Interbrain data analysis

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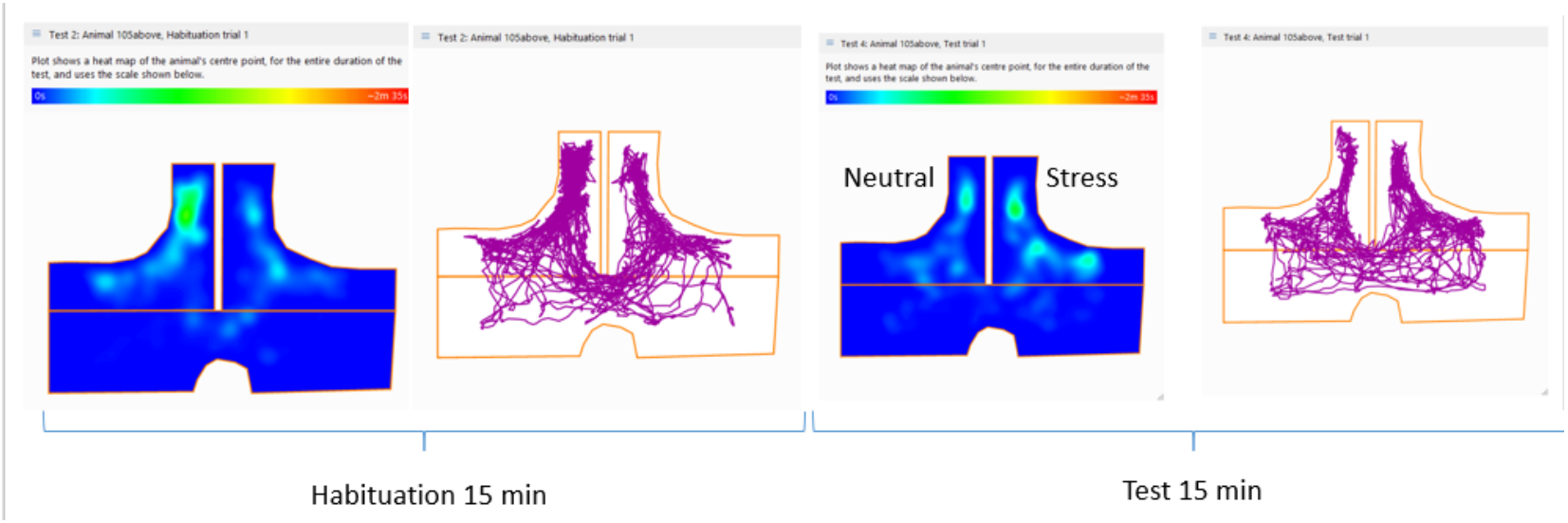
The experiment



- Observer, neutral and stressed mice in an arena
- 5 minutes of home cage, 15 of habituation, 15 of test

The dataset

- Observer, neutral and stressed neuronal activities over time
- Recording of observer's position during habituation and test
- Recording of reciprocal sniffing during test

Goals

- Study single neuronal activity and aggregate activity of 3 mice
- Look for relationship between activity and interactions between mice
- Investigate the presence of synchronized activity between mice, studying relationship with mice interactions

Preparing the dataset

First technical steps consisted in:

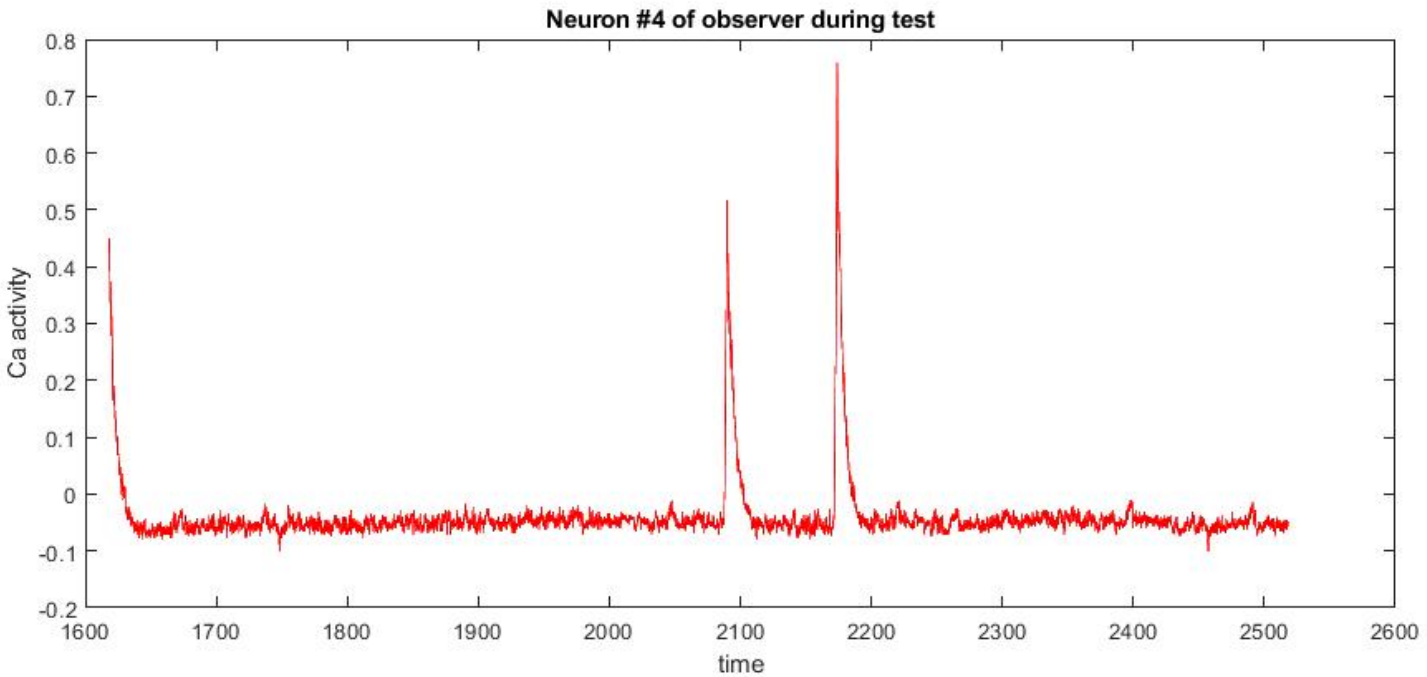
- Excluding the neurons marked as *rejected* from Inscopix and separate the dataset for the three mice and the three stages
- Adapting the times based on the A keyboard information in the sniff file
- Final time adapting which aligns the three time intervals and considers the same time points (using linear interpolation)
- z-score, min-max and homecage normalizations are provided

Single neuron activity

obs_test

18013x13 double

	1	2	3	4	5	6	7	8	9	10	11	12	13
1	1.6182e+03	0.0049	0.0253	-0.0136	0.4320	0.0184	-0.0406	-5.9200e-05	0.0446	0.0802	0.0040	7.2164e-04	0.0073
2	1.6182e+03	0.0084	0.0109	-0.0093	0.4345	0.0134	-0.0367	-8.4523e-04	0.0396	0.0827	0.0041	-0.0055	0.0095
3	1.6183e+03	-0.0037	0.0175	-0.0248	0.4483	0.0105	-0.0442	-0.0089	0.0409	0.0827	0.0030	0.0028	0.0017
4	1.6183e+03	-2.1388e-04	0.0107	-0.0222	0.4394	0.0114	-0.0383	-0.0011	0.0360	0.0854	0.0036	6.5395e-04	0.0071
5	1.6184e+03	-0.0035	0.0030	-0.0180	0.4337	0.0170	-0.0398	-0.0054	0.0334	0.0746	-0.0027	-0.0088	0.0058
6	1.6184e+03	-0.0055	0.0123	-0.0170	0.4166	0.0095	-0.0381	-0.0010	0.0287	0.0717	0.0029	-0.0097	0.0038
7	1.6185e+03	-2.6808e-04	0.0084	-0.0155	0.4112	0.0178	-0.0429	0.0084	0.0256	0.0698	-2.5608e-04	-0.0054	0.0069
8	1.6185e+03	-3.3051e-04	0.0062	-0.0236	0.3932	0.0158	-0.0434	-0.0022	0.0198	0.0638	0.0052	-0.0098	0.0053



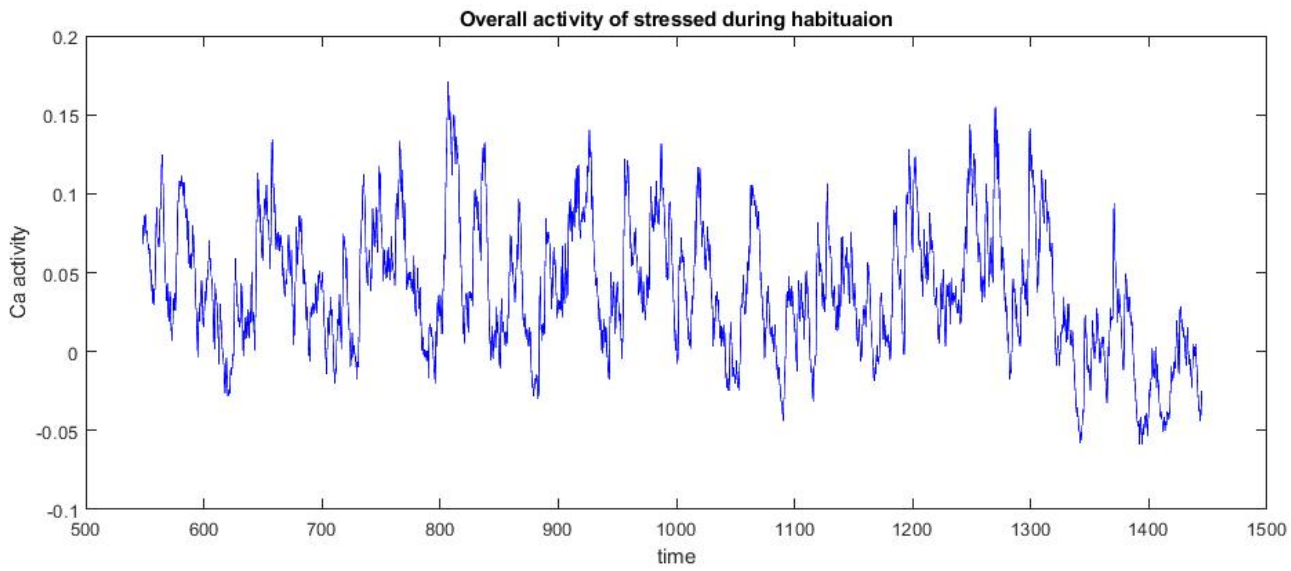
Mice overall activity

The overall activity for one mouse is computed as the average of all its neuronal activities at each time step

