Navigated transcranial magnetic stimulation for language mapping

Language mapping by navigated transcranial magnetic stimulation (TMS) is commonly applied over the left language- dominant hemisphere to indicate the language-related cortex. Detailed language mapping of Broca's area including stimulation targets in the immediate vicinity to the premotor cortex may raise concern about confounding unspecific motor effects. Sakreida et al. performed interhemispheric comparisons to delineate such possible unspecific effects from true TMS-induced language inhibition.

Fifteen healthy German speakers named object pictures during navigated TMS over a left- and right-hemispheric target array covering the left inferior frontal junction area. Six mapping repetitions were conducted per hemisphere. Order of stimulation side was randomized between participants. Self-rating of discomfort was assessed after each stimulation; language errors and motor side effects were evaluated offline.

Naming errors were observed significantly more frequently during left- than right-hemispheric stimulation. The same pattern was found for the most frequent error category of performance errors. Hierarchical cluster analyses of normalized ratings of error severity revealed a clear focus of TMS susceptibility for language inhibition in object naming at the dorsoposterior target sites only in the left hemisphere. We found no statistical difference in discomfort ratings between both hemispheres and also no interhemispheric difference in motor side effects, but we observed significantly stronger muscle contractions of the eyes as compared with the mouth.

The results of (1) unspecific pre-/motor effects similarly induced in both hemispheres, and (2) a specific focus of TMS susceptibility in the language-dominant hemisphere render any substantial contribution of nonlanguage-specific effects in TMS language mapping of the inferior frontal junction area highly unlikely [1)].

In comparison with fMRI, navigated transcranial magnetic stimulation (rTMS) is a more sensitive but less specific tool for preoperative language mapping than direct cortical stimulation DCS.

A wide range of studies on language assessment during awake brain surgery is nowadays available. Yet, a consensus on a standardized protocol for intraoperative language mapping is still lacking. More specifically, very limited information is offered about intraoperative assessment of a crucial component of language such as syntax.

A review of the Epistemogy and Theoretical Syntax Research Center (NETS), Scuola Universitaria Superiore IUSS Pavia, Piazza della Vittoria, 15, 27100, Pavia, Italy and the Unit of Oncological Neurosurgery, Humanitas Research Hospital, 20089 Rozzano, Milan, Italy, aims at critically analyzing the intraoperative studies investigating the cerebral basis of syntactic processing. A comprehensive query was performed on the literature, returning a total of 18 studies. These papers were analyzed according to two complementary criteria, based on the distinction between morphosyntax and syntax. The first criterion focused on the tasks and stimuli employed intraoperatively. Studies were divided into three different groups: group 1 included those studies that overtly aimed at investigating morphosyntactic processes; group 2 included studies that did not explicitly focus on syntax, yet employed stimuli requiring morphosyntactic processing; and group 3 included studies reporting some

generic form of syntactic deficit, although not further investigated. The second criterion focused on the syntactic structures of the sentences assessed intraoperatively, analyzing the canonicity of sentence structure (i.e., canonical versus non-canonical word order). The global picture emerging from our analysis indicates that what was investigated in the intraoperative literature is morphosyntactic processing, rather than pure syntax. The study of the neurobiology of syntax during awake surgery seems thus to be still at an early stage, in need of systematic, linguistically grounded investigations [2)].

A study describes development of a novel language mapping approach using high-γ modulation in electrocorticography (ECoG) during spontaneous conversation, and its comparison with electrical cortical stimulation (ECS) in childhood-onset drug-resistant epilepsy.

This study supports the feasibility of language mapping with ECoG HGS during spontaneous conversation, and its accuracy compared to traditional ECS. Given long-standing concerns about ecological validity of ECS mapping of cued language tasks, and difficulties encountered with its use in children, ECoG mapping of spontaneous language may provide a valid alternative for clinical use [3)].

Repetitive navigated transcranial magnetic stimulation (rTMS) is now increasingly used for preoperative language mapping in patients with lesions in language-related areas of the brain. Yet its correlation with intraoperative direct cortical stimulation (DCS) has to be improved.

