ATNx w Sub, RSC, CA1 LFP + spike recordings

Beth has roughly 46,912 LFP signals - how can we approach analysing these? Matheus has further signals in the CA1.

Questions

Primary Questions

- Is theta in RSC maintained after ATNx?
- Did the anterior thalamus lesions/inactivations disrupt theta in subiculum and CA1? Could this contribute to the effects observed?
- Is coherence present between RSC and SUB, and is this coherence different in Lesion/musc. Is this coherence reliably directed?

Secondary Questions

- Sean: Thinking along the line of; can we predict the L/R choice that rat makes in t-maze any worse after ATNx?

Plan

1. Decide on a full method to select LFP signals and to handle artefacts.
2. From this, perform general power spectrum calculations and autocorrelations between control and lesion data. [*This is ready to go once step 1 is complete*]
3. If there are differences (or none), what about the possible communication between SUB and RSC (e.g. coherence, see ideas).
4. With 2 and 3 in mind, are there any differences in coding? For example, could one more accurately decode the t-maze choice from the LFP signal in the control data.
5. What about the spike to LFP relationship. Is the spike-phase relationship widely different, or is the spike triggered average different? What about the spike lfp coherence?
6. Are there major differences in the sleep data to the awake data?

Methods

Process

Sean: I use this https://github.com/seankmartin/SIMURAN, but it is in progress and might be hard to work with, along with https://github.com/seankmartin/ATNxLFP.

Signal Processing

There will inevitably be some artefacts in the LFP recordings. Depending on the analysis being performed, this can be fine (e.g. if comparing two full recordings for changes in theta

power in the same animal, then the artefacts will likely cancel out). This is something I have worked a lot with Ham on, since his data is primarily LFP. The best tool we have found is MNE, see an Overview of artifact detection. What has worked best for us to clean signals is to use ICA, but it is quite a manual process, since you have to manually pick the decomposed channels that are full of clear artefacts. See the Images section.

For us, the best bet might be to take the mean of them, but also remove signals which seem to be dead/noisy (e.g. large deviation from the other signals).

Another option to combat artefacts in a simpler manner is to apply smoothing e.g. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7038754/. Actually the spectrogram after smoothing is a really good example of why removing artefacts often won't make a difference on a large scale. Also https://www.mathworks.com/help/signal/examples/signal-smoothing.html.

→ (Beth) previous data I've gone through and used 'good' electrodes and discarded 'bad' ones based on PSD, by plotting all and excluding weird looking ones - the official artefact detection looks like a more consistent way of doing it, and I've generally known at the beginning / when recording which are dead / noisy so it;s worked as a comparison… I guess this all mostly comes down to the same outcome, sortof? I'll have a proper look at it as it;s better to say in a paper 'we used this method' rather than 'took our the funny looking ones'

Behaviour

Bow-tie maze and the T-maze were the two in the paper. Also have wine bottle task. For now, probably best to focus on just BTM and T-maze since in the paper. Can do:

1. Decoding of decisions from LFP (e.g predict T-maze direction from a chunk of LFP data around the decision time [Would be nice to see. I think we dont have enough data to distinguish from the noise LFP - Matheus]).
2. Describe the power, coherence.

Also have open field recordings, in which case the running speed is probably also of interest.

Sleep

Other than looking for ripples, my knowledge of sleep analysis is not very good...

Spike-LFP interactions

Spike phase for e.g.

Thoughts

Concerns

1. I have not decided on a strategy for LFP selection and handling artefacts.
2. There are concerns over the volume conduction of signals from the rodent hippocampus to the rest of the brain, corrupting the coherence statistics, and leading to invalidity of the analysis. Furthermore, the SNR seems to have a large impact on the coherence statistic, and I am not sure how to address this. For more information on this topic, see Pesaran et al. in Nature neuro 2018.

