Language mapping

Language mapping is often used to protect language functions during surgery for temporal lobe epilepsy or brain tumors.

Language mapping is done during surgery while the patient is awake and interactive. This is possible because the brain itself does not have pain receptors.

The patient is shown sequential pictures of common objects, while a region of the brain is electrically stimulated in one-centimeter increments.

When the patient cannot successfully name objects during stimulation of a particular part of the brain, that brain area is concluded to be important for visual object naming.

The widely held belief is that visual object naming is primarily a function of the lateral [outermost] temporal lobe.

Mapping the language system has been crucial in preoperative evaluation especially when the area to be resected is near the relevant eloquent cortex. Functional magnetic resonance imaging (fMRI) proved to be a noninvasive alternative to the Wada test that can account not only for language lateralization but also for localization when appropriate tasks and MRI sequences are being used. The tasks utilized during the fMRI acquisition are playing a crucial role in which areas will be activated. Recent studies demonstrated that key language regions exist outside the classical "Wernicke-Lichtheim-Geschwind model," but sensitive tasks must take place in order to be revealed. On top of that, the tasks should be in the mother tongue for appropriate language mapping to be possible.

For that reason, in this study, Gkiatis et al. adopted an English protocol that can reveal six language critical regions even in clinical setups and we translated it into Greek to prove its efficacy in a Greek population. Twenty healthy right-handed volunteers were recruited and performed the fMRI acquisition in a standardized manner.

Results demonstrated that all six language critical regions were activated in all subjects as well as the group mean map. Furthermore, activations were found in the thalamus, the caudate, and the contralateral cerebellum.

Gkiatis et al. standardized an fMRI protocol in Greek and proved that it can reliably activate six critical language regions. They validated its efficacy for presurgical language mapping in Greek patients capable to be adopted in clinical setup [1)].

Methodologies

There are numerous methodologies. One protocol for cortical mapping:

1. requires awake craniotomy

2. once the temporal lobe is exposed, a recording electrode strip is placed on the brain surface

3. using a bipolar stimulator, start with a low current (e.g. 2 mA) and begin stimulating an area of the cortex for 3–5 seconds, and observe for afterdischarges (akin to a focal seizure) on the recording strip. If no afterdischarges, increase the current in 2 mA increments up to a maximum of ≈ 10 mA. If afterdischarges occur, back off by 1–2 mA and then test that area for speech changes as follows

4. stimulate cortex while patient names objects shown on picture cards (automatic verbalization, such as counting, is robust and may persist). Observe for effects including [2]:

a) total speech arrest [3]: on the dominant hemisphere typically in the pars opercularis or precentral gyrus, but also in frontal operculum and temporoparietal region. On the non dominant hemisphere, this ocurred only in the pars opercularis.

b) able to speak but unable to name [4] [5] (dysnomia): in dominant hemisphere, typically in posterior inferior frontal gyrus, and posterior temporal and inferior parietal regions

c) semantic errors: posterior middle temporal gyrus, anterior supramarginal gyrus and inferior frontal gyrus

d) phonological paraphrasias, neologisms and circumlocution: superior temporal sulcus

e) NB: subcortical fiber mapping may identify white matter tracts that participate in language processing (see reference [6])

5. repeat the above steps at the next area (first finding threshold for afterdischarges and then stimulating while testing).

Navigated transcranial magnetic stimulation for language mapping

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Case series

A novel analytic approach for task-related high-gamma modulation (HGM) in stereoelectroencephalography (SEEG) was developed and evaluated for language mapping.

SEEG signals, acquired from drug-resistant epilepsy patients during a visual naming task, were analyzed to find clusters of 50-150 Hz power modulations in time-frequency domain. Classifier models to identify electrode contacts within the reference neuroanatomy and Electrostimulation mapping (ESM) speech/language sites were developed and validated.

In 21 patients (9 females), aged 4.8-21.2 years, SEEG HGM model predicted electrode locations within Neurosynth language parcels with high diagnostic odds ratio (DOR 10.9, $p < 0.0001$), high specificity (0.85), and fair sensitivity (0.66). Another SEEG HGM model classified ESM speech/language sites with significant DOR (5.0, $p < 0.0001$), high specificity (0.74), but insufficient sensitivity. Time to largest power change reliably localized electrodes within Neurosynth language parcels, while, time to center-of-mass power change identified ESM sites.

SEEG HGM mapping can accurately localize neuroanatomic and ESM language sites.

Significance: Predictive modelling incorporating time, frequency, and magnitude of power change is a useful methodology for task-related HGM, which offers insights into discrepancies between HGM language maps and neuroanatomy or ESM [7].

References

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