Collective oscillations in the rat barrel-thalamus network

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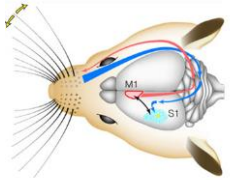
PADOVA neuroscience CENTER

Experimental paradigm



Probe Atlas # E32+R-65-S1-L6 NT pitch 65 µm

	Depth (µm)	Layer
32	+ 200	
31	+ 135	
30	+ 70	
29	+ 5	Layer
28		
27	- 60	I
26	- 125	
25	- 190	II
24	- 255	
23	- 320	
22	- 385	III
21	- 450	
20	- 515	
19	- 580	IV
18	- 645	
17	- 710	
16	- 775	
15	- 840	
14	- 905	
13	- 970	
12	- 1035	Va
11	- 1100	
10	- 1165	
09	- 1230	
08	- 1295	
07	- 1360	
06	- 1425	Vb
05	- 1490	
04	- 1555	
03	- 1620	
02	- 1685	VI
01	- 1750	
	- 1815	

&

Probe Atlas # E32+R-200-S1-L20 NT pitch 200 µm

	Depth (µm)	Layer BARREL CORTEX
32	+ 400	
31	+ 200	
30	0	I
29	- 200	II
28	- 400	III
27	- 600	IV
26	- 800	
25	- 1000	Va
24	- 1200	
23	- 1400	Vb
22	- 1600	
21	- 1800	VI
20	- 2000	
19	- 2200	
18	- 2400	
17	- 2600	*VUOTO*
16	- 2800	
15	- 3000	
14	- 3200	
13	- 3400	
12	- 3600	
11	- 3800	
10	- 4000	
09	- 4200	
08	- 4400	
07	- 4600	TALAMO - VPM
06	- 4800	
05	- 5000	
04	- 5200	
03	- 5400	
02	- 5600	
01	- 5800	
	- 5860	

- LFPs and MUAs recordings from urethane anesthetized rats.
- Both from a 32 channels probe inserted in a barrel column, and from a 32 channels probe inserted in a barrel column and thalamus.
- Recordings after single whisker stimulation (through a piezoelectric actuator) and during spontaneous activity.

AIMS:

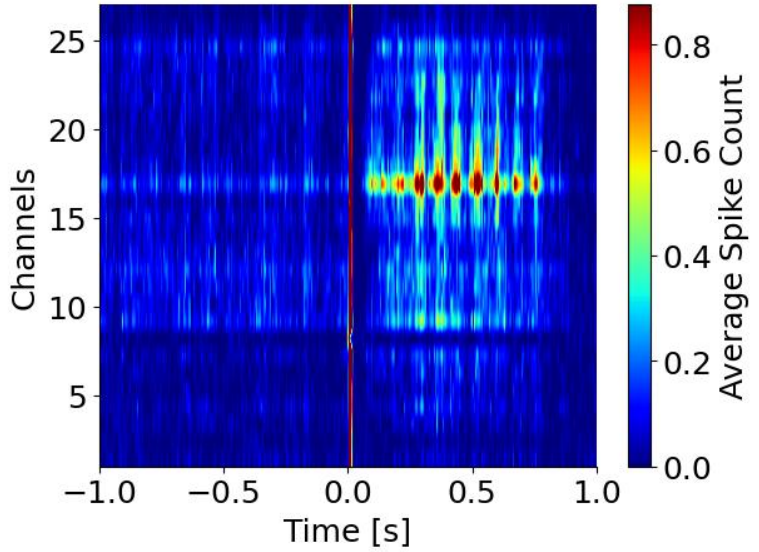
Study the oscillatory behavior of the rat barrel-thalamus network after whisker stimulation and during spontaneous activity.