stress_activity_hab

17945x2 double

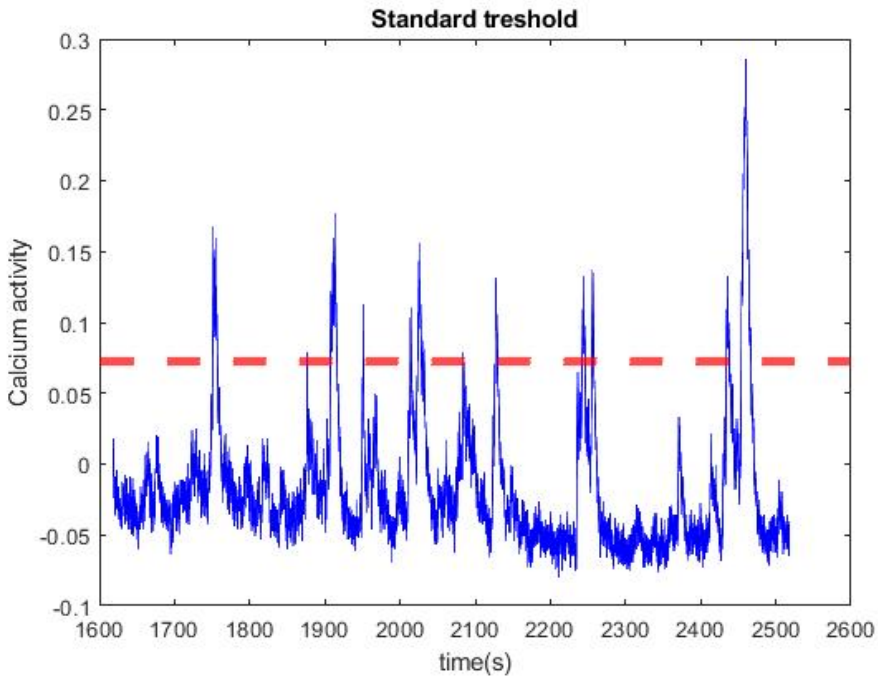
	1	2
1	548.2738	0.0796
2	548.3237	0.0786
3	548.3737	0.0791
4	548.4236	0.0763
5	548.4736	0.0783
6	548.5236	0.0747
7	548.5735	0.0693
8	548.6235	0.0690
9	548.6735	0.0694
10	548.7234	0.0678
11	548.7734	0.0702

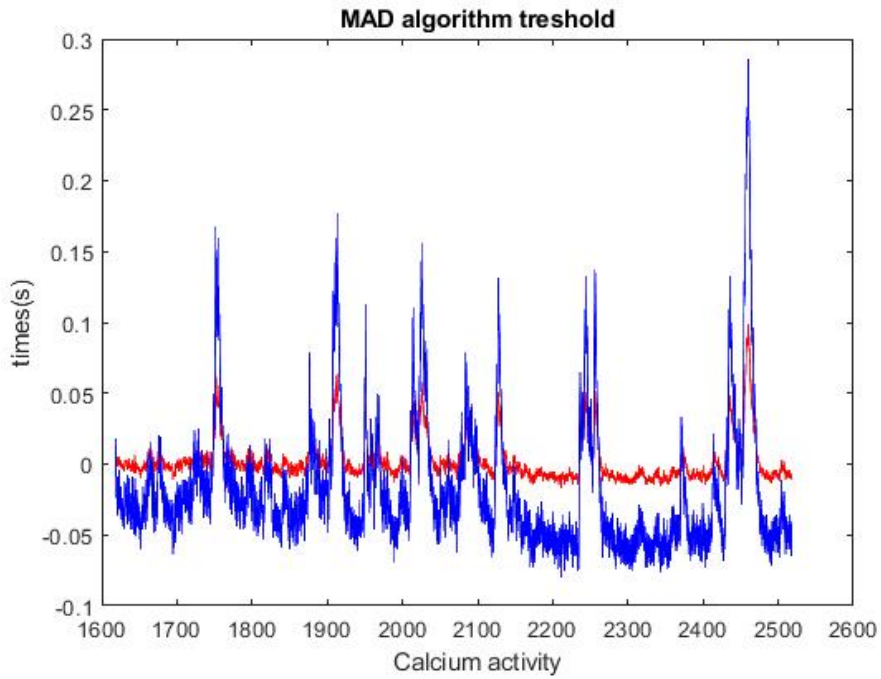


Activity detection

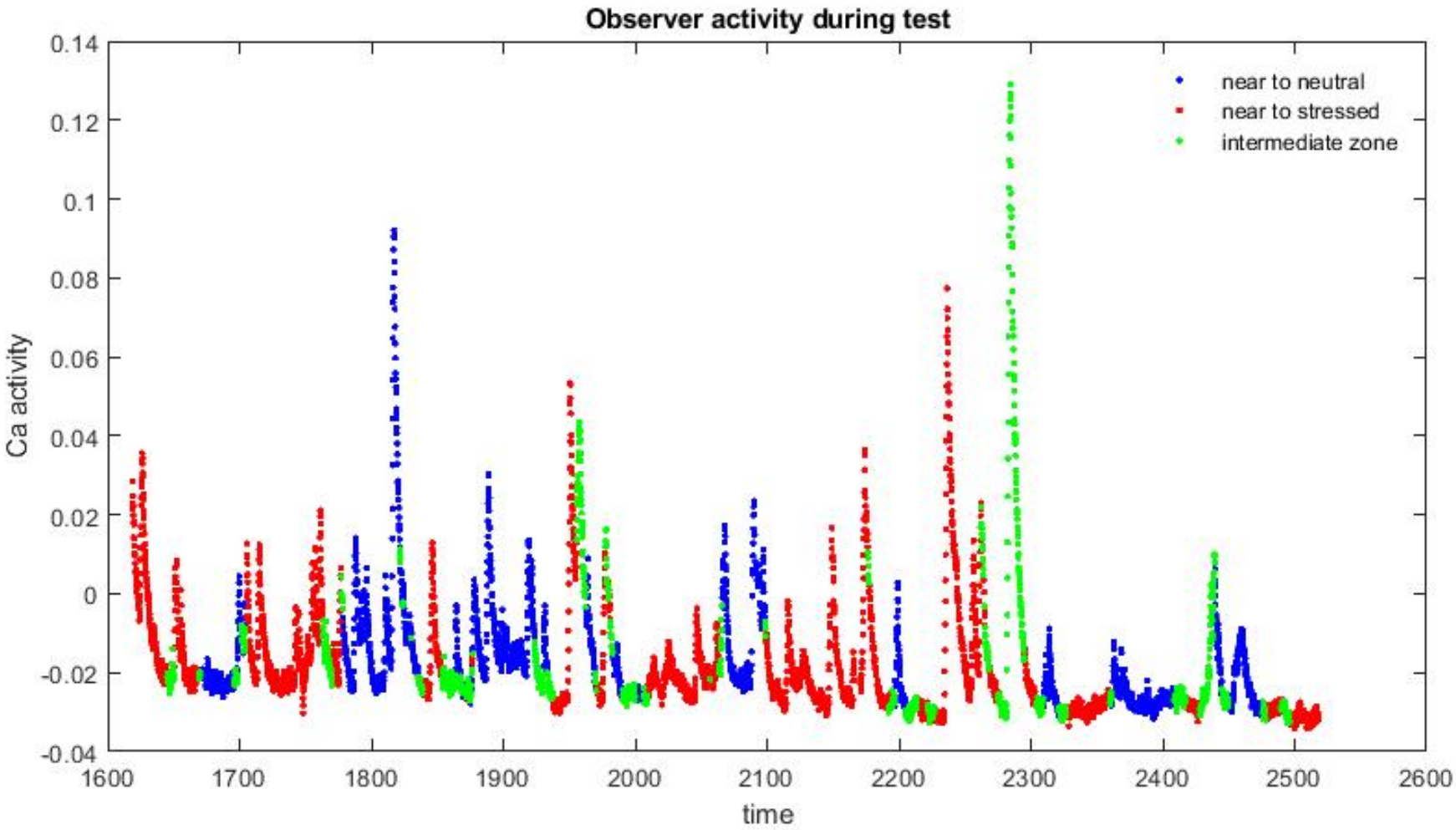
How do we establish if a neuron is active or not?

- Standard way: all above a treshold line ($y = \mu + 2\sigma$) is active and vieversa
- **MAD** algorithm (Inscopix manual): the treshold line varies with the signal

