UNIVERSITAT POLITÈCNICA DE CATALUNYA
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Escola d'Enginyeria de Barcelona Est

FINAL BACHELOR THESIS

Bachelor's Degree in Biomedical Engineering

SPIKE AND WAVE IDENTIFICATION ALGORITHM FOR THE DETECTION OF EPILEPTIC SEIZURES

Appendix

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POLITECNICO DI TORINO

Dipartimento di Elettronica e Telecomunicazioni

Bachelor Degree in Biomedical Engineering

Spike and Wave Identification Algorithm for the Detection of Epileptic Seizures

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Recordings with seizures

code	N. of seizures	File start time	File end time	Seizure start time	Seizure end time	Total s of seizure	Channel configuration
chb1							
1_3	1	13:43:04	14:43:04	2996	3036	40	FP1-F7
1_4	1	14:43:12	15:43:12	1467	1494	27	FP1-F7
1_15	1	1:44:44	2:44:44	1732	1772	40	FP1-F7
1_16	1	2:44:51	3:44:51	1015	1066	51	FP1-F7
1_18	1	4:45:06	5:45:06	1720	1810	90	FP1-F7
1_21	1	7:33:46	8:33:46	327	420	93	FP1-F7
1_26	1	12:34:22	13:13:07	1862	1963	101	FP1-F7
chb02							
2_16	1	9:31:46	9:47:45	130	212	82	FP1-F7
2_16+	1	10:50:23	11:50:23	2972	3053	81	FP1-F7
2_19	1	13:50:45	14:40:45	3369	3378	9	FP1-F7
chb03							
3_1	1	13:23:36	14:23:36	362	414	52	FP1-F7
3_2	1	14:23:39	15:23:39	731	796	65	FP1-F7
3_3	1	15:23:47	16:23:47	432	501	69	FP1-F7
3_4	1	16:23:54	17:23:54	2162	2214	52	FP1-F7
3_34	1	1:51:23	2:51:23	1982	2029	47	FP1-F7
3_35	1	2:51:30	3:51:30	2592	2656	64	FP1-F7
3_36	1	4:51:45	5:51:45	1725	1778	53	FP1-F7
chb04							
4_5	1	10:02:37	12:41:33	7804	7853	49	FP1-F7
4_8	1	18:53:30	22:53:30	6446	6557	111	FP1-F7
4_28.1	2	0:04:47	4:05:10	1679	1781	102	FP1-F7
4_28.2				3782	3898	116	FP1-F7
chb05							
05_06	1	22:21:25	23:21:25	417	532	115	FP1-F7
05_13	1	5:22:15	6:22:15	1086	1196	110	FP1-F7

05_16	1	8:22:35	9:22:35	2317	2413	96	FP1-F7
05_17	1	9:22:42	10:22:42	2451	2571	120	FP1-F7
05_22	1	14:23:17	15:23:17	2348	2465	117	FP1-F7
chb06							
06_01.1	3	19:08:32	23:08:59	1724	1738	14	FP1-F7
06_01.2				7461	7476	15	FP1-F7
06_01.3				13525	13540	15	FP1-F7
06_04.1	2	7:09:51	10:50:52	327	347	20	FP1-F7
06_04.2				6211	6231	20	FP1-F7
06_09	1	2:51:47	6:51:47	12500	12516	16	FP1-F7
06_10	1	6:51:54	10:51:54	10833	10845	12	FP1-F7
06_13	1	18:52:20	22:52:20	506	519	13	FP1-F7
06_18	1	11:45:55	13:58:03	7799	7811	12	FP1-F7
chb07							
07_12	1	7:46:22	11:46:22	4920	5006	86	FP1-F7
07_13	1	11:46:29	12:48:35	3285	3381	96	FP1-F7
07_19	1	8:12:32	12:12:43	13688	13831	143	FP1-F7
chb08							
08_02	1	12:28:57	13:28:57	2670	2841	171	FP1-F7
08_05	1	15:29:14	16:29:14	2856	3046	190	FP1-F7
01_11	1	20:37:01	21:37:01	2988	3122	134	FP1-F7
08_13	1	22:37:16	23:37:16	2417	2577	160	FP1-F7
08_21	1	6:38:16	7:38:16	2083	2347	264	FP1-F7
chb09							
09_06	1	12:21:42	16:21:41	12231	12295	64	FP1-F7
09_08.1	2	20:22:17	24:22:17	2951	3030	79	FP1-F7
09_08.2				9196	9267	71	FP1-F7
09_19	1	12:34:46	14:09:46	5299	5361	62	FP1-F7
chb10							
10_12	1	15:55:00	17:55:00	6313	6348	35	FP1-F7
10_20	1	7:56:00	9:56:12	6888	6958	70	FP1-F7
10_27	1	22:02:08	24:02:26	2382	2447	65	FP1-F7

10_30	1	4:03:19	6:03:32	3021	3079	58	FP1-F7
10_31	1	6:04:00	8:04:21	3801	3877	76	FP1-F7
10_38	1	14:33:05	16:33:05	4618	4707	89	FP1-F7
10_89	1	16:21:55	18:21:55	1383	1437	54	FP1-F7
chb11							
11_82	1	21:47:24	22:47:24	298	320	22	FP1-F7
11_92	1	7:48:31	8:48:31	2695	2727	32	FP1-F7
11_99	1	14:49:19	15:36:58	1454	2206	752	FP1-F7
chb12							
12_06.1	2	22:44:34	23:44:40	1665	1726	61	FP1-F7
12_06.2				3415	3447	32	FP1-F7
12_08.1	4	0:46:38	1:46:38	1426	1439	13	FP1-F7
12_08.2				1591	1614	23	FP1-F7
12_08.3				1957	1977	20	FP1-F7
12_08.4				2798	2824	26	FP1-F7
12_09.1	2	1:46:45	2:46:57	3082	3114	32	FP1-F7
12:09.2				3503	3535	32	FP1-F7
12_10.1	2	2:47:45	3:47:56	593	625	32	FP1-F7
12_10.2				811	856	45	FP1-F7
12_11	1	3:48:28	4:28:59	1085	1122	37	FP1-F7
12_23.1	3	12:06:43	13:06:43	253	333	80	FP1-F7
12_23.2				425	522	97	FP1-F7
12_23.3				630	670	40	FP1-F7
12_27.1	6	16:07:06	17:07:06	916	951	35	F7-CS2
12_27.2				1097	1124	27	FP1-F7
12_27.3				1728	1753	25	FP1-F7
12_27.4				1921	1963	42	FP1-F7
12_27.5				2388	2440	52	FP1-F7
12_27.6				2621	2669	48	FP1-F7
12_28	1	17:07:12	18:07:12	181	215	34	F7, T7, P7
12_29.1	6	18:07:19	19:07:43	107	146	39	FP1-F7
12_29.2				554	592	38	FP1-F7

12_29.3				1163	1199	36	FP1-F7
12_29.4				1401	1447	46	FP1-F7
12_29.5				1884	1921	37	FP1-F7
12_29.6				3557	3584	27	FP1-F7
12_33.1	2	22:09:51	23:09:51	2185	2206	21	FP1-F7
12_33.2				2427	2450	23	FP1-F7
12_36	1	1:10:11	2:10:11	653	680	27	FP1-F7
12_38.1	5	3:11:04	4:11:04	1548	1573	25	FP1-F7
12_38.2				2798	2821	23	FP1-F7
12_38.3				2966	3009	43	FP1-F7
12_38.4				3146	3201	55	FP1-F7
12_38.5				3364	3410	46	FP1-F7
12_42.1	5	7:11:30	8:11:30	699	750	51	FP1-F7
12_42.2				945	973	28	FP1-F7
12_42.3				1170	1199	29	FP1-F7
12_42.4				1676	1701	25	FP1-F7
12_42.5				2213	2236	23	FP1-F7
chb13							
13_19	1	9:14:25	10:14:25	2077	2121	44	FP1-F7
13_21	1	11:14:59	21:14:59	934	1004	70	FP1-F7
13_40.1	2	6:17:50	7:17:50	142	173	31	FP1-F7
14_40.2				530	594	64	FP1-F7
13_55.1	2	21:20:07	22:"0:07	458	478	20	FP1-F7
13_55.2				2436	2454	18	FP1-F7
13_58	1	0:20:28	1:20:28	2474	2491	17	FP1-F7
13_59	1	1:20:34	2:20:34	3339	3401	62	FP1-F7
13_60	1	2:20:41	3:20:41	638	660	22	FP1-F7
13_62.1	3	4:20:55	5:20:55	851	916	65	FP1-F7
13_62.2				1626	1691	65	FP1-F7
13_62.3				2664	2721	57	FP1-F7
chb14							
14_03	1	16:35:00	17:35:00	1986	2000	14	FP1-F7

14_04.1	2	17:05:07	18:35:07	1372	1392	20	FP1-F7
14_04.2				2817	2839	22	FP1-F7
14_06	1	19:35:21	20:35:21	1911	1925	14	FP1-F7
14_11	1	0:35:55	1:35:55	1838	1879	41	FP1-F7
14_17	1	6:36:36	7:36:36	3239	3259	20	FP1-F7
14_18	1	7:36:43	8:36:43	1039	1061	22	FP1-F7
14_27	1	16:37:45	17:37:45	2833	2849	16	FP1-F7
chb15							
15_06	1	23:24:10	24:24:10	272	397	125	FP1-F7
15_10	1	3:24:38	4:24:38	1082	1113	31	FP1-F7
15_15	1	8:25:13	9:25:13	1591	1748	157	FP1-F7
15_17	1	10:25:27	11:25:27	1925	1960	35	FP1-F7
15_20	1	13:25:48	14:25:48	607	662	55	FP1-F7
15_22	1	15:26:01	16:26:02	760	965	205	FP1-F7
15_28	1	21:27:58	22:27:58	876	1066	190	FP1-F7
15_31	1	0:28:28	1:28:18	1751	1871	120	FP1-F7
15_40.1	3	9:29:21	10:29:21	834	894	60	FP1-F7
15_40.2				2378	2497	119	FP1-F7
15_40.3				3362	3425	63	FP1-F7
15_46	1	15:30:07	16:30:07	3322	3429	107	FP1-F7
15_49	1	18:38:05	19:38:30	1108	1248	140	FP1-F7
15_52	1	21:39:10	22:39:!9	778	849	71	FP1-F7
15_54.1	5	23:39:54	24:39:54	263	318	55	FP1-F7
15_54.2				843	1020	177	FP1-F7
15_54.3				1524	1595	71	FP1-F7
15_54.4				2179	2250	71	FP1-F7
15_54.5				3428	3460	32	FP1-F7
15_62	1	7:41:10	8:41:10	751	859	108	FP1-F7
chb16							
16_10	1	1:40:40	2:40:40	2290	2299	9	FP1-F7
16_11	1	2:40:47	3:40:47	1120	1129	9	FP1-F7
16_14	1	5:41:08	6:41:08	1854	1868	14	FP1-F7

16_16	1	7:41:22	8:41:22	1214	1220	6	FP1-F7
16_17.1	4	8:41:29	9:41:29	227	236	9	FP1-F7
16_17.2				1694	1700	6	FP1-F7
16_17.3				2162	2170	8	FP1-F7
16_17.4				3290	3298	8	FP1-F7
16_18.1	2	9:41:36	10:41:36	627	635	8	FP1-F7
16_18.2				1909	1916	7	FP1-F7
chb18						0	
18_29	1	5:58:59	6:58:59	3477	3527	50	FP1-F7
18_30	1	6:59:06	7:59:06	541	571	30	FP1-F7
18_31	1	10:00:32	10:38:26	2087	2155	68	FP1-F7
18_32	1	11:38:42	12:38:42	1908	1963	55	FP1-F7
18_35	1	8:42:06	9:42:06	2196	2264	68	FP1-F7
18_36	1	8:45:57	9:45:57	463	509	46	FP1-F7
chb19							
19_28	1	1:09:35	2:09:47	299	377	78	FP1-F7
19_29	1	7:11:12	8:11:12	2964	3041	77	FP1-F7
19_30	1	11:12	12:08:25	3159	3240	81	FP1-F7
chb20							
20_12	1	3:56:53	4:56:53	94	123	29	FP1-F7
20_13.1	2	4:57:00	5:57:00	1440	1470	30	FP1-F7
20_13.2				2498	2537	39	FP1-F7
20_14	1	5:57:07	6:57:07	1971	2009	38	FP1-F7
20_15.1	2	6:57:14	7:57:14	390	425	35	FP1-F7
20_15.2				1689	1738	49	FP1-F7
20_16	1	7:57:20	8:55:09	2226	2261	35	FP1-F7
20_68	1	9:45:07	10:21:14	1393	1432	39	FP1-F7
chb21							
21_19	1	11:59:13	12:59:13	1288	1344	56	FP1-F7
21_20	1	12:59:20	13:49:10	2627	2677	50	FP1-F7
21_21	1	15:49:35	16:49:35	2003	2084	81	FP1-F7
21_22	1	16:49:42	17:49:42	2553	2565	12	FP1-F7

chb22							
22_20	1	17:45:03	18:45:03	3367	3425	58	FP1-F7
22_25	1	22:45:37	23:45:37	3139	3213	74	FP1-F7
22_38	1	11:47:09	12:47:09	1263	1335	72	FP1-F7
chb23							
23_06	1	8:57:57	11:02:43	3962	4075	113	FP1-F7
23_08.1	2	11:48:05	14:40:27	325	345	20	FP1-F7
23_08.2				5104	5151	47	FP1-F7
23_09.1	4	14:40:47	18:41:13	2589	2660	71	FP1-F7
23_09.2				6885	6947	62	FP1-F7
23_09.3				8505	8532	27	FP1-F7
23_09.4				9580	9664	84	FP1-F7
chb24		time is not provided for the recordings					
24_01.1	2			480	505	25	FP1-F7
24_01.2				2451	2476	25	FP1-F7
24_03.1	2			231	260	29	FP1-F7
24_03.2				2883	2908	25	FP1-F7
24_04.1	3			1088	1120	32	FP1-F7
24_04.2				1411	1438	27	FP1-F7
24_04.3				1745	1764	19	FP1-F7
24_06	1			1229	1253	24	FP1-F7
24_07	1			38	60	22	FP1-F7
24_09	1			1745	1764	19	FP1-F7
24_11	1			3527	3597	70	FP1-F7
24_13	1			3288	3304	16	FP1-F7
24_14	1			1939	1966	27	FP1-F7
24_15	1			3552	3569	17	FP1-F7
24_17	1			3515	3581	66	FP1-F7
24_21	1			2804	2872	68	FP1-F7

Table 1. Seizures in the recordings and corresponding times

Patient results

chb01

Patient overview

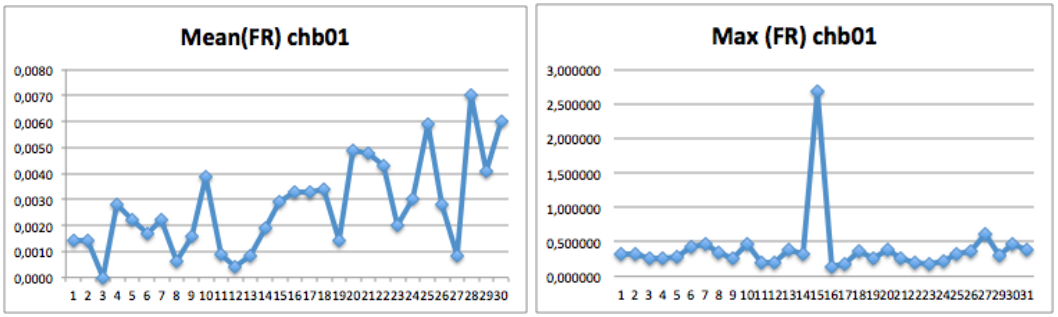


Figure 1, 2. (1) Mean firing rate and (2) Max firing rate

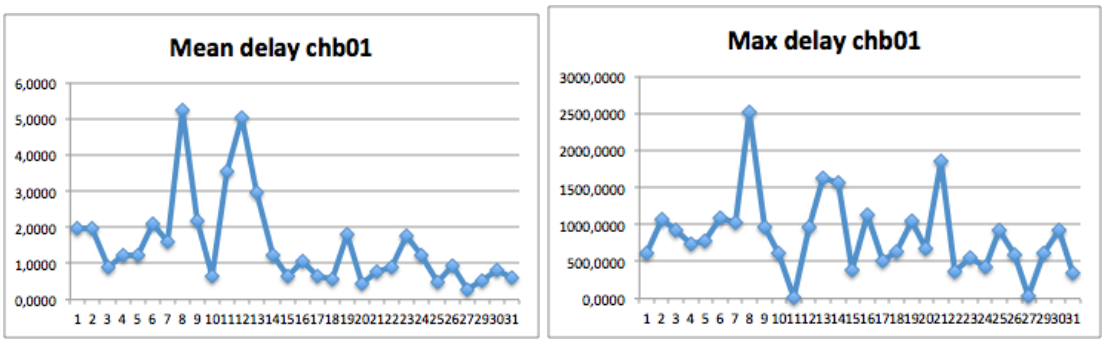


Figure 3, 4. (3) Mean delay and (4) Max delay

As it can be seen on the graphs, there is some variation in the obtained values. Considering that the recordings with seizures are 3, 4, 15, 16, 18, 21 and 26, it can be studied the effects of the seizure regarding the mean and the maximum firing rate of each recording and the mean and maximum delay.

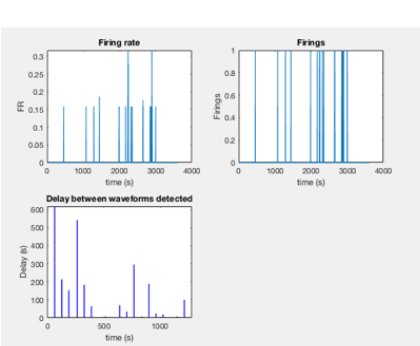
Considering the firing rates, the recording 15 (with seizures) contains the maximum firing rate overall, where the others have a similar value between them. The mean firing rate stays quite low between all the recordings.

As for the delays, the overall delay of each recording stays very low, especially during recordings with seizures. The difference can be clearly seen during the analysis of the mean delay of 18, 19, 20 and 21; where 19 and 20 do not contain any seizure, showing a higher delay, more concretely the recording 19. The maximum delays are seen on recording 8 (no seizure) and on recording 21 (seizure). The last one has to be closely studied, thus the maximum delay is at around 2000 seconds, being a post-seizure period and not during the seizure, where the delays are very low.

CHB01	Mean(FR)	Max(FR)	Mean Delay	Max delay
1	0,0014	0,317400	1,9899	618,2031
2	0,0014	0,317400	1,9899	1067,0000
3 (seizure)	0.0029	0,262200	0,8855	933,1250
4 (seizure)	0,0028	0,252000	1,2256	731,1719
5	0,0022	0,288100	1,2381	783,5547
6	0,0017	0,433500	2,0785	1081,6000
7	0,0022	0,461200	1,6023	1025,5000
8	0,0006	0,348100	5,2542	2513,4000
9	0,0016	0,262000	2,1599	967,7812
10	0,0039	0,473400	0,6509	612,6133
11	0,0009	0,195700	3,5624	6,1898
12	0,0004	0,201900	5,0157	963,3516
13	0,0009	0,390700	2,9787	1632,8000
14	0,0019	0,319800	1,2470	1571,2000
15 (seizure)	0,0029	2,672000	0,6627	375,8242
16 (seizure)	0,0033	0,145200	1,0514	1123,3000
17	0,0033	0,176100	0,6405	517,9023
18 (seizure)	0,0034	0,371700	0,5794	631,1484
19	0,0014	0,268500	1,8092	1053,5000
20	0,0049	0,386500	0,4590	669,3711
21 (seizure)	0,0048	0,268800	0,7691	1846,9000
22	0,0043	0,206300	0,9098	374,9414
23	0,0020	0,185600	1,7620	545,5898
24	0,0030	0,229900	1,2254	430,1797
25	0,0059	0,331600	0,4879	922,7031
26 (seizure)	0,0028	0,370600	0,9559	585,3906
27	0,0008	0,611700	0,2882	35,5352
29	0,0070	0,303600	0,5246	610,1211
30	0,0041	0,464000	0,8195	933,0000
31	0,0060	0,386500	0,5896	351,1641

Table 2. Parameters obtained for each recording

1.



