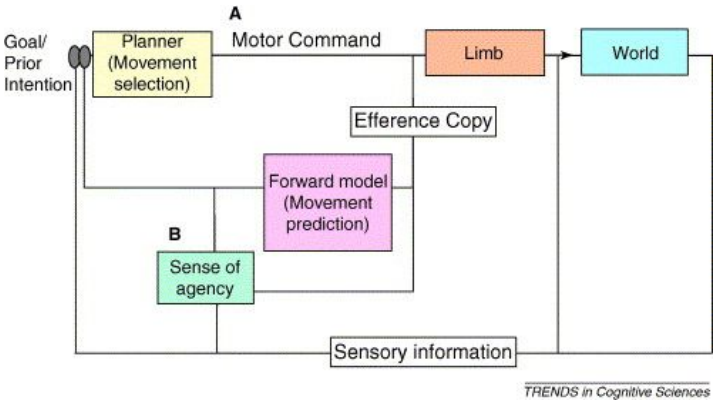
Movement Intention After Parietal Cortex Stimulation in Humans

Desmurget et al. (2009)
Presentation by Charles Guan

Pretty short paper, but cool results and interesting implications.

Background

- 1641 (Descartes): conscious intent enters the brain
- 1983 (Libet): brain activity before awareness of motor intent
- 2004 (Sirigu, Lau): parietal cortex/pre-SMA involved in conscious intent



Haggard (2005)

Here's the context that the authors set up for the paper:

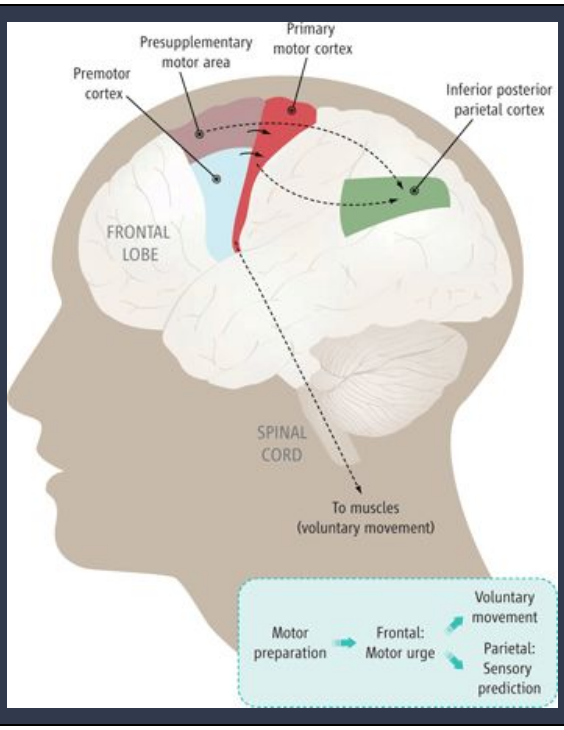
1641: not sure the last time I saw a paper that cites something from the 17th century.

This review from 2005 shows this abstraction that I think is interesting to think about.

- Descartes thought this was outside the brain.
- After Libet, some thought that perhaps only sensory information mattered - we just applied rationale to it
- I believe some of Richard's work showed that parietal cortex is involved in this forward model

Scientific Questions

1. Where in the brain are intentions formed?
2. How do we become aware of these intentions?



7 Patients

- Brain tumors near central sulcus

Electrical Stimulation

- Parietal and premotor regions
- 2, 5, and 8mA
- 1, 2, and 4 seconds

Measurements

- EMG signal
- "Did you move?" / "Did you feel something?"