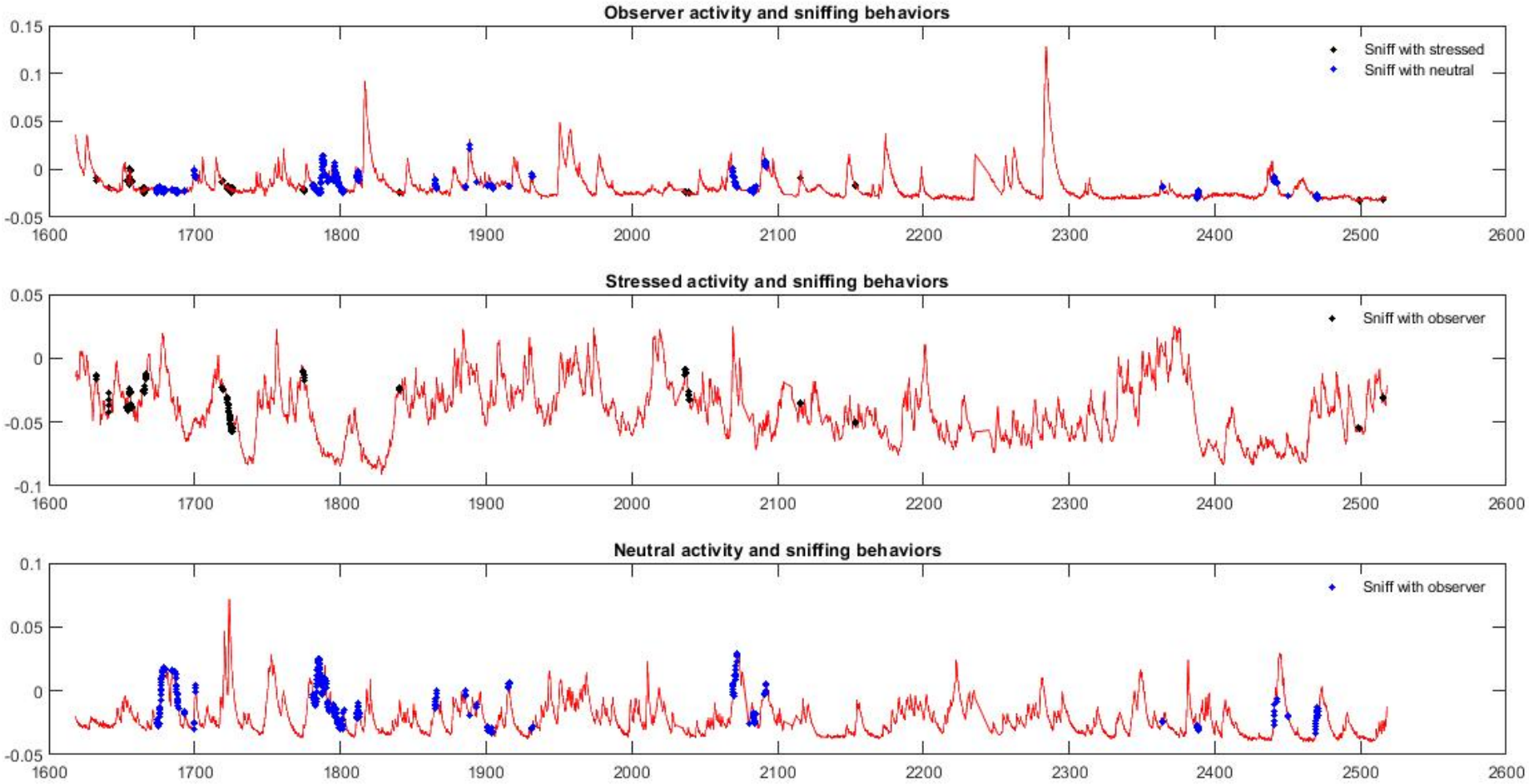




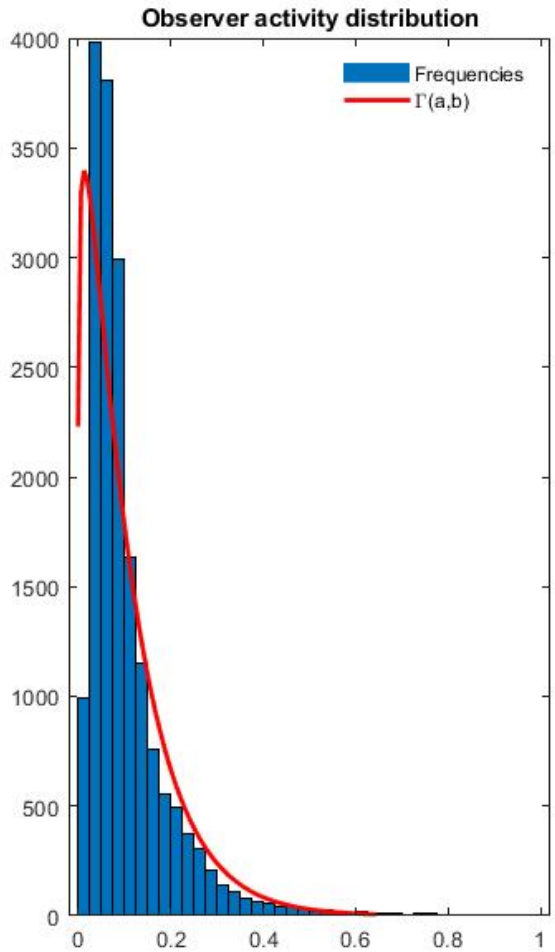
Other features (1)

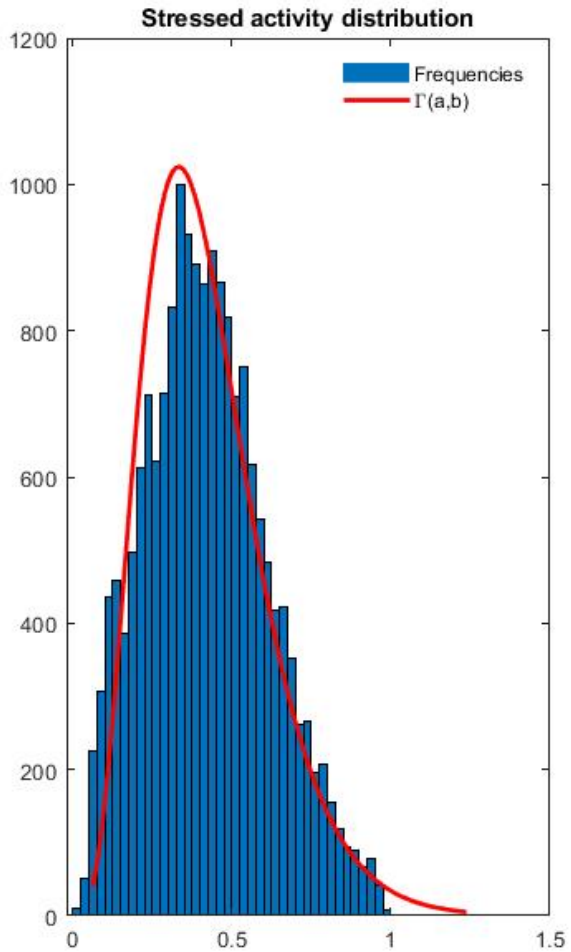


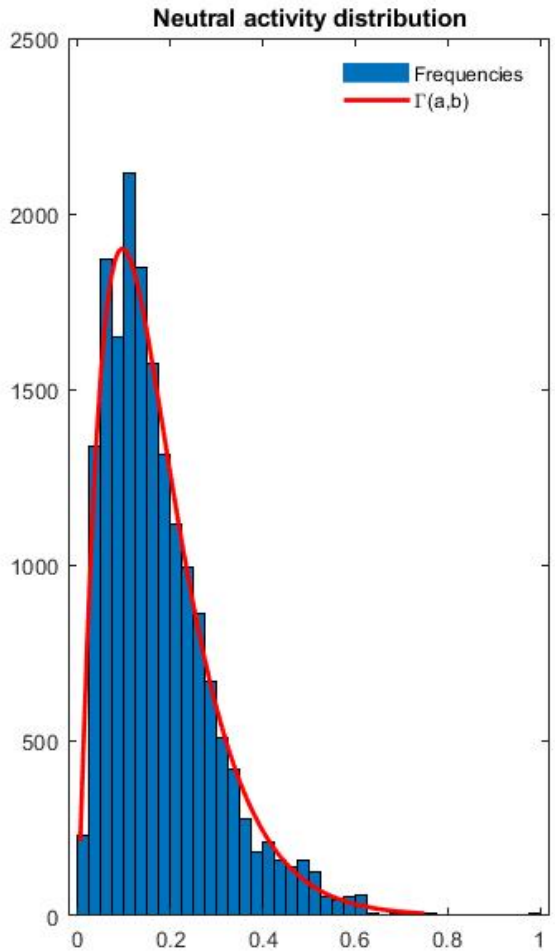
Other features (2)



Other features (3)







First conclusions on single activity analysis

- No particular relationship between neuronal activity peaks and mice vicinity
- Sniffing in observer seems to be usually followed by activity peaks
- The mean activity of neurons is higher in stressed mouse respect to the other two
- More data should be necessary to infer conclusions

Correlation indicators

1. **Pearson correlation**: it tells how *linearly* correlated two random quantities are

$$Corr_P(X,Y) = \frac{Cov(X,Y)}{\sigma_X \sigma_Y}$$

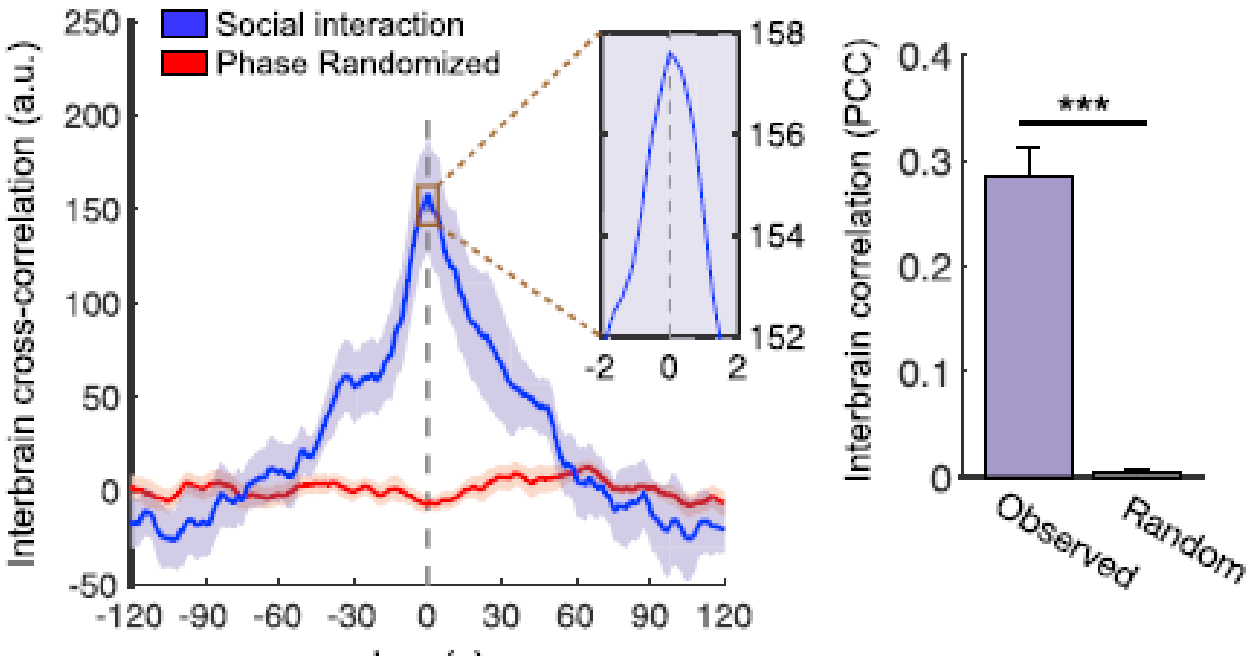
2. **Cross correlation**: similarity measure for signals, given as function of the reciprocal delay

$$Corr_C(X,Y) = X \star Y(t) = X(-t) * Y(t) = \int_{-\infty}^{\infty} X(t-\tau)Y(t)dt$$

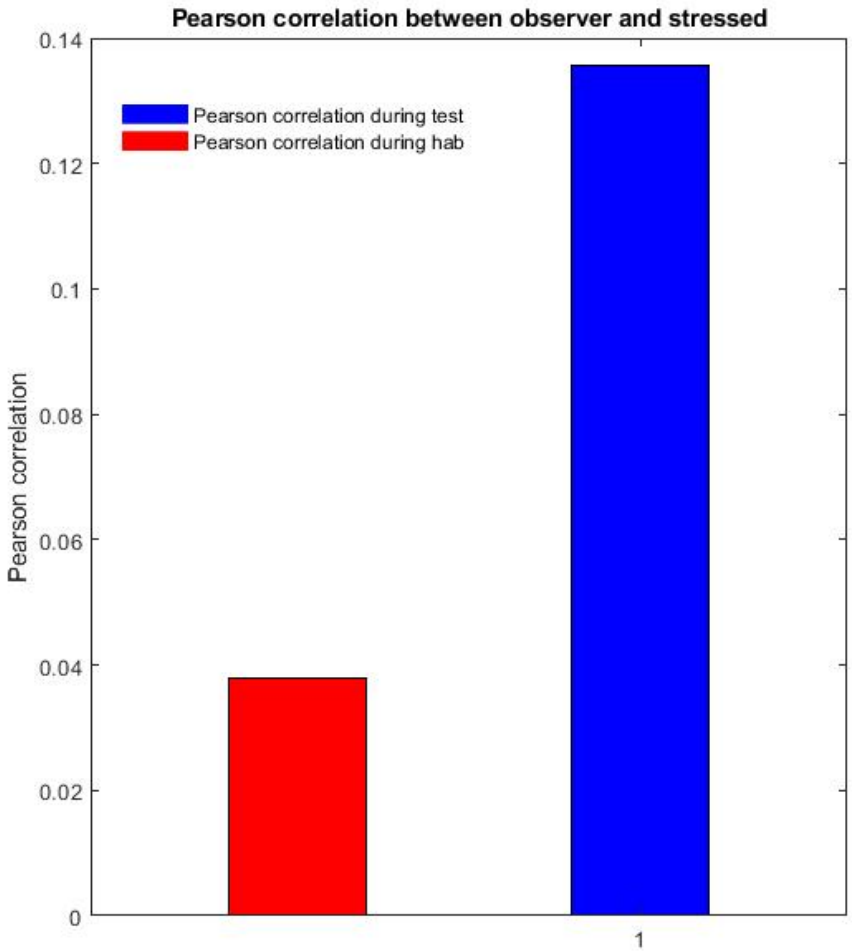
$$Corr_C(X,Y) = X \star Y(m) = \sum_{n=0}^{N-m-1} X_{n+m}Y_n$$

