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The LFP represents the synchronous firing activity of ~~hundreds of thousands~~ of neurons (xx) in an area around 250 µm from the recording electrode (Katzner, Nauhaus, Benucci, Bonin, Ringach et al., 2009, Neuron; Xing, Yeh, & Shapley, 2009, J Neurosc). In contrast, because the amplitude of single neurons rapidly declines with an increasing distance to the neuron soma, we cannot reliably record single neuron activity further than 100 μm away with current methods (doi.org/10.1529/biophysj.107.111179; doi.org/10.1038/nn1233).

POS is a measure of phase opposition between to conditions. That means even if there is a high Inter Spike Consistency (ISC) within each condition (e.g., encoding and retrieval) if the phase preference is the same between conditions the phase opposition will be low. In order to compute the POS, we require at least 11 spikes in each condition. We computed the POS on the level of the neuron to account of inter-neuron difference in phase preference. The formular for POS is given by:

(1)

ISC is defined as (xx Tallon-Baudry et al., 1996; Lachaux et al., 1999 10.3389/fnins.2016.00426 xx?):

(2)

(3)

(4)

is a complex number that represents the theta component at the times when the spikes occur (| is the magnitude of the signal and () is the phase at that time point). nenc and nret correspond to the numbers of spikes in the encoding and retrieval episodes, respectively, and nall  = nenc + nret.

To test the statistical significance of the empirical POS we shuffled the group identity for each trial 1,000 times and recomputed the POS. This allowed us to generate a baseline against which we compared the empirical POS. We have analysed the POS between encoding and encoding separately for ESN for reinstated trials contrasting the phase preference during encoding and retrieval, for later non-reinstated trials and for all other single neurons. We also calculated the POS for ESNs between reinstated and non-reinstated trials where we pooled the encoding and retrieval trials because there was no significant POS between encoding and retrieval trials for later reinstated and non-reinstated ESN trials.

I also show figures for SFC for encoding and retrieval for rESNs and SUs (?) and tested it using the Rayleigh test (cite toolbox)

-> calculate the difference and visualize

-> how do I shuffle for POS??

-> POS shuffling for rESN does not work because you just shuffle the one trial

However, there was a significant fast theta oscillation during encoding for reinstated episodes and non-reinstated episodes (reinstated episodes: *trein*(122) = 3.4233, *meanrein* = 6.9518, *serein* = 2.0307, *prein* = 0.00084282; non-reinstated episodes: *tnon-rein*(122) = 3.8151, *meanno-rein* = 10.4919, *seno-rein* = 2.7501, *pnon-rein* = 0.00021506) and during retrieval (reinstated episodes: *trein*(122) = 4.6513, *meanrei*n = 6.7263, *serein* = 1.4461, *prein* = 0.0000084372; non-reinstated episodes*: tnon-rein*(122) = 4.5176, *meanno-rein* = 10.4407, *seno-rein* = 2.3111, *pnon-rein* = 0.000014556).

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We next determined if there is significant oscillatory (i.e., periodic) activity in the (2-5 Hz) and fast (5-9 Hz) theta ranges. Using one-sample t-tests we found no significant slow theta oscillatory activity in experiment 1 (all p > 0.18). However, there was a significant fast theta oscillation in reinstated episodes and non-reinstated episodes during encoding (reinstated episodes: trein (122) = 3.4233, prein = 0.00084282; non-reinstated episodes: tnon-rein (122) = 3.8151, pnon-rein = 0.00021506) and during retrieval (reinstated episodes: trein (122) = 4.6513, prein = 0.0000084372; non-reinstated episodes: tnon-rein (122) = 4.5176, pnon-rein = 0.000014556) in experiment 1. In experiment 2 we found a significant slow and fast oscillation in reinstated and non-reinstated episodes during encoding (t slow rein (32) = 3.1599, pslow rein = 0.0034; t slow non-rein (32) = 4.9958, pslow non-rein = 0.000020117; t fast rein (32) = 3.7464, pfast rein = 0.00070996; t fast non-rein (32) = 3.9249, pfast non-rein = 0.0004323) and retrieval (tslow rein (32) = 3.8057, pslow rein = 0.00060249; t slow non-rein (32) = 5.4284, pslow non-rein < 0.00001; t fast rein (32) = 2.8623, pfast rein = 0.0074; tfast non-rein (32) = 3.4827, pfast non-rein = 0.0015).

An open question remains if all theta is created equal. Compared to rodents human theta activity is slower (xx) (hippocampal?) and hippocampal theta is split into slow (2-5 Hz) and fast (5-9 Hz) components (xx). Contrary to what has been believed for a long time there are separate theta generators in the hippocampus (septum, xx) and the cortex (xx).

On theta as well:

* Buzsaki STDP idea

Result section before I describe the phase opposition analysis:

For each neuron we determined the complex value of the narrowband component at the time of the relevant spikes during encoding and retrieval.

3B (High Frequency Power)

Assuming that the high frequency activity in the LFP in each high impedance microwire is independent, but in reality they are referenced using the same/a shared low impedance microwire. This is a problem depending on how local the high frequency component is (if it is only picked up by the low impedance microwire then they are all reflecting the same signal + noise; this is fine because the same is true for the 2nd order oscillation; if they reflect very local activity they might differ or form clusters of neurons that all have the same spatial orientation; we do not know how they relatively move during implantation). Hinges upon how local the high imedance and how local the low impedance wire records. HAven't found anything on behnke fried, only in the buzsaki paper on 100ym spikes and 250ym lfp but that was for grid electrodes.

gaussian for convolving is a problem for spikes~HFP. The other problem might be how I shuffle for the second order permutation. I do zscore but maybe the permuted correlation is low if I shuffle HFA of one microwire with a low firing neuron on another microwire. This should not be a problem if I shuffle episodes where I compare LFP and spikes of the same microwire.

Do something as a spike locked LFP? I did a time frequency plot but it wasn't anything nice.

Check out again “more notes”, “unknown” which has more theta info and notes on laptop with more details on HFP. I also have some interesting tabs open.