

Report.

Analysis of the new data has been done in two steps. First, analysis of 3s-windows free of artifacts based on AC channels data, we chose the 3s windows only from time when the bell was ringing, i.e. during first 6s of Go trials and 10s of NoGo trials. Second, analysis of 4 consequent 0.5s-windows free of artifacts that are corresponding to an inter-stimulus-interval of 500 ms. In other words, each window contains frequency modulated tone (200 ms) and pause after the tone (300 ms). We considered exactly the first four such inter-stimulus-intervals in each trial. We determine windows free of artifacts in a similar way as it's done before, that is, movement artifacts is defined by amplitude size, i.e. if it is $> 0.0005V$.

In general we have 20 channels with spatial arrangement of surface array electrodes as shown in fig. 1. We included only 18 in the following studies due to significant movement artifacts in channels 10 and 26. The other 18 channels have almost all 96 trials free of movement artifacts (there are in total 3 trials among all 6 days with artifacts).

28	12	26	10	24
8	22	6	20	4
18	2	23	7	21
5	19	3	17	1

Fig. 1: Spatial arrangement of the electrodes over the auditory cortex on the gerbil.

Using data selected following Table 1, power spectral density (PSD) functions were determined for each channel using standard FFT-based method. Once the PSD were determined, we calculated the power in the frequency band 20-80Hz by summing up the amplitudes and determined the RMS using the formula:

$$RMS_{\{i\}} = \sqrt{\sum_{k=20Hz}^{80Hz} PSD_{\{i\}}(k)},$$

where i is a channel among 18 channels that were considered in the analysis (see fig. 1). Finally, amplitude modulation (AM) patterns were created for each trial by using RMS values of each channel. These will be the AM patterns in the 18-dimensional space.

After these preprocessing steps we trained a MLP for each day separately. Using standard Levenberg Marquart learning, with about 120 training iterations. At the end of the training, all training examples were classified correctly. The testing results are after the tables.

Based on the classification results we may assume the conclusion that AM patterns exhibit information about different type of tones (i.e. Go and NoGo trials). However, it is hard to see in these data learning process.

Learning based on the number of shocks per day is summarized in table 2 and fig. 1.

Table 1.

140605		140606		140607		140610		140611		140613	
Go	NoGo	Go	NoGo	Go	NoGo	Go	NoGo	Go	NoGo	Go	NoGo
1	3	1	3	1	3	1	3	1	3	1	3
2	4	2	4	2	4	2	4	2	4	2	4
5	8	5	8	5	8	5	8	5	8	5	8
6	9	6	9	6	9	6	9	6	9	6	9
7	10	7	10	7	10	7	10	7	10	7	10
11	12	11	12	11	12	11	12	11	12	11	12
14	13	14	13	14	13	14	13	14	13	14	13
15	17	15	17	15	17	15	17	15	17	15	17
16	18	16	18	16	18	16	18	16	18	16	18
20	19	20	19	20	19	20	19	20	19	20	19
22	21	22	21	22	21	22	21	22	21	22	21
23	24	23	24	23	24	23	24	23	24	23	24
25	27	25	27	25	27	25	27	25	27	25	27
26	28	26	28	26	28	26	28	26	28	26	28
29	32	29	32	29	32	29	32	29	32	29	32
30	33	30	33	30	33	30	33	30	33	30	33
31	34	31	34	31	34	31	34	31	34	31	34
35	36	35	36	35	36	35	36	35	36	35	36
38	37	38	37	38	37	38	37	38	37	38	37
39	41	39	41	39	41	39	41	39	41	39	41
40	42	40	42	40	42	40	42	40	42	40	42
44	43	44	43	44	43	44	43	44	43	44	43
46	45	46	45	46	45	46	45	46	45	46	45
47	48	47	48	47	48	47	48	47	48	47	48
49	51	49	51	49	51	49	51	49	51	49	51
50	52	50	52	50	52	50	52	50	52	50	52
53	56	53	56	53	56	53	56	53	56	53	56
54	57	54	57	54	57	54	57	54	57	54	57
--55	58	55	58	55	58	55	58	55	58	55	58
59	60	59	60	59	60	59	60	59	60	59	60
62	61	62	61	62	61	62	61	62	61	62	61
63	65	63	65	63	65	63	65	63	65	63	65
64	66	64	66	64	66	64	66	64	66	64	66
68	67	68	67	68	67	68	67	68	67	68	67
70	69	70	69	70	69	70	69	70	69	70	69
71	72	71	72	71	72	71	72	71	72	71	72
73	75	73	75	73	75	73	75	73	75	73	75
74	76	74	76	74	76	74	76	74	76	74	76
77	80	77	80	77	80	77	80	77	80	77	80
78	81	78	81	78	81	78	81	78	81	78	81