Although language mapping by repetitive navigated transcranial magnetic stimulation (rTMS) gains importance in neuropsychological research and clinical utility, neuroscientists still use different mapping protocols including different stimulation frequencies.

The stimulation frequency has to be adapted to the aim of the rTMS language investigation [4)].

Signal dropouts and distortions caused by susceptibility effects in the current standard echo planar imaging (EPI)-based fMRI images are well-known problems and pose a major hurdle for the application of fMRI in several brain regions, many of which are related to language mapping in presurgical planning. Such artifacts are particularly problematic in patients with previous surgical resection cavities, craniotomy hardware, hemorrhage, and vascular malformation. A recently developed T2-prepared (T2prep) fMRI approach showed negligible distortion and dropouts in the entire brain even in the presence of large susceptibility effects. Here, we present initial results comparing T2prep- and multiband EPI-fMRI scans for presurgical language mapping using a sentence completion task in patients with brain tumor and epilepsy. In all patients scanned, T2prep-fMRI showed minimal image artifacts (distortion and dropout) and greater functional sensitivity than EPI-fMRI around the lesions containing blood products and in air-filled cavities. This enhanced sensitivity in T2prep-fMRI was also evidenced by the fact that functional activation during the sentence completion task was detected with T2prep-fMRI but not with EPI-fMRI in the affected areas with the same statistical threshold, whereas cerebrovascular reactivity during a breath-hold task was preserved in these same regions, implying intact neurovascular coupling in these patients. Although further investigations are required to validate these findings with invasive methods such as direct cortical stimulation mapping as the gold standard, this approach provides an alternative method for performing fMRI in brain regions with large susceptibility effects [5)].

Navigated transcranial magnetic stimulation for motor mapping is a reliable and clinically validated tool to identify functional areas belonging to both normal and lesioned primary motor cortex.

In respect to language mapping with repetitive nTMS, literature reports have yielded variable results, and it is currently not routinely performed for presurgical language localization.

The expert panel recommends nTMS motor mapping in routine neurosurgical practice, as it has a sufficient level of evidence supporting its reliability. The panel recommends that nTMS language mapping be used in the framework of clinical studies to continue refinement of its protocol and increase reliability [6].

Although language mapping by repetitive navigated transcranial magnetic stimulation (rTMS) gains importance in neuropsychological research and clinical utility, neuroscientists still use different mapping protocols including different stimulation frequencies.

The stimulation frequency has to be adapted to the aim of the rTMS language investigation [7].

Case series

Navigated transcranial magnetic stimulation for language mapping case series.

1)
Sakreida K, Blume-Schnitzler J, Frankemölle G, Drews V, Heim S, Willmes K, Clusmann H, Neuloh G. Hemispheric Dominance for Language and Side Effects in Mapping the Inferior Frontal Junction Area with Transcranial Magnetic Stimulation. J Neurol Surg A Cent Eur Neurosurg. 2020 Feb 11. doi: 10.1055/s-0040-1701236. [Epub ahead of print] PubMed PMID: 32045945.
2)
Zanin E, Riva M, Bambini V, Cappa SF, Magrassi L, Moro A. The contribution of surgical brain mapping to the understanding of the anatomo-functional basis of syntax: A critical review. Neurol Sci. 2017 Jun 17. doi: 10.1007/s10072-017-3016-4. [Epub ahead of print] Review. PubMed PMID: 28624915.
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Arya R, Wilson JA, Vannest J, Byars AW, Greiner HM, Buroker J, Fujiwara H, Mangano FT, Holland KD, Horn PS, Crone NE, Rose DF. Electrocorticographic language mapping in children by high-gamma synchronization during spontaneous conversation: Comparison with conventional electrical cortical stimulation. Epilepsy Res. 2015 Feb;110:78-87. doi: 10.1016/j.eplepsyres.2014.11.013. Epub 2014 Nov 22. PubMed PMID: 25616459.
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5)
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6)
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