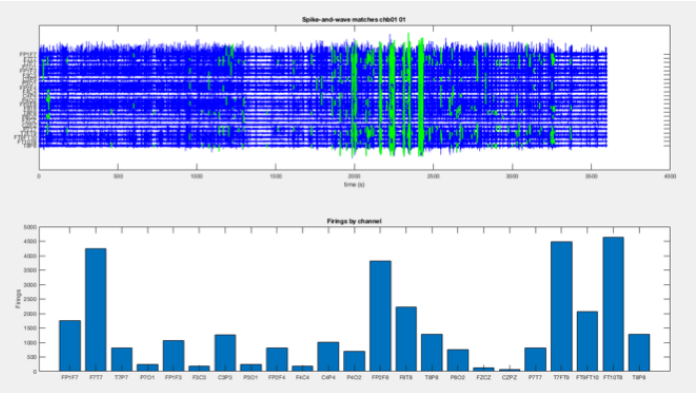
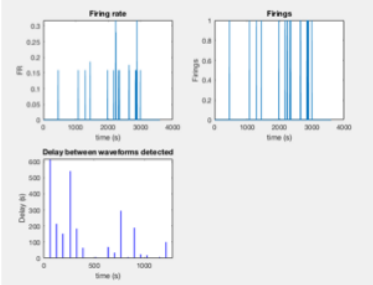


Figure 5, 6. (5) Firing rate, firings by time and delay between firings; (6) Spike-and-wave detections and firings by channel

2.



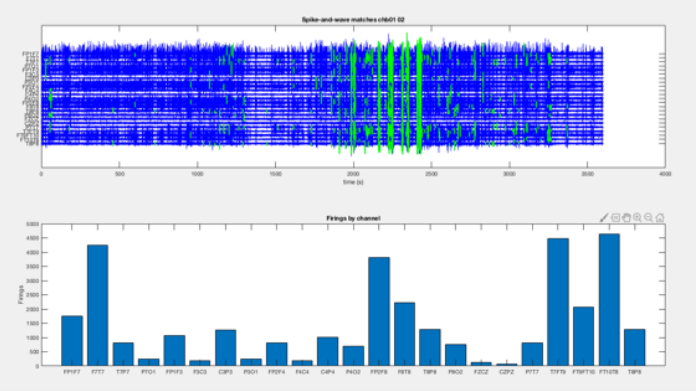


Figure 7, 8. (7) Firing rate, firings by time and delay between firings; (8) Spike-and-wave detections and firings by channel

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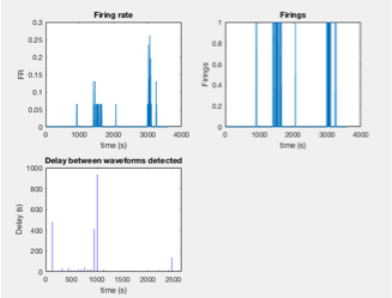

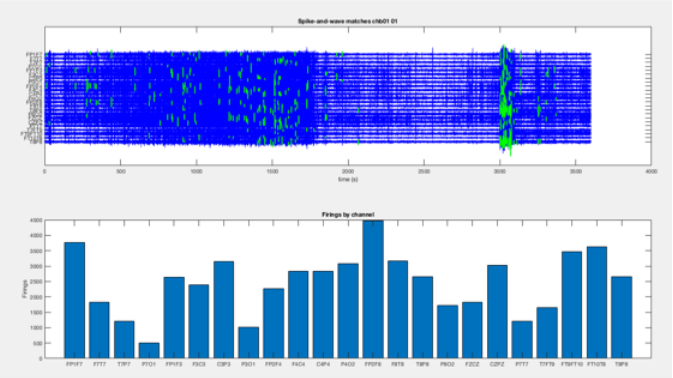

Figure 9, 10. (9) Firing rate, firings by time and delay between firings; (10) Spike-and-wave detections and firings by channel

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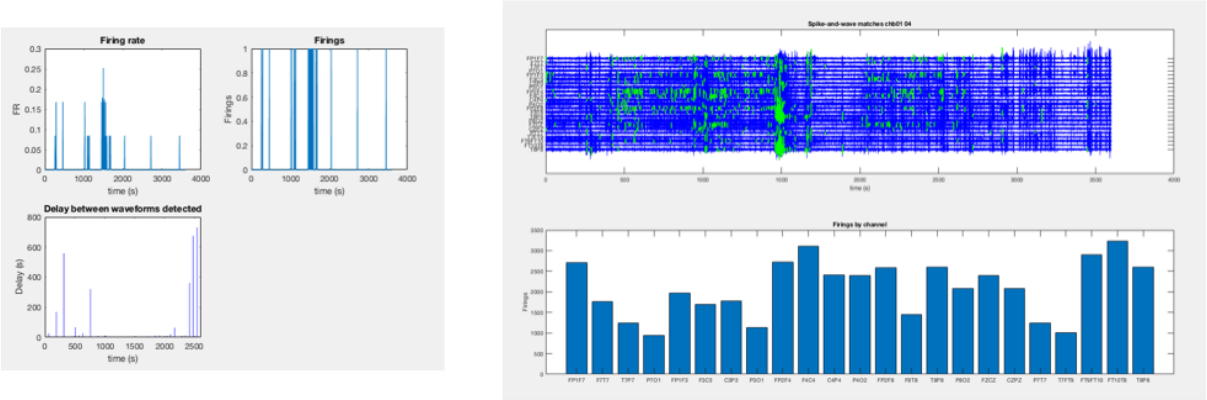

Figure 11, 12. (11) Firing rate, firings by time and delay between firings; (12) Spike-and-wave detections and firings by channel

5.

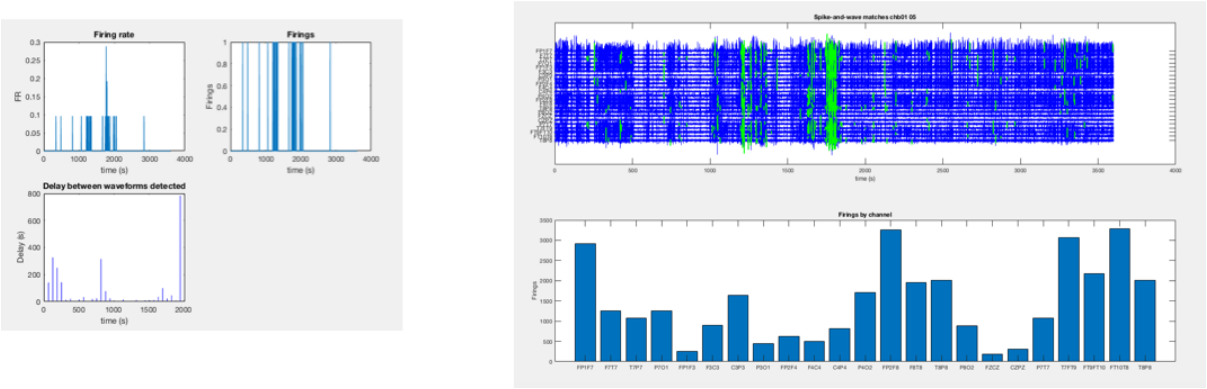

Figure 13, 14. (13) Firing rate, firings by time and delay between firings; (14) Spike-and-wave detections and firings by channel

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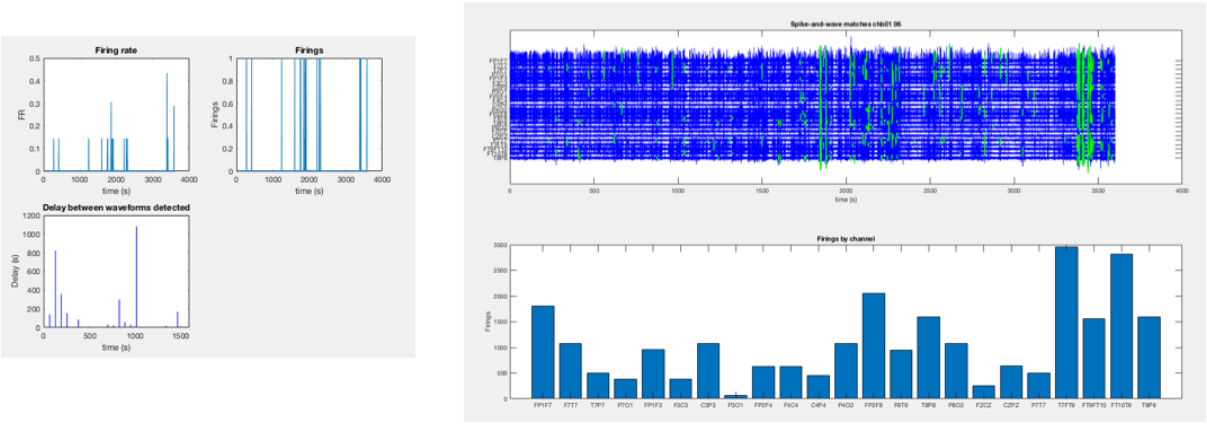

Figure 15, 16. (15) Firing rate, firings by time and delay between firings; (16) Spike-and-wave detections and firings by channel

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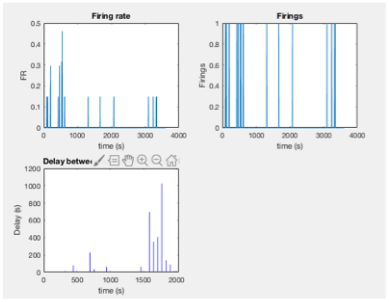


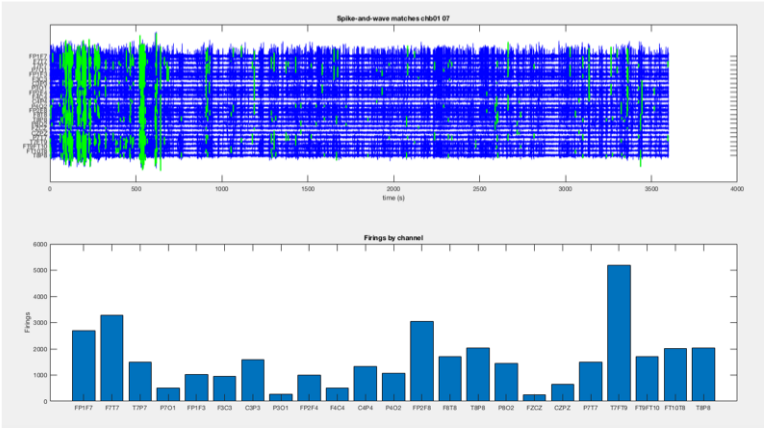
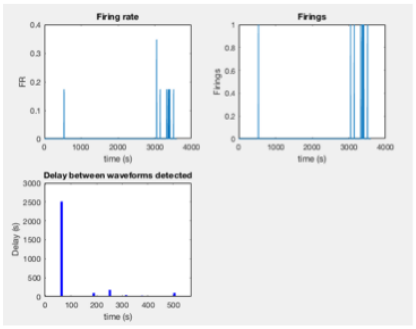


Figure 17, 18. (17) Firing rate, firings by time and delay between firings; (18) Spike-and-wave detections and firings by channel

8.



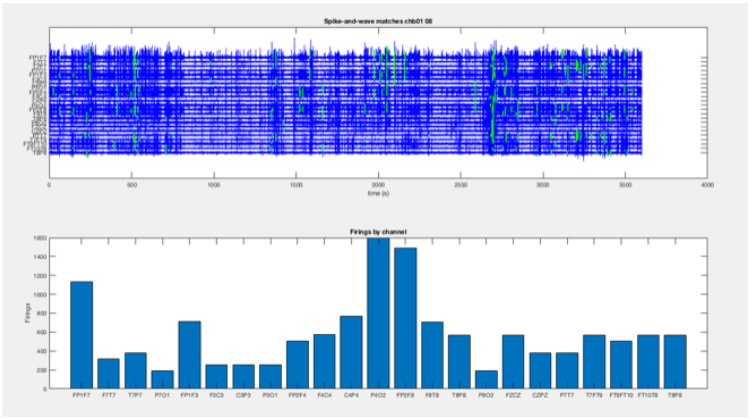
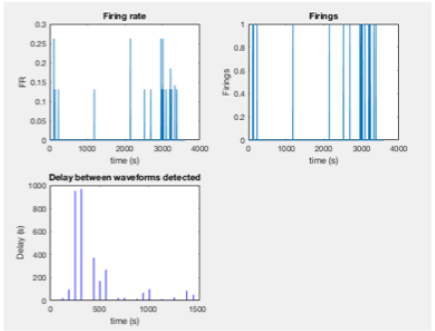


Figure 19, 20. (19) Firing rate, firings by time and delay between firings; (20) Spike-and-wave detections and firings by channel

9.



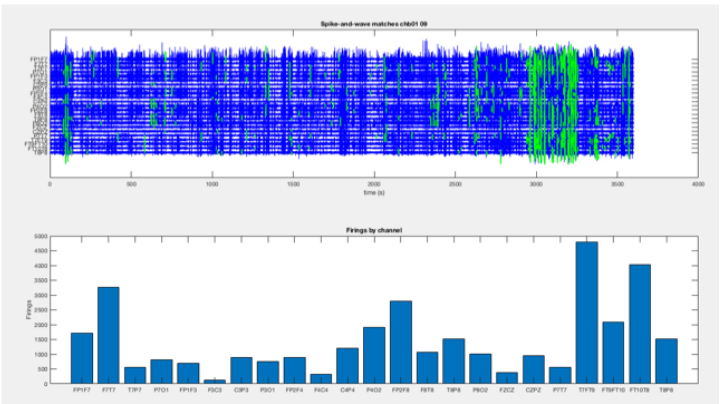


Figure 21, 22. (21) Firing rate, firings by time and delay between firings; (22) Spike-and-wave detections and firings by channel

10.

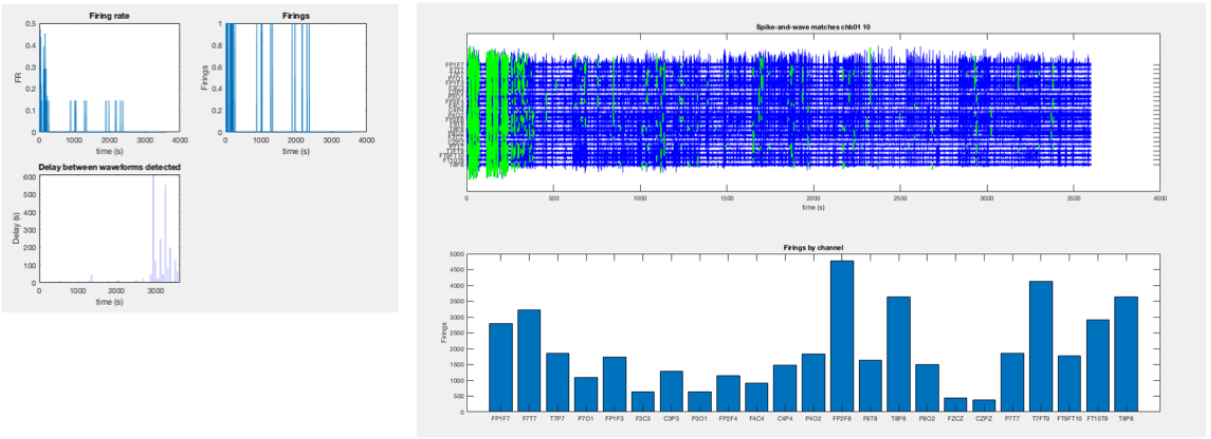


Figure 23, 24. (23) Firing rate, firings by time and delay between firings; (24) Spike-and-wave detections and firings by channel

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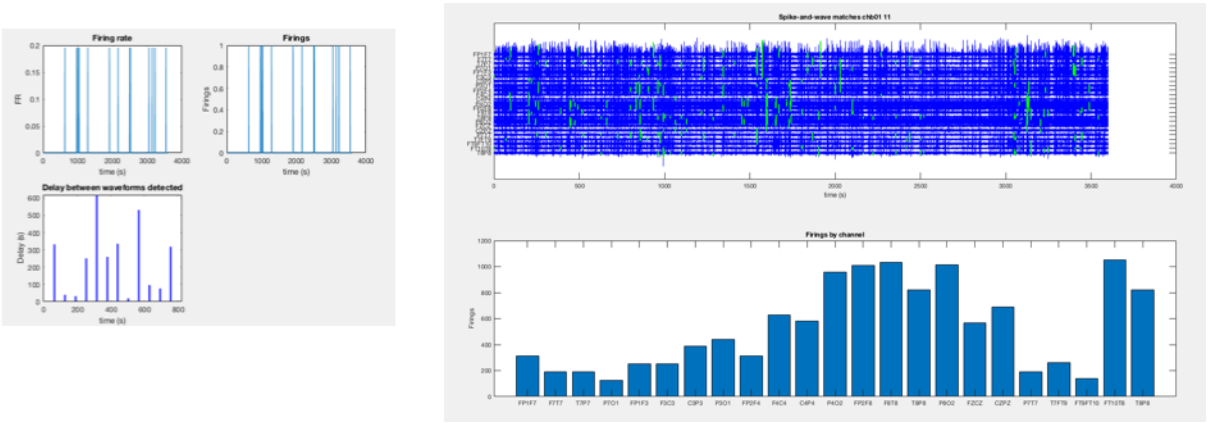

Figure 25, 26. (25) Firing rate, firings by time and delay between firings; (26) Spike-and-wave detections and firings by channel

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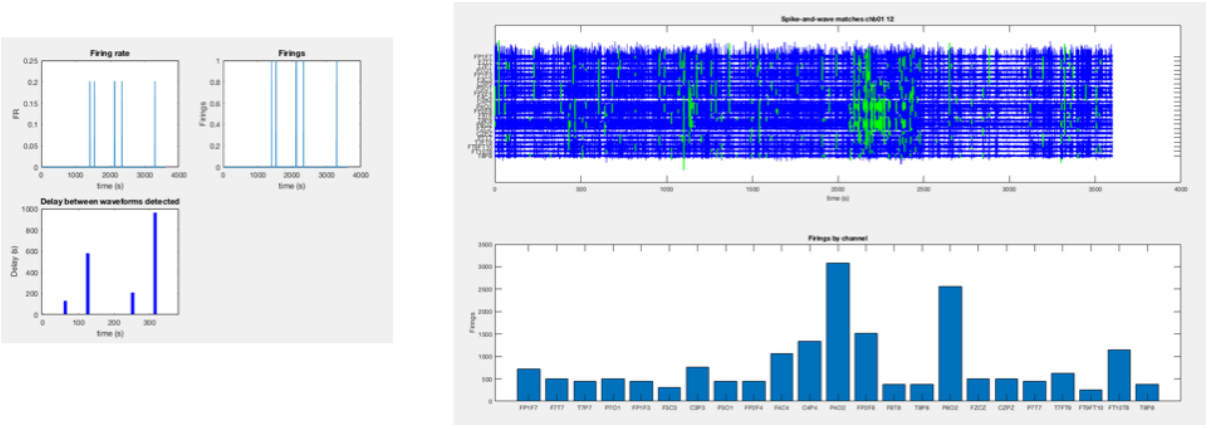

Figure 27, 28. (27) Firing rate, firings by time and delay between firings; (28) Spike-and-wave detections and firings by channel

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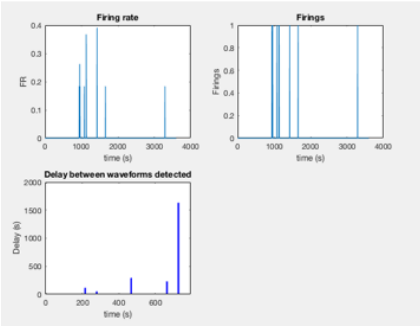

