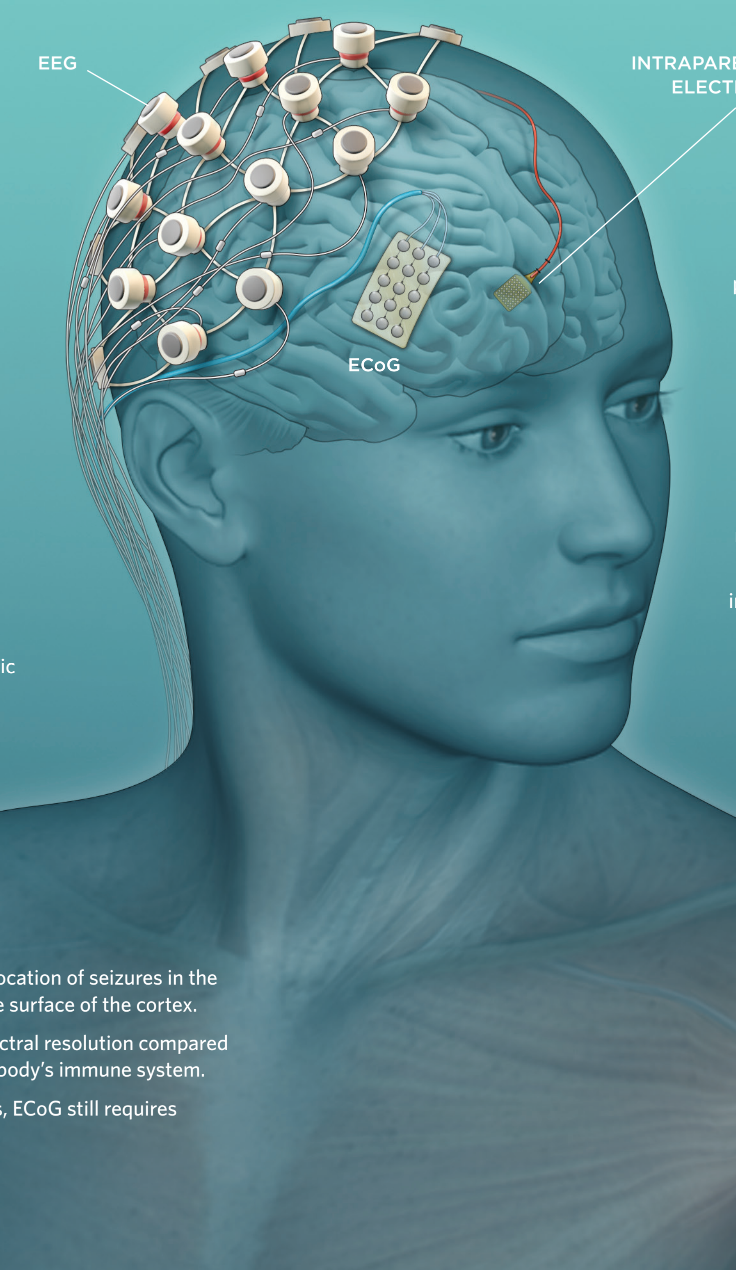
BRAIN INTERFACING

Cortical activity can be measured in a number of ways, with electrodes placed on the skull, on the surface of the brain, or within the brain tissue itself. Changes in this activity can then be correlated with a cognitive action—a real or imagined movement, for example—and these changes can in turn signal the subject's intention to a computer, which converts the signal into some kind of output, such as the movement of a cursor on a screen or of a robotic limb.



ELECTROENCEPHALOGRAPHY (EEG)

Electrodes placed on a subject's scalp

Pro: EEG is an easy-to-use, noninvasive method for recording brain activity averaged over specific regions of the cortex.

Con: Recording from the outside of the skull means that electrodes must pick up brain activity through bone, scalp, and membranes, which limit signal resolution both spatially and temporally.

ELECTROCORTICOGRAPHY (ECoG)

Electrode constructs, long used to identify the location of seizures in the surgical treatment of epilepsy, are placed on the surface of the cortex.

Pro: These electrodes have high spatial and spectral resolution compared with EEG and are generally not attacked by the body's immune system.