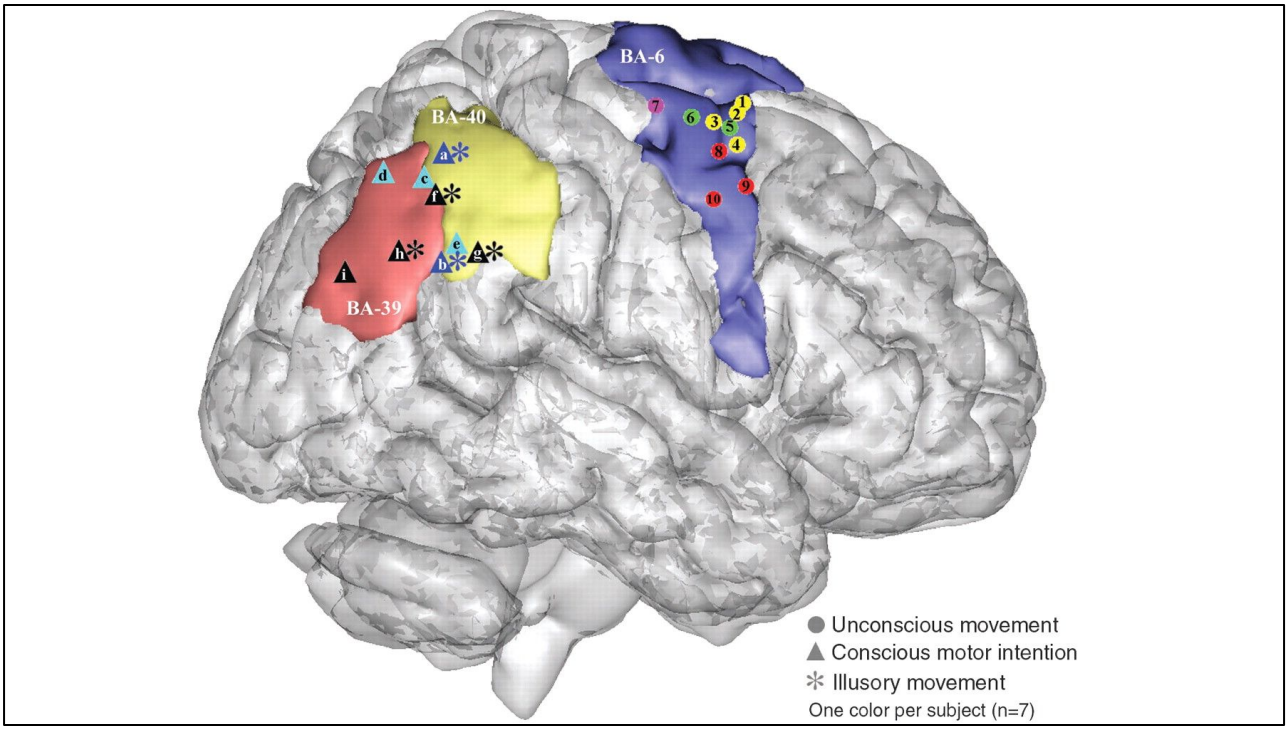
Haggard (2009)

Central sulcus: posterior to motor cortex, in between that and primary somatosensory area

Inferior PPC: generates sensory representations of forward model - expected sensation

"The premotor cortex prepares commands for voluntary actions triggered by external stimuli, whereas the presupplementary motor area prepares commands for internally generated “intentional” actions, which are then executed by the primary motor cortex. Signals containing copies of prepared motor commands are also sent to the parietal cortex, where they are used to predict sensory consequences of movement"

contralaterlal = "opposite side"