Ideas

- One idea I have for this (though not ideal) is actually just to see how different it would be taking a random signal (or the first one for e.g.) vs taking an average of all the signals.
- Theory that coherence may indicate communication. However, based on the paper in nat neuro 2018 by Pesaran ea., it would seem coherence can be more corrupted in rodents that I originally thought (I suspected distant sources would peter out, leaving the signal mostly local - seems HC breaks this though due to volume conductivity in the rodent brain.) I may need to use some different measures. However, the overall goal here is to indicate correlations between SUB and RSC, to see if there seems to be differences between Lesion and control.

Progress

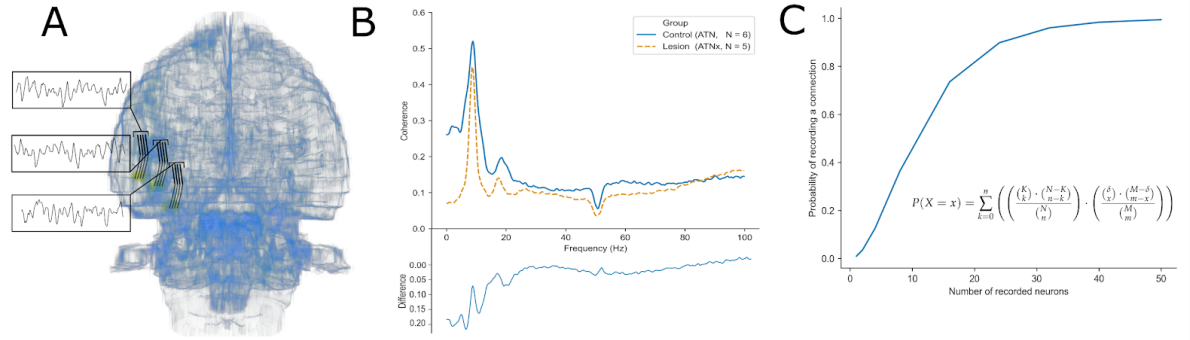
13/07/2020:

Started describing the recordings (so where each LFP is from and how many LFPs and single unit tetrodes there are) and running simple power calculations. Will need to do larger calculations, and some representative PSD and periodograms. Picture shows an example.

Recording_name	sub_delta	sub_theta	sub_low_gamma	sub_high_gamma	sub_total	sub_delta_rel	sub_theta_rel	sub_low_gamma_rel	sub_high_gamma_rel
04092017_CSubRet1_smallsq_d2_1.set	2399.294	6817.291	689.34	290.781	13845.776	0.173	0.492	0.05	0.021
07092017_CSubRet1_smallsq_d3_1.set	2352.027	7563.295	720.452	297.906	14828.41	0.159	0.51	0.049	0.02
11092017_CSubRet1_smallsq_d4_1.set	2348.103	7575.992	736.147	299.928	14941.012	0.157	0.507	0.049	0.02
13092017_CSubRet1_smallsq_d5_1.set	2547.554	7749.265	745.696	318.281	15571.755	0.164	0.498	0.048	0.02
26092017_CSubRet1_smallsq_d6_1.set	2410.489	8673.339	861.812	359.847	17184.826	0.14	0.505	0.05	0.021
31082017_CSubRet1_smallsq_d1_1.set	2422.845	6656.94	694.184	342.62	13781.937	0.176	0.483	0.05	0.025
	rsc_delta	rsc_theta	rsc_low_gamma	rsc_high_gamma	rsc_total	rsc_delta_rel	rsc_theta_rel	rsc_low_gamma_rel	rsc_high_gamma_rel
04092017_CSubRet1_smallsq_d2_1.set	1293.597	4180.504	384.683	154.941	8058.75	0.161	0.519	0.048	0.019
07092017_CSubRet1_smallsq_d3_1.set	1186.789	4644.67	397.838	157.793	8566.709	0.139	0.542	0.046	0.018
11092017_CSubRet1_smallsq_d4_1.set	1753.002	5016.616	432.923	160.947	10010.097	0.175	0.501	0.043	0.016
13092017_CSubRet1_smallsq_d5_1.set	1702.387	4610.409	429.798	168.756	9580.732	0.178	0.481	0.045	0.018
26092017_CSubRet1_smallsq_d6_1.set	1307.693	4583.504	507.927	205.312	9138.04	0.143	0.502	0.056	0.022
31082017_CSubRet1_smallsq_d1_1.set	1422.433	3930.642	410.118	216.703	8025.292	0.177	0.49	0.051	0.027

20/07/2020:

At this point, I could describe the coherence between SUB and RSC with PSD between ctrl and lesion over all free exploration recordings. Prelim results inset.