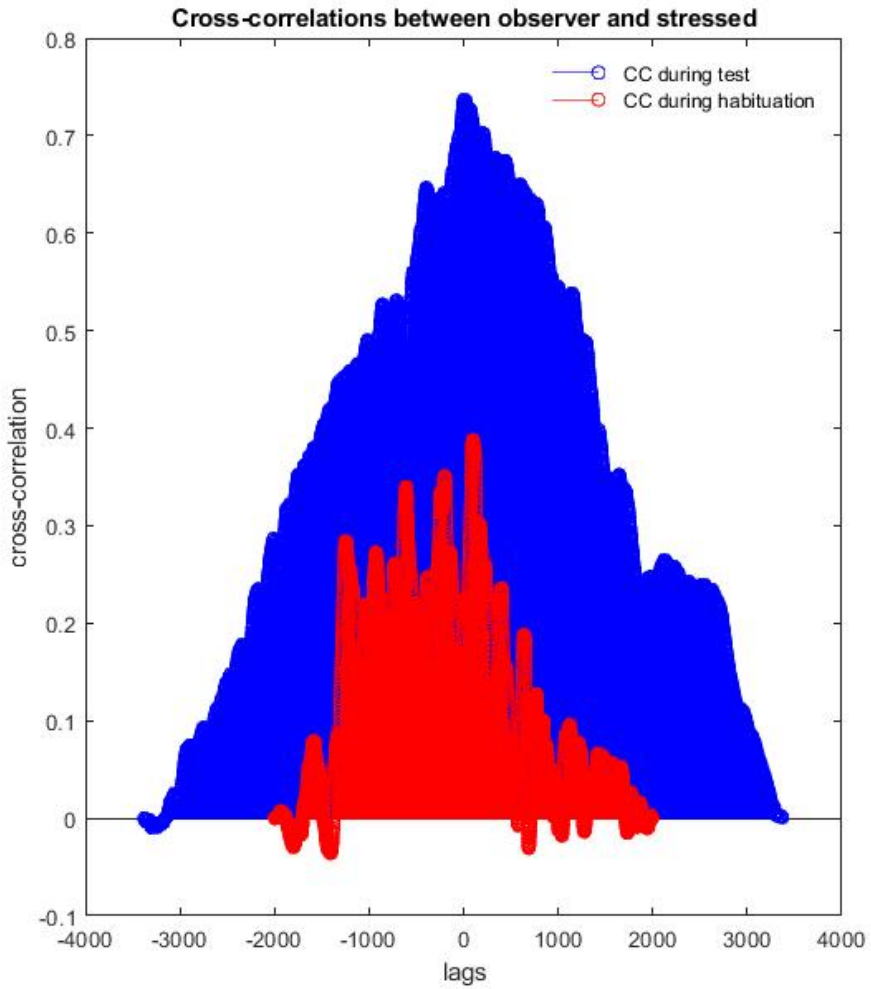
Correlation indicators

- Pearson correlation may not be the best choice for a strongly nonlinear signal (but it may still have some significance as term of comparison between two scenarios)
- Cross correlation, on the other hand, seems the best way to quantify similarity between two signals

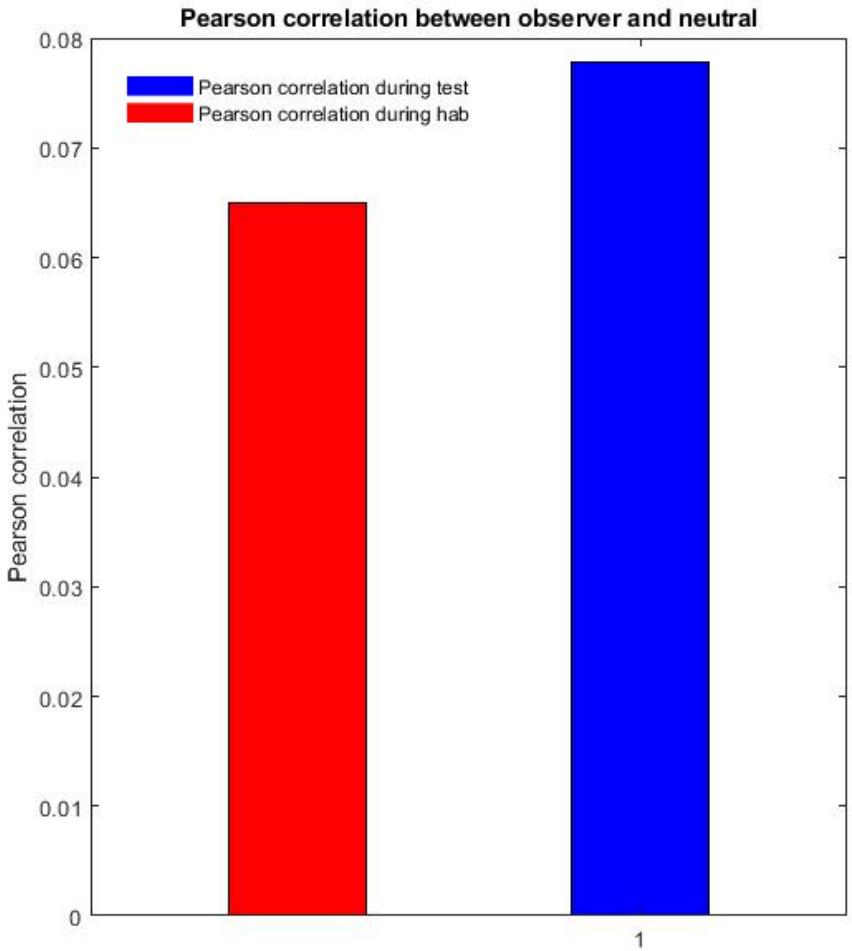


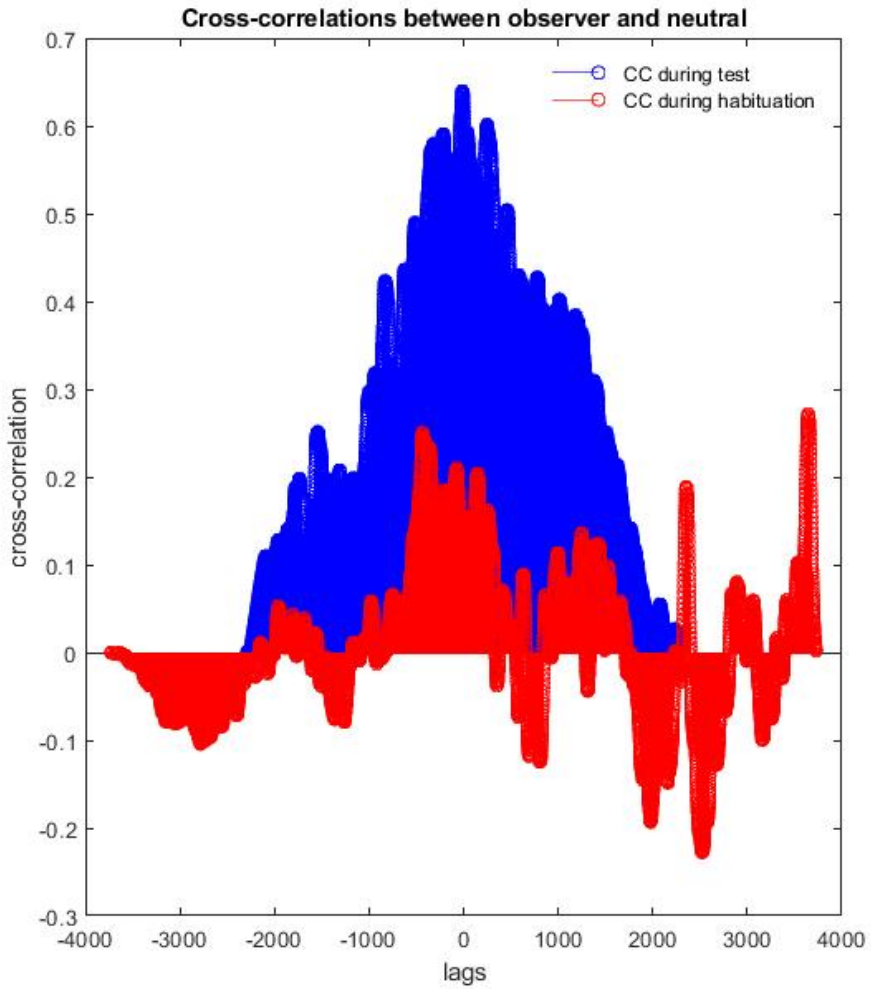
Activities synchronization: observer vs stressed



