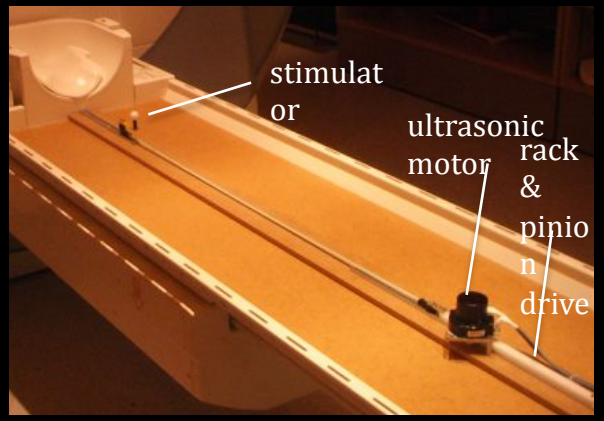
3

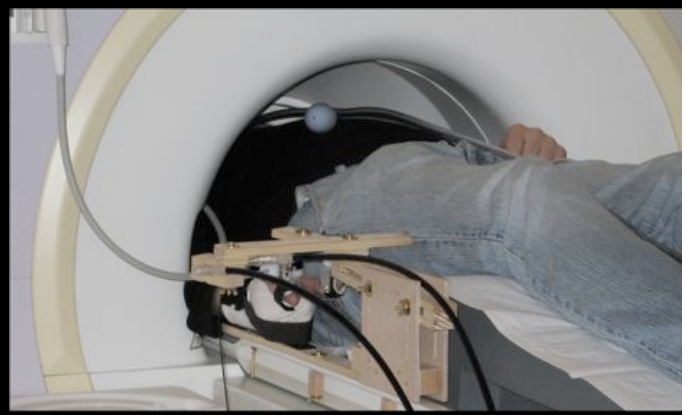
Neurology
Cognitive Science & Virtual Reality
Neuroimaging & Robotics

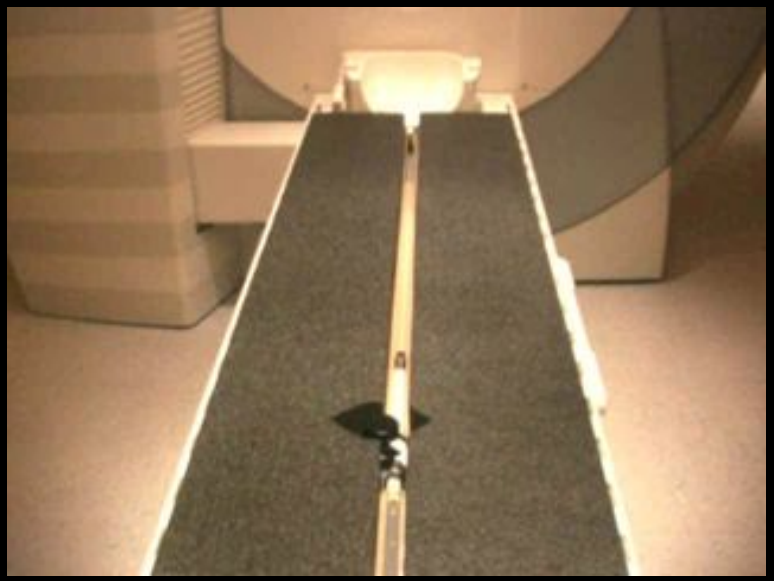


Neural mechanisms of self-location and the first-person perspective: robotic stimulation