15/12/2020:

Picking back up on this after a long time working on something else.

Appendix

Recording Wire Layout

Note that generally the order of the S, R, and Ca1 generally indicate what is LFP and what is single unit.

Glossary

- C - Control
- L - ATN lesion
- Can - Cannulated ATN
- S, Sub - Subiculum
- R, Ret - Retrospenial Cortex
- Ca - Hippocampal CA1 region

[C, L]SR[1 - 3]

(Before signal duplicator)
Tetrodes: 2 - 8 in SUB
LFP channels: 3 - 4 in RSC, 1 - 2 in SUB

[C, L]SR[4+]

Tetrodes: 1 - 4, 9 - 12 in SUB
LFP channels: 3 - 4 in RSC, 1 - 2, 5 - 32 in SUB

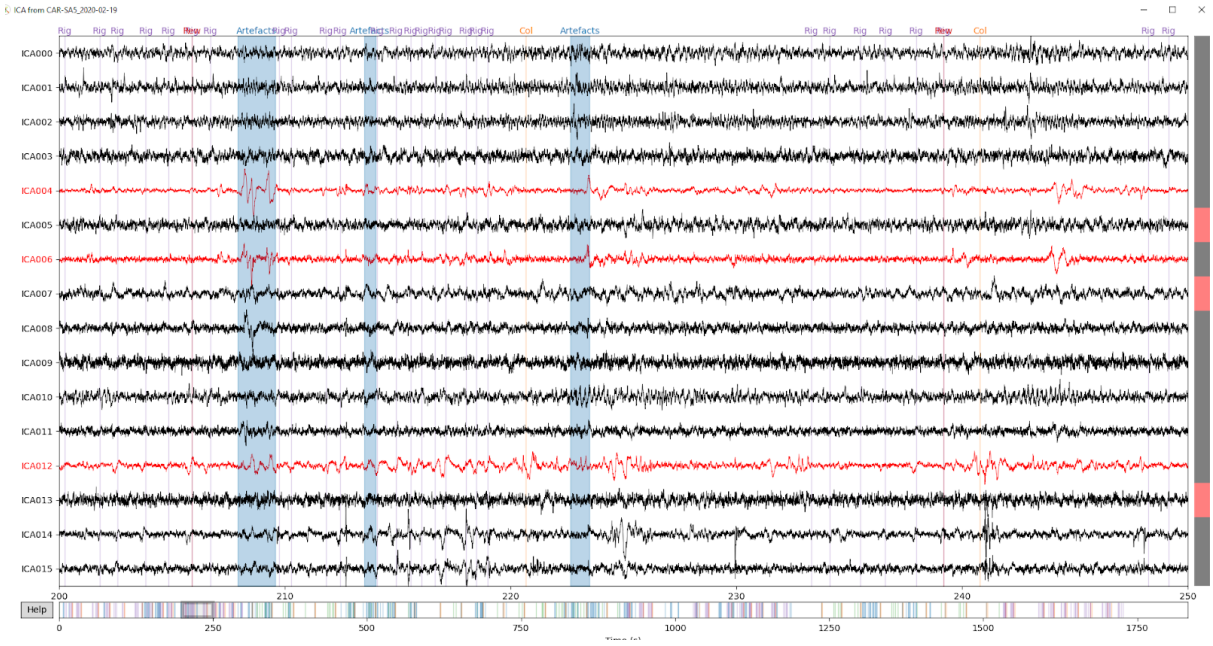
[C, L]RS

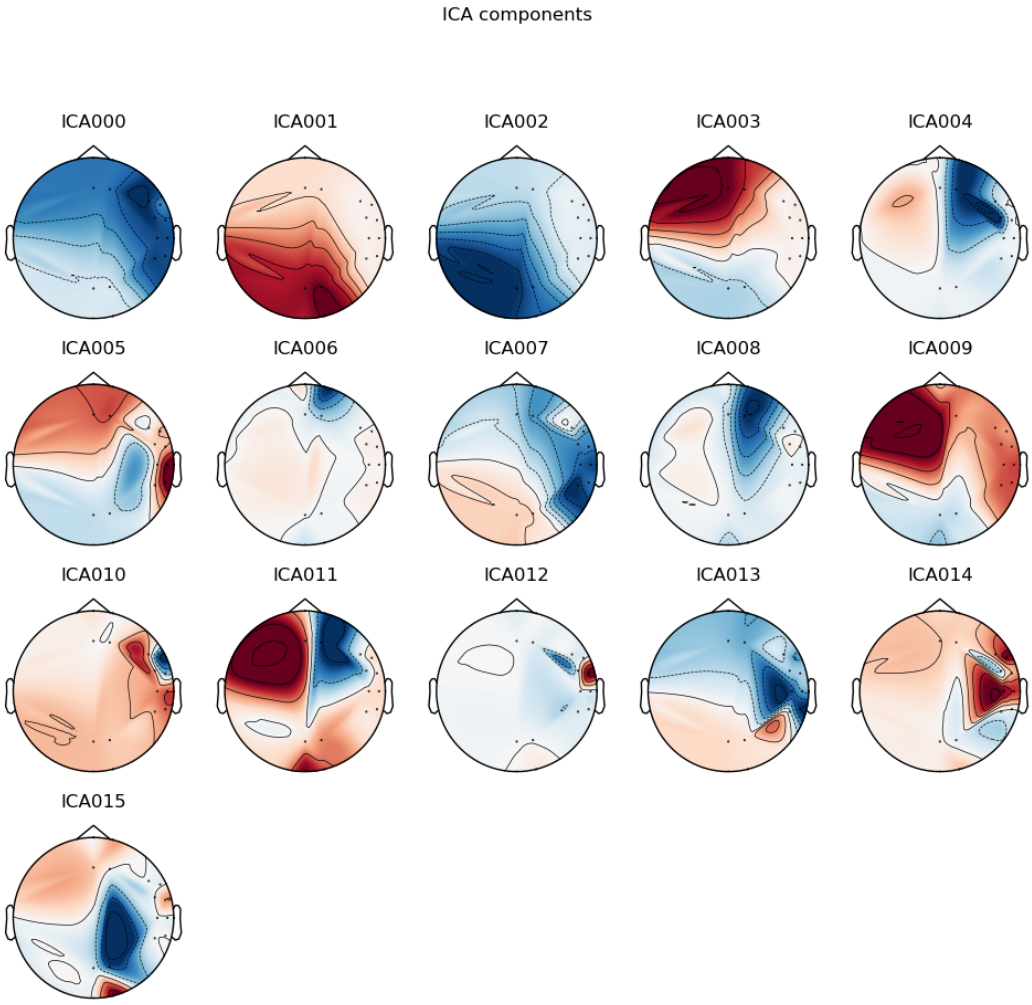
Tetrodes: 1 - 4, 9 - 12 in RSC
LFP channels: 3 - 4 in SUB, 1 - 2, 5 - 32 in RSC

Can[S, R, Ca]

CanCSCa (x1):
    Note: Hard to use as LFP electrode in CA1.
    Tetrodes: 1 - 4, 9 - 12 in SUB
    LFP channels: 3, 4 in CA1, 1 - 2, 5 - 32 in SUB
CanCCaRet (x2):
    Tetrodes: 1 - 4, 9 - 12 in CA1
    LFP channels: 3, 4 in RSC, 1 - 2, 5 - 32 in CA1
CanCSR (x2):
    Tetrodes: 1 - 4, 9 - 12 in SUB
    LFP channels: 3, 4 in RSC, 1 - 2, 5 - 32 in SUB
CanCSRetCa (x2):
    Tetrodes: 1 - 4 in CA1, 9 - 12 in SUB
    LFP channels: 3, 4 in RSC, 1, 2, 3 - 16 in CA1, 17 - 32 in SUB
CanCSCaR (x5):
    Tetrodes: 1, 2, 9, 10 in SUB, 3, 11, 12 in Ca1, 4 in RSC
    LFP channels: 1 - 8, 17 - 24 in SUB, 9 - 12, 25 - 32 in Ca1, 13 - 16 in RSC