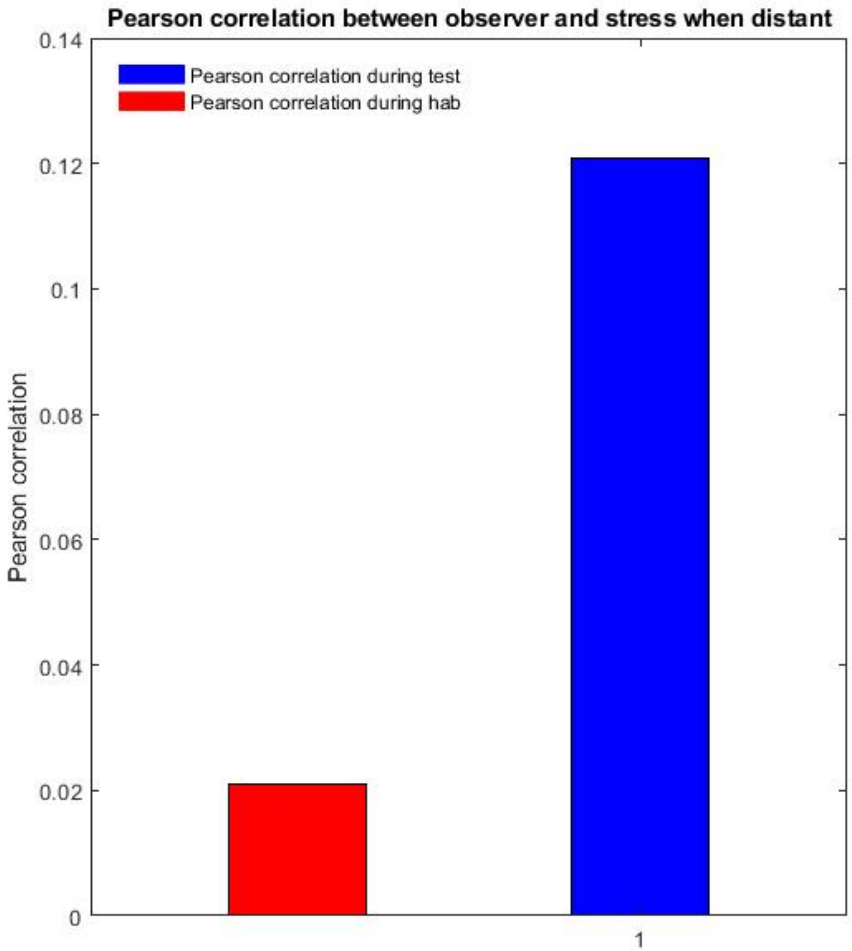


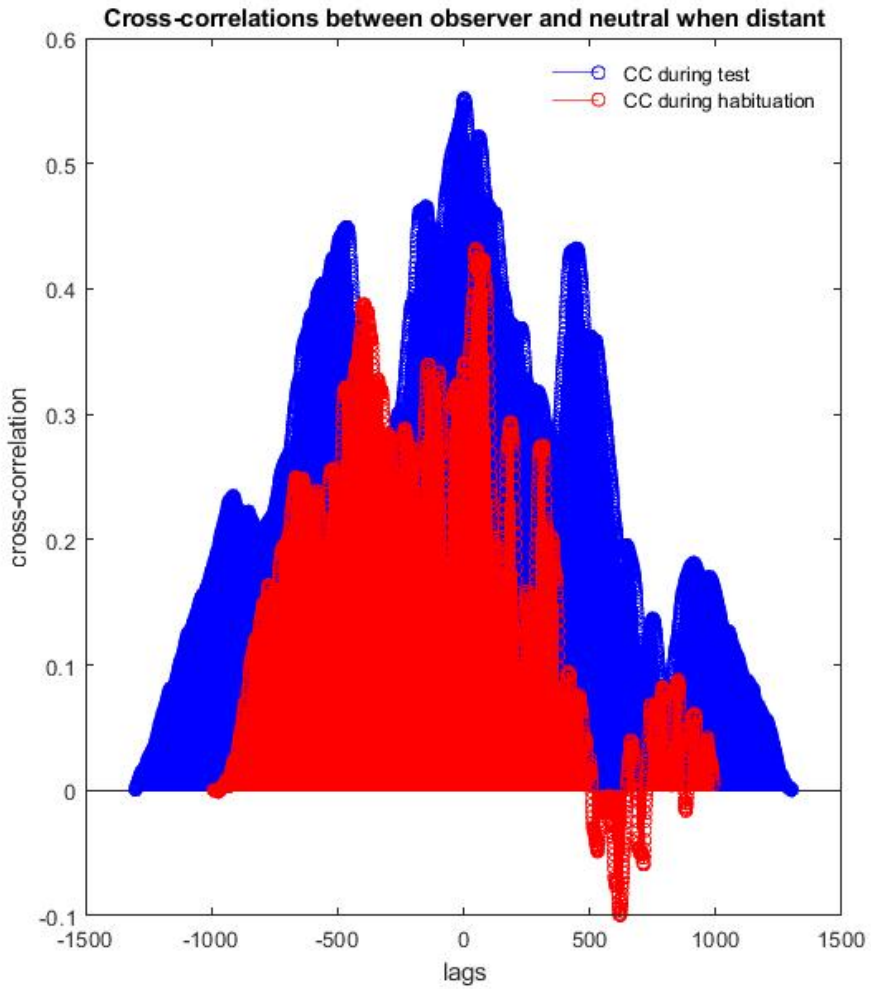
Activities synchronization: observer vs neutral



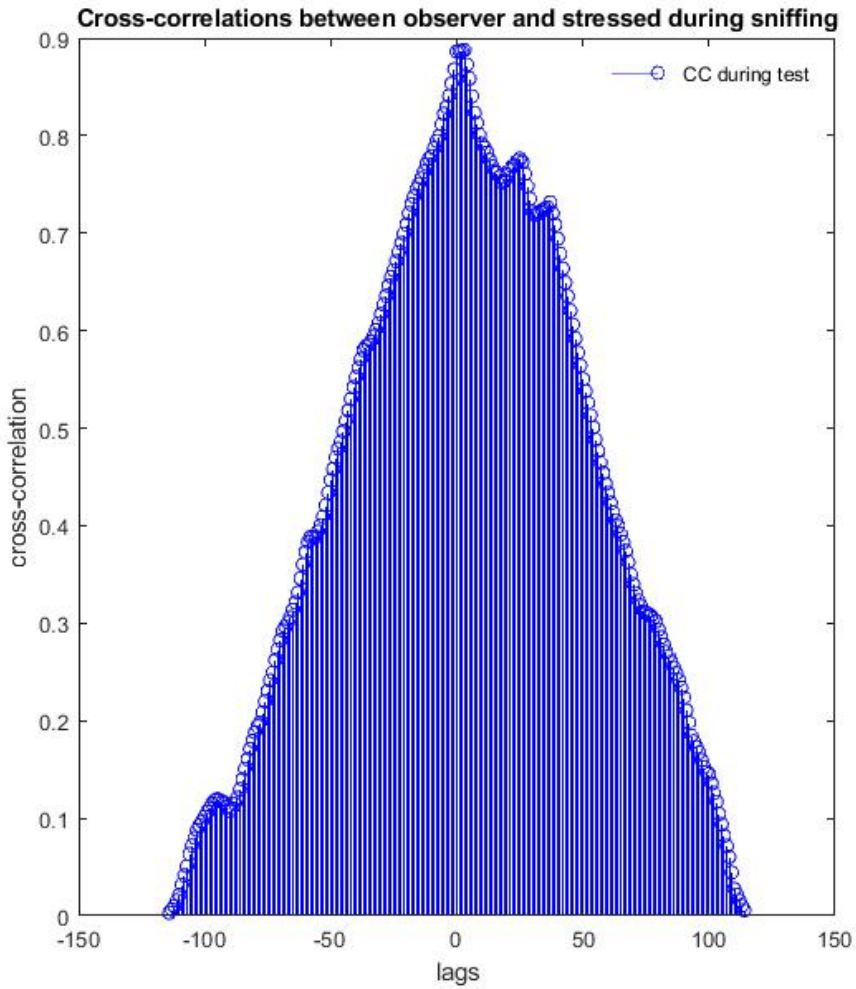


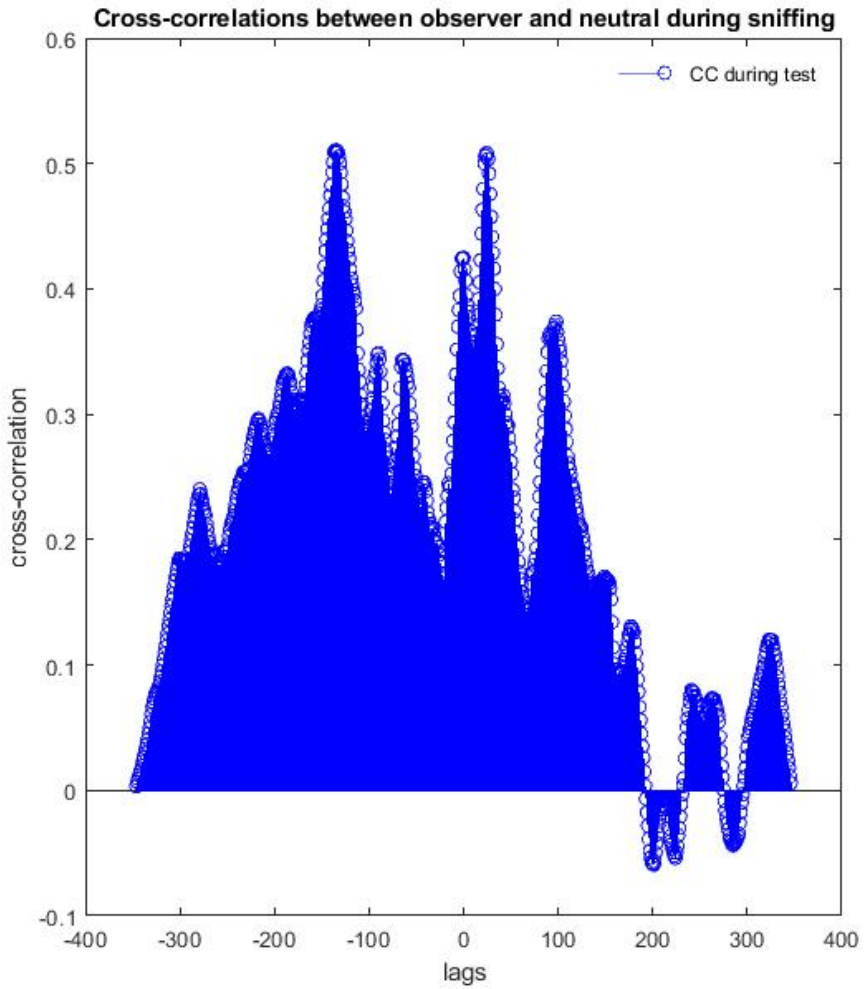
Activities synchronization: distant mice