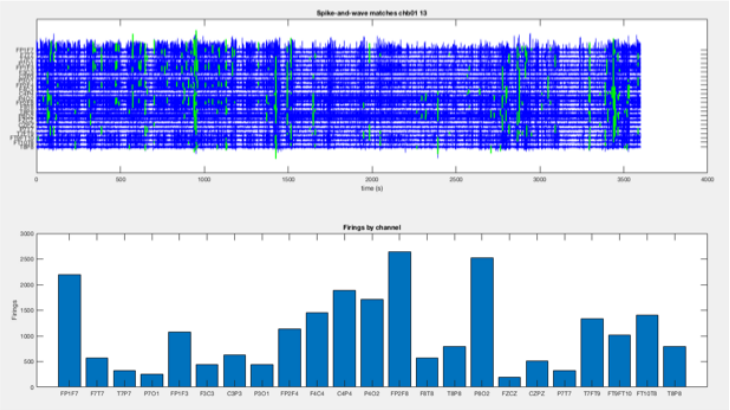

Figure 29, 30. (29) Firing rate, firings by time and delay between firings; (30) Spike-and-wave detections and firings by channel

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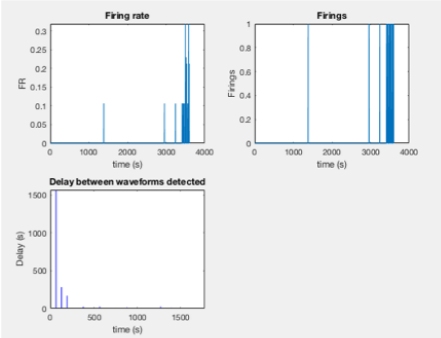

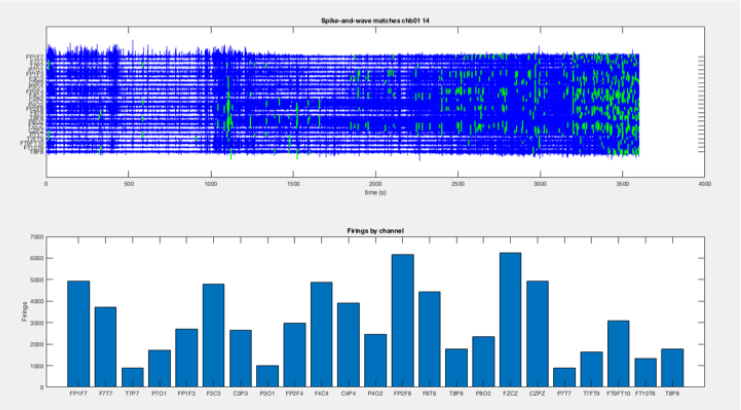

Figure 31, 32. (31) Firing rate, firings by time and delay between firings; (32) Spike-and-wave detections and firings by channel

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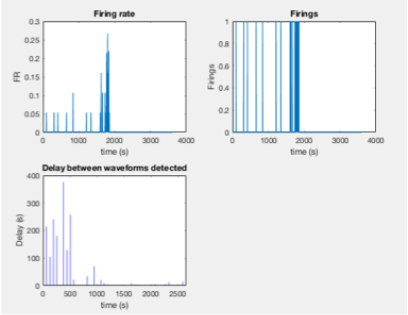

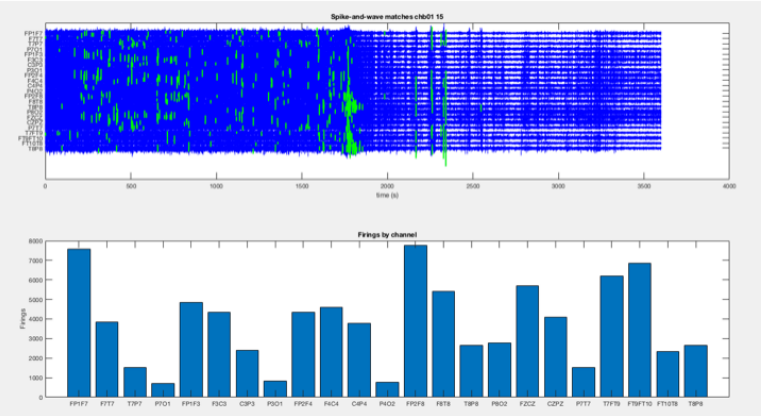

Figure 33, 34. (33) Firing rate, firings by time and delay between firings; (34) Spike-and-wave detections and firings by channel

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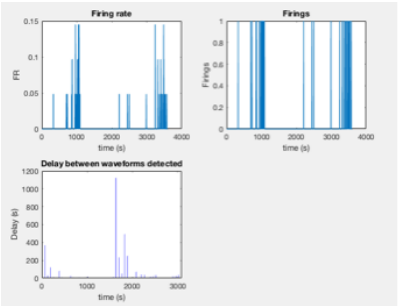

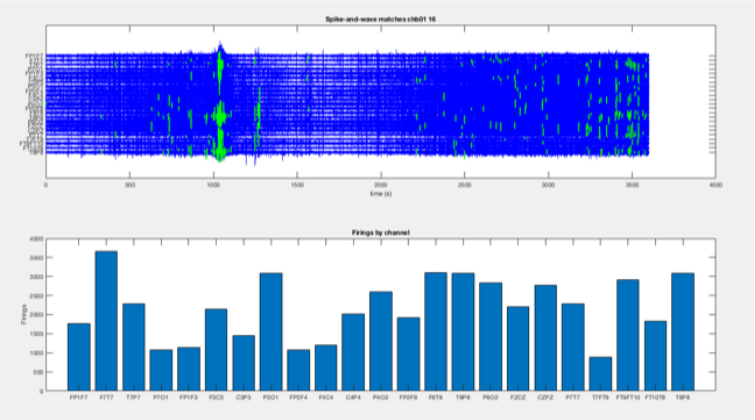

Figure 35, 36. (35) Firing rate, firings by time and delay between firings; (36) Spike-and-wave detections and firings by channel

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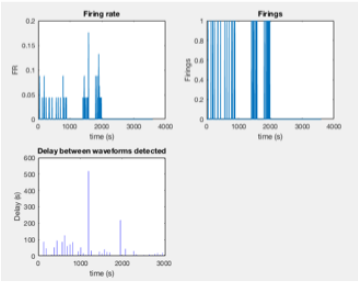

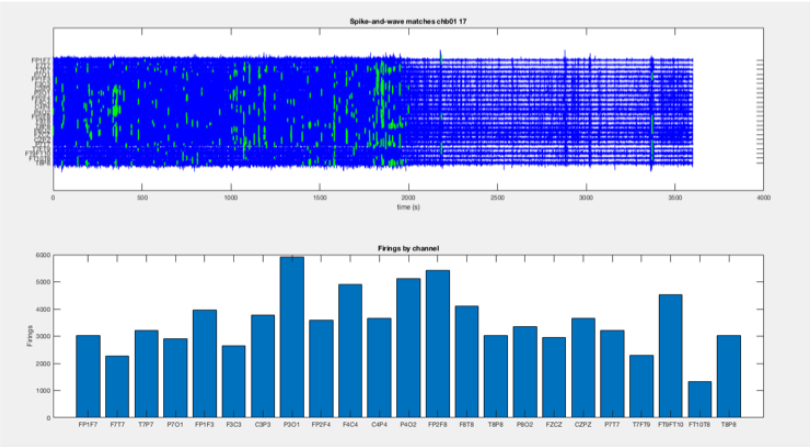

Figure 37, 38. (37) Firing rate, firings by time and delay between firings; (38) Spike-and-wave detections and firings by channel

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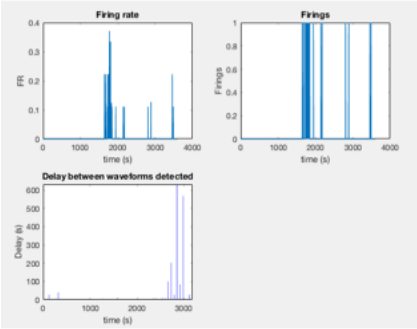

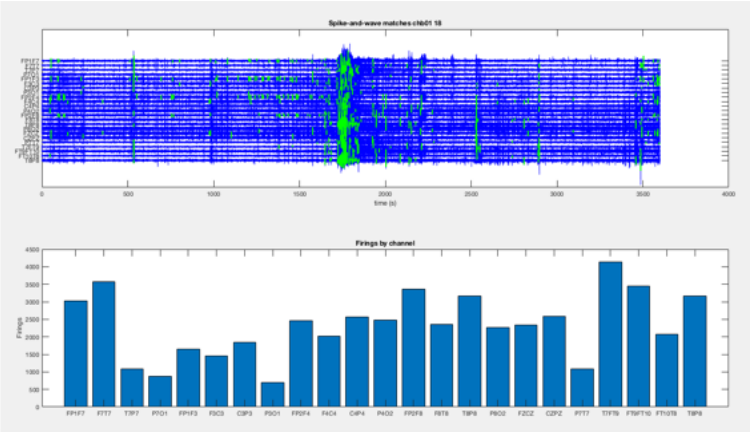

Figure 39, 40. (39) Firing rate, firings by time and delay between firings; (40) Spike-and-wave detections and firings by channel

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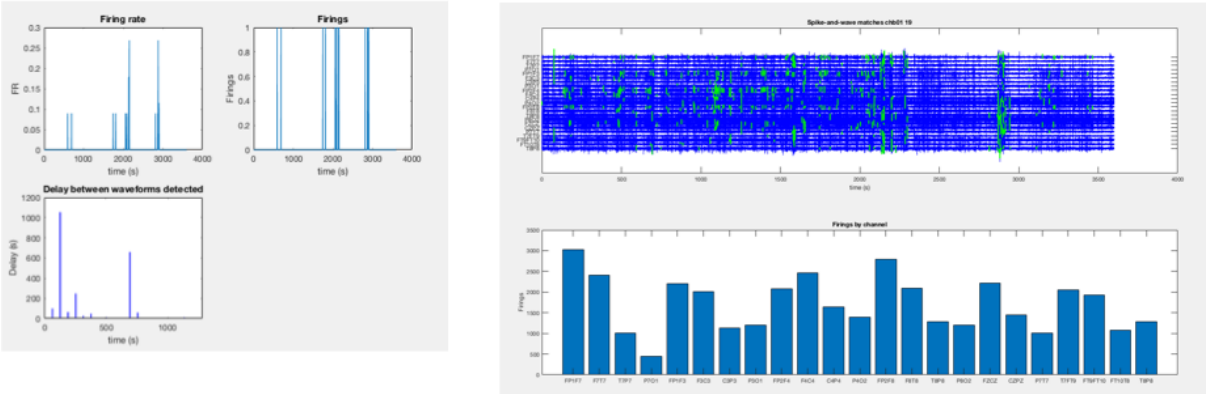

Figure 41, 42. (41) Firing rate, firings by time and delay between firings; (42) Spike-and-wave detections and firings by channel

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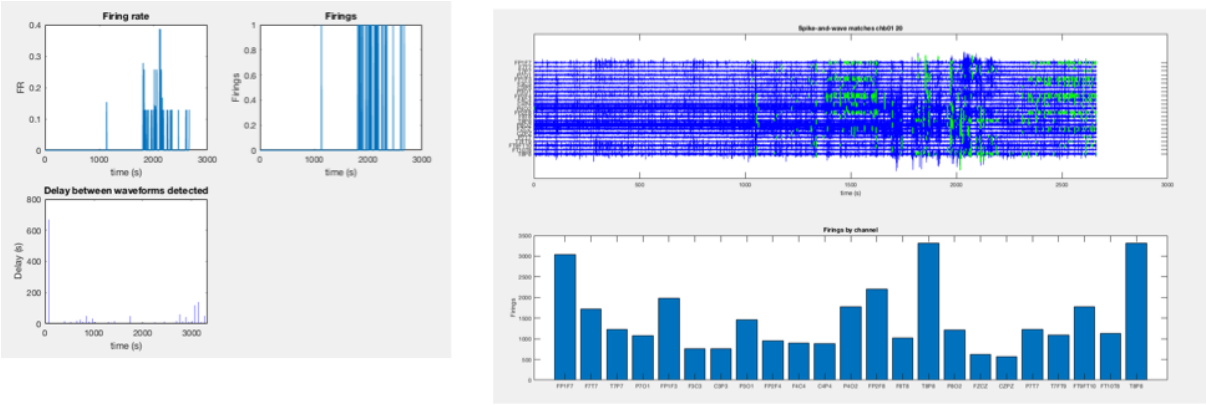

Figure 43, 44. (43) Firing rate, firings by time and delay between firings; (44) Spike-and-wave detections and firings by channel

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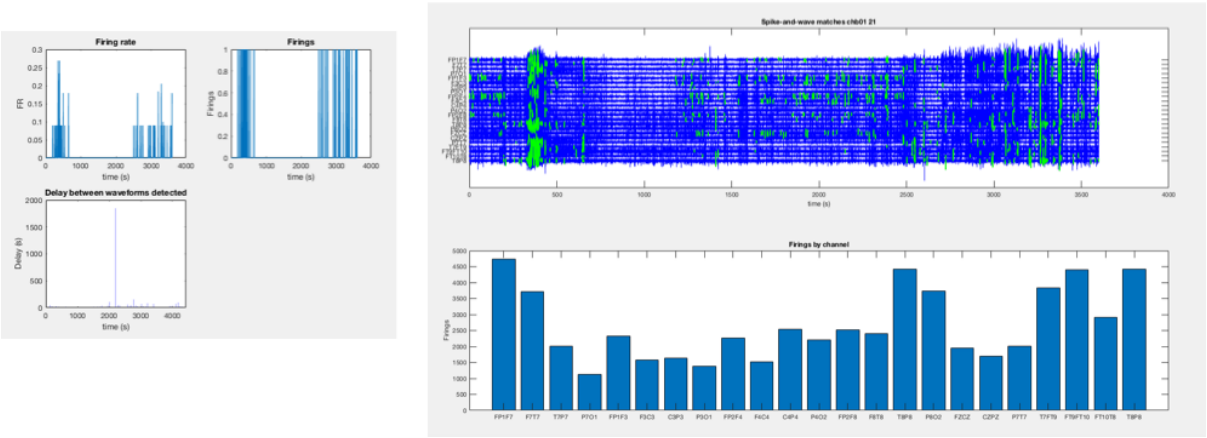

Figure 45, 46. (45) Firing rate, firings by time and delay between firings; (46) Spike-and-wave detections and firings by channel

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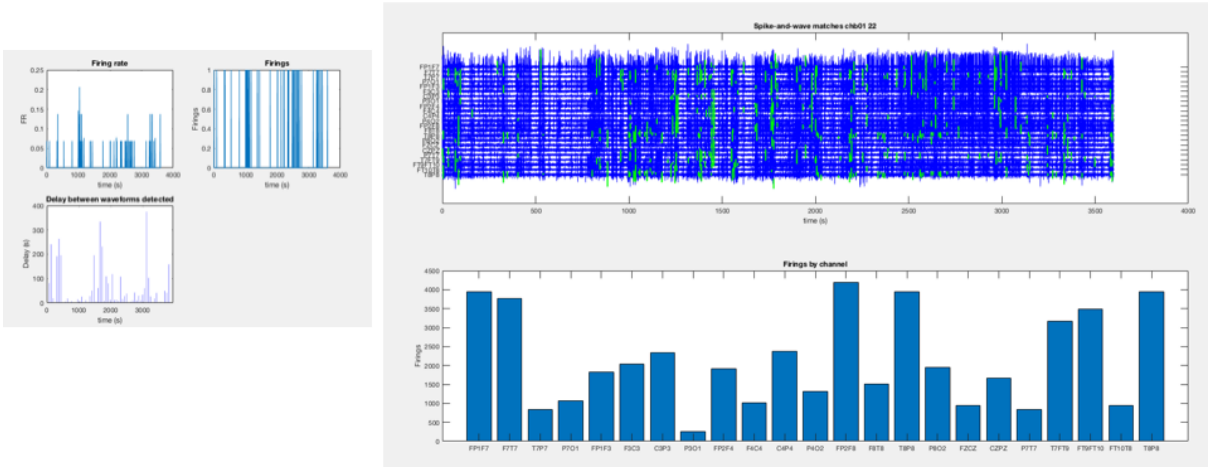

Figure 47, 48. (47) Firing rate, firings by time and delay between firings; (48) Spike-and-wave detections and firings by channel

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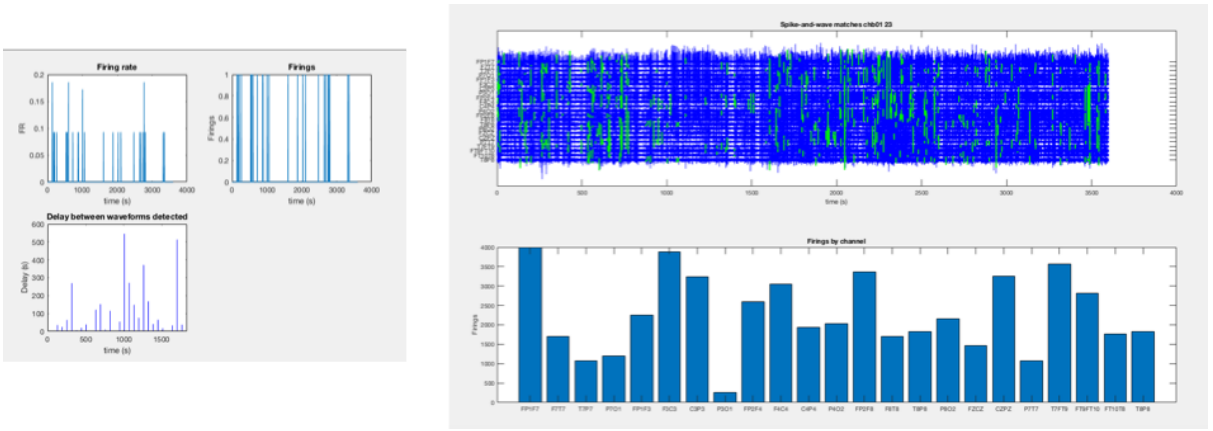

Figure 49, 50. (49) Firing rate, firings by time and delay between firings; (50) Spike-and-wave detections and firings by channel

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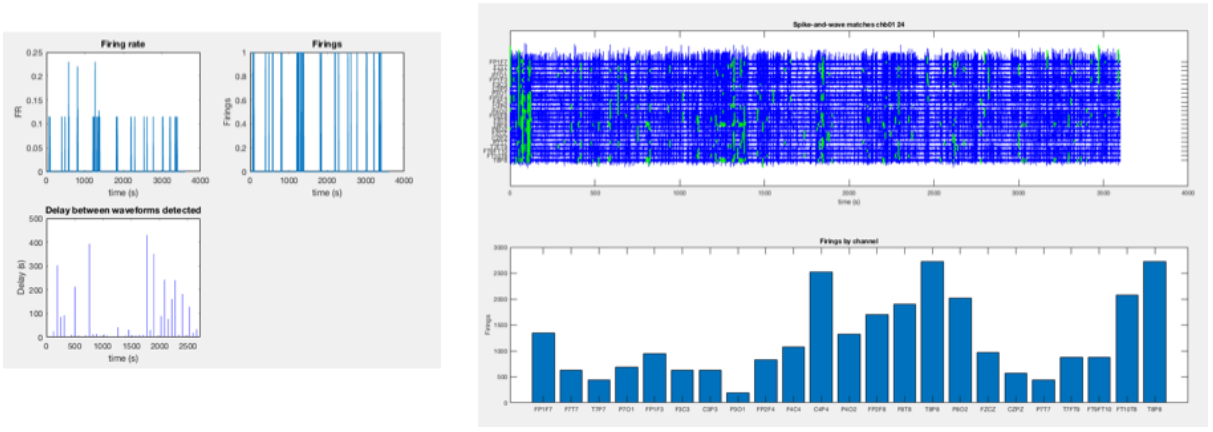

Figure 51, 52. (51) Firing rate, firings by time and delay between firings; (52) Spike-and-wave detections and firings by channel

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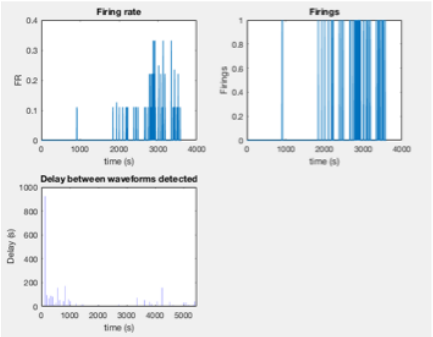