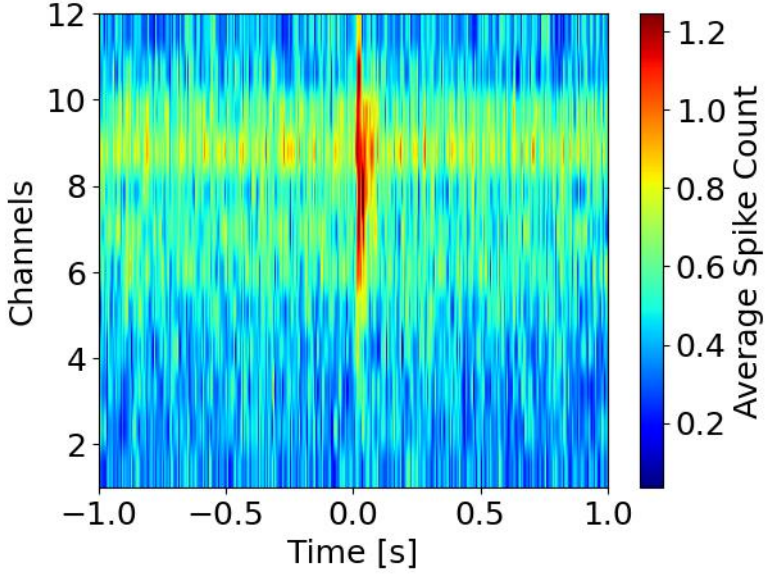
Evoked oscillations in the barrel after whisker stimulation