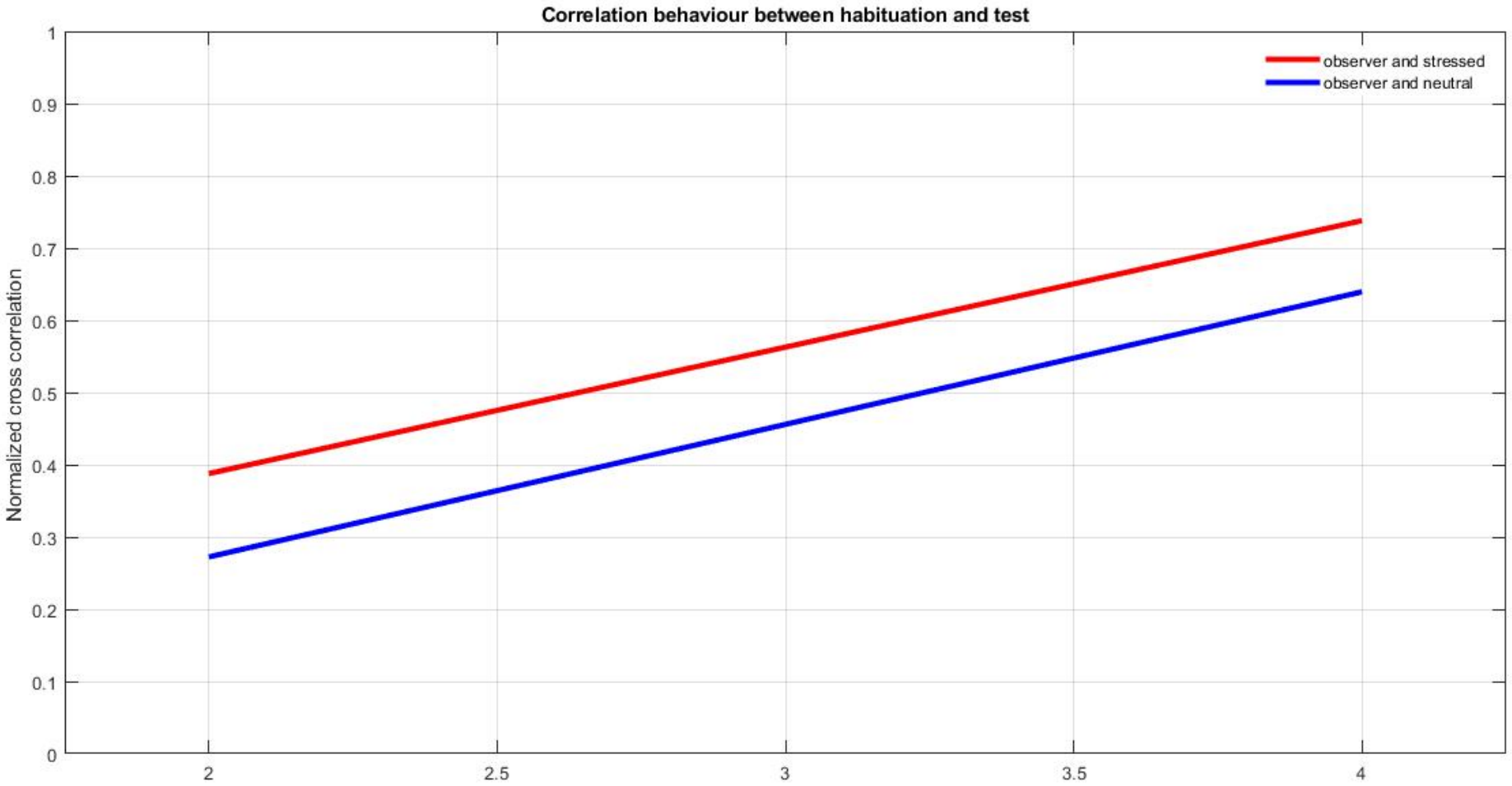


Activities synchronization: reciprocal sniffing





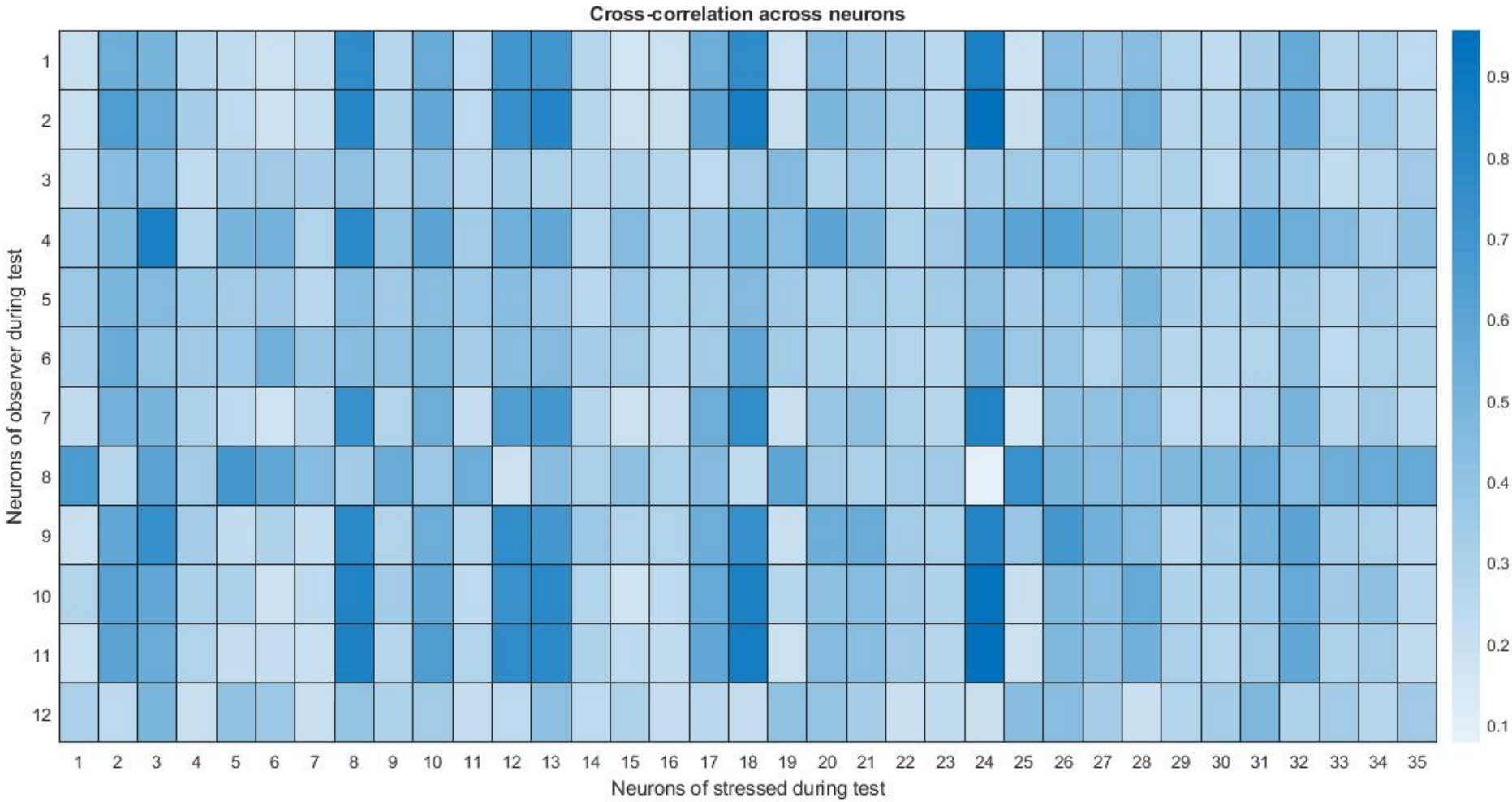
Overall correlation change



Conclusions on the overall correlation analysis

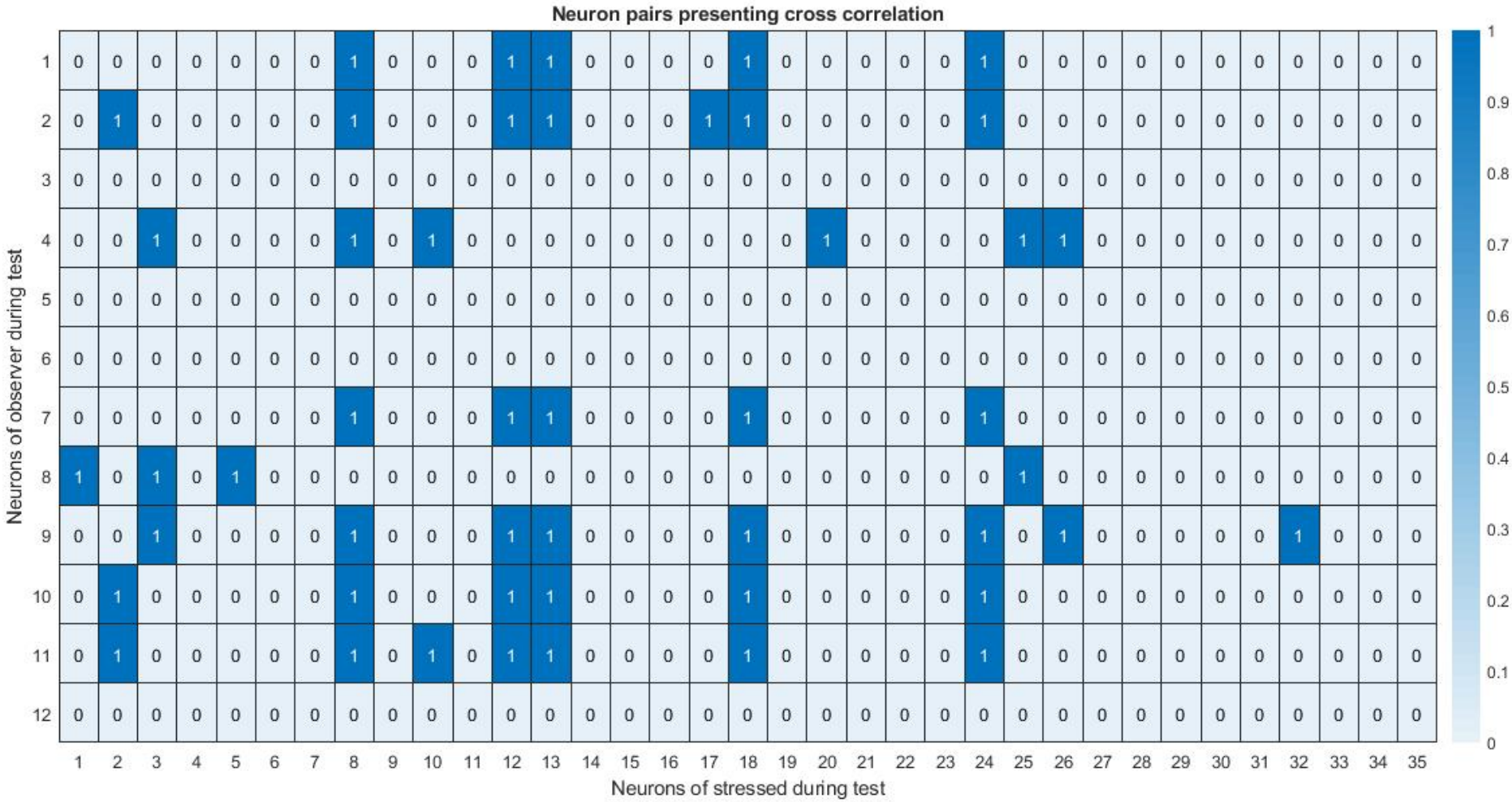
- The correlation between the observer and the stressed mice appears strong and in counterposition with the habituation phase
- Altough less marked than the previous one, also the correlation between observer and neutral mice is definitely higher during the test than the habituation
- This difference is less evident when the two mice are not in contact
- When sniffing, the correlation between observer and stressed is the highest recorded

Neuron pairs synchronization: observer vs stressed during test (1)