PPC stimulation BA 7, 39, 40

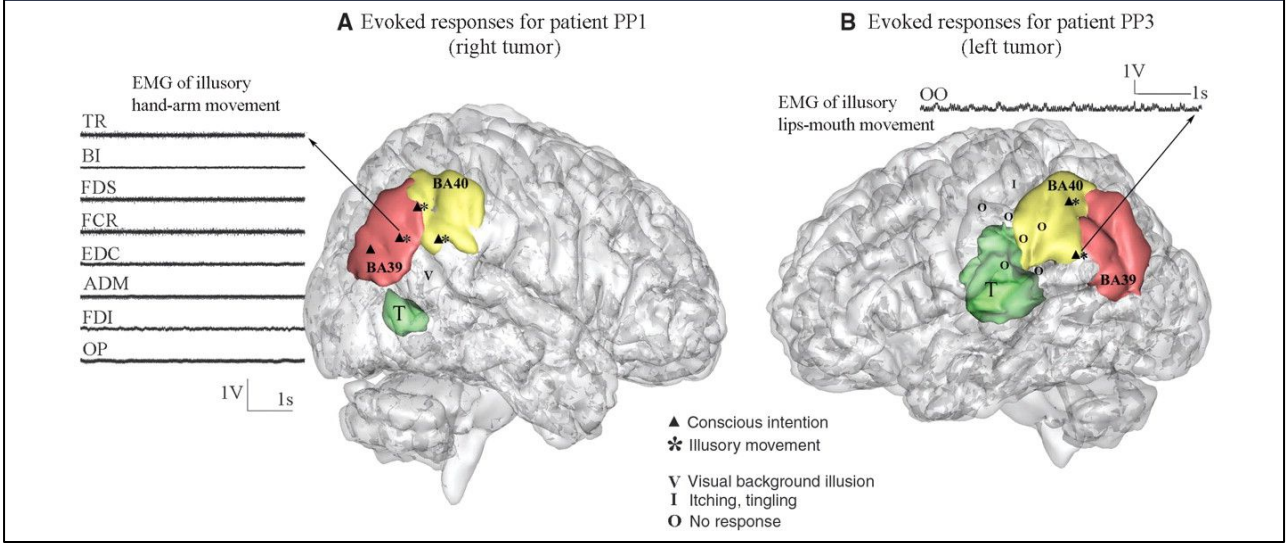
- BA 7
- BA 39 - also semantic aphasia
- Broadmann area 40 - part of parietal cortex, somatosensory association cortex, probably involved in reading/language,
    - lesions can cause ppl to not understand language

Premotor stimulation, BA6

These are the stimulations across all patients, mapped to an "average brain." Each patient had 3-17 sites stimulated
On a macro-scale, motor intent and illusory movement seem to be mixed in regions

46% of stimulation sites had no effect

Intention without Movement (9 / 57 sites)



In the parietal cortex, they found sites, shown by these triangles, where stimulation elicited a desire to move.
These illusory movement indicators next to them are the same location, increased stim current = illusory movement

Now the question is: is it simply because of slight muscle contractions that are not visible? No, because no EMG

What's interesting is that these feelings are associated with specific body parts, and that EMG shows that there's no actual movement

PPC Stimulation

- Shows 2 examples.
  - Patient 1, relatively easy to elicit illusory
  - Patient 2, some no-response, some responses. Result in
- Perceived movement, no movement (visual + EMG)

" Stimulation here produced a desire or intention to move, although no movement actually occured:

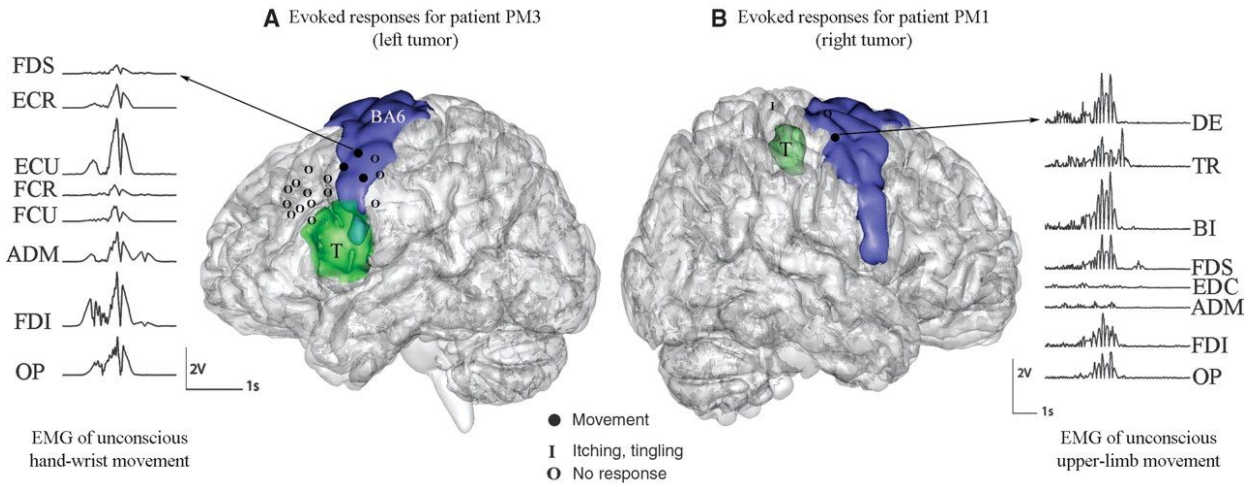
Stimulation of all these sites produced a pure intention, that is, a felt desire to move without any overt movement being produced… Without prompting by the examiner, all three patients spontaneously used terms such as “will,” “desire,” and “wanting to,”