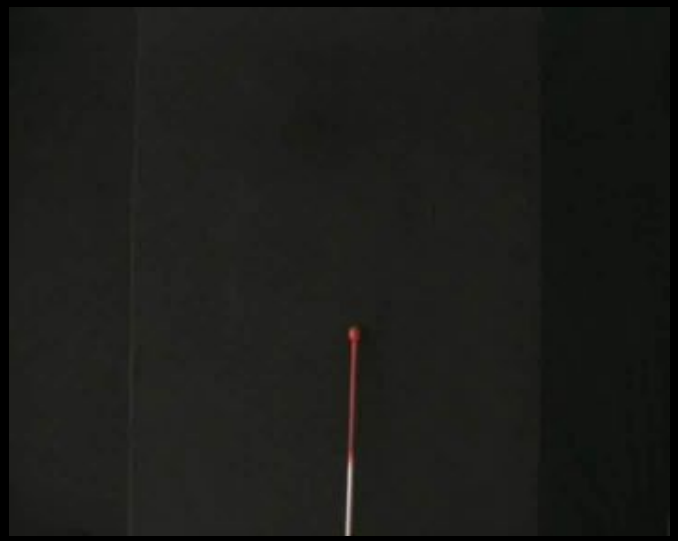


[Ionta et al., submitted]