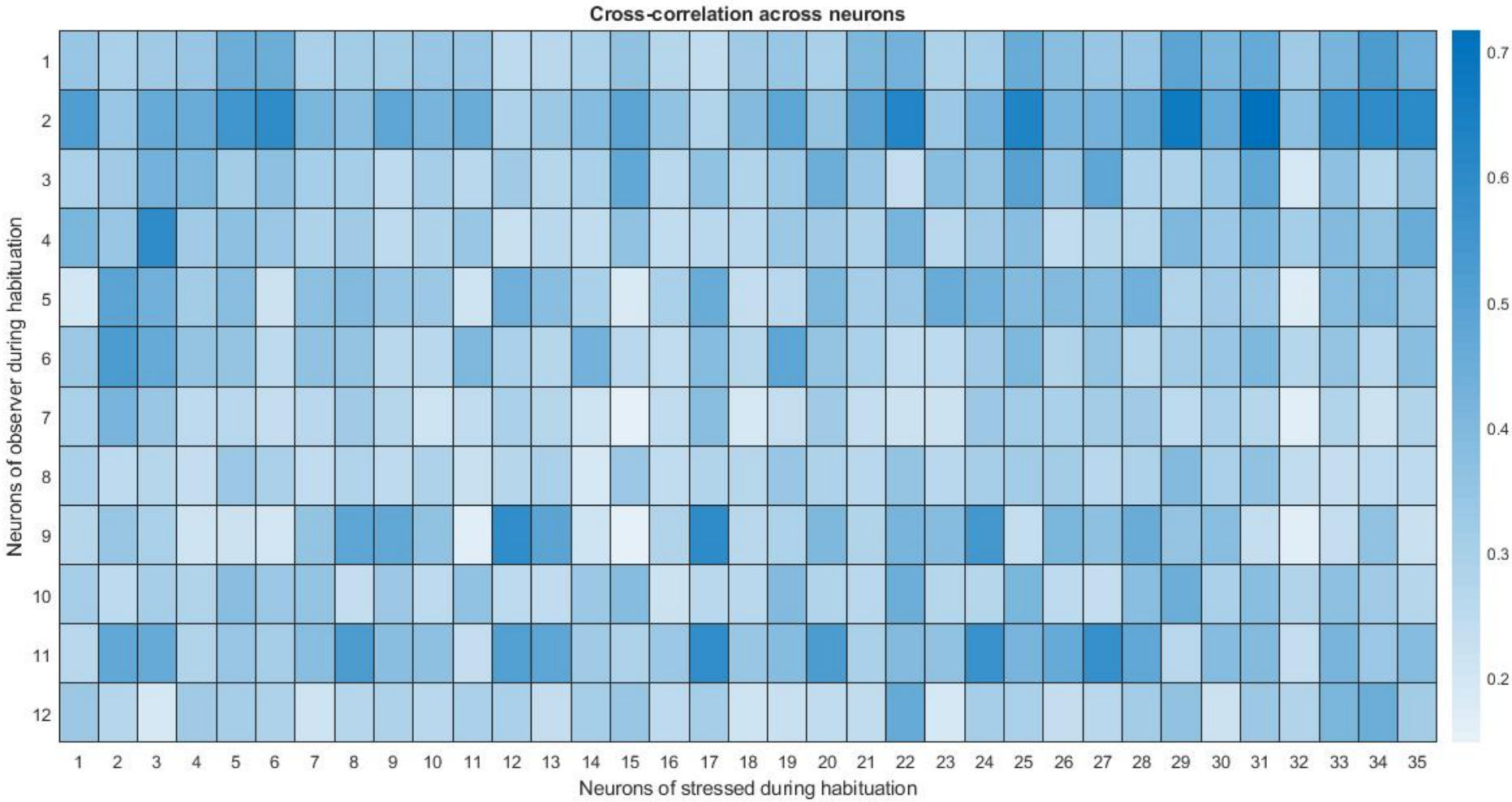


Neuron pairs synchronization: observer vs stressed during test (2)

Fraction of pairs showing correlation = 11.43%

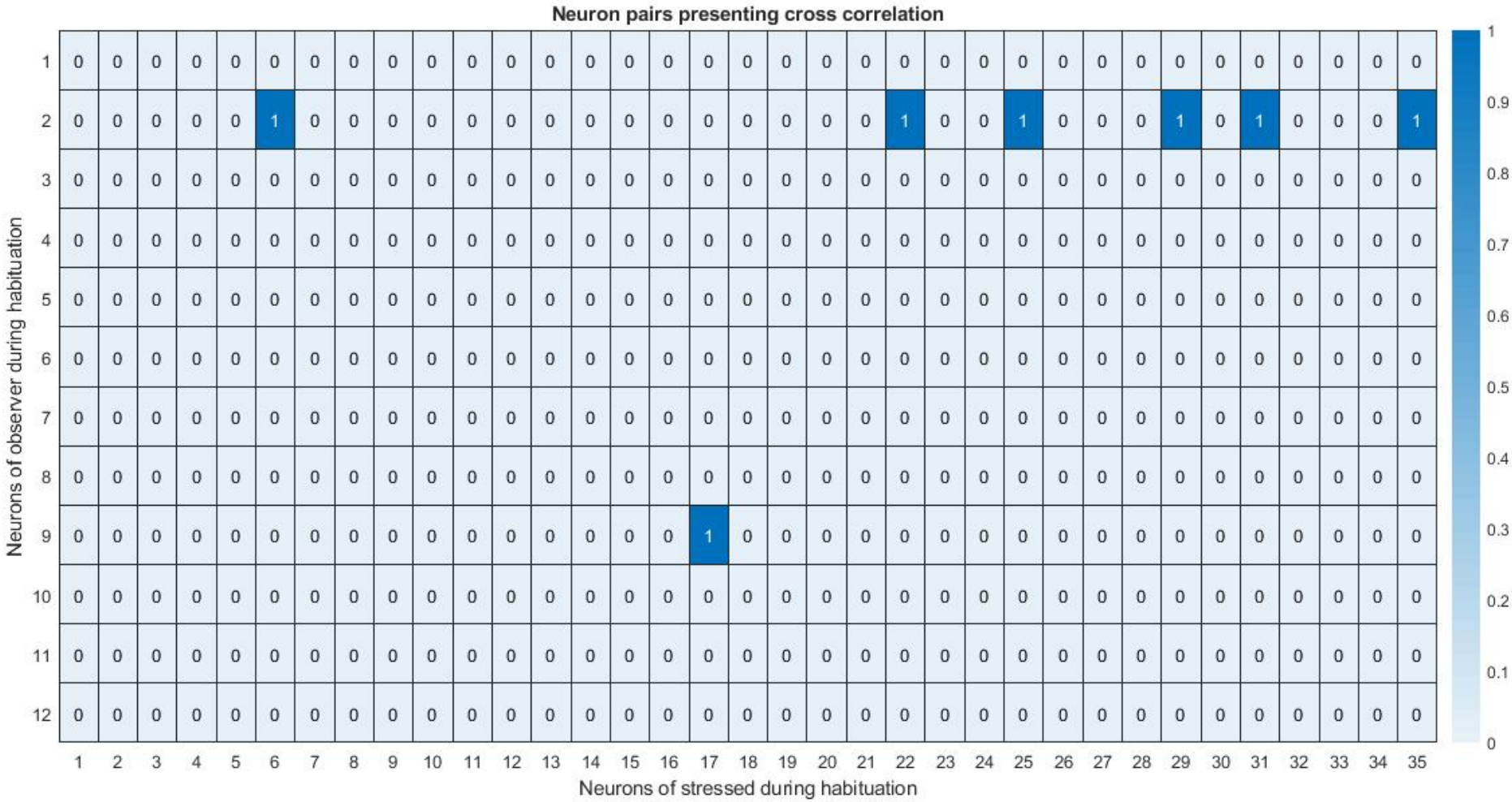


Neuron pairs synchronization: observer vs stressed during habituation (1)

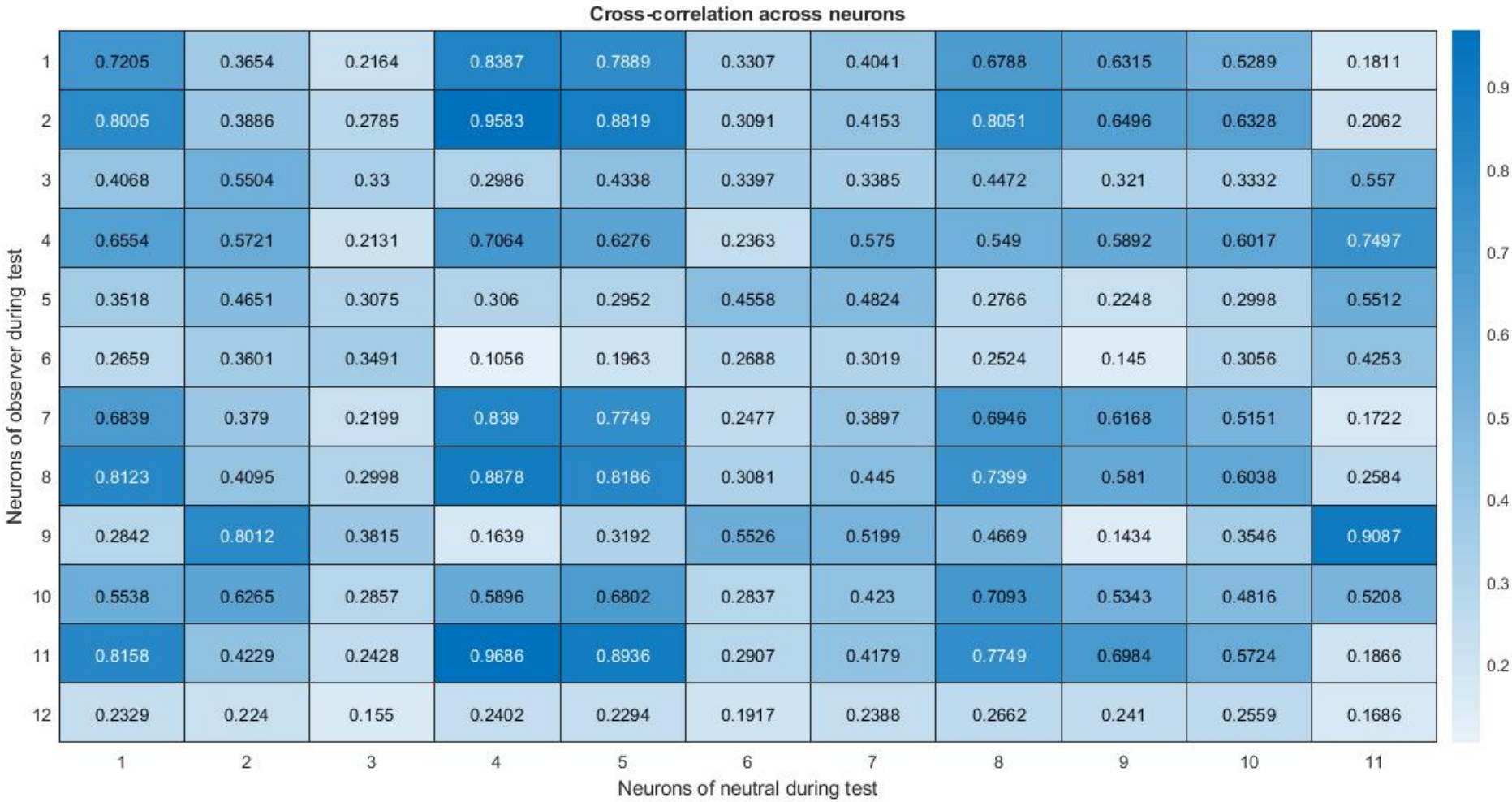


Neuron pairs synchronization: observer vs stressed during habituation (2)