79	82	79	82	79	82	79	82	79	82	79	82
83	84	83	84	83	84	83	84	83	84	83	84
86	85	86	85	86	85	86	85	86	85	86	85
87	89	87	89	87	89	87	89	87	89	87	89
88	90	88	90	88	90	88	90	88	90	88	90
92	91	92	91	92	91	92	91	92	91	92	91
94	93	-----	-----	94	93	94	93	94	93	94	93
95	96	-----	-----	95	96	95	96	95	96	95	96

Table 2: Trials without shock for each day

140605		140606		140607		140610		140611		140613	
Go	NoGo	Go	NoGo	Go	NoGo	Go	NoGo	Go	NoGo	Go	NoGo
6/48	44/48	11/46	43/46	29/48	46/48	25/48	45/48	28/48	42/48	42/48	45/48
12.5%	91.6%	23.9%	93.5%	60.4%	95.8%	52%	93.75%	58%	87.5%	87.5%	93.75%

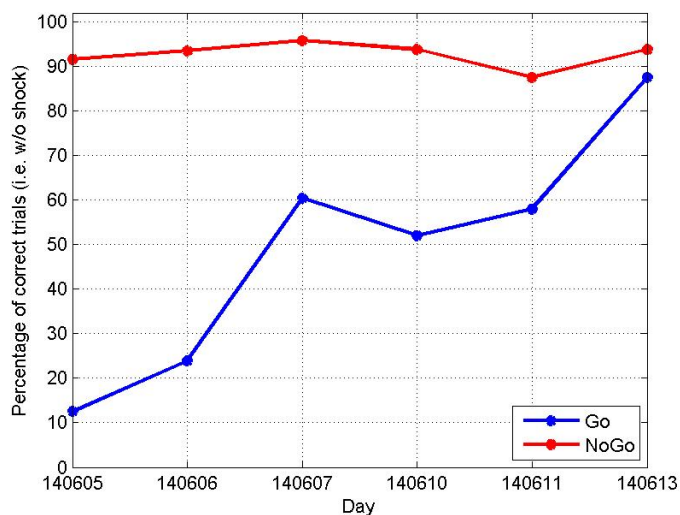


Fig. 2: Percentage of trials without shock.

Step #1, “3-second windows”.

After such preprocessing, we obtained a data blocks as follows:

Day 140605: 18x47 Go, 18x48 NoOGO; training: 26 Go and NoGo

Day 140606: 18x46 Go, 18x46 NoOGO; training: 26 Go and NoGo

Day 140607: 18x48 Go, 18x48 NoOGO; training: 28 Go and NoGo

Day 140610: 18x48 Go, 18x48 NoOGO; training: 26 Go and NoGo

Day 140611: 18x48 Go, 18x48 NoOGO; training: 26 Go and NoGo

Day 140613: 18x48 Go, 18x48 NoGo; training: 28 Go and NoGo

Results of the testing are summarized in A_1, \dots, A_6 confusion matrices:

- Day 140605

$$A_1 = \begin{bmatrix} 19.54 & 1.46 \\ 0.06 & 21.94 \end{bmatrix}$$

Correct classification of patterns with Go trials is 93%, and with NoGo trials is 99.7%.