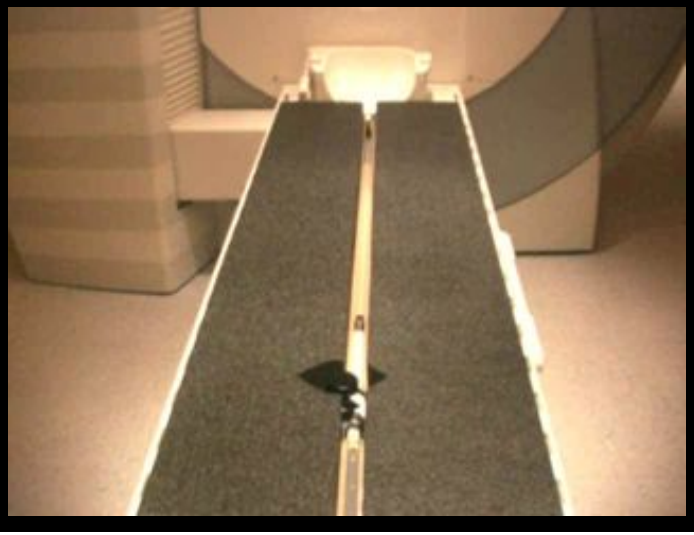
Experimental conditions

With body condition

Without body condition



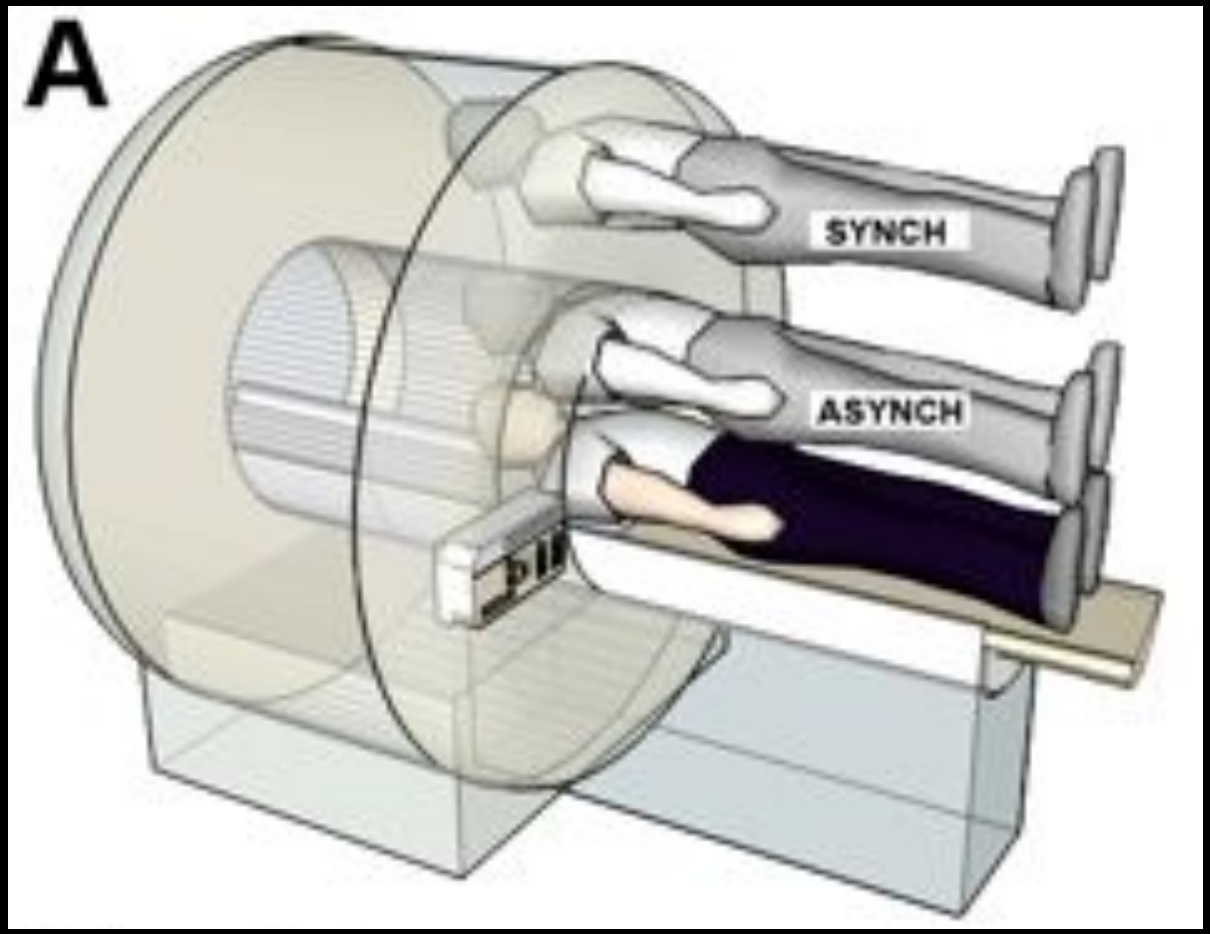
Synchronous/asynchronous



[Ionta et al., submitted]