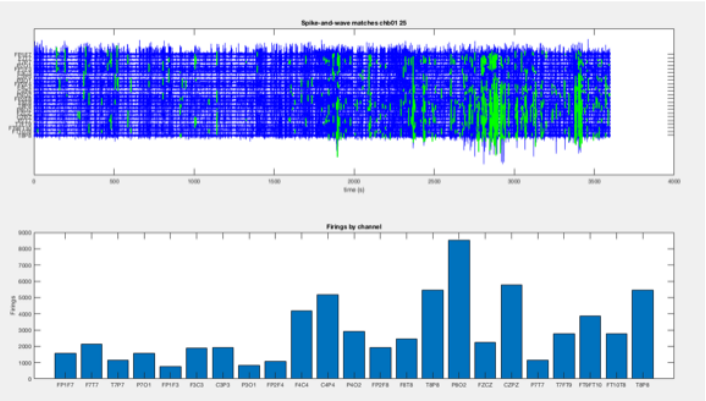

Figure 53, 54. (53) Firing rate, firings by time and delay between firings; (54) Spike-and-wave detections and firings by channel

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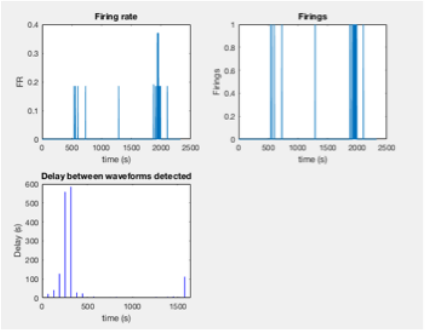

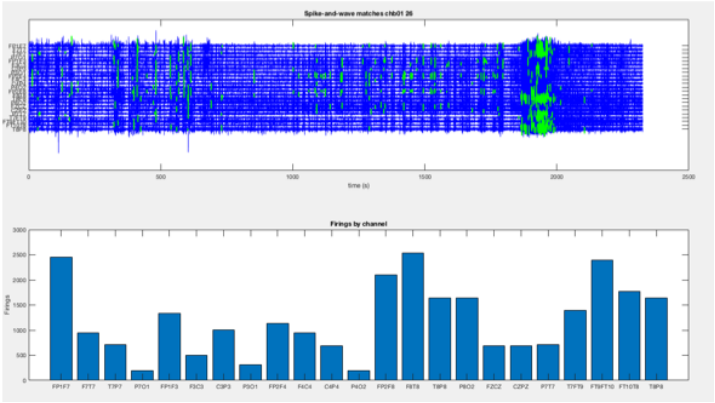

Figure 55, 56. (55) Firing rate, firings by time and delay between firings; (56) Spike-and-wave detections and firings by channel

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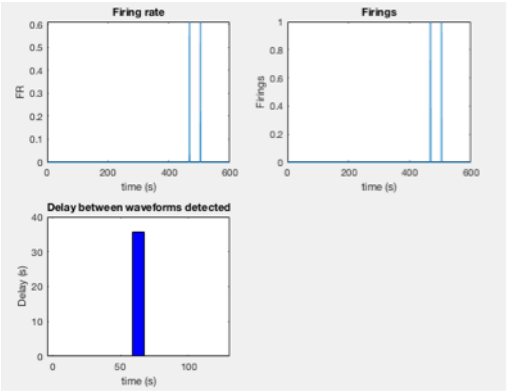


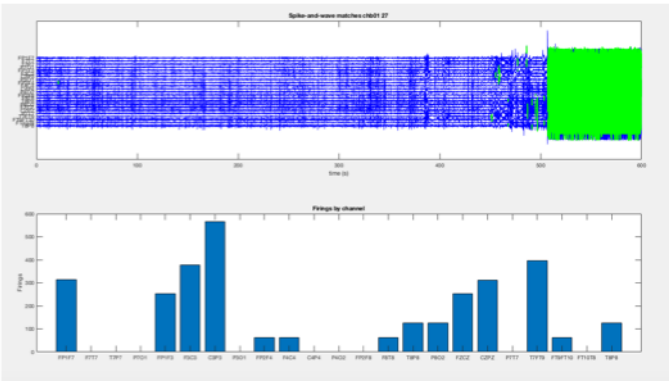
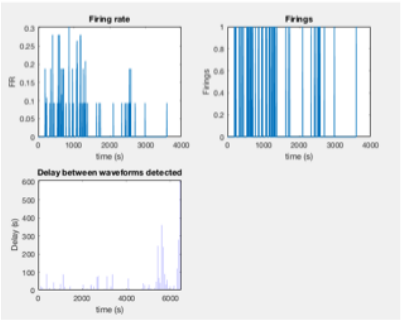


Figure 57, 58. (57) Firing rate, firings by time and delay between firings; (58) Spike-and-wave detections and firings by channel

29.



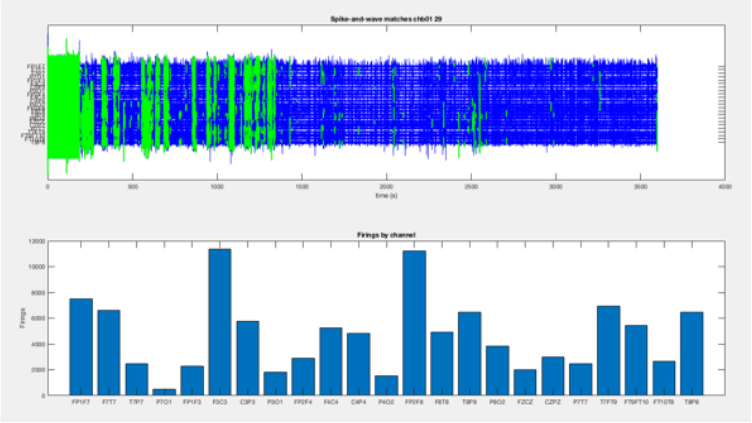


Figure 59, 60. (59) Firing rate, firings by time and delay between firings; (60) Spike-and-wave detections and firings by channel

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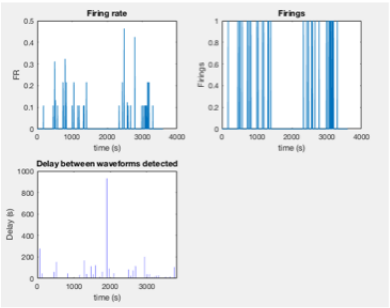


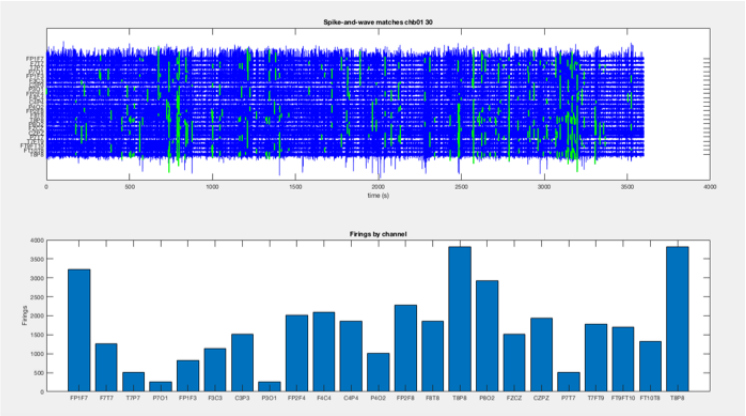
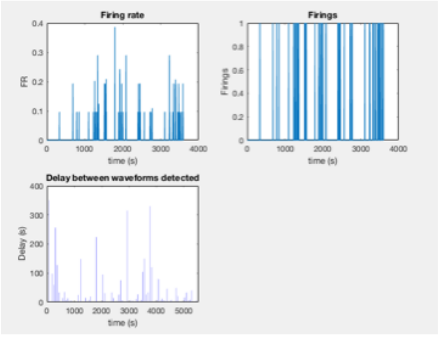


Figure 61, 62. (61) Firing rate, firings by time and delay between firings; (62) Spike-and-wave detections and firings by channel

31.



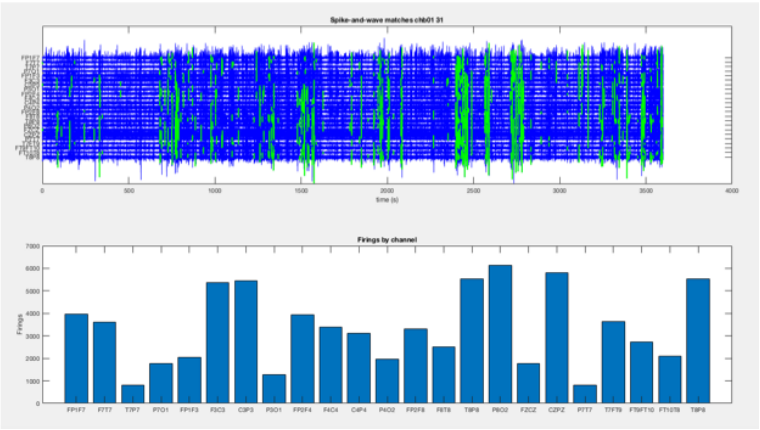


Figure 63, 64. (63) Firing rate, firings by time and delay between firings; (64) Spike-and-wave detections and firings by channel

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Patient overview

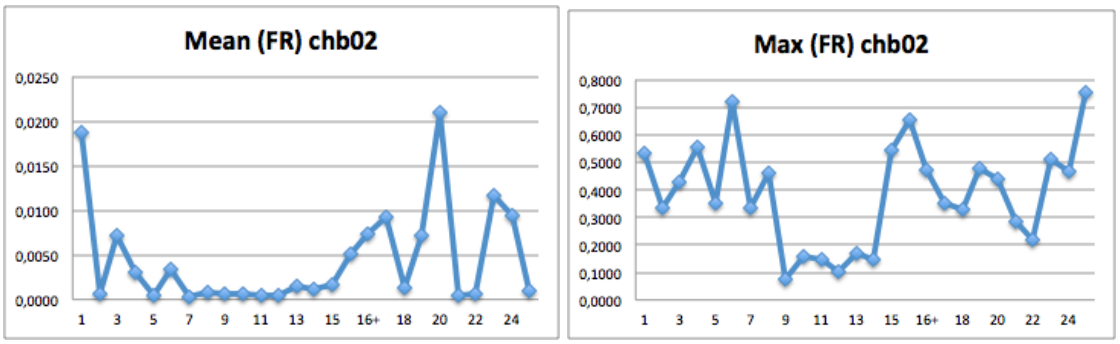


Figure 65, 66. (65) Mean firing rate and (66) Max firing rate

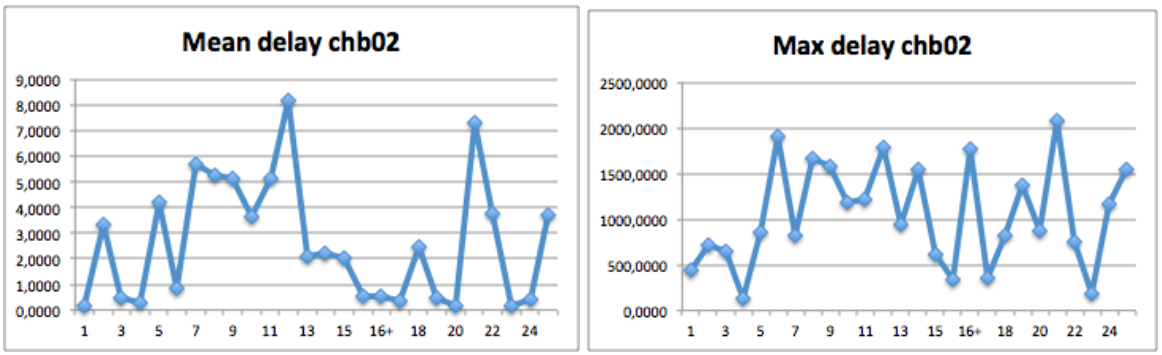


Figure 67, 68. (67) Mean delay and (68) Max delay

Analyzing the graphs, first of all, the mean firing rate stays quite low during all the recordings. It can be seen that during the 7th and the 15 it is low and on the 16 (containing seizure), 16+(containing seizure) and 17, the values increase and on 18 it decreases again. The recording 19, also a seizure recording, has again a high value and, surprisingly, the 20, with no seizure, gets even a higher mean firing rate.
Considering the delays, the values stay quite low when it is around seizure recordings, and the maximum delays are very varied during all recordings.

CHB02	Mean(FR)	Max(FR)	Mean Delay	Max delay
1	0,0188	0,5316	0,1565	441,8281
2	0,0006	0,3351	3,3014	722,1914
3	0,0072	0,4305	0,4963	649,5312
4	0,0030	0,5551	0,3193	126,1250
5	0,0005	0,3500	4,1983	850,4961
6	0,0034	0,7214	0,8456	1905,1000
7	0,0003	0,3351	5,6875	823,8164

8	0,0007	0,4601	5,2704	1663,3000
9	0,0007	0,0730	5,1485	1572,2000
10	0,0006	0,1571	3,6273	1185,6000
11	0,0004	0,1460	5,1278	1226,1000
12	0,0004	0,1023	8,1439	1781,7000
13	0,0015	0,1717	2,1117	934,8750
14	0,0012	0,1493	2,1847	1552,5000
15	0,0016	0,5415	2,0130	610,0898
16 (seizure)	0,0051	0,6528	0,5647	342,9922
16+ (seizure)	0,0074	0,4746	0,5271	1777,7000
17	0,0092	0,3495	0,3719	363,9961
18	0,0014	0,3264	2,4912	823,2344
19 (seizure)	0,0071	0,4780	0,4729	1369,3000
20	0,0209	0,4406	0,1767	870,2617
21	0,0004	0,2851	7,2971	2082,7000
22	0,0007	0,2203	3,7802	760,6055
23	0,0117	0,5117	0,1881	186,8242
24	0,0094	0,4675	0,3979	1161,3000
25	0,0010	0,7530	3,6858	1549,3000

Table 3. Parameters obtained for each recording

1.

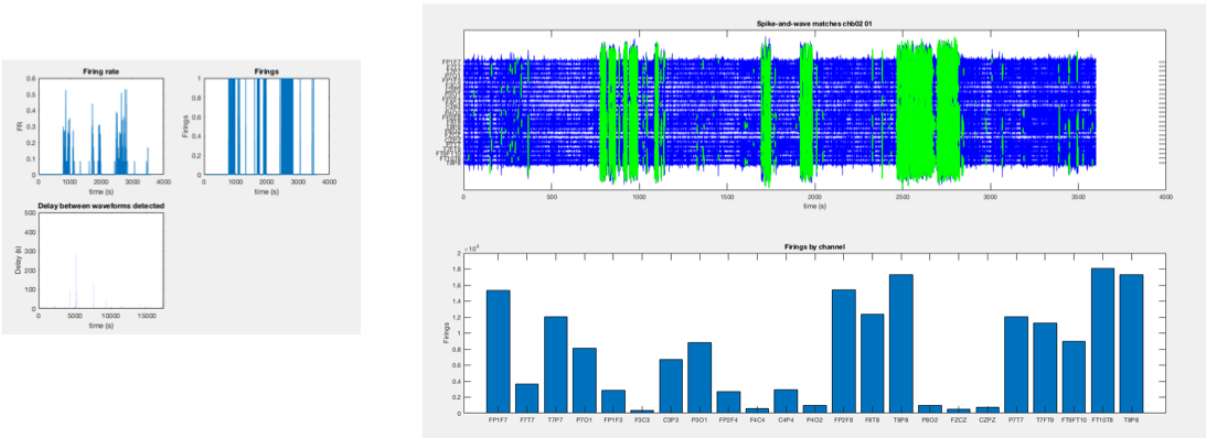


Figure 69, 70. (69) Firing rate, firings by time and delay between firings; (70) Spike-and-wave detections and firings by channel

2.

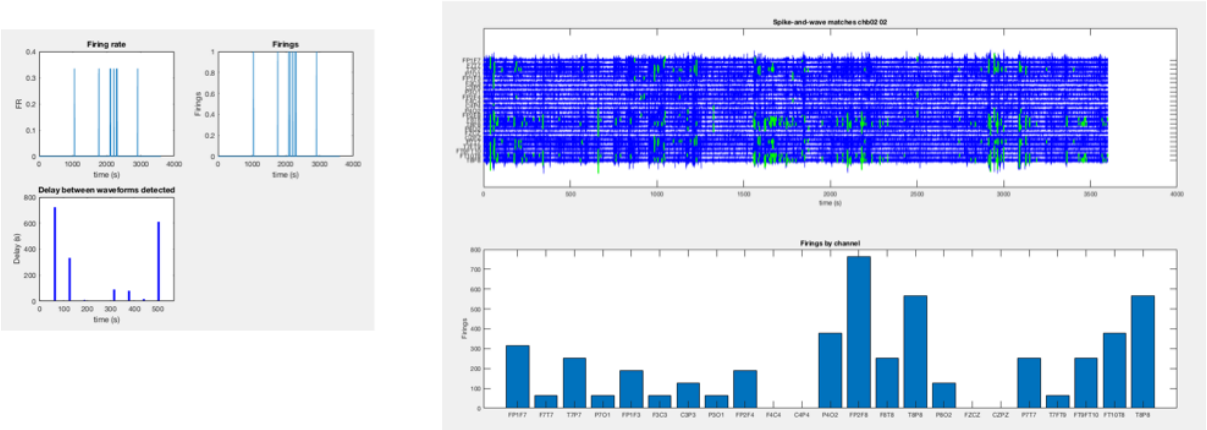


Figure 71, 72. (71) Firing rate, firings by time and delay between firings; (72) Spike-and-wave detections and firings by channel

3.

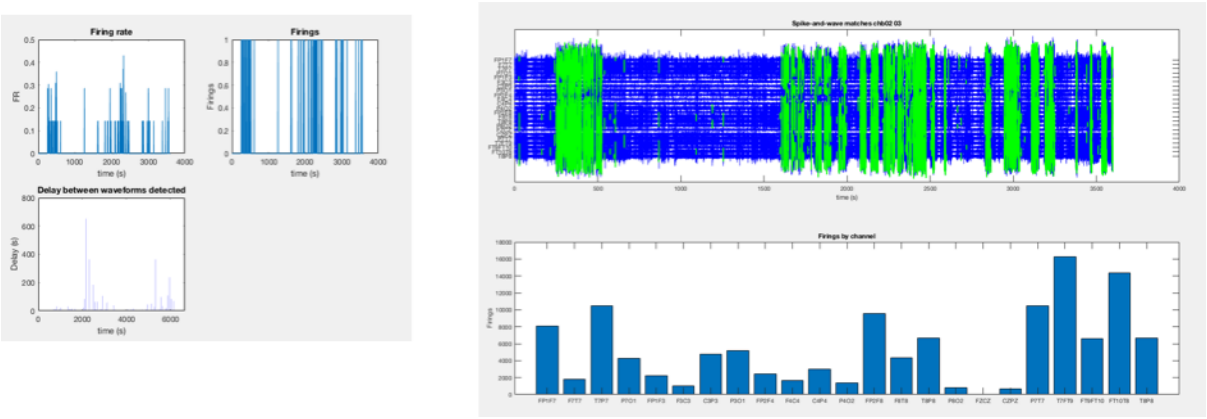


Figure 73, 74. (73) Firing rate, firings by time and delay between firings; (74) Spike-and-wave detections and firings by channel

4.