- Day 140606

$$A_2 = \begin{bmatrix} 18.74 & 1.26 \\ 0.33 & 19.67 \end{bmatrix}$$

Correct classification of patterns with Go trials is 93.7%, and with NoGo trials is 98%.

- Day 140607

$$A_3 = \begin{bmatrix} 15 & 5 \\ 0.86 & 19.14 \end{bmatrix}$$

Correct classification of patterns with Go trials is 75%, and with NoGo trials is 95.7%.

- Day 140610

$$A_4 = \begin{bmatrix} 21.8 & 0.2 \\ 0.86 & 21.14 \end{bmatrix}$$

Correct classification of patterns with Go trials is 99%, and with NoGo trials is 96%.

- Day 140611

$$A_5 = \begin{bmatrix} 21.74 & 0.26 \\ 1.26 & 20.74 \end{bmatrix}$$

Correct classification of patterns with Go trials is 98.8%, and with NoGo trials is 94%.

- Day 140613

$$A_6 = \begin{bmatrix} 16.4 & 3.6 \\ 3.86 & 16.14 \end{bmatrix}$$

Correct classification of patterns with Go trials is 82%, and with NoGo trials is 80.7%.

Step #2, “0.5-second windows”.

Results of the testing are summarized in A_{ij} confusion matrices (where i corresponds to day and j is tone):

- Day 140605

$$A_{11} = \begin{bmatrix} 14.8 & 5.2 \\ 1.8 & 18.2 \end{bmatrix}$$

$$A_{12} = \begin{bmatrix} 18.1 & 1.9 \\ 0.3 & 19.7 \end{bmatrix}$$

$$A_{13} = \begin{bmatrix} 17.9 & 2.1 \\ 5.2 & 14.8 \end{bmatrix}$$

$$A_{14} = \begin{bmatrix} 18.3 & 1.7 \\ 1.3 & 18.7 \end{bmatrix}$$

Tone 1. Correct classification of patterns with Go trials is 74%, and with NoGo trials is 91%.

Tone 2. Correct classification of patterns with Go trials is 90.5%, and with NoGo trials is 98.5%.

Tone 3. Correct classification of patterns with Go trials is 89.5%, and with NoGo trials is 74%.

Tone 4. Correct classification of patterns with Go trials is 91.5%, and with NoGo trials is 93.5%.

- Day 140606

$$A_{21} = \begin{bmatrix} 13.6 & 4.4 \\ 0 & 18 \end{bmatrix}$$

$$A_{22} = \begin{bmatrix} 17 & 1 \\ 2.2 & 15.8 \end{bmatrix}$$

$$A_{23} = \begin{bmatrix} 11.9 & 6.1 \\ 0.2 & 17.8 \end{bmatrix}$$

$$A_{24} = \begin{bmatrix} 16.3 & 1.7 \\ 0 & 18 \end{bmatrix}$$

Tone 1. Correct classification of patterns with Go trials is 75.5%, and with NoGo trials is 100%.

Tone 2. Correct classification of patterns with Go trials is 94.4%, and with NoGo trials is 87.7%.

Tone 3. Correct classification of patterns with Go trials is 66%, and with NoGo trials is 98.8%.

Tone 4. Correct classification of patterns with Go trials is 90.5%, and with NoGo trials is 100%.

- Day 140607

$$A_{31} = \begin{bmatrix} 17.9 & 2.1 \\ 6.1 & 13.9 \end{bmatrix}$$

$$A_{32} = \begin{bmatrix} 17.4 & 2.6 \\ 6.6 & 13.4 \end{bmatrix}$$

$$A_{33} = \begin{bmatrix} 19.7 & 0.3 \\ 4.3 & 15.7 \end{bmatrix}$$

$$A_{34} = \begin{bmatrix} 17.1 & 2.9 \\ 1.6 & 18.4 \end{bmatrix}$$

Tone 1. Correct classification of patterns with Go trials is 89.5%, and with NoGo trials is 69.5%.