Measuring self-location during fMRI

Mental ball dropping task

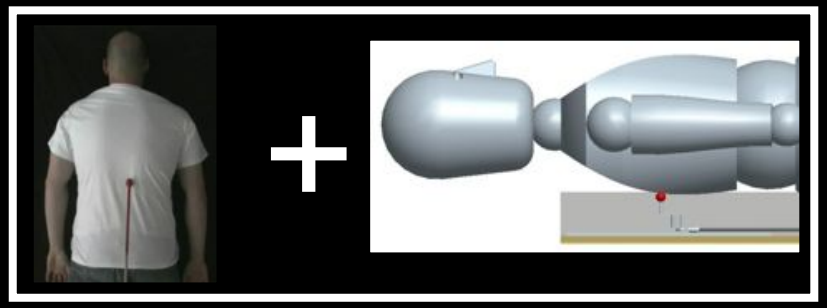


…we also measured self-identification → adapted from Lenggenhager et al., 2009

fMRI paradigm

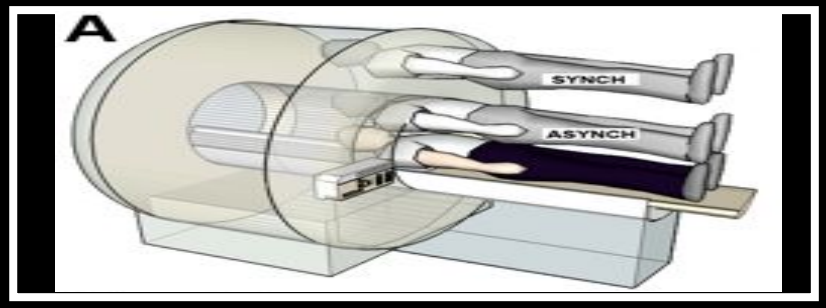
Timeline

Visuo-tactile stimulation



39s

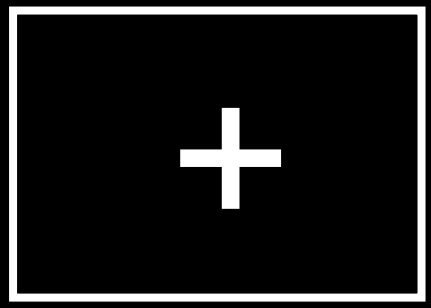
Self-location task



15s

3 x Mental Ball Dropping Task

Baseline



24s

0

39

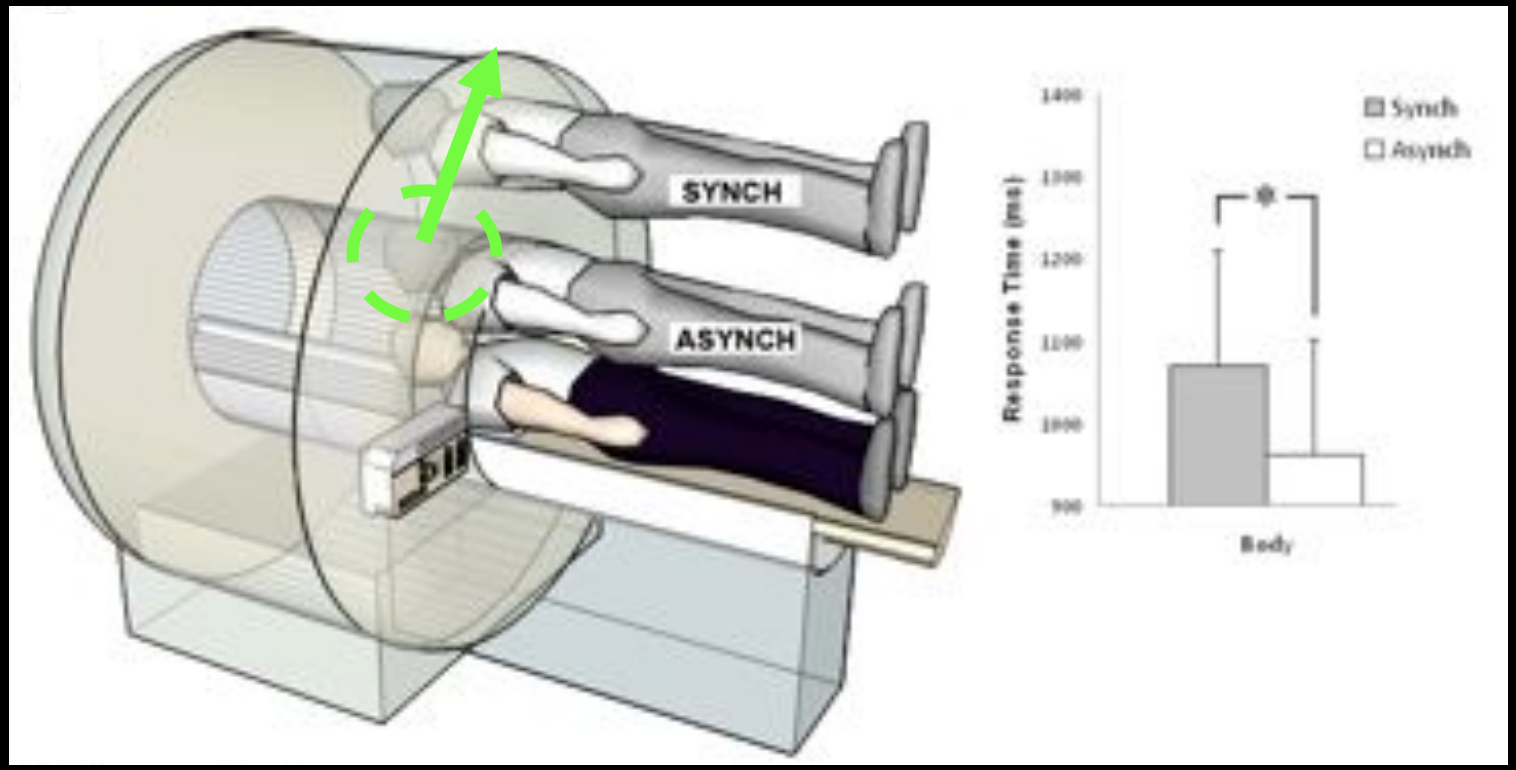
54

78 [s]