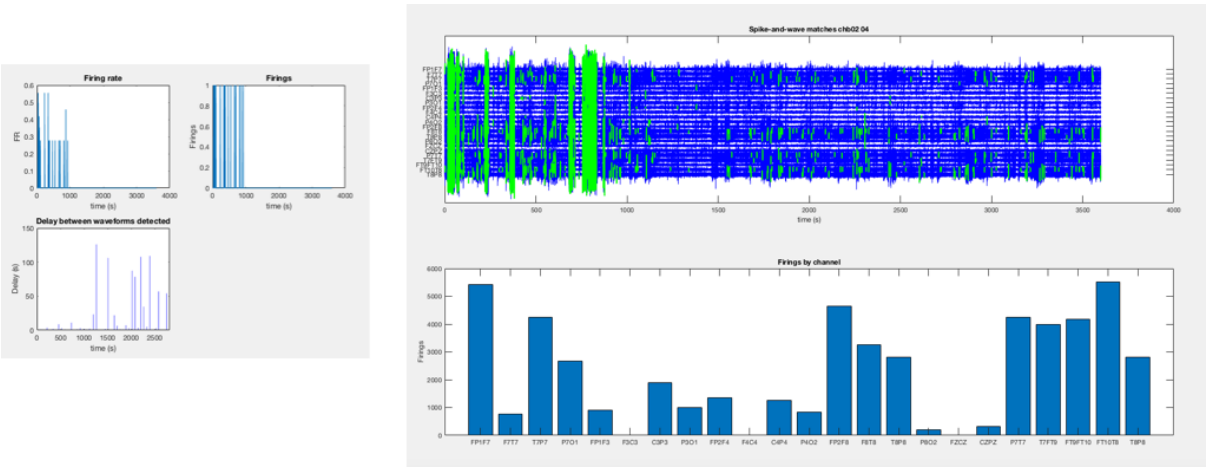
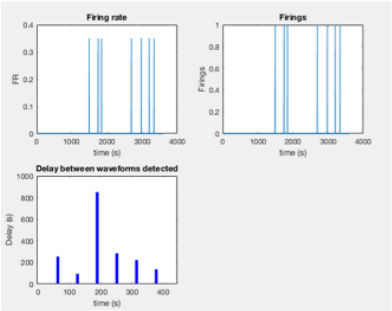


Figure 75, 76. (75) Firing rate, firings by time and delay between firings; (76) Spike-and-wave detections and firings by channel

5.



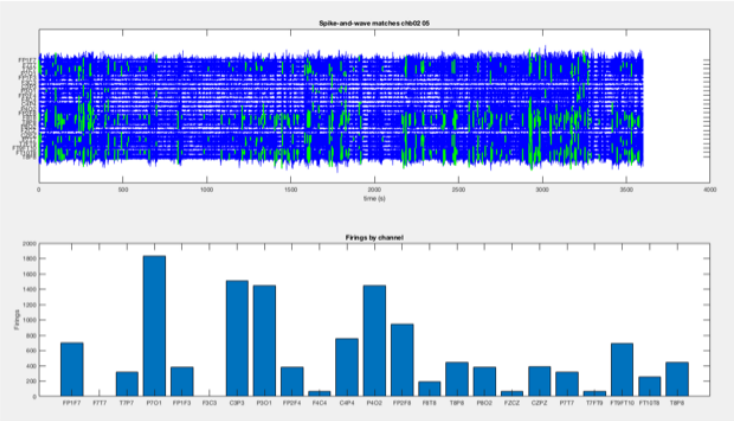
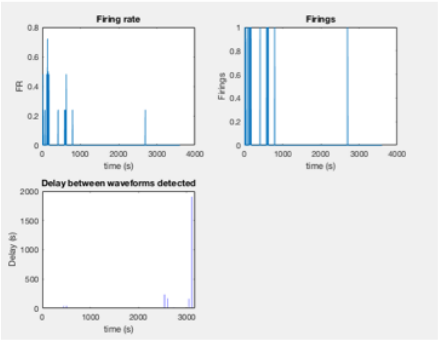


Figure 77, 78. (77) Firing rate, firings by time and delay between firings; (78) Spike-and-wave detections and firings by channel

6.



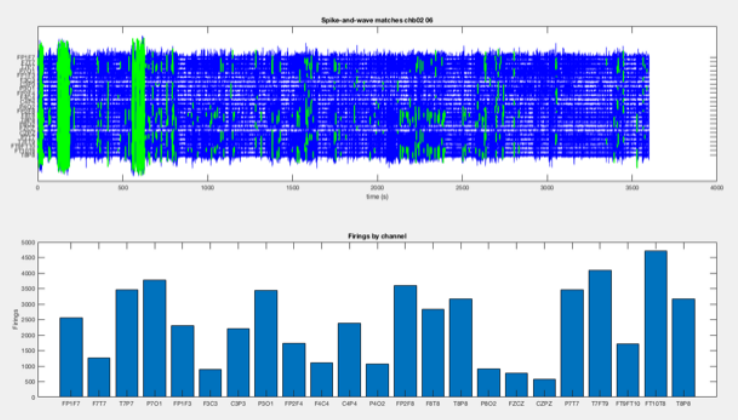
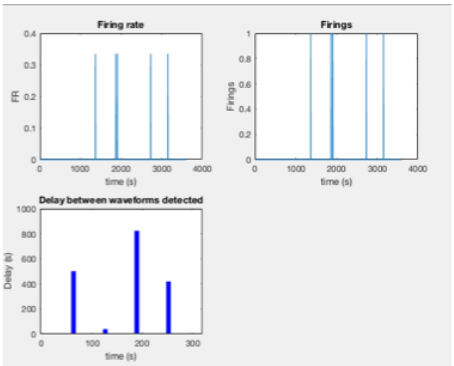


Figure 79, 80. (79) Firing rate, firings by time and delay between firings; (80) Spike-and-wave detections and firings by channel

7.



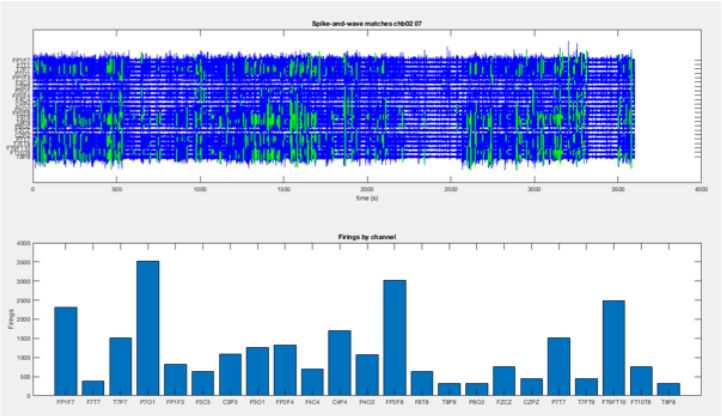


Figure 81, 82. (81) Firing rate, firings by time and delay between firings; (82) Spike-and-wave detections and firings by channel

8.

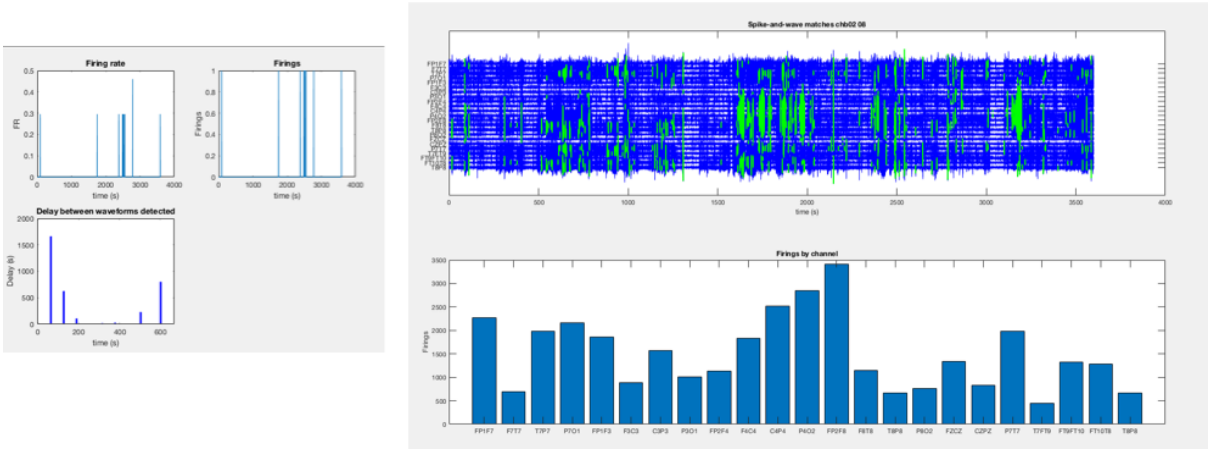


Figure 83, 84. (83) Firing rate, firings by time and delay between firings; (84) Spike-and-wave detections and firings by channel

9.

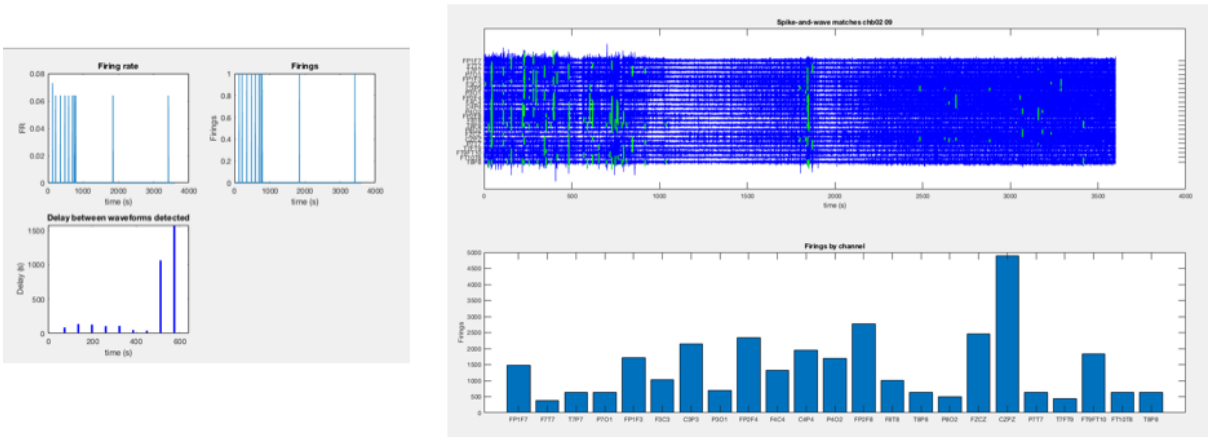


Figure 85, 86. (85) Firing rate, firings by time and delay between firings; (86) Spike-and-wave detections and firings by channel

10.

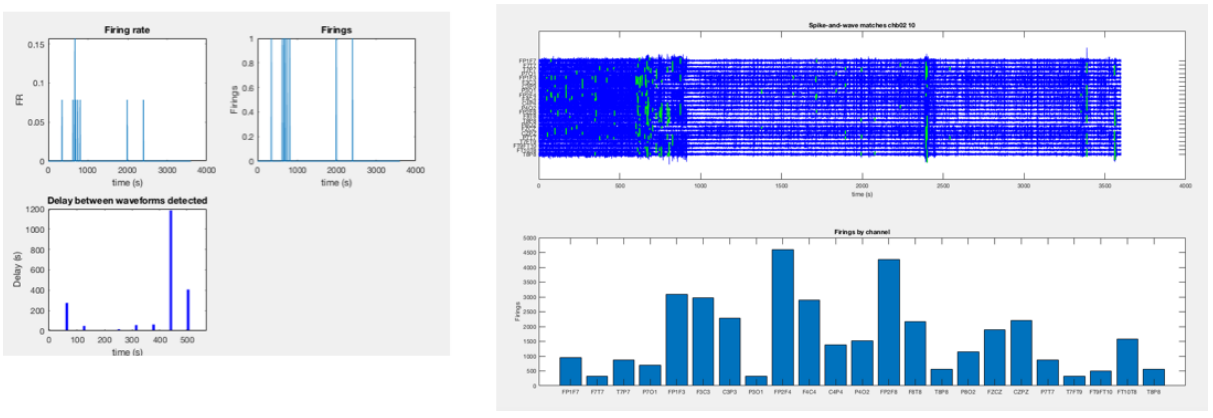


Figure 87, 88. (87) Firing rate, firings by time and delay between firings; (88) Spike-and-wave detections and firings by channel

11.

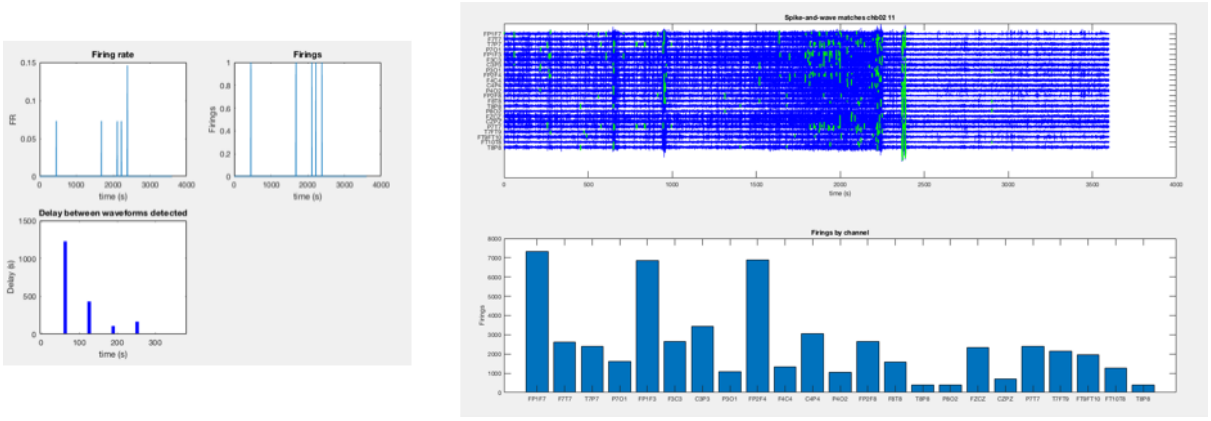


Figure 89, 90. (89) Firing rate, firings by time and delay between firings; (90) Spike-and-wave detections and firings by channel

12.

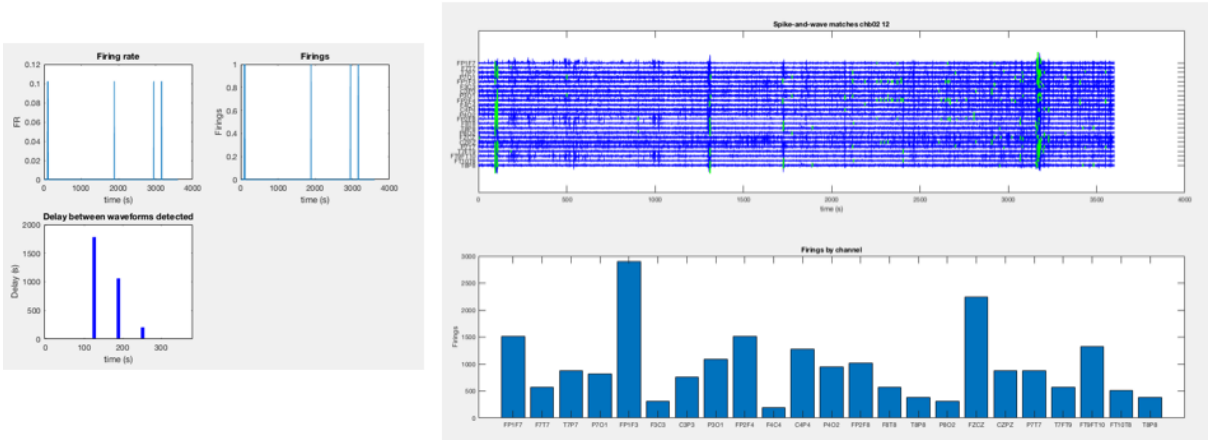


Figure 91, 92. (91) Firing rate, firings by time and delay between firings; (92) Spike-and-wave detections and firings by channel

13.

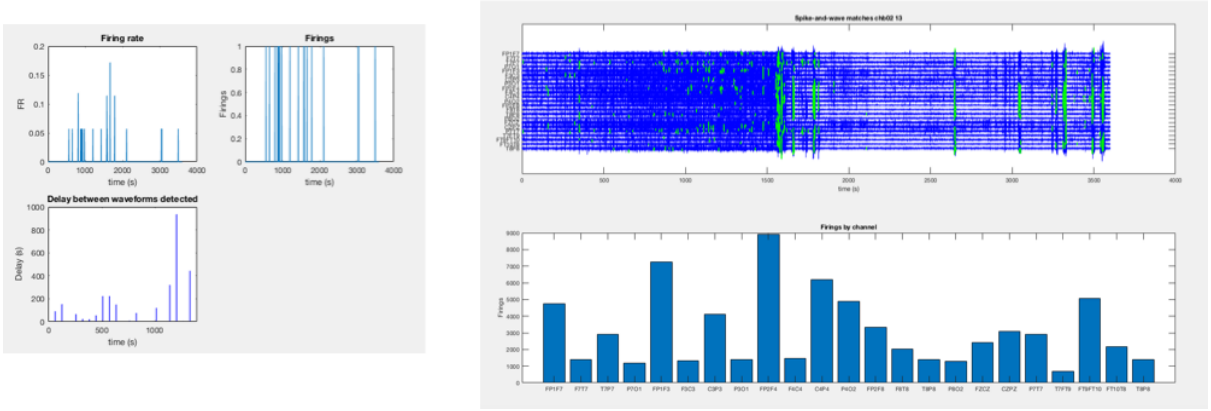


Figure 93, 94. (93) Firing rate, firings by time and delay between firings; (94) Spike-and-wave detections and firings by channel

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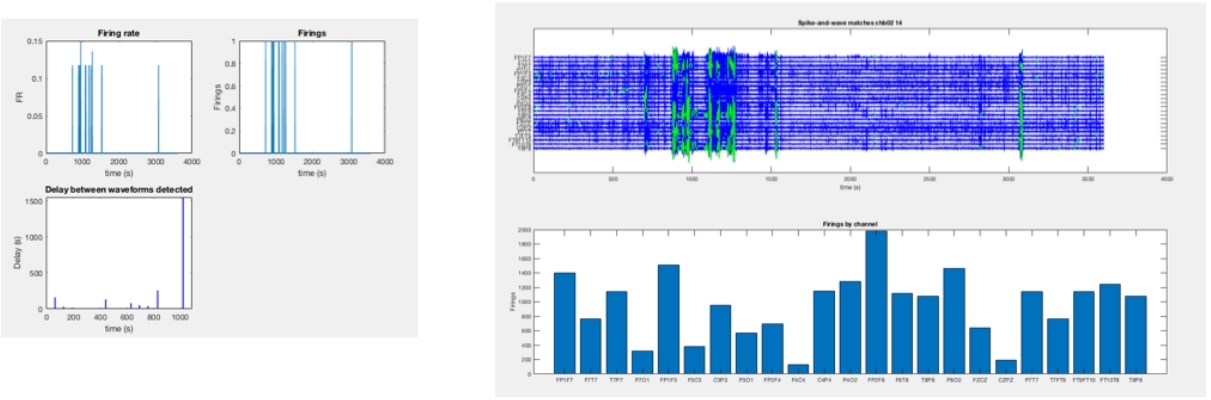


Figure 95, 96. (95) Firing rate, firings by time and delay between firings; (96) Spike-and-wave detections and firings by channel

15.

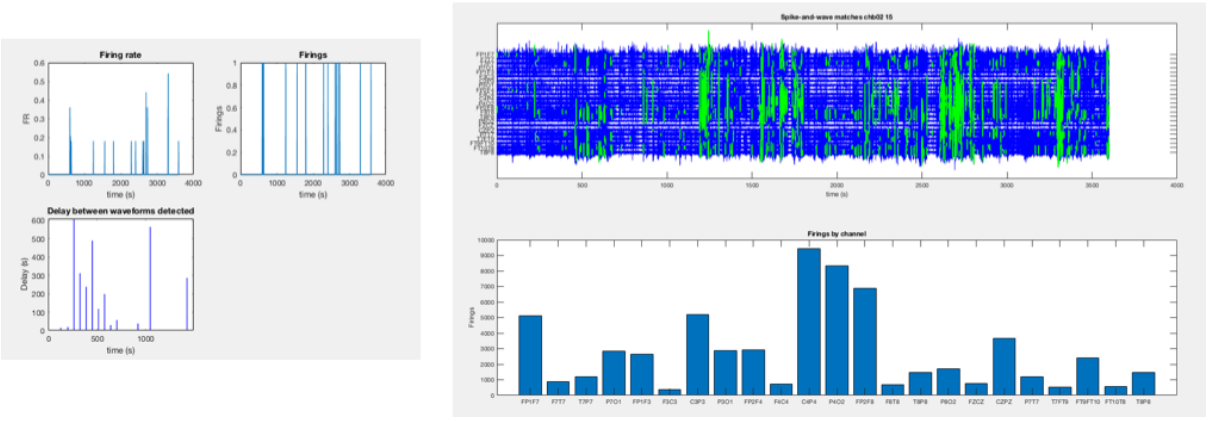


Figure 97, 98. (97) Firing rate, firings by time and delay between firings; (98) Spike-and-wave detections and firings by channel

16.