Tone 2. Correct classification of patterns with Go trials is 87%, and with NoGo trials is 67%.

Tone 3. Correct classification of patterns with Go trials is 98.5%, and with NoGo trials is 78.5%.

Tone 4. Correct classification of patterns with Go trials is 85.5%, and with NoGo trials is 92%.

- Day 140610

$$A_{41} = \begin{bmatrix} 13.8 & 6.2 \\ 0 & 20 \end{bmatrix}$$

$$A_{42} = \begin{bmatrix} 17.4 & 2.6 \\ 1 & 19 \end{bmatrix}$$

$$A_{43} = \begin{bmatrix} 15.8 & 4.2 \\ 5.7 & 14.3 \end{bmatrix}$$

$$A_{44} = \begin{bmatrix} 18.4 & 1.6 \\ 2 & 18 \end{bmatrix}$$

Tone 1. Correct classification of patterns with Go trials is 69%, and with NoGo trials is 100%.

Tone 2. Correct classification of patterns with Go trials is 87%, and with NoGo trials is 95%.

Tone 3. Correct classification of patterns with Go trials is 79%, and with NoGo trials is 71.5%.

Tone 4. Correct classification of patterns with Go trials is 92%, and with NoGo trials is 90%.

- Day 140611

$$A_{51} = \begin{bmatrix} 15.2 & 3.8 \\ 3.3 & 16.7 \end{bmatrix}$$

$$A_{52} = \begin{bmatrix} 16.7 & 2.3 \\ 1.6 & 18.4 \end{bmatrix}$$

$$A_{53} = \begin{bmatrix} 14.8 & 4.2 \\ 1.8 & 18.2 \end{bmatrix}$$

$$A_{54} = \begin{bmatrix} 18.3 & 0.7 \\ 5.7 & 14.3 \end{bmatrix}$$

Tone 1. Correct classification of patterns with Go trials is 80%, and with NoGo trials is 83.5%.

Tone 2. Correct classification of patterns with Go trials is 87.8%, and with NoGo trials is 92%.

Tone 3. Correct classification of patterns with Go trials is 77.8%, and with NoGo trials is 91%.

Tone 4. Correct classification of patterns with Go trials is 96.3%, and with NoGo trials is 71.5%.

- Day 140613

$$A_{61} = \begin{bmatrix} 19 & 0 \\ 1.8 & 18.2 \end{bmatrix}$$

$$A_{62} = \begin{bmatrix} 18.8 & 0.2 \\ 0 & 20 \end{bmatrix}$$

$$A_{63} = \begin{bmatrix} 17.5 & 1.5 \\ 3 & 17 \end{bmatrix}$$

$$A_{64} = \begin{bmatrix} 16.8 & 2.2 \\ 1.6 & 18.4 \end{bmatrix}$$

Tone 1. Correct classification of patterns with Go trials is 100%, and with NoGo trials is 91%.

Tone 2. Correct classification of patterns with Go trials is 98.9%, and with NoGo trials is 100%.

Tone 3. Correct classification of patterns with Go trials is 92%, and with NoGo trials is 85%.

Tone 4. Correct classification of patterns with Go trials is 88.4%, and with NoGo trials is 92%.

“0.25-second windows”.

We were looking for four consequent 250ms windows before and after the start of a trial that is in total we have 1s before and after the start of a trial. 1 sec after the start has 2 tones (200ms each) and 2 pauses (300ms each).