BLOCK

Results: Self-location estimation during fMRI

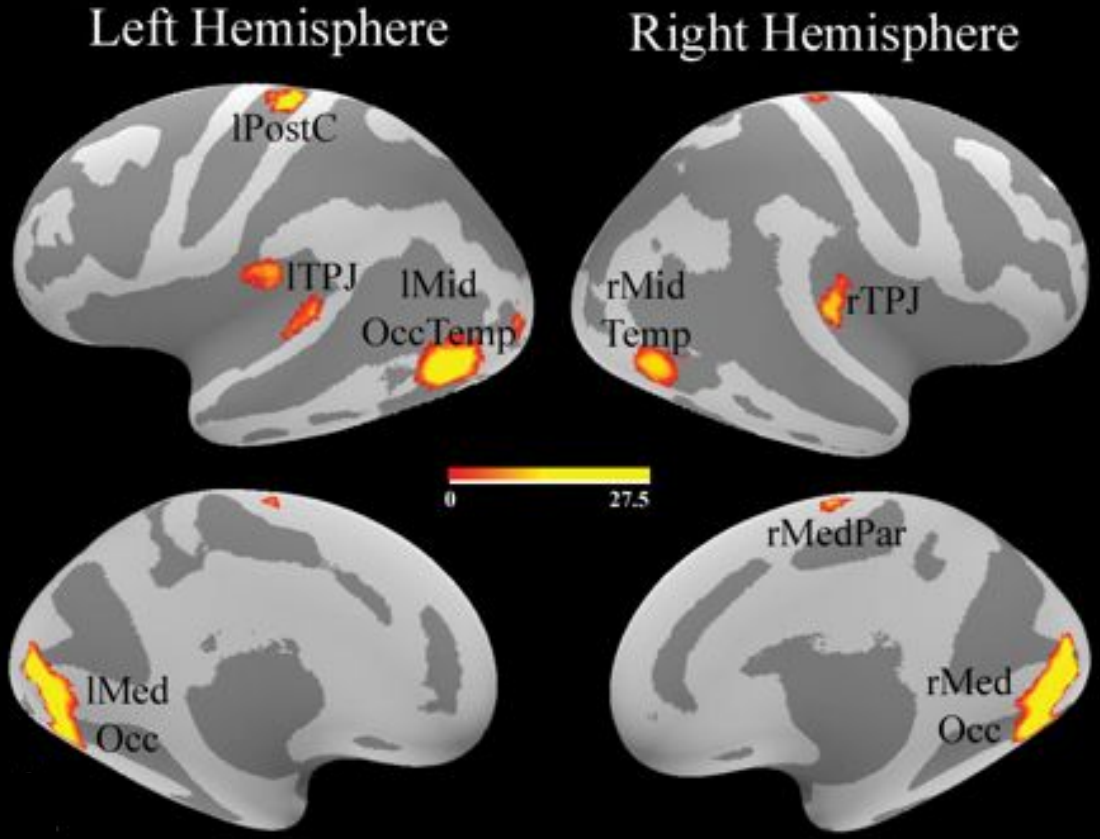
sync. stimulation leads to ascending drift in self-location “towards the virtual body”) (longer RTs)



Body-specific and synchrony dependant changes in self-location (elevation)

[n=11]