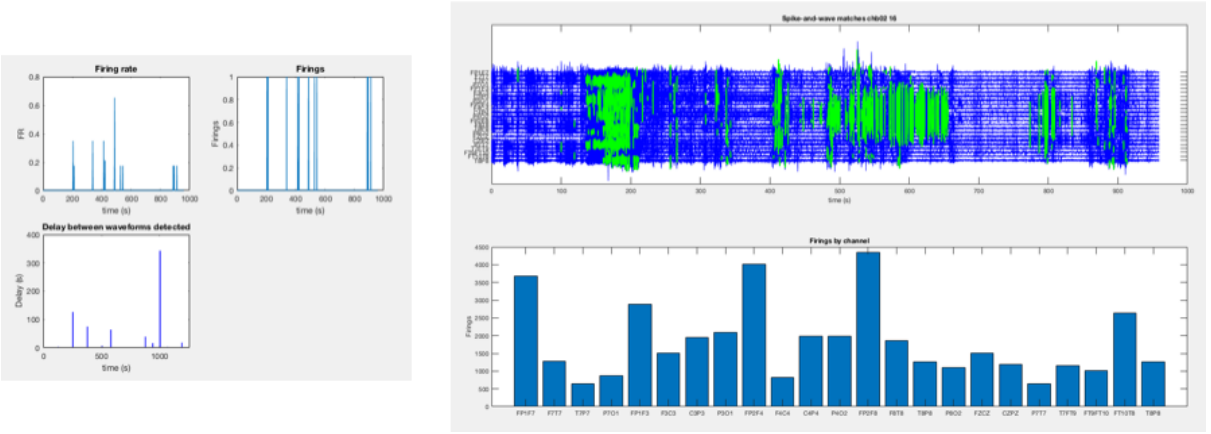


Figure 99, 100. (99) Firing rate, firings by time and delay between firings; (100) Spike-and-wave detections and firings by channel

16+.

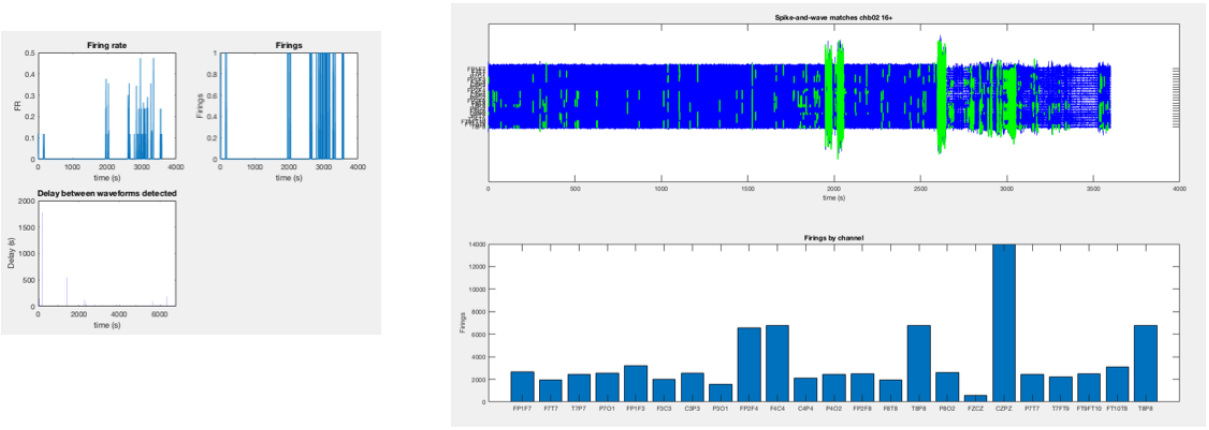


Figure 101, 102. (101) Firing rate, firings by time and delay between firings; (102) Spike-and-wave detections and firings by channel

17.

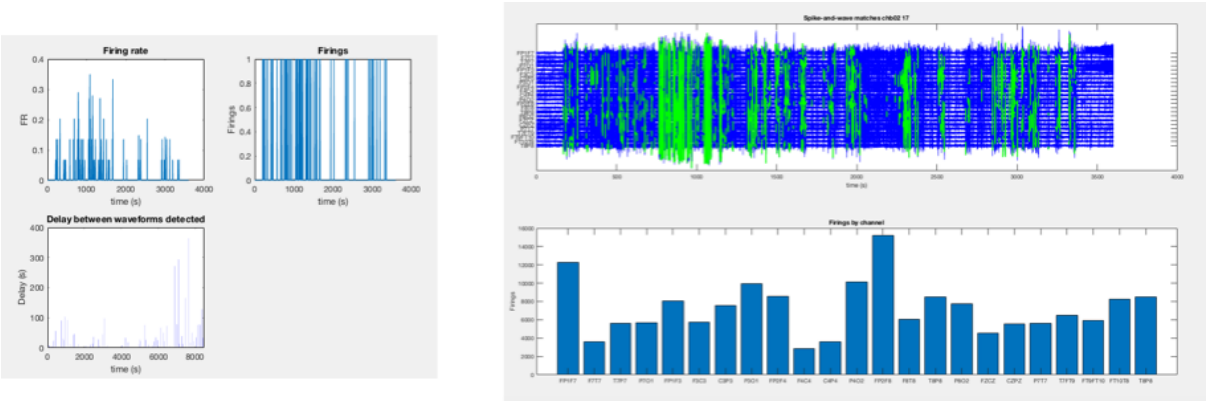


Figure 103, 104. (103) Firing rate, firings by time and delay between firings; (104) Spike-and-wave detections and firings by channel

18.

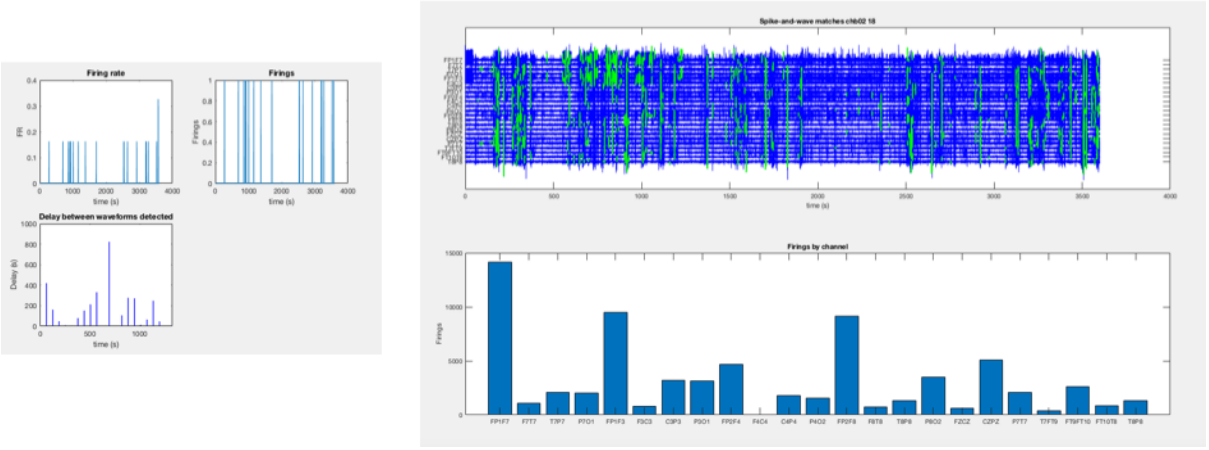


Figure 105, 106. (105) Firing rate, firings by time and delay between firings; (106) Spike-and-wave detections and firings by channel

19.

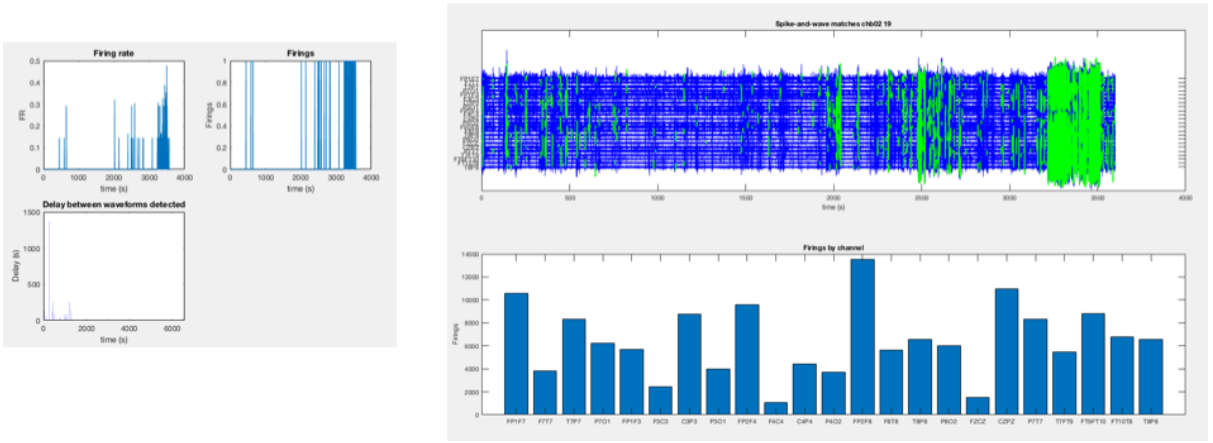


Figure 107, 108. (107) Firing rate, firings by time and delay between firings; (108) Spike-and-wave detections and firings by channel

20.

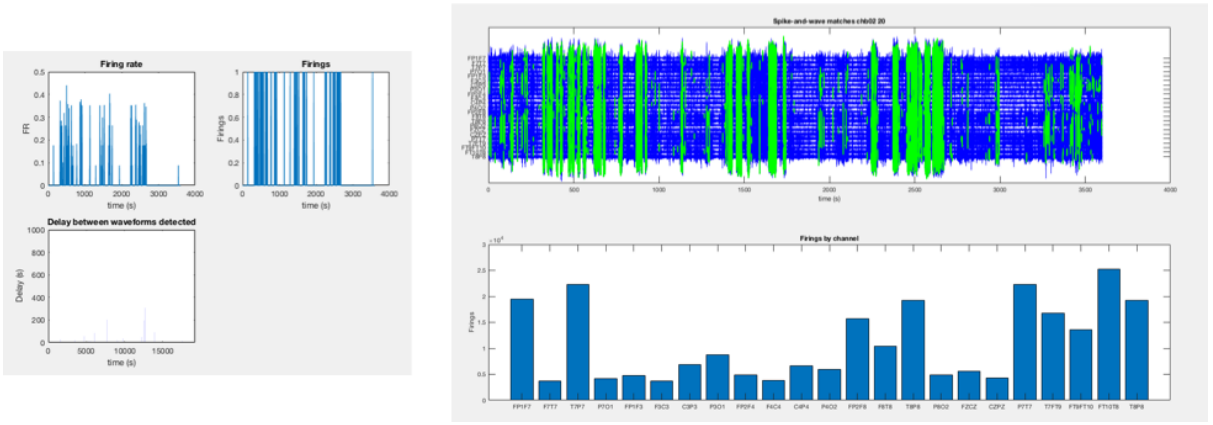


Figure 109, 110. (109) Firing rate, firings by time and delay between firings; (110) Spike-and-wave detections and firings by channel

21.

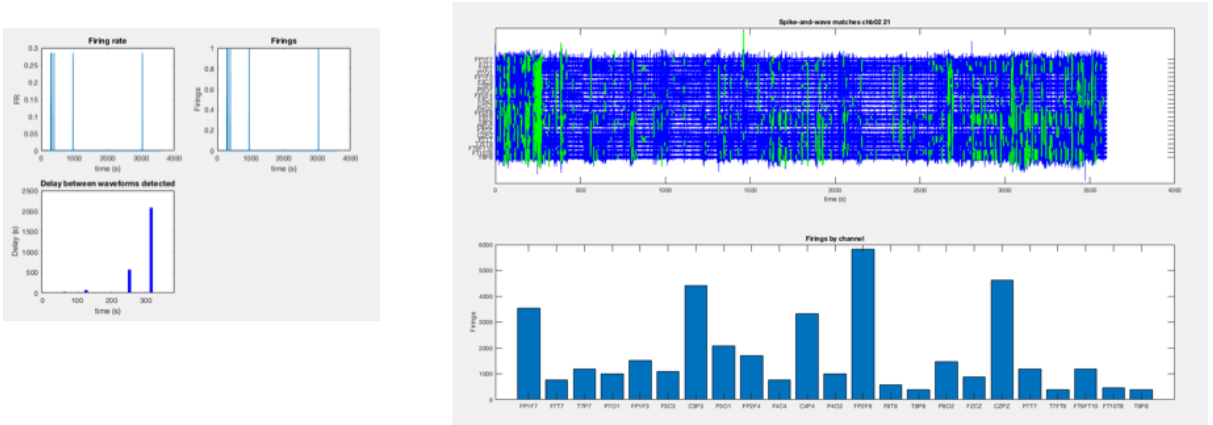


Figure 111, 112. (111) Firing rate, firings by time and delay between firings; (112) Spike-and-wave detections and firings by channel

22.

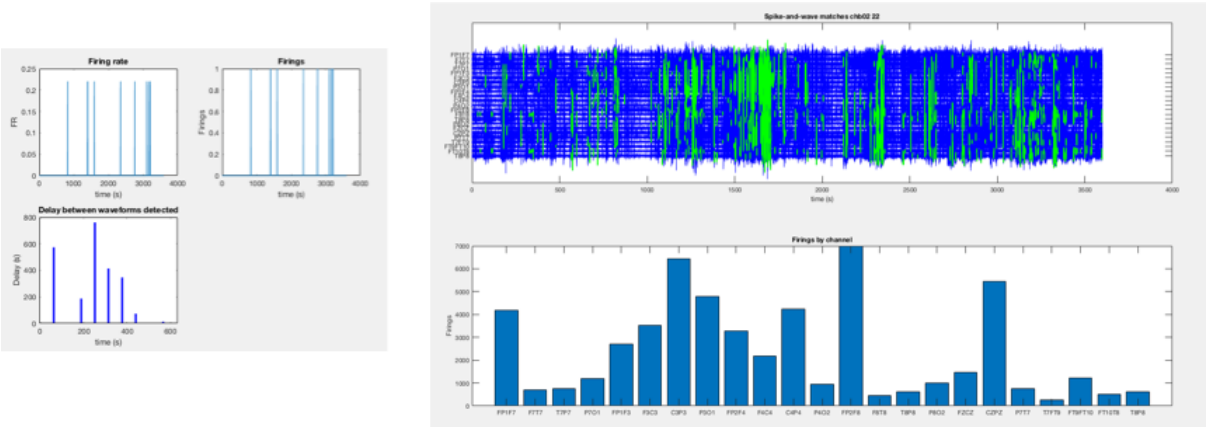


Figure 113, 114. (113) Firing rate, firings by time and delay between firings; (114) Spike-and-wave detections and firings by channel

23.

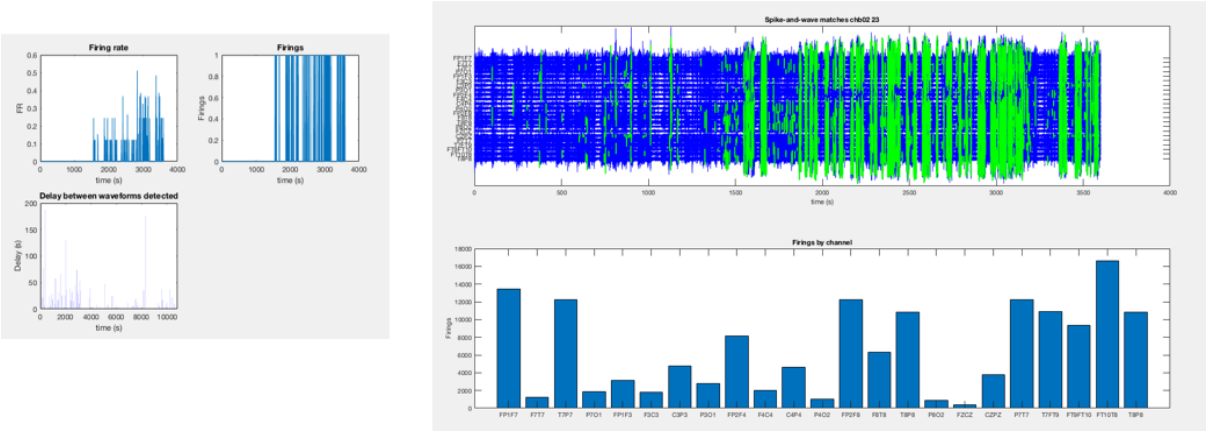


Figure 115, 116. (115) Firing rate, firings by time and delay between firings; (116) Spike-and-wave detections and firings by channel

24.

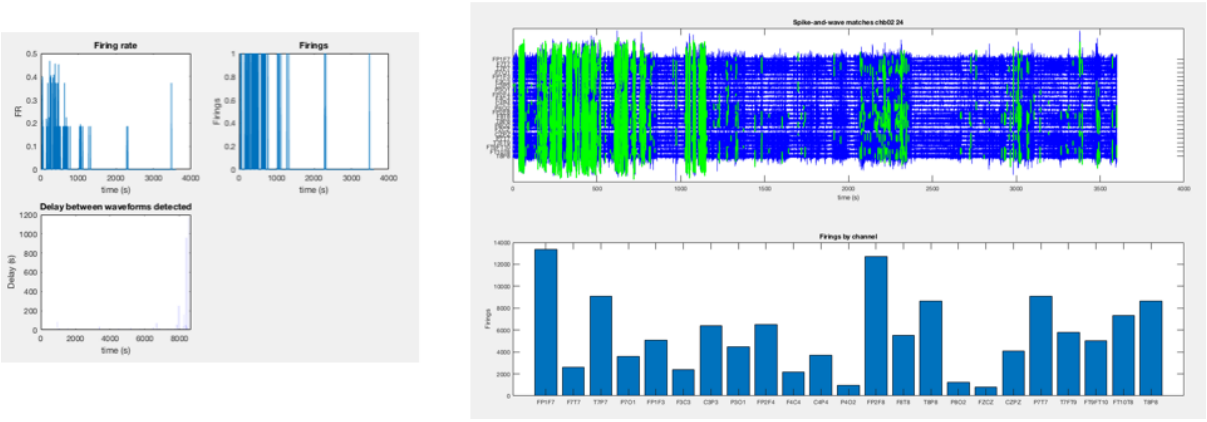
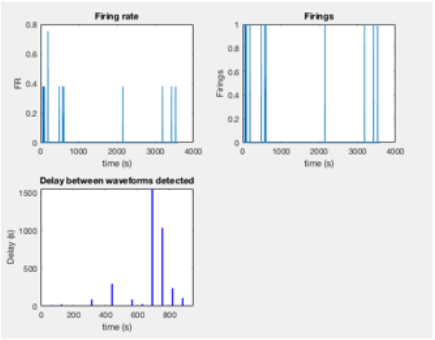


Figure 117, 118. (117) Firing rate, firings by time and delay between firings; (118) Spike-and-wave detections and firings by channel

25.