Fraction of pairs showing correlation = 1.66%

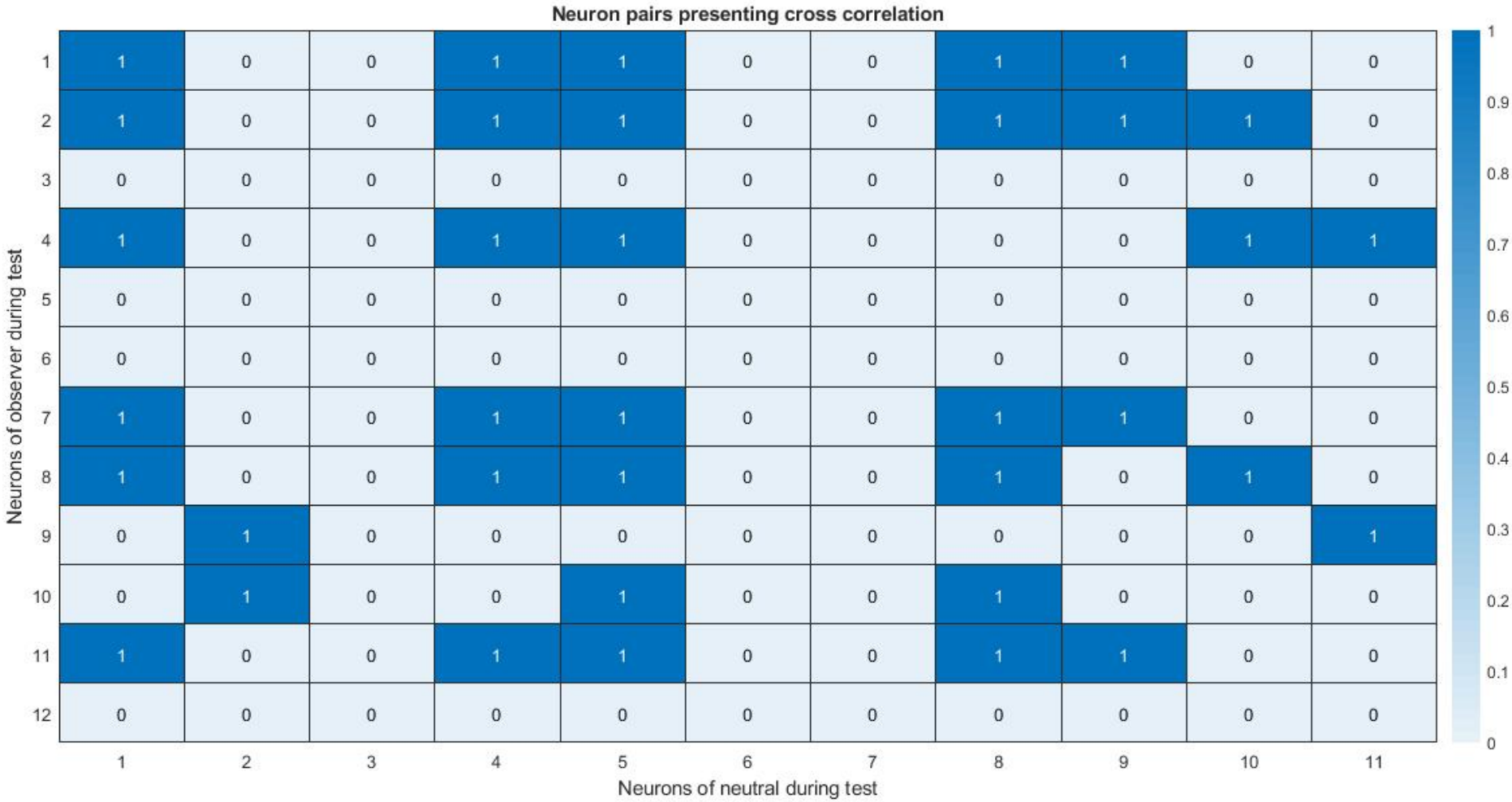


Neuron pairs synchronization: observer vs neutral during test (1)

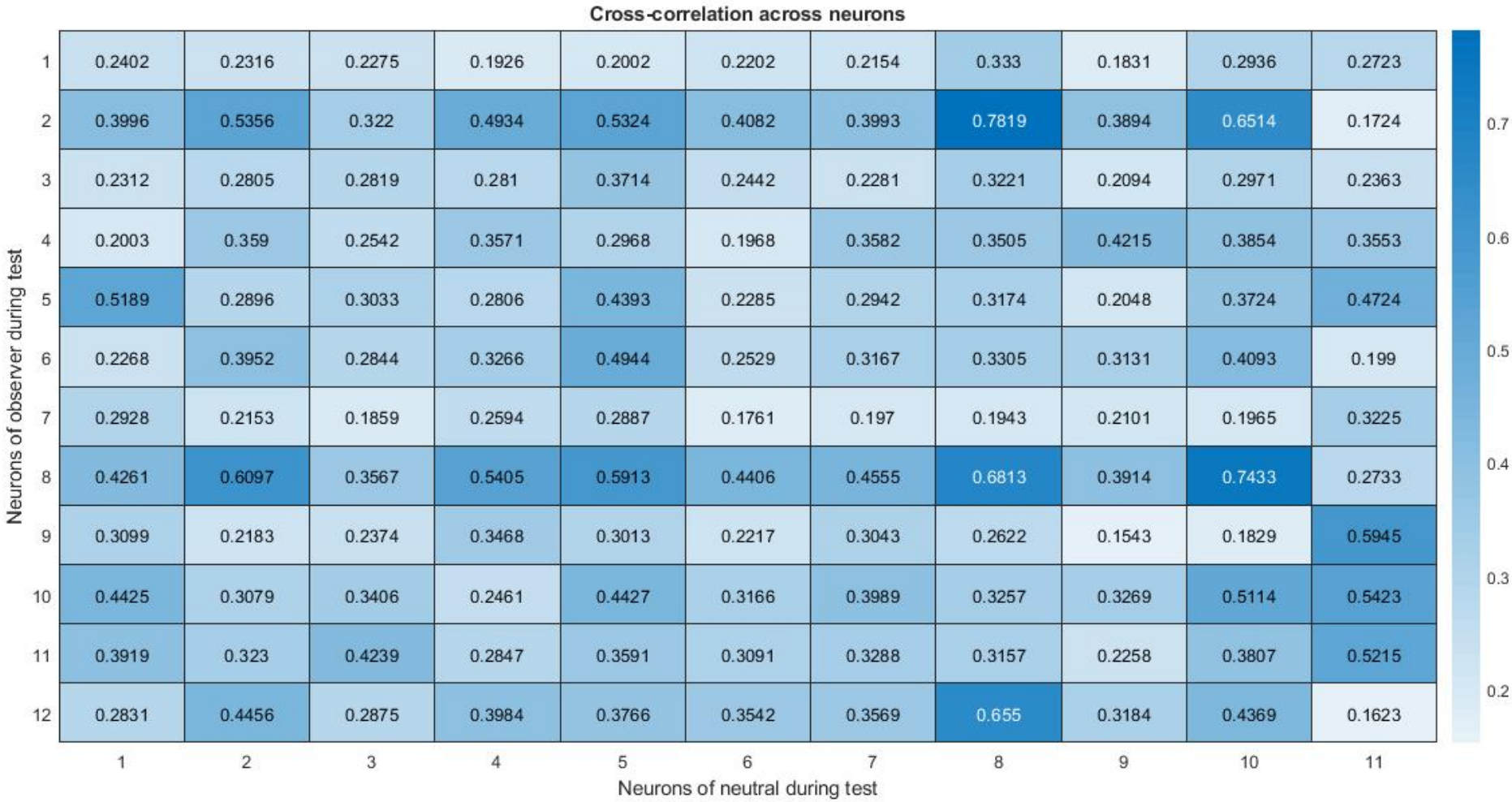


Neuron pairs synchronization: observer vs neutral during test (2)

Fraction of pairs showing correlation = 23%

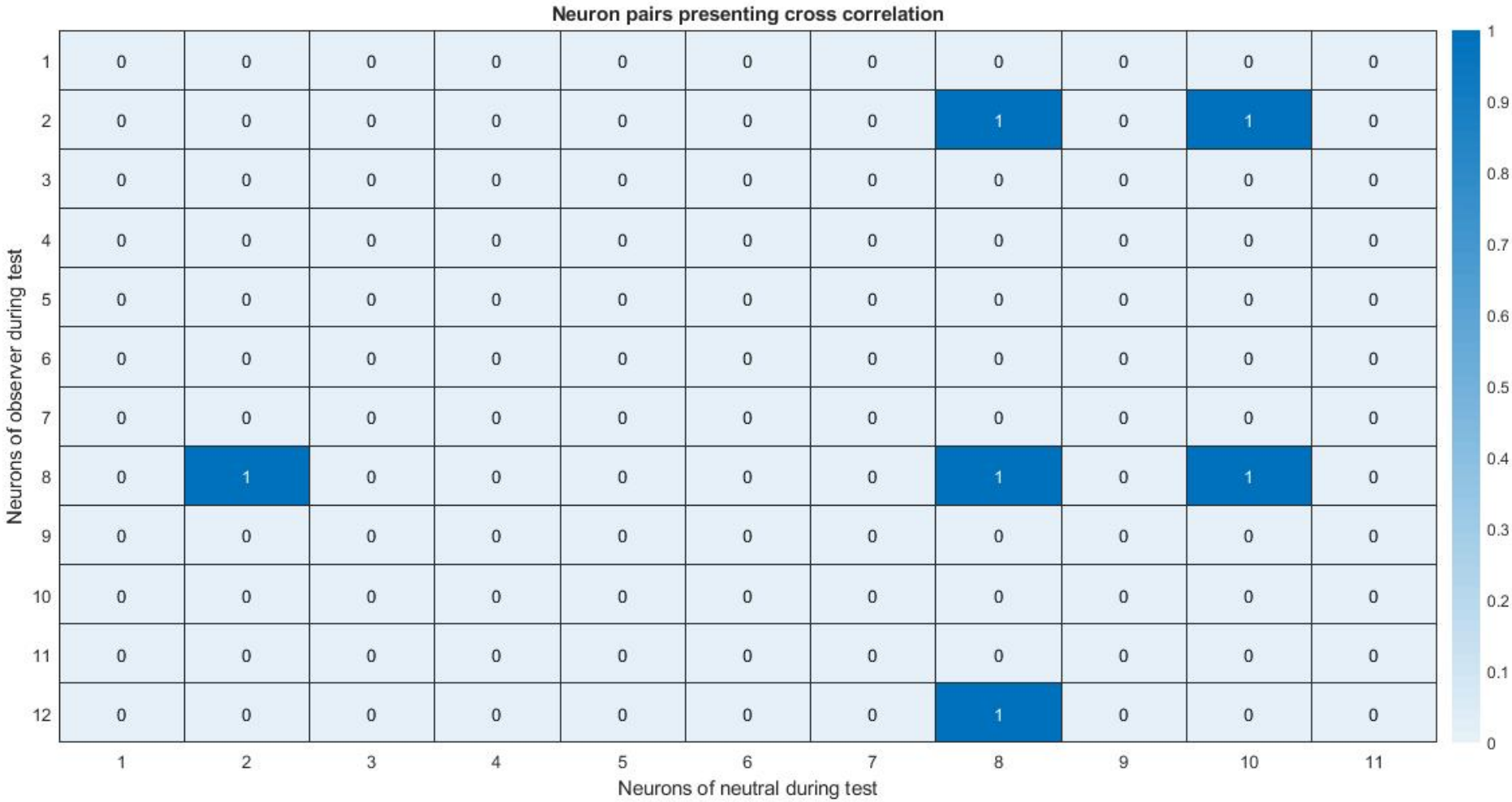


Neuron pairs synchronization: observer vs neutral during habituation (1)



Neuron pairs synchronization: observer vs neutral during habituation (2)

Fraction of pairs showing correlation = 4.5%



Conclusions on the pairs correlation analysis

- For both the couples observer/stressed and observer/neutral, the fraction of neuronal pairs exhibiting correlation is higher during the test rather then the habituation
- We can identify the neurons contributing the most to the correlation:
  Neurons $C00, C01, C03, C06, C07, C08, C09, C10$ for the observer
  Neurons $C01, C02, C07, C09, C11, C12, C17, C23, C24, C25$ for the stressed
  Neurons $C00, C01, C03, C04, C07, C08, C09, C10$ for the neutral