Brain-machine interfaces using motor cortex (M1) and posterior parietal cortex (PPC) recordings

(background only)

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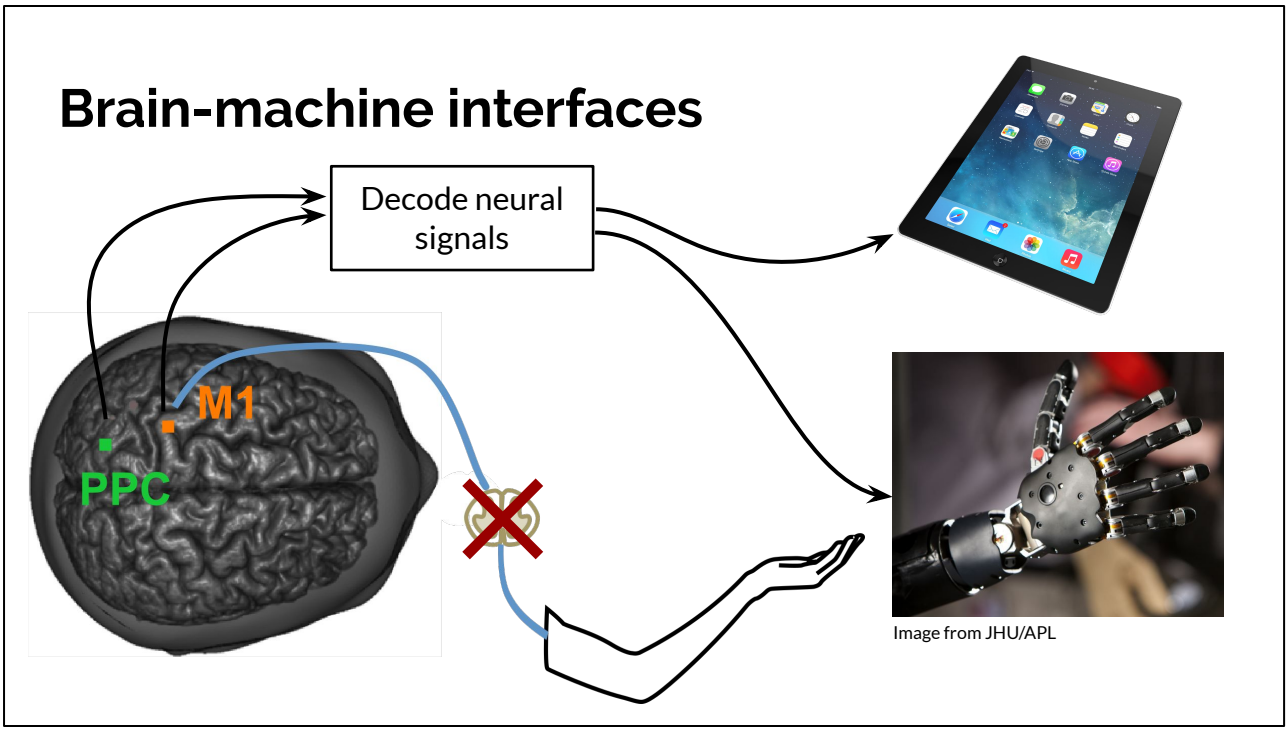
Background slides for a talk I gave at the Human Single-Neuron social at Society for Neuroscience 2019 in Chicago.



Our lab works with spinal cord injury patients to study the brain and develop neural prosthetics.

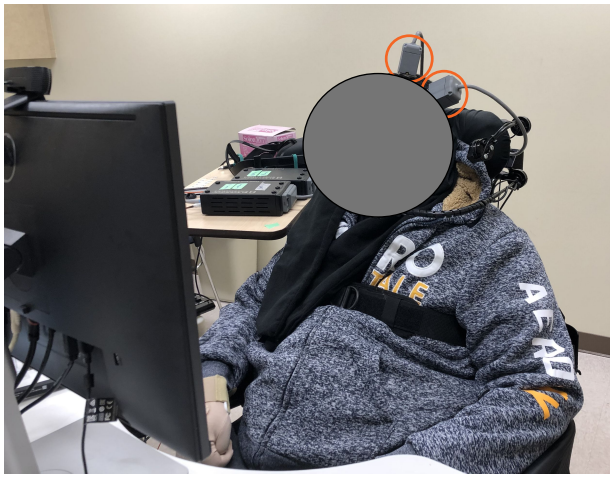
In able-bodied humans, the brain sends motor commands through the spinal cord. For people with severe spinal cord injuries, this signal pathway is damaged, resulting in paralysis.

