Local field potential

A local field potential (LFP) is an electrophysiological signal generated by the summed electric current flowing from multiple nearby neurons within a small volume of nervous tissue. Voltage is produced across the local extracellular space by action potentials and graded potentials in neurons in the area, and varies as a result of synaptic activity.

Thompson et al. studied local field potential (LFP) recordings in PD subjects undergoing STN-DBS over the course of a full night's sleep.

They examined the changes in oscillatory activity recorded from STN between ultradian sleep states to determine whether sleep-stage-dependent spectral patterns might reflect underlying dysfunction. For this study, PD (n=10) subjects were assessed with concurrent polysomnography and LFP recordings from the DBS electrodes, for an average of 7.5 hours in an 'off' dopaminergic medication state. Across subjects, we found conserved spectral patterns among the canonical frequency bands (delta 0-3 Hz, theta 3-7 Hz, alpha 7-13 Hz, beta 13-30 Hz, gamma 30-90 Hz, and high frequency 90-350 Hz) that were associated with specific sleep cycles: delta (0-3 Hz) activity during non-rapid eye movement (NREM) associated stages was greater than during Awake, whereas beta (13-30 Hz) activity during NREM states was lower than Awake and rapid eye movement (REM). In addition, all frequency bands significantly differed between NREM states and REM. However, each individual subject exhibited a unique mosaic of spectral interrelationships between frequency bands. Our work suggests that LFP recordings from human STN differentiate between sleep cycle states, and sleep-state-specific spectral mosaics may provide insight into mechanisms underlying sleep pathophysiology [1].

Although recently introduced directional leads provide control of the stimulation field, programming is time-consuming.

Tinkhauser et al. validate local field potentials recorded from directional contacts as a predictor of the most efficient contacts for stimulation in patients with PD.

Intraoperative local field potentials were recorded from directional contacts in the STN of 12 patients and beta activity was compared with the results of the clinical contact review performed after 4 to 7 months.

The normalized beta activity was positively correlated with the contact's clinical efficacy. The two contacts with the highest beta activity included the most efficient stimulation contact in up to 92% and that with the widest therapeutic window in 74% of cases.

Local field potentials predict the most efficient stimulation contacts and may provide a useful tool to expedite the selection of the optimal contact for directional DBS [2].

Local field potentials were recorded from 8 patients implanted with depth-electrodes in Heschl's gyrus and the planum temporale (55 recording sites in total), usually considered as human primary and secondary auditory cortices. Using a frequency-tagging approach, Nozaradan et al. show that both low-frequency (<30 Hz) and high-frequency (>30 Hz) neural activities in these structures faithfully track auditory rhythms through frequency-locking to the rhythm envelope. A selective gain in the amplitude of the response frequency locked to the beat frequency was observed for the low-frequency activities but not for the high-frequency activities, and was sharper in the planum temporale, especially for the more challenging syncopated rhythm. Hence, this gain process is not systematic in all activities produced in these areas and depends on the complexity of the rhythmic input. Moreover, this gain was disrupted when the rhythm was presented at a fast speed, revealing low-pass response properties which could account for the propensity to perceive a beat only within the musical tempo range. Together, these observations show that, even though part of these neural transforms of rhythms could already take place in subcortical auditory processes, the earliest auditory cortical processes shape the neural representation of rhythmic inputs in favor of the emergence of a periodic beat [3).

A study compared the cortical local field potentials (LFPs) in the primary motor cortex (M1) and the supplementary motor area (SMA) of non-human primates rendered Parkinsonian with the administration of dopaminergic neurotoxin, 1-methyl-4-phenyl-1,2,3,6-tetrahydropyridine. The dynamic of the LFPs was investigated under several mathematical frameworks and machine learning was used to discriminate the recordings based on these features between healthy, parkinsonian with off-medication, and parkinsonian with on-medication states. The importance of each feature in the discrimination process was further investigated. The dynamic of the LFPs in M1 and SMA was affected by its variability (time domain analysis), oscillatory activities (frequency domain analysis), and complex patterns (non-linear domain analysis). Machine learning algorithms achieved accuracy near 0.90 for comparisons between conditions. The TreeBagger algorithm provided the best accuracy. The relative importance of these features differed with the cortical location, condition, and treatment. Overall, the most important features included beta oscillation, fractal dimension, gamma oscillation, entropy, and asymmetry of amplitude fluctuation. The importance of features in discriminating between normal and pathological states, and on- or off-medication states depends on the paired comparison and it is region-specific. These findings are discussed regarding the refinement of current models for movement disorders and the development of on-demand therapies [4).

1)

Thompson JA, Tekriwal A, Felsen G, Ozturk M, Telkes I, Wu J, Ince NF, Abosch A. Sleep patterns in Parkinson's disease: direct recordings from the subthalamic nucleus. J Neurol Neurosurg Psychiatry. 2017 Sep 2. pii: jnnp-2017-316115. doi: 10.1136/jnnp-2017-316115. [Epub ahead of print] PubMed PMID: 28866626.

2)

Tinkhauser G, Pogosyan A, Debove I, Nowacki A, Shah SA, Seidel K, Tan H, Brittain JS, Petermann K, di Biase L, Oertel M, Pollo C, Brown P, Schuepbach M. Directional local field potentials: A tool to optimize deep brain stimulation. Mov Disord. 2017 Nov 18. doi: 10.1002/mds.27215. [Epub ahead of print] PubMed PMID: 29150884.

3)

Nozaradan S, Mouraux A, Jonas J, Colnat-Coulbois S, Rossion B, Maillard L. Intracerebral evidence of rhythm transform in the human auditory cortex. Brain Struct Funct. 2016 Dec 18. [Epub ahead of print] PubMed PMID: 27990557.

4)

Darbin O, Hatanaka N, Takara S, Kaneko M, Chiken S, Naritoku D, Martino A, Nambu A. Local field potential dynamics in the primate cortex in relation to parkinsonism reveled by machine learning: A comparison between the primary motor cortex and the supplementary area. Neurosci Res. 2020 Jan 25. pii: S0168-0102(20)30015-8. doi: 10.1016/j.neures.2020.01.012. [Epub ahead of print] PubMed

PMID: 31991205.