which convey the voluntary character of the movement intention and its attribution to an internal source, that is, located within the self."

All examples in supplementary materials were on longer end: 4 seconds of stim

Figure notes:
T indicates tumor; TR, triceps;
BI, biceps; FDS, flexor digitorium superficialis; FCR, flexor carpi radialis;
EDC, extensor digitorium communis; ADM, abductor digiti minimi; FDI,
first dorsal interosseous; OP, opponens pollicis; and OO, orbicularis oris.
Colored areas define the anatomical boundaries of the tumor (green), BA
40 (yellow), and BA 39 (orange).

Movement without Awareness (10 / 57 sites)



Also interesting was that when the premotor cortex were stimulated, the patients sometimes moved. But they were not aware that they had done so.

" Patient PM 1, shown on the right, had this large multijoint movement involving flexion of the left wrist, fingers, and elbow … He did not spontaneously comment on this, and when asked whether he had felt a movement he responded negatively."
PM1 and PM2 actually experienced seizures. Not aware of current scales - but maybe it was too high?

At what point would you recognize that you're moving?

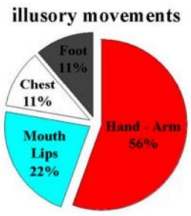
- Proprioception?

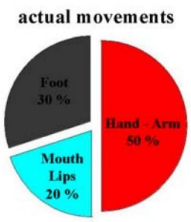
Supplementary materials - seems to be variety of different lengths. As you can see from EMG: only takes a few seconds to elicit motion

Figure notes
"Individual brains and stimulation sites reconstructed for two patients harboring precentral tumors. EMG signals are shown for the
stimulation sites identified by arrows. DE, deltoid; ECR, extensor carpi radialis; ECU, extensor carpi ulnaris; and FCU, flexor carpi ulnaris. Colored areas
define the anatomical boundaries of the tumor (green) and BA 6 (blue)."

Summary of Observations

	Intent/Belief	Actual
Right Inferior Parietal	Move left limbs	No movement
Left Inferior Parietal	Move lips and talk	No movement
Premotor	No movement	Moved mouth / contralateral limbs





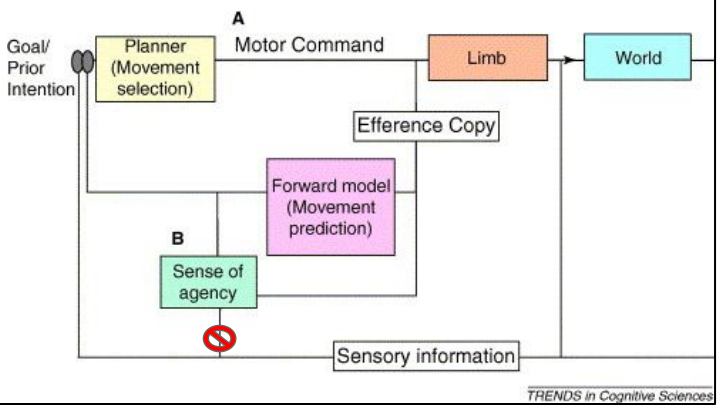
All of the parietal "will to move" needed 4 seconds of stimulation

The premotor cortex only needed 2 seconds

Movement unaware despite different sizes of movement?