Barrel cortex

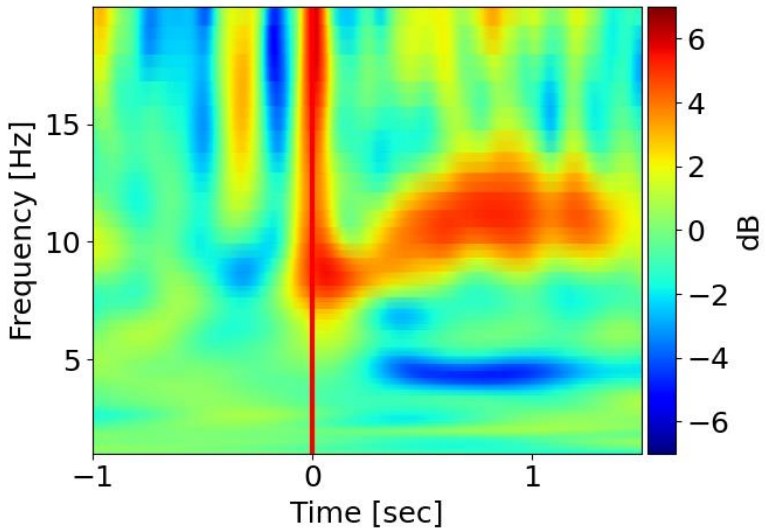
Thalamus

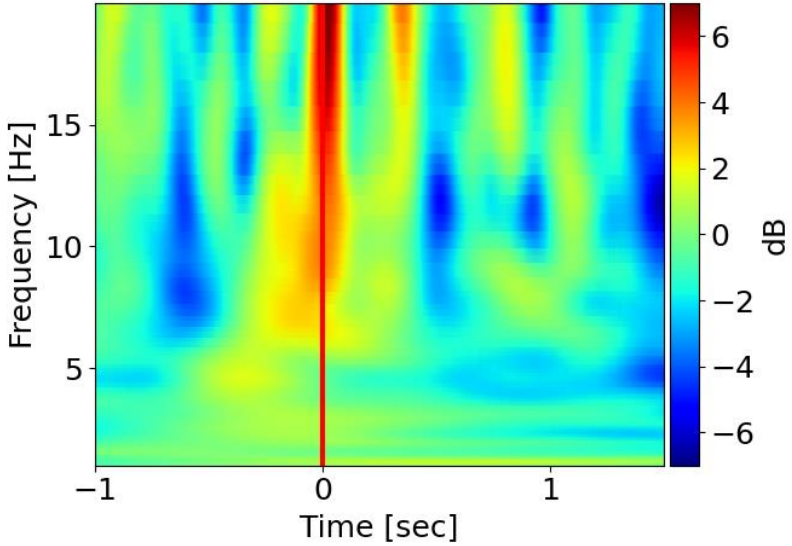
MUAs



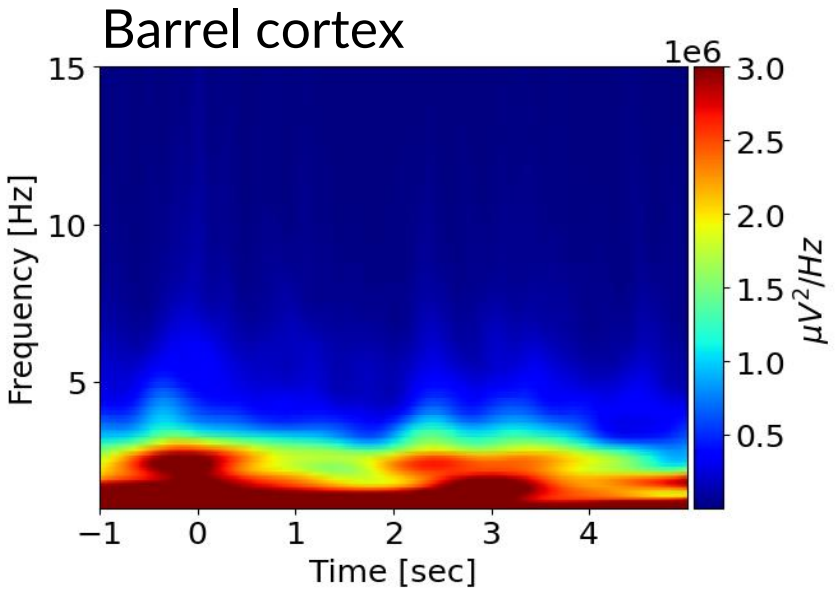


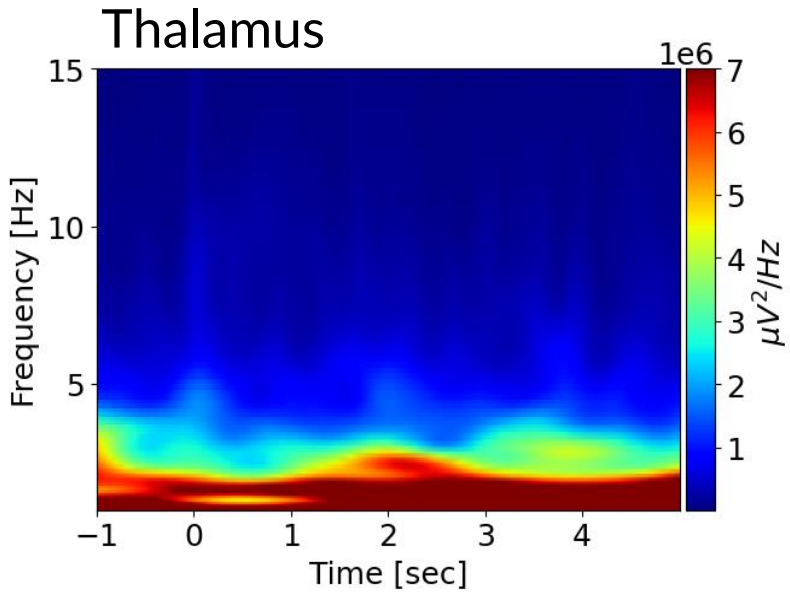
LFPs



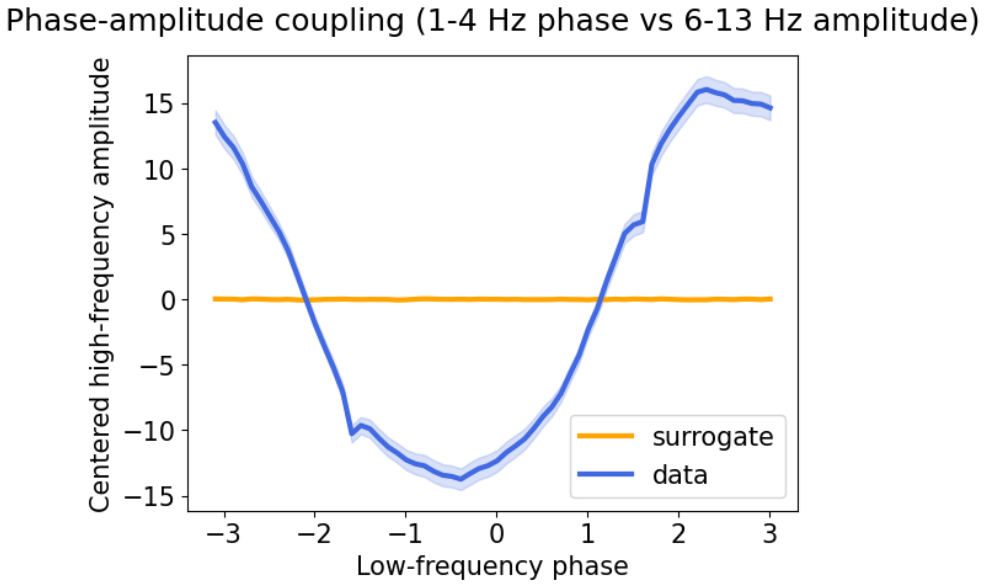


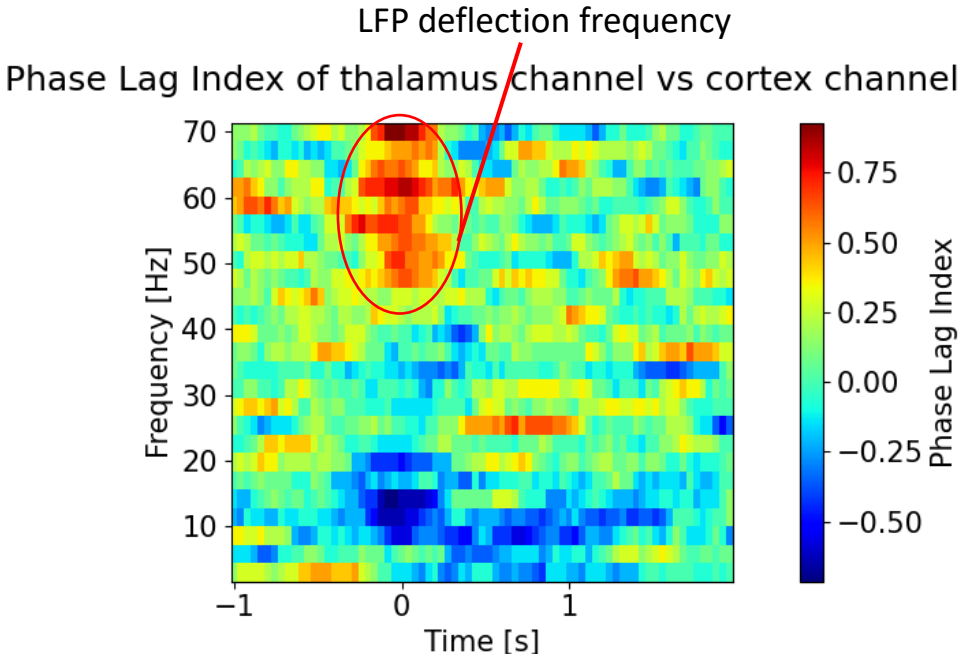