Images

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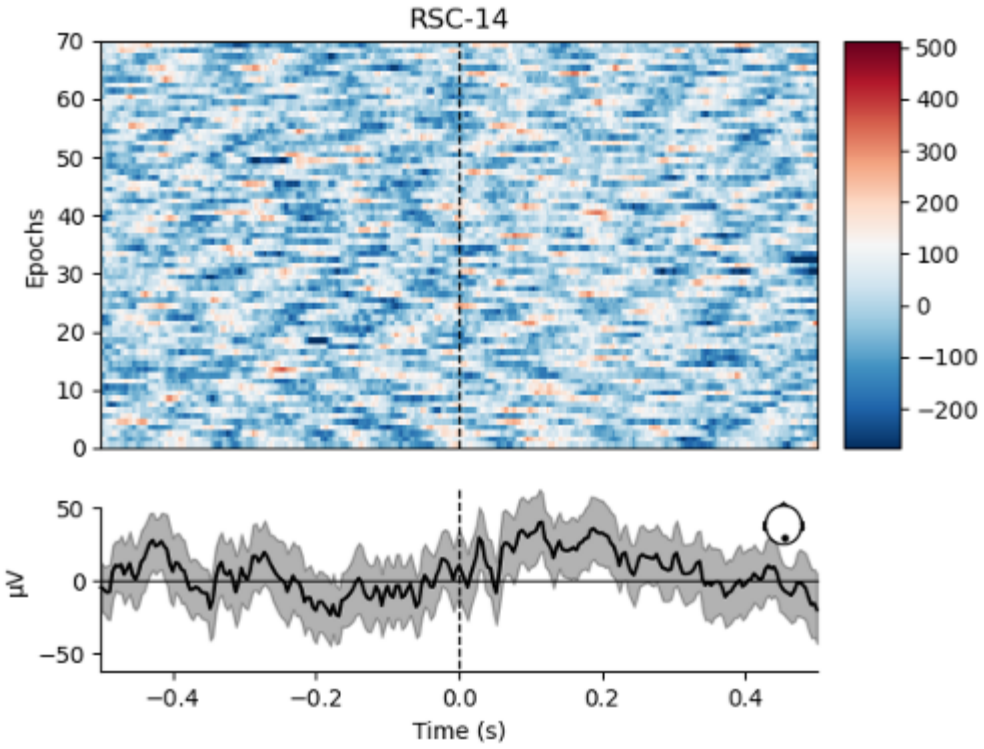
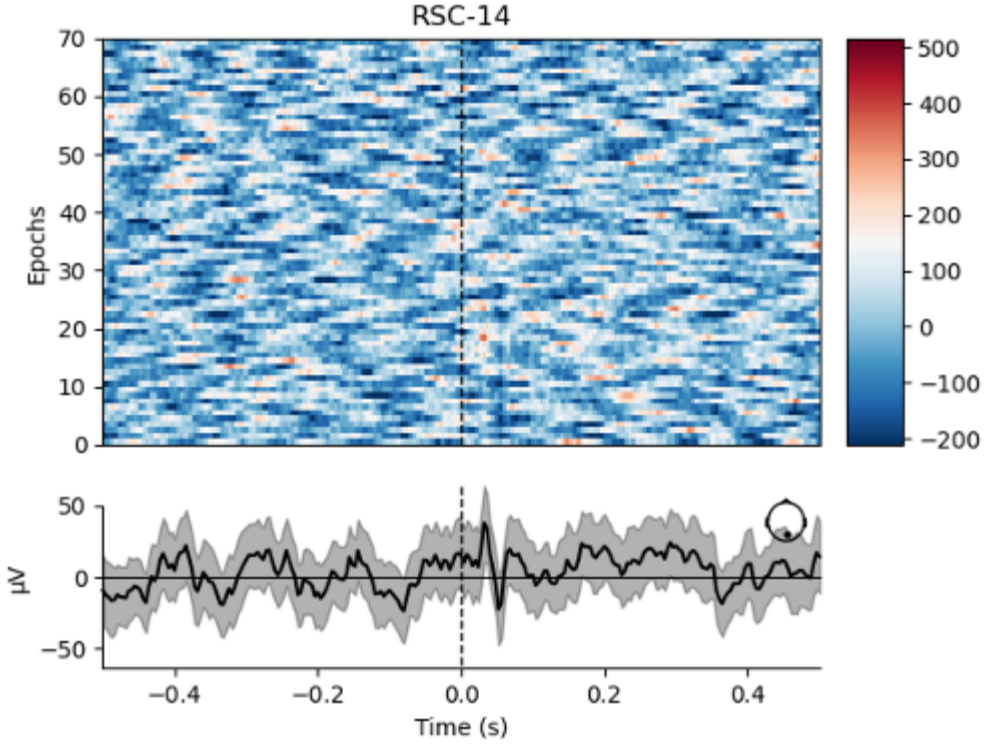