After, we considered 4 NN for a day with structure 18-3-3, that is, there are 3 classes “Go”, “NoGo” and “Background”.

win i = 250ms, for any i



After 250 ms windows were found, we obtained a data blocks as follows:

Day 140605, Day 140607, Day 140610, Day 140611, Day 140613:

training: 28 trials for Background, Go and NoGo. Total 84.

testing: 20 trials for Background, Go and NoGo, Total 60

Day 140606:

training: 28 trials for Background, Go and NoGo. Total 84.

testing: 18 trials for Background, Go and NoGo, Total 54

Results of the testing are summarized in A_{ij} (where i corresponds to day and j is tone).

A_{ij} contains three elements: the correct average number of classification of Background, Go and NoGo patterns. See also attached pdf files that contain percentage of correct classifications.

- Day 140605

$$A_{11} = [13.8, \quad 12, \quad 17]$$

$$A_{12} = [11.4, \quad 16, \quad 12.3]$$

$$A_{13} = [8.1, \quad 15.1, \quad 13.3]$$

$$A_{14} = [14, \quad 15.6, \quad 16.6]$$

- Day 140606

$$A_{21} = [9.2, \quad 9.9, \quad 13.8]$$

$$A_{22} = [12.8, \quad 1.25, \quad 10.1]$$

$$A_{23} = [7.8, \quad 10.7, \quad 14.2]$$

$$A_{24} = [12.5, \quad 11.9, \quad 11.3]$$

- Day 140607

$$A_{31} = [8.9, \quad 15.6, \quad 9.7]$$

$$A_{32} = [10, \quad 11.1, \quad 9.1]$$

$$A_{33} = [10.6, \quad 15.8, \quad 13.6]$$

$$A_{34} = [12.1, \quad 11.2, \quad 14]$$

- Day 140610

$$A_{41} = [13.6, \quad 10.2, \quad 17]$$

$$A_{42} = [16.1, \quad 10.7, \quad 16.2]$$

$$A_{43} = [17.6, \quad 13.8, \quad 9.7]$$

$$A_{44} = [15.1, \quad 14.9, \quad 13.2]$$

- Day 140611

$$A_{51} = [9.6, \quad 10.6, \quad 14.1]$$

$$A_{52} = [11.5, \quad 11.9, \quad 11.1]$$

$$A_{53} = [14.8, \quad 14.2, \quad 14.1]$$

$$A_{54} = [12, \quad 15.4, \quad 13.5]$$

- Day 140613