Con: While less invasive than deeper electrodes, ECoG still requires invasive brain surgery.

INTRAPARENCHYMAL ELECTRODES

Recording electrodes placed directly into brain tissue

Pro: The high resolution that comes with direct recording of neurons—down to the level of individual action potentials—allows more precise control over neuroprosthetic devices.

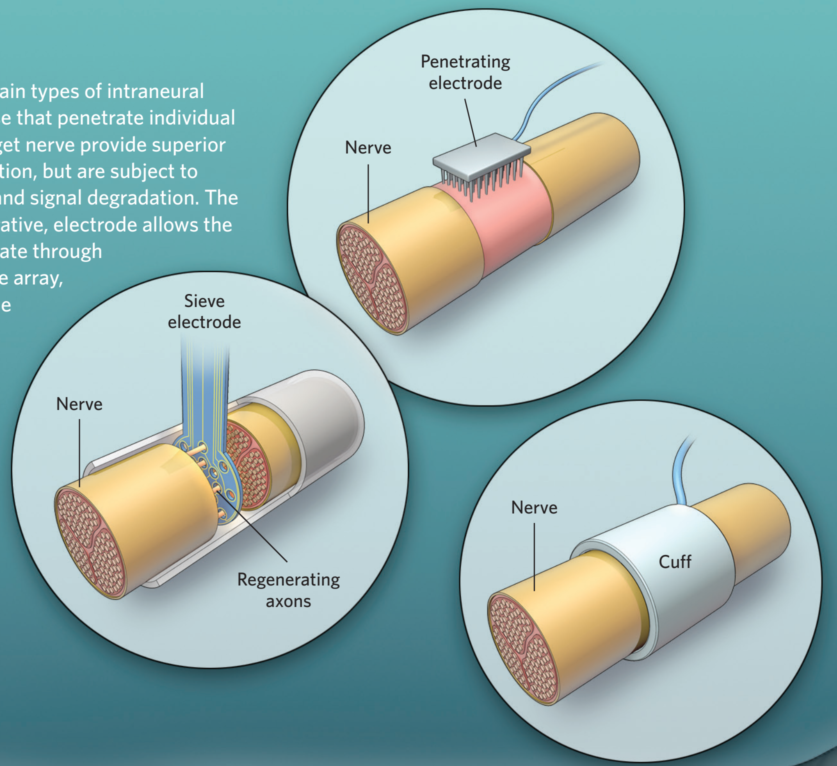
Con: Such recording involves invasive surgery, and the electrodes are subject to gliosis, an immune process that results in scarring at the electrode interface, thereby limiting their recording ability.

PERIPHERAL INTERFACING

Peripheral nerves, those outside of the brain and spinal cord, can also serve as the source signal for neuroprosthetic device control, as well as help patients recover sensory and autonomic functions. Peripheral nerves are more easily exposed, allowing researchers to link them with devices with less surgical risk.

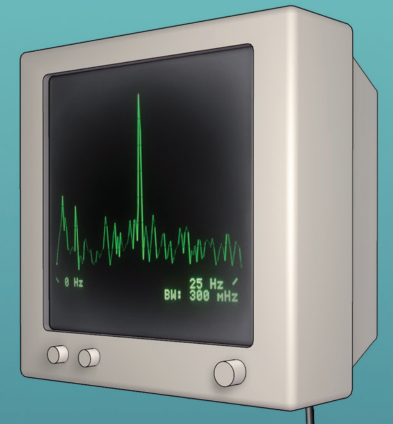
INTRANEURAL

There are two main types of intraneural electrodes. Those that penetrate individual axons of the target nerve provide superior recording resolution, but are subject to immune attack and signal degradation. The sieve, or regenerative, electrode allows the nerve to regenerate through small holes in the array, providing a stable interface. But inserting such electrode arrays requires transecting the nerve to position the electrode in the cross section.



ELECTROMYOGRAPHY (EMG)

Monitoring the electrical signature generated by muscle contractions can provide yet another source signal for neuroprosthetic devices.



EXTRANEURAL

Extraneural designs wrap around the nerve, avoiding penetrating individual axons, but offer reduced selectivity to different fibers within the nerve. Such electrodes could also result in compression injury, restricted blood flow, and poor contact properties.