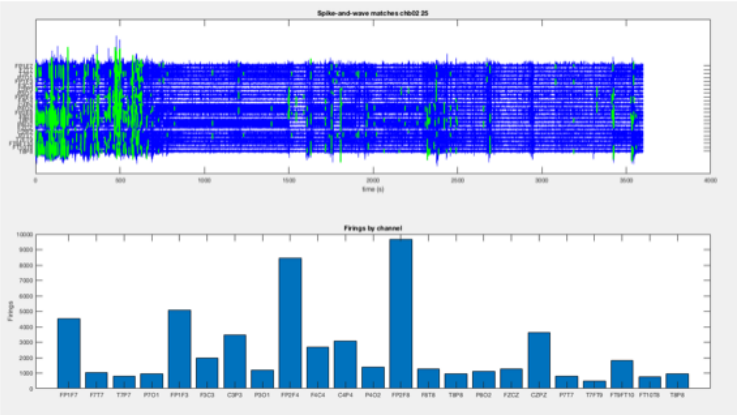


Figure 119, 120. (119) Firing rate, firings by time and delay between firings; (120) Spike-and-wave detections and firings by channel

chb03

Patient overview

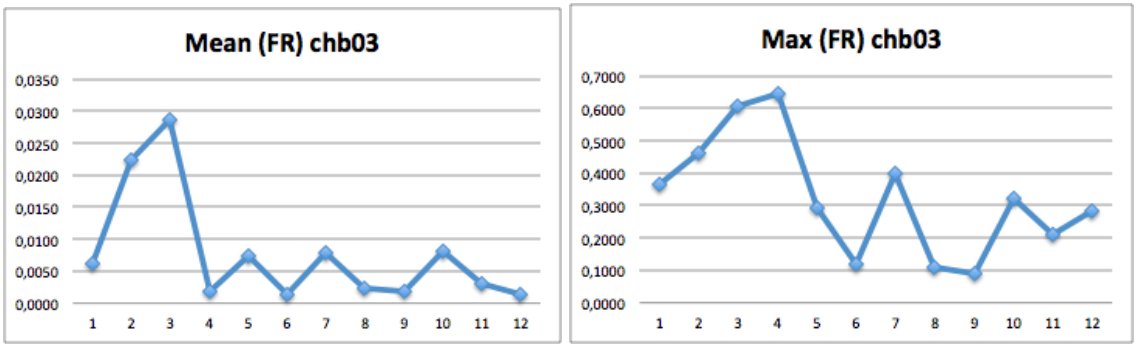


Figure 121, 122. (121) Mean firing rate and (122) Max firing rate

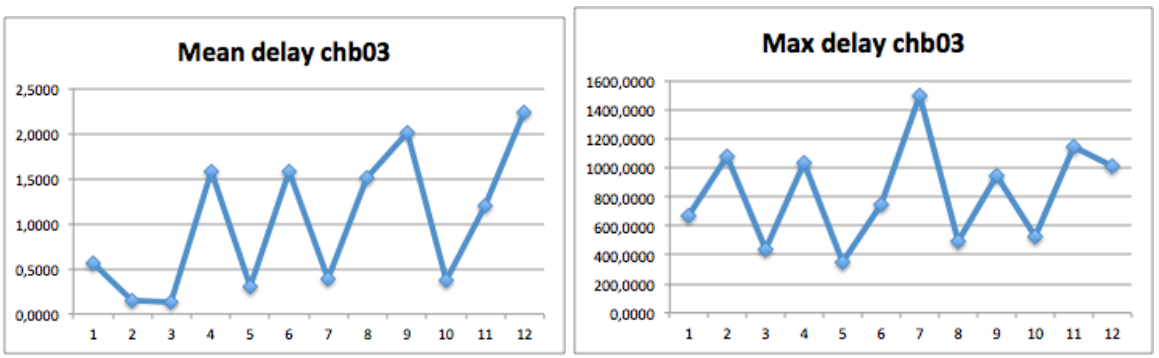


Figure 123, 124. (123) Mean delay and (124) Max delay

From the first recording to the 4th, there is an increase in the mean firing rate and after that it decreases and stays quite low during the rest of the recordings, where there are no seizures. The maximum firing rates are also higher during these first recordings and also stay generally lower on the others, except 7, 10, 11 and 12, which get a slightly higher value than the others with no recordings, due to the fact that there are some peaks of firings, although not very significant. Overall, the delay values are not very stable, but the mean delay during 1,2 and 3 stays low.

CHB03	Mean(FR)	Max(FR)	Mean Delay	Max delay
1 (seizure)	0,0061	0,3643	0,5714	664,2344
2 (seizure)	0,0223	0,4638	0,1465	1082,0000
3 (seizure)	0,0287	0,6048	0,1260	442,0781
4 (seizure)	0,0018	0,6452	1,5757	1028,9000
5	0,0075	0,2928	0,2986	345,6172
6	0,0014	0,1178	1,5868	743,3555
7	0,0078	0,3981	0,3891	1496,6000
8	0,0023	0,1086	1,5135	495,9531
9	0,0019	0,0889	2,0138	945,2656
10	0,0081	0,3200	0,3683	528,0703
11	0,0031	0,2109	1,2027	1138,2000
12	0,0014	0,2814	2,2316	1007,3000

Table 4. Parameters obtained for each recording

1.

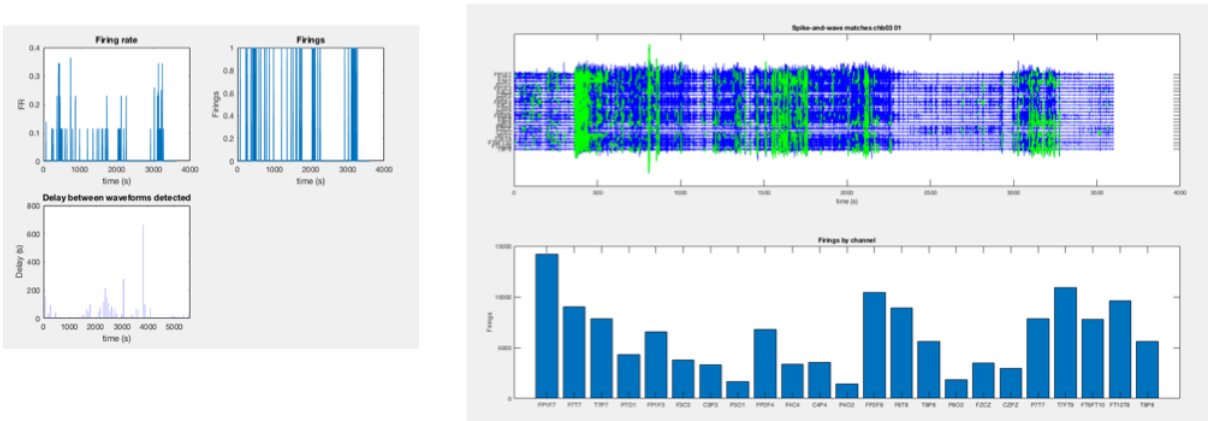


Figure 125, 126. (125) Firing rate, firings by time and delay between firings; (126) Spike-and-wave detections and firings by channel

2.

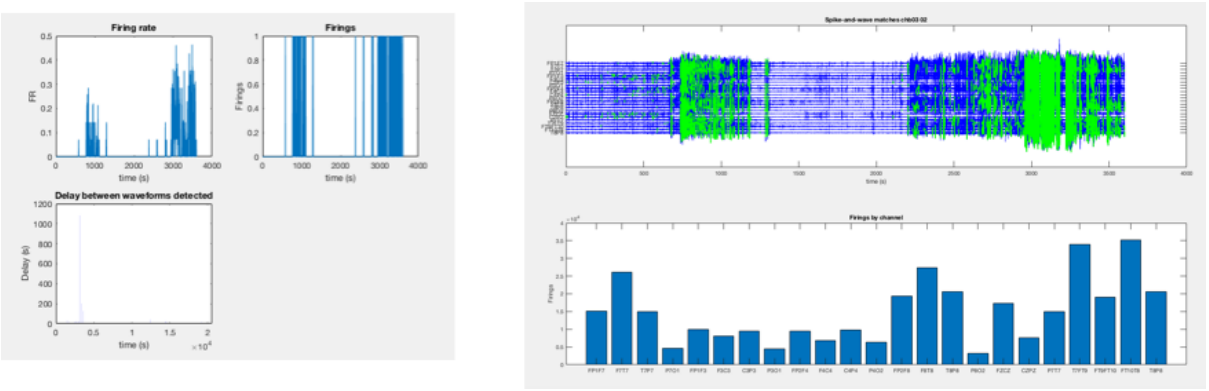


Figure 127, 128. (127) Firing rate, firings by time and delay between firings; (128) Spike-and-wave detections and firings by channel

3.

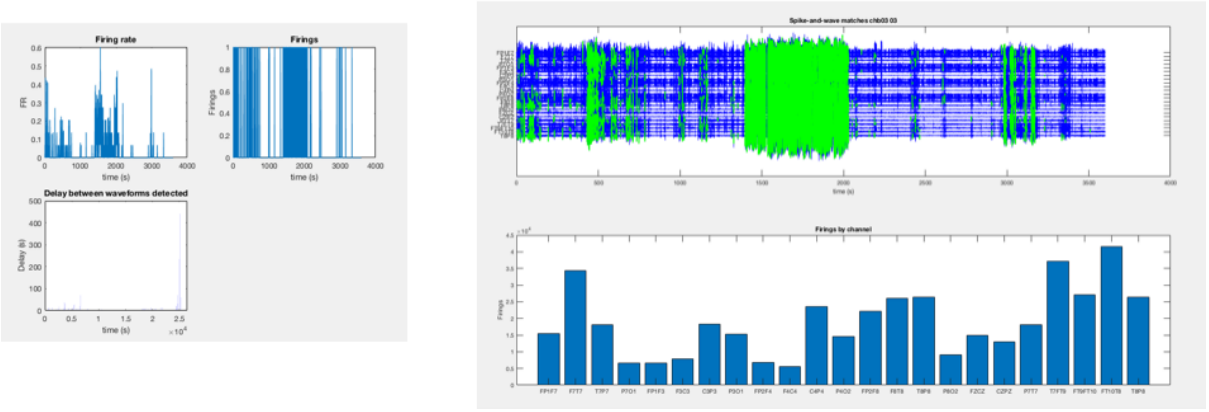


Figure 129, 130. (129) Firing rate, firings by time and delay between firings; (130) Spike-and-wave detections and firings by channel

4.

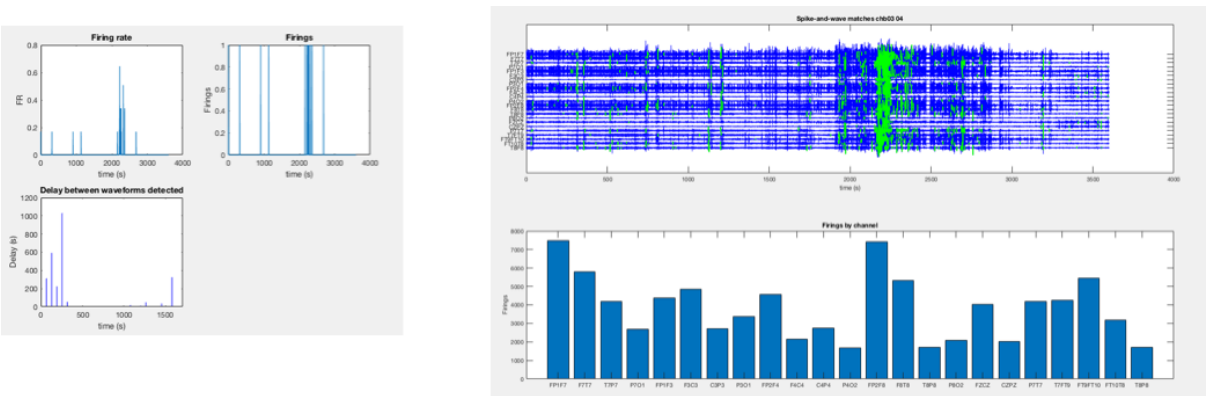


Figure 131, 132. (131) Firing rate, firings by time and delay between firings; (132) Spike-and-wave detections and firings by channel

5.

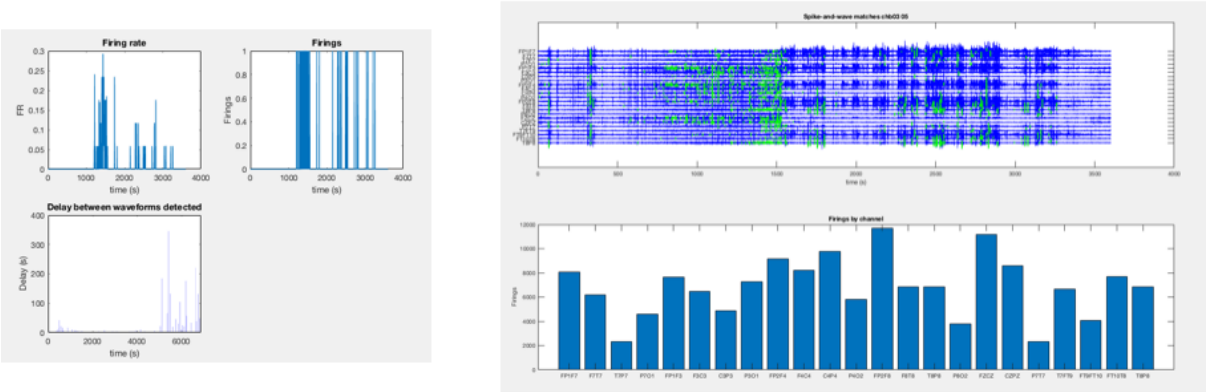


Figure 133, 134. (133) Firing rate, firings by time and delay between firings; (134) Spike-and-wave detections and firings by channel

6.

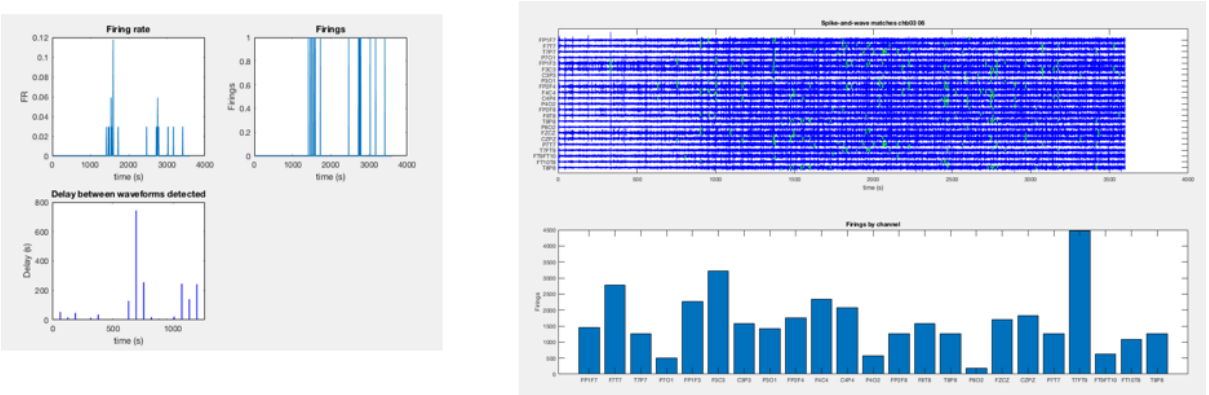


Figure 135, 136. (135) Firing rate, firings by time and delay between firings; (136) Spike-and-wave detections and firings by channel

7.

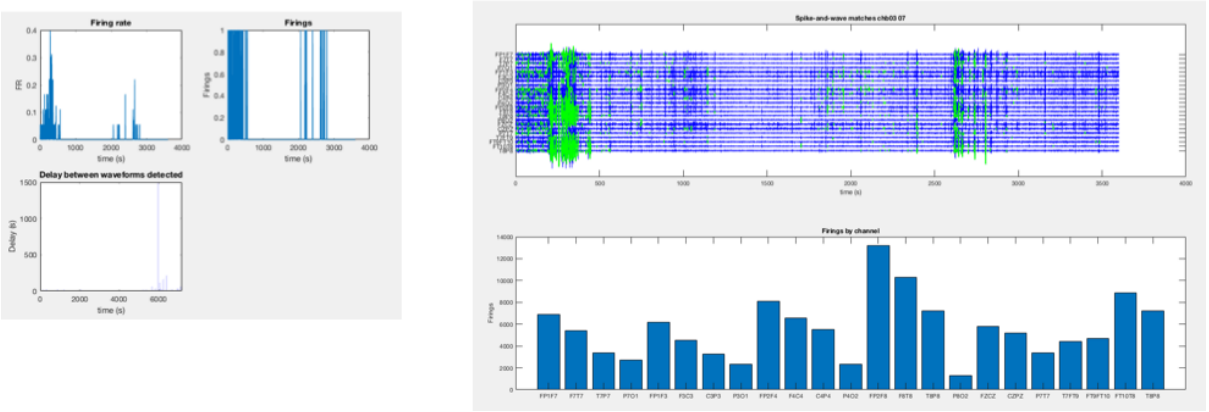


Figure 137, 138. (137) Firing rate, firings by time and delay between firings; (138) Spike-and-wave detections and firings by channel

8.

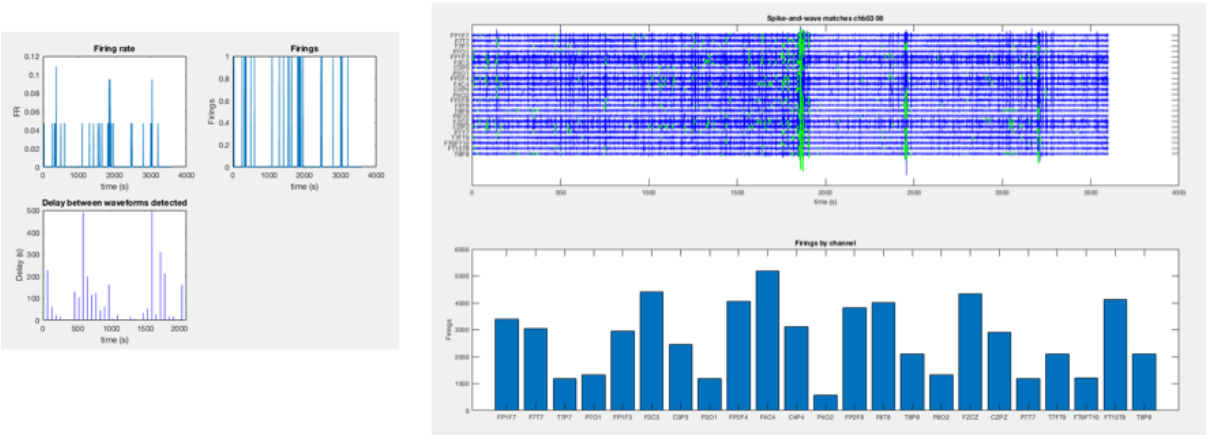


Figure 139, 140. (139) Firing rate, firings by time and delay between firings; (140) Spike-and-wave detections and firings by channel

9.

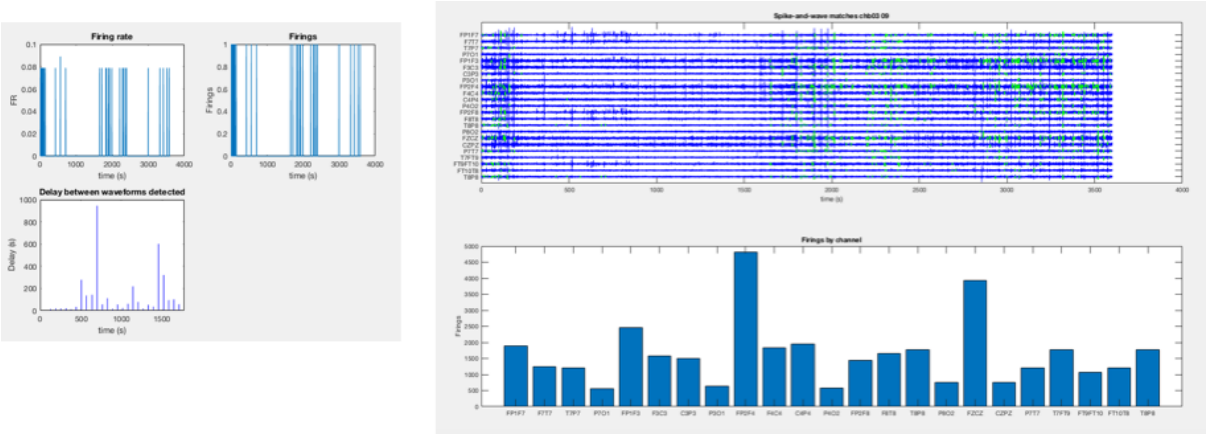


Figure 141, 142. (141) Firing rate, firings by time and delay between firings; (142) Spike-and-wave detections and firings by channel

10.