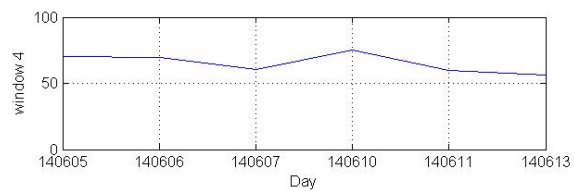
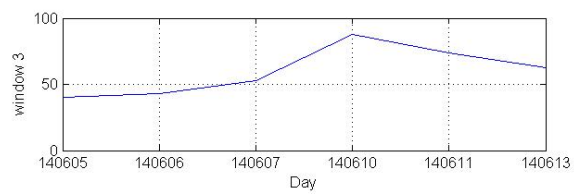
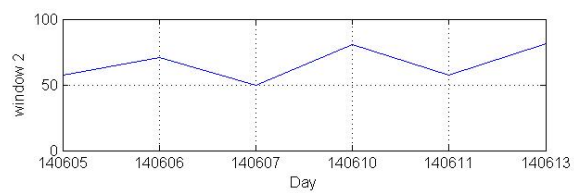
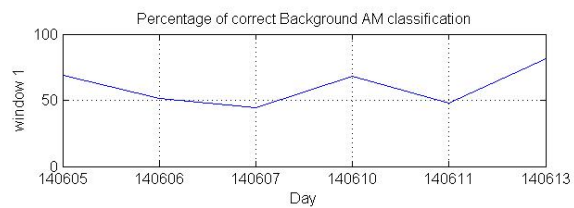
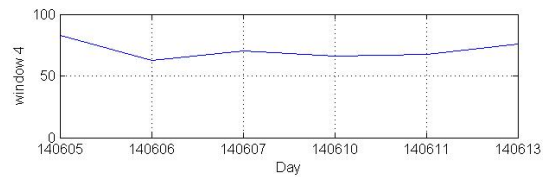
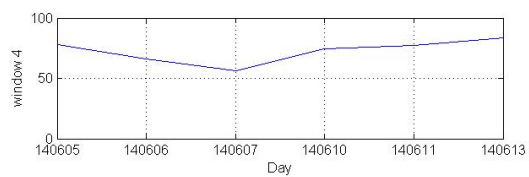
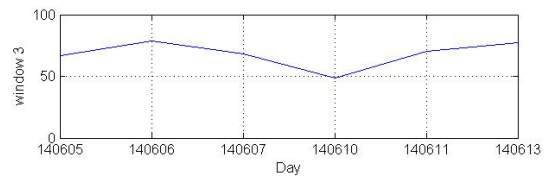
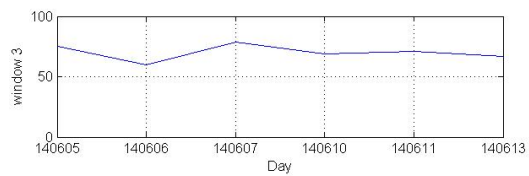
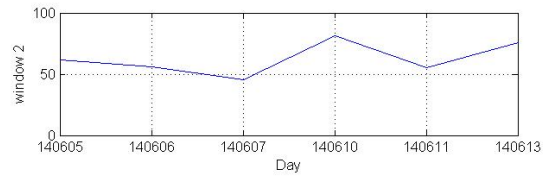
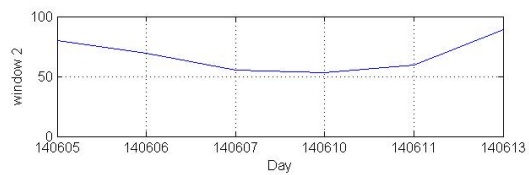
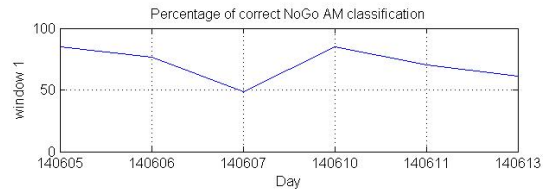
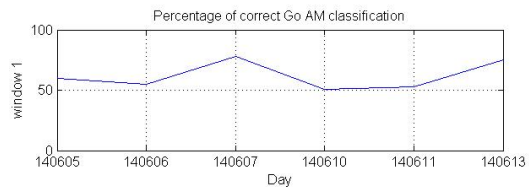
$$A_{61} = [16.3, \quad 15, \quad 12.2]$$

$$A_{62} = [16.3, \quad 17.8, \quad 15.1]$$

$$A_{63} = [12.5, \quad 13.4, \quad 15.5]$$

$$A_{64} = [11.3, \quad 16.7, \quad 15.2]$$

Thus, the correct classification of 3 classes “Go”, “NoGo” and “Background” is shown for each day on the next figures



Based on the analysis described above we suggest the following conclusions and open questions that form the next step for our analysis:

- It is enough to consider windows of size just 250ms that allows to compare AM patterns of pauses during experiments (right after the tones) and AM patterns during resting period (last seconds of a trial). In this case, there are three classes for classification analysis.
- Among three classes the Go trials are of the main interest. Trials without shocks are shown on fig. 2 and it is easy to see based on Go trials how gerbil develops correct strategy day by day – that is learning. Thus, it is necessary to find the transition between the last observation and AM patterns of Go trials.
- We checked that there are enough free of artifacts windows for depth electrode (Striatum). So, the analysis above is applicable to those channels as well. The question is whether it is necessary to consider AC channels and Striatum together or not?