However, people with SCI can still plan and attempt movements, and we can decode these neural signals to control a robotic limb or a cursor on a computer screen

Appendix:

- paralysis >750,000 / year (US)
    - Not all tetraplegia though, just paralysis of some sort

Human recording for BMI



Research subject J.J.

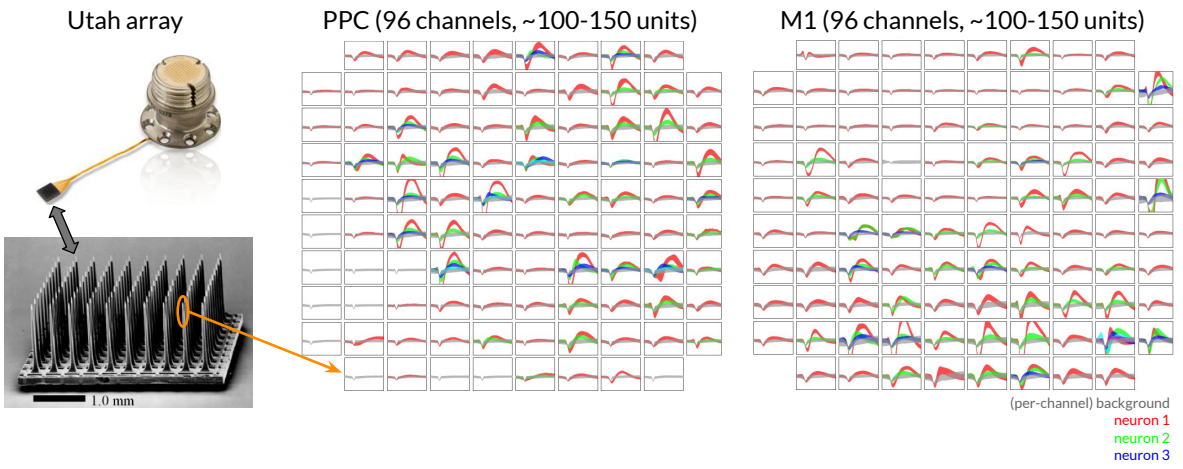
The data I'm going to present is from J.J., pictured here. J.J. puts as much into our research as we do, so we like to acknowledge that by showing his photo.

J.J. had a spinal cord injury, leaving him tetraplegic, meaning he can't move his hands or legs. We still can record his cortical signals during attempted movements, sending those signals through these cables highlighted in orange.

Appendix

- ~25 people who have undergone this surgery, 12 associated with BrainGate

Microelectrode array recordings



We record using 2 intracortical microelectrode arrays implanted on JJ's cortex.

The left image shows 2 views of the Utah array we use, manufactured by Blackrock.

The bottom left shows the array's 10x10 grid of recording electrodes, which are connected through thin cables through a pedestal that can connect to outside the body, shown in the top left.

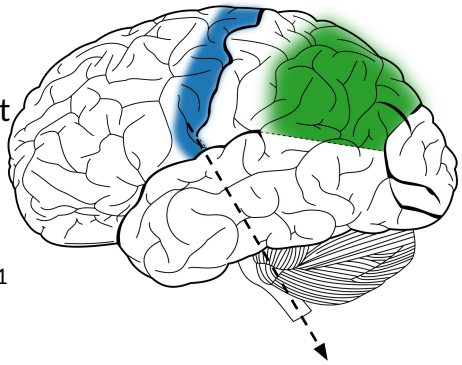
Each of the 96 channels (circled in orange) record from around 1-3 single neurons, shown in an individual box. The waveforms are example neuron action potentials, colored by neuron index (unique per electrode).

Since we implant 1 array in PPC and 1 array in motor cortex, we simultaneously record from a few hundred neurons. We process these signals to decode motor intent

Implant Regions

Primary Motor Cortex (M1)

- Generate movement commands
- Hand-knob
- Used in human BMI[1]



Posterior Parietal Cortex (PPC)

- High-level plans
- Forward model
- Reach/grasp
- Used in human BMI[2]

[1] Hochberg et al. (2006). [2] Aflalo et al. (2015)

We've implanted JJ's arrays in 2 areas of the brain.

In blue, the more anterior shaded region:

- primary motor cortex, which I'll refer to as M1
- Involved in movement command generation
- implanted near hand-knob, which is associated with hand/finger movements
- M1 signals were used in early human BMI

In green, the more posterior region:

- posterior parietal cortex, which I will refer to PPC.
- parts of PPC have been associated with
  - high-level movement plans
  - forward model for movement
  - reach/grasp actions
- A few years ago, our own lab demonstrated a BMI using PPC signals alone

These areas have been used separately for previous BMIs, and a natural question: do the 2 brain areas work well together?