Takeaways

- Movement intent and awareness arise from increased parietal activity
- Perception of movement not from proprioception



Might have thought: we would still be aware of our actions, based on proprioception, etc

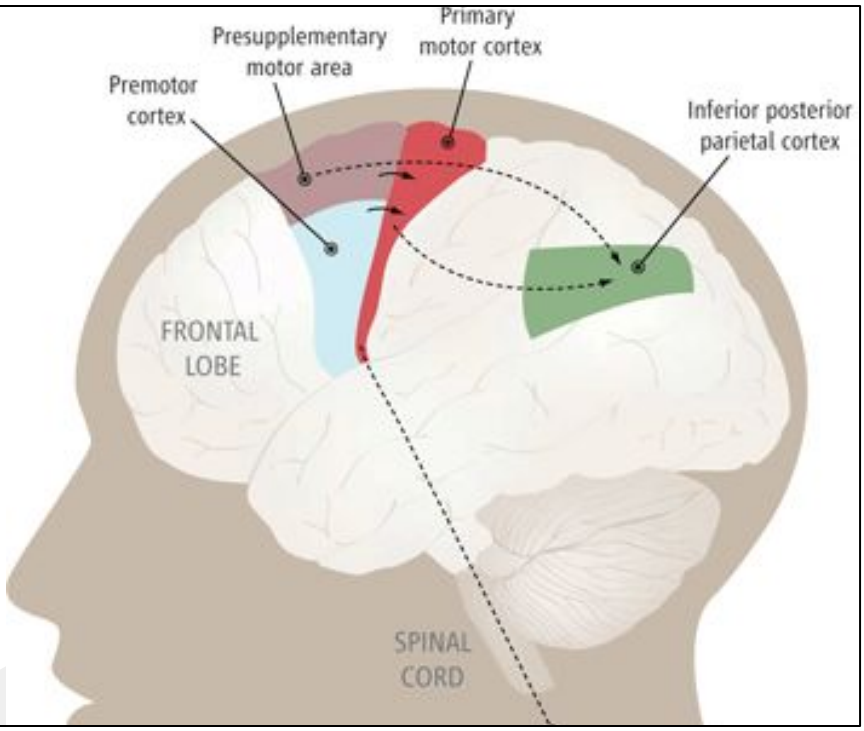
"perception of movement depends upon the neurones encoding the intention to move rather than those involved in producing the actual motor act."

"largely unaware of sensory feedback about the ongoing state ofour motor system, as long as our intentions are achieved"
Cited in another paper: hemiplegic patients with dorsal premotor cortex lesioned - claim they can move their limbs, even though they can't - because of this forward model?

Conversely, also suggests that inferior parietal lesions could cause a sense of no control over body movements. However, reverse is true: patients with parietal lesions often overly attribute actions to their own

Mechanisms and Open Questions

- Activation vs deactivation
- Presupplementary motor area
- "Planner" area



https://cellbiology.med.unsw.edu.au/cellbiology/index.php?title=File:Convergence_and_Divergence_of_Neural_Pathways.jpg

If you can stimulate + generate behavior, we must be involving networks. Question is: are we stimulating in the middle of the network, or at the generating spot?

We can have a sense of agency without sensory feedback

"SMA triggers an urge to move that resembles an irrepressible desire tomove going beyond patients' will (26). This suggests a potential role of SMA in generating motor intentions (2, 27). However, intentions evoked by stimulation of SMA stand"

"Intentions in the parietal lobe may be processed in relation to sensory predictions, whereas in the SMA intentions may be more closely related to motor commands"

Answered the question of how we become aware of motor intent. Rising activity in PPC, but still not exactly sure where that input comes from in the first place.

Thanks for listening!

Questions?