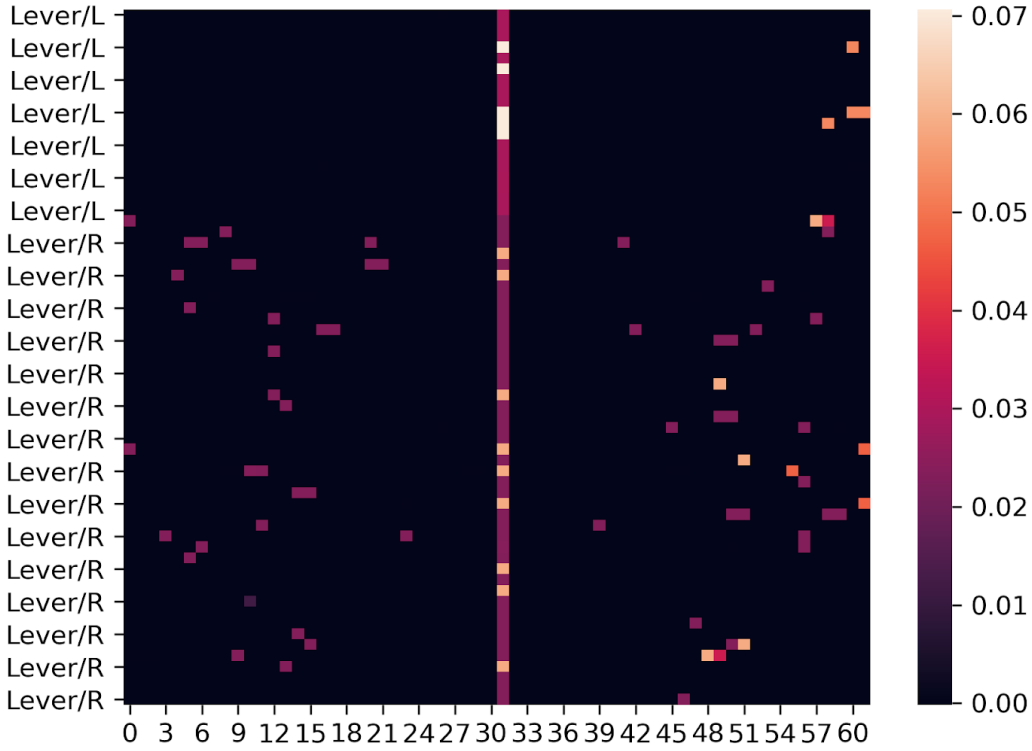
FR Response



FI response

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