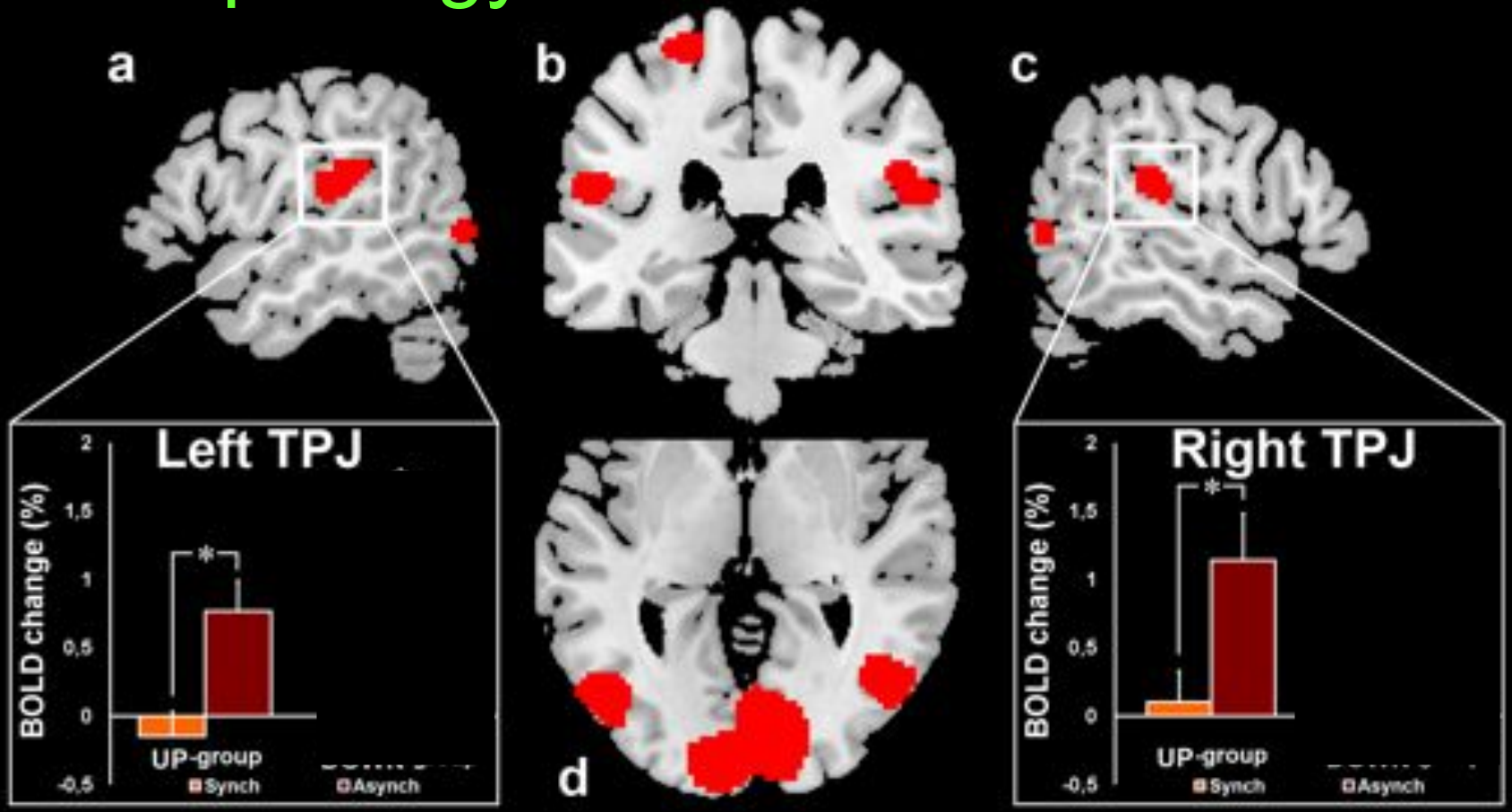
Seven regions activated compared to the control condition



-Bilateral TPJ
-Bilateral precentral gyrus (medial)
-Bilateral temporo-occipital cortex; occipital

[Ionta et al., in prep.]

Activity in right and left posterior superior temporal gyrus reflects self-location



[Ionta et al., in prep.]

Bodily Self-consciousness (relevance for philosophy)

Self-location
(Where am I localized ?)

First-person perspective
(Where do I perceive from?)

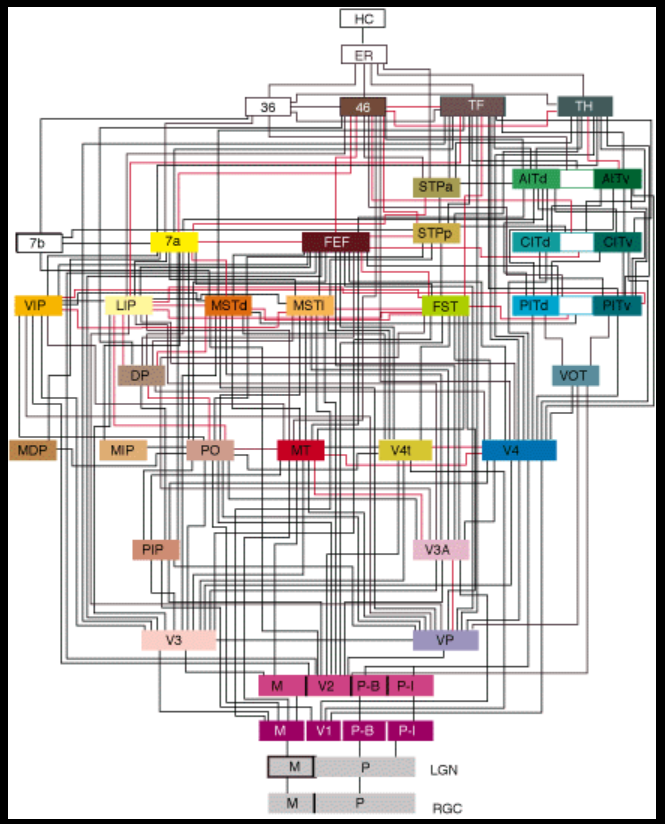
Self-identification
(What do I experience as my body?)