Spontaneous slow waves….





… & high frequency bands





The model

Stochastic terms

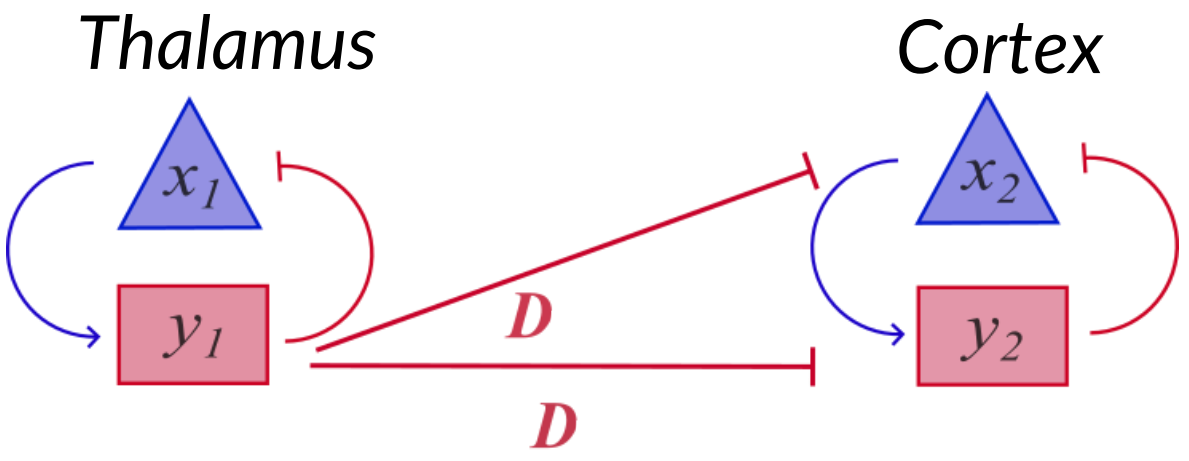
$$\frac{d}{dt}x_i = \frac{1}{\gamma_i}\left(F\left[s_{x_i}\right] - x_i\right) + \frac{1}{\gamma_i\sqrt{V1}}\sqrt{F\left[s_{x_i}\right] + x_i}\,\lambda_i^{(1)}$$

