Brain function

Brain functions such as perception, motor control, learning, and memory arise from the coordinated activity of neuronal assemblies distributed across multiple brain regions.

Information from the sense organs is collected in the brain. There it is used to determine what actions the organism is to take. The brain processes the raw data to extract information about the structure of the environment. Next it combines the processed information with information about the current needs of the animal and with memory of past circumstances. Finally, on the basis of the results, it generates motor response patterns. These signal-processing tasks require an intricate interplay between a variety of functional subsystems.

The function of the brain is to provide coherent control over the actions of an animal. A centralized brain allows groups of muscles to be co-activated in complex patterns; it also allows stimuli impinging on one part of the body to evoke responses in other parts, and it can prevent different parts of the body from acting at cross-purposes to each other.

While major progress has been made in understanding the function of individual neurons, circuit interactions remain poorly understood. A fundamental obstacle to deciphering circuit interactions is the limited availability of research tools to observe and manipulate the activity of large, distributed neuronal populations in humans.

Chiang et al. described the development, validation, and dissemination of flexible, high-resolution, thin-film (TF) electrodes for recording neural activity in animals and humans.

They leveraged standard flexible printed-circuit manufacturing processes to build high-resolution TF electrode arrays. They used biocompatible materials to form the substrate (liquid-crystal polymer; LCP), metals (Au, PtIr, and Pd), molding (medical-grade silicone), and 3D-printed housing (nylon). They designed a custom, miniaturized, digitizing headstage to reduce the number of cables required to connect to the acquisition system and reduce the distance between the electrodes and the amplifiers. A custom mechanical system enabled the electrodes and headstages to be pre-assembled prior to sterilization, minimizing the setup time required in the operating room. PtIr electrode coatings lowered impedance and enabled stimulation. High-volume, commercial manufacturing enables cost-effective production of LCP-TF electrodes in large quantities.

The LCP-TF arrays achieve 25× higher electrode density, 20× higher channel count, and 11× reduced stiffness than conventional clinical electrodes. We validated our LCP-TF electrodes in multiple human intraoperative recording sessions and have disseminated this technology to >10 research groups. Using these arrays, we have observed high-frequency neural activity with sub-millimeter resolution.

This LCP-TF electrodes will advance human neuroscience research and improve clinical care by enabling broad access to transformative, high-resolution electrode arrays [1)].

Functional architecture

The intrinsic functional organization of the brain changes into older adulthood. Age differences are

observed at multiple spatial scales, from global reductions in modularity and segregation of distributed brain systems, to network-specific patterns of dedifferentiation. Whether dedifferentiation reflects an inevitable, global shift in brain function with age, circumscribed, experience-dependent changes, or both, is uncertain. Setton et al. employed a multimethod strategy to interrogate dedifferentiation at multiple spatial scales. Multi-echo (ME) resting-state fMRI was collected in younger (n = 181) and older (n = 120) healthy adults. Cortical parcellation sensitive to individual variation was implemented for precision functional mapping of each participant while preserving group-level parcel and network labels. ME-fMRI processing and gradient mapping identified global and macroscale network differences. Multivariate functional connectivity methods tested for microscale, edge-level differences. Older adults had lower BOLD signal dimensionality, consistent with global network dedifferentiation. Gradients were largely age-invariant. Edge-level analyses revealed discrete, network-specific dedifferentiation patterns in older adults. Visual and somatosensory regions were more integrated within the functional connectome; default and frontoparietal control network regions showed greater connectivity; and the dorsal attention network was more integrated with heteromodal regions. These findings highlight the importance of multiscale, multimethod approaches to characterize the architecture of functional brain aging [2].

1)
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2)
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