[Blanke & Metzinger, TiCS 2009]

1- Bodily self-consciousness as the foundation of the many-dimensional Self?

- **Visual Recognition:** Recognizing one's image in a mirror
- **Memory:** Autobiographical memory
- **Thought**: Ability to think "I" thoughts; ability to think of oneself as oneself, have a self concept,…
- **Language**: first-person pronouns, self-narrative
- **Social: ability to** adapt the perspective of the other to oneself,
- …

2- Although self-consciousness is often regarded as the greatest mystery in science (and consciousness studies), it may turn out to be less complex than we think and less complex than consciousness.


HC
ER
36
46
TF
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STPa
AITd
AITv
7b
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FEF
STPp
CITd
CITv
VIP
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MSTd
MSTl
FST
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DP
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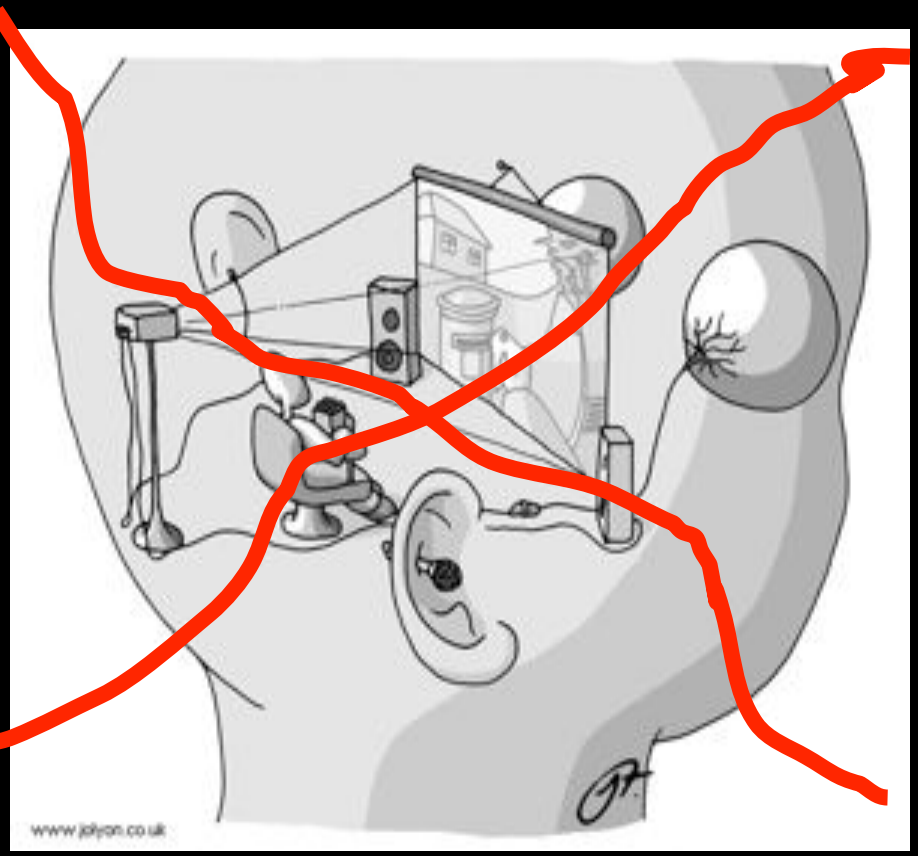
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