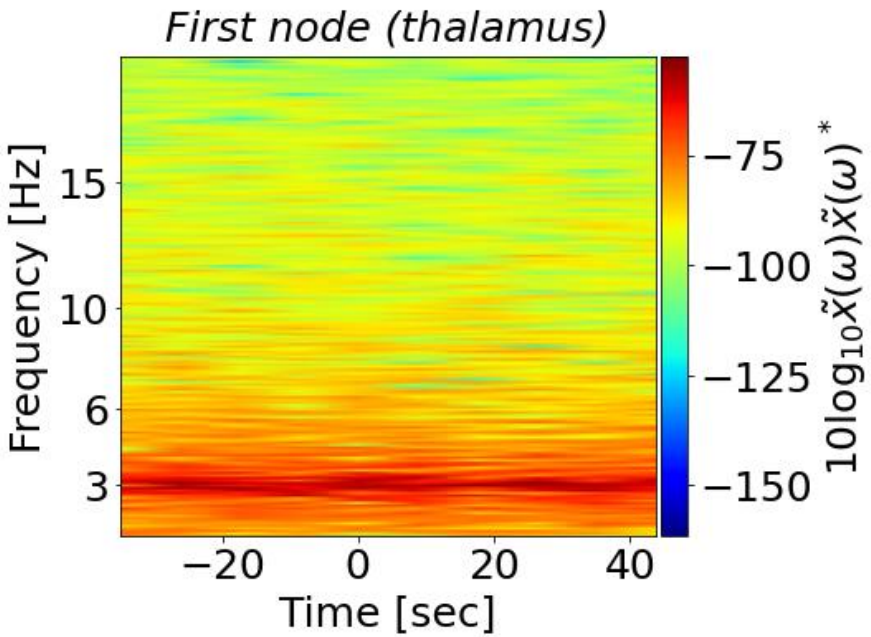
$$\frac{d}{dt}y_i = \frac{1}{\gamma_i}\left(F\left[s_{y_i}\right] - y_i\right) + \frac{1}{\gamma_i\sqrt{V1}}\sqrt{F\left[s_{y_i}\right] + y_i}\,\lambda_i^{(2)}$$

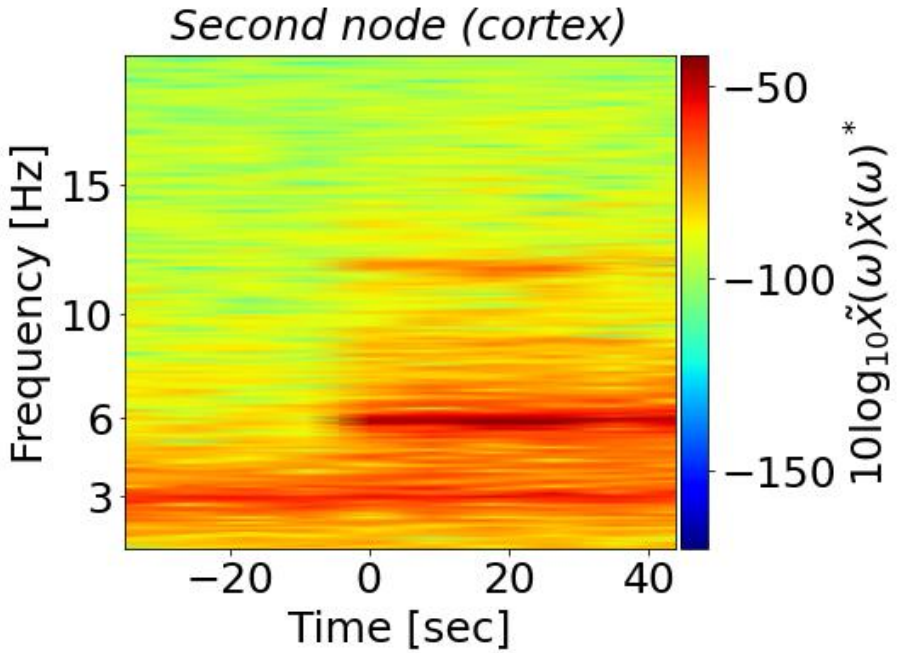
$$s_{x_i} = -r(y_i - p) - Dy_{i-1}$$

$$s_{y_i} = r(x_i - (1-p)) - Dy_{i-1}$$

$$F(s) \propto \frac{1}{1 + e^{-s}} \qquad p = 0.2, r_1 = r_2 = r$$







Conclusions

- **Evoked collective oscillations**, modulated by **slow oscillations**, are present in the barrel after whisker stimulation, whose **response propagates** from thalamus to cortex.

- Our modeling framework highlights the importance of a **thalamo-cortical effective coupling** for the birth of the higher frequency in the barrel, that coexists with the δ one.