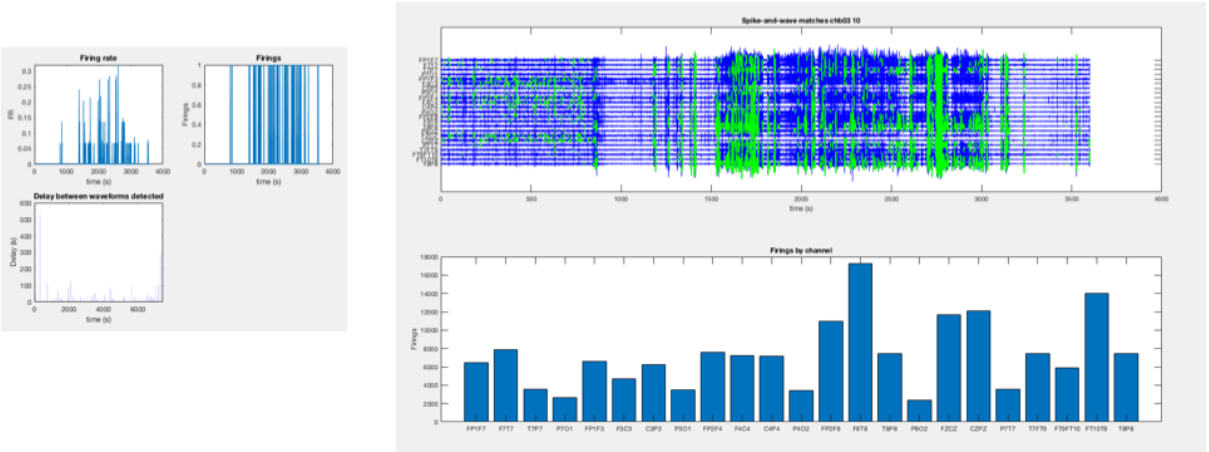


Figure 143, 144. (143) Firing rate, firings by time and delay between firings; (144) Spike-and-wave detections and firings by channel

11.

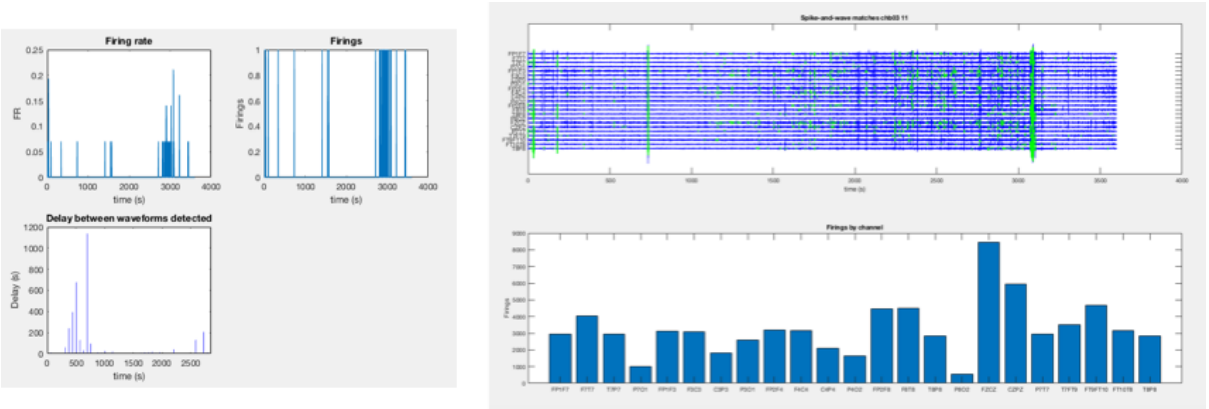


Figure 145, 146. (145) Firing rate, firings by time and delay between firings; (146) Spike-and-wave detections and firings by channel

chb04

Patient overview

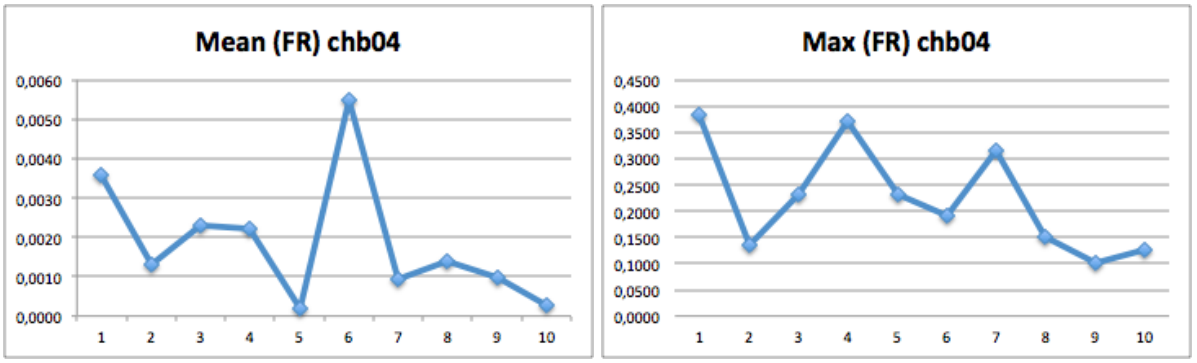


Figure 147, 148. (147) Mean firing rate and (148) Max firing rate

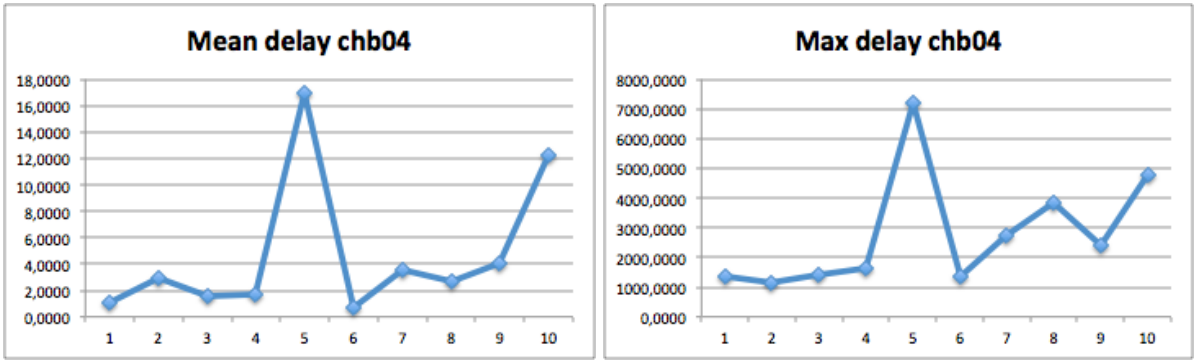


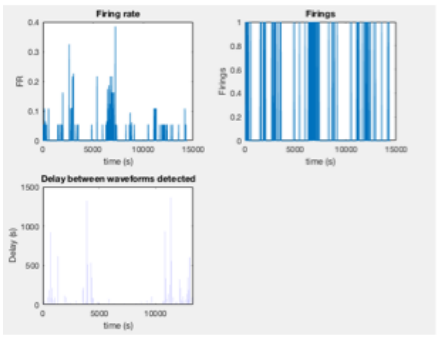
Figure 149, 150. (149) Mean delay and (150) Max delay

The mean firing rates stay generally around the same values, with a peak during the recording 6, which does not contain any seizure. But when we compare it to the maximum firing rate, the value is not the highest. The other recordings are quite varied.
The mean and maximum delays stay quite low during all the recordings, showing an increased tendency during the last recordings and a peak in the 5th.

CHB03	Mean(FR)	Max(FR)	Mean Delay	Max delay
1 (seizure)	0,0061	0,3643	0,5714	664,2344
2 (seizure)	0,0223	0,4638	0,1465	1082,0000
3 (seizure)	0,0287	0,6048	0,1260	442,0781
4 (seizure)	0,0018	0,6452	1,5757	1028,9000
5	0,0075	0,2928	0,2986	345,6172
6	0,0014	0,1178	1,5868	743,3555
7	0,0078	0,3981	0,3891	1496,6000
8	0,0023	0,1086	1,5135	495,9531
9	0,0019	0,0889	2,0138	945,2656
10	0,0081	0,3200	0,3683	528,0703
11	0,0031	0,2109	1,2027	1138,2000
12	0,0014	0,2814	2,2316	1007,3000

Table 5. Parameters obtained for each recording

1.



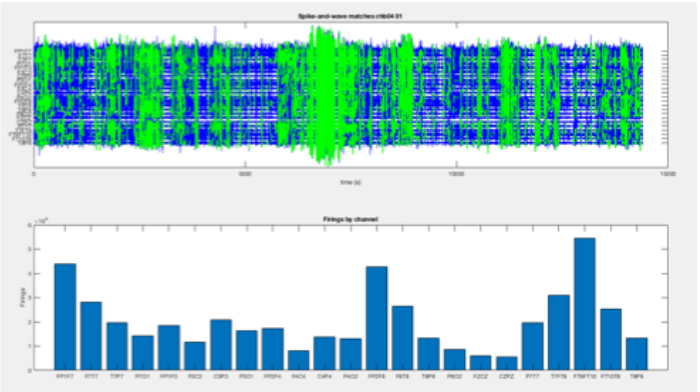


Figure 151, 152. (151) Firing rate, firings by time and delay between firings; (152) Spike-and-wave detections and firings by channel

2.

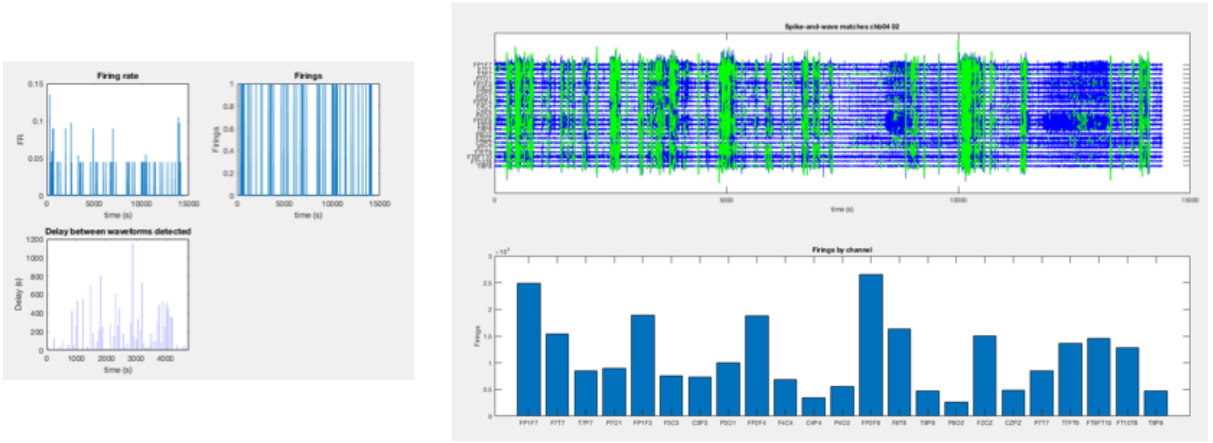


Figure 153, 154. (153) Firing rate, firings by time and delay between firings; (154) Spike-and-wave detections and firings by channel

3.

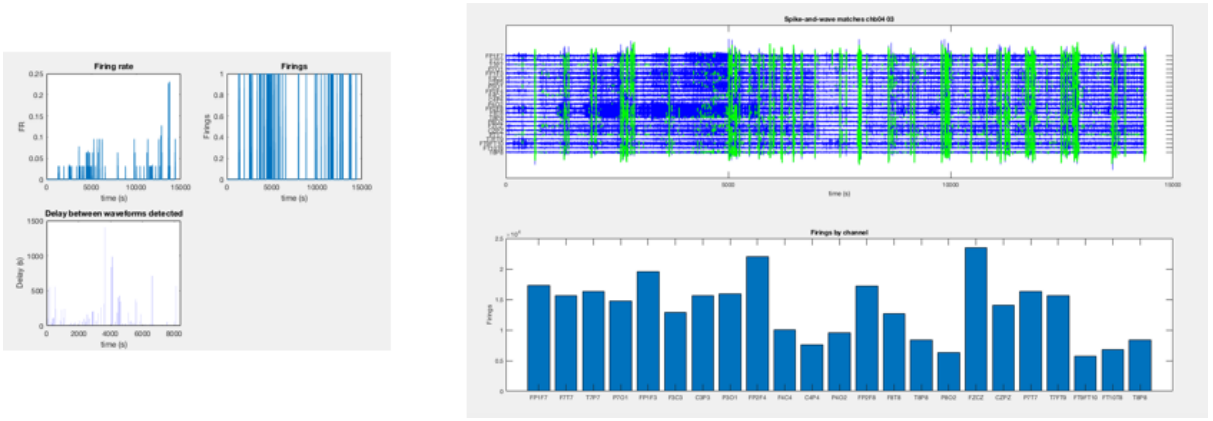


Figure 155, 156. (155) Firing rate, firings by time and delay between firings; (156) Spike-and-wave detections and firings by channel

4.

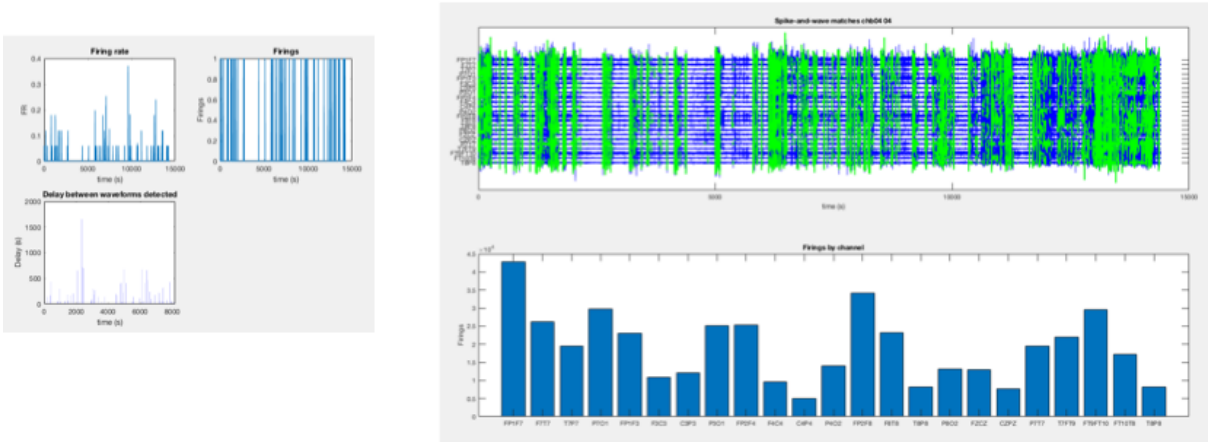


Figure 157, 158. (157) Firing rate, firings by time and delay between firings; (158) Spike-and-wave detections and firings by channel

5.

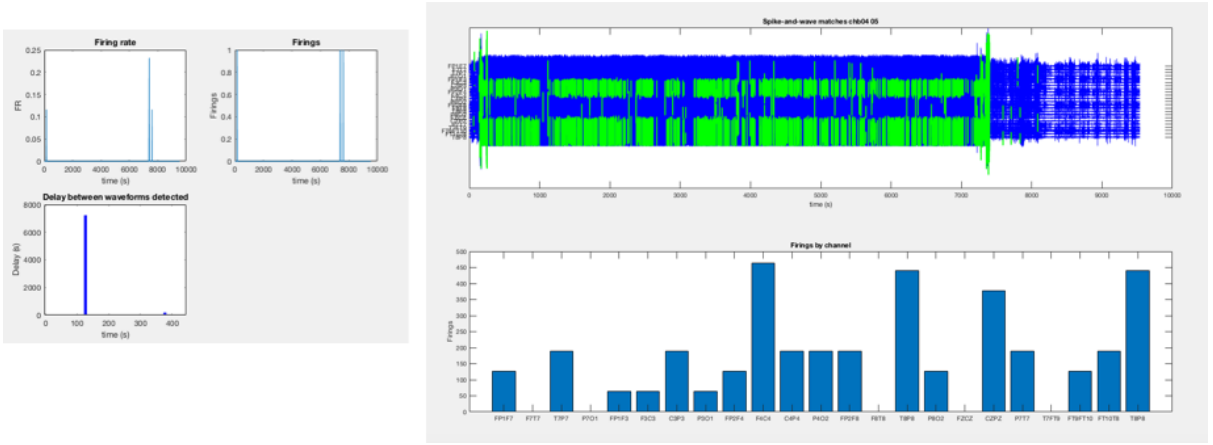


Figure 159, 160. (159) Firing rate, firings by time and delay between firings; (160) Spike-and-wave detections and firings by channel

6.

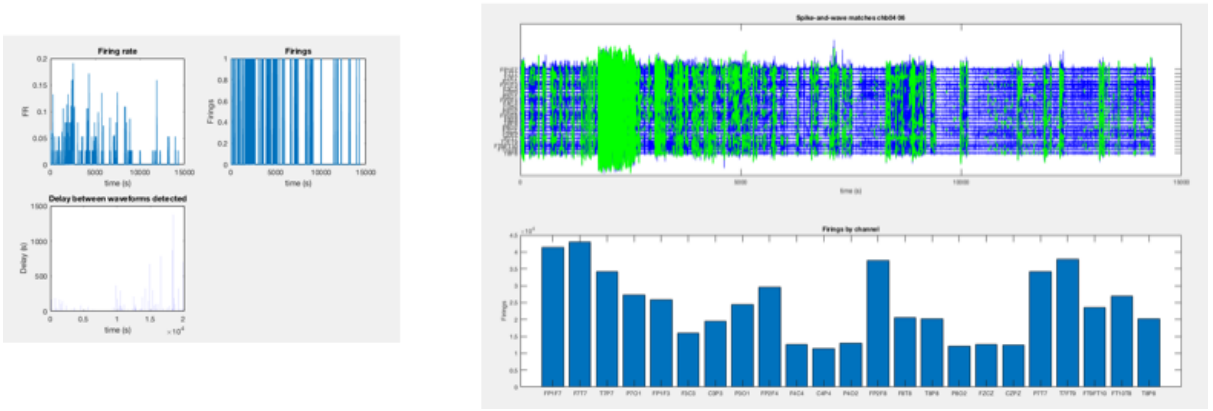


Figure 161, 162. (161) Firing rate, firings by time and delay between firings; (162) Spike-and-wave detections and firings by channel

7.

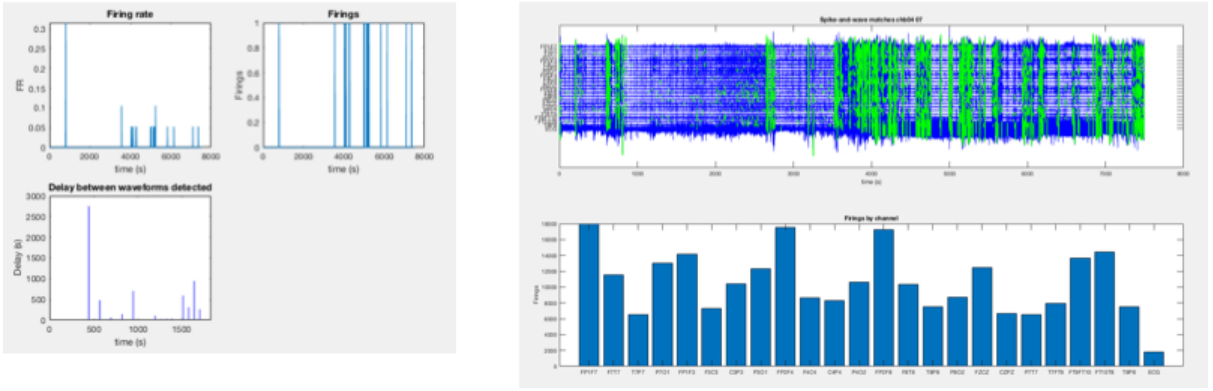


Figure 163, 164. (163) Firing rate, firings by time and delay between firings; (164) Spike-and-wave detections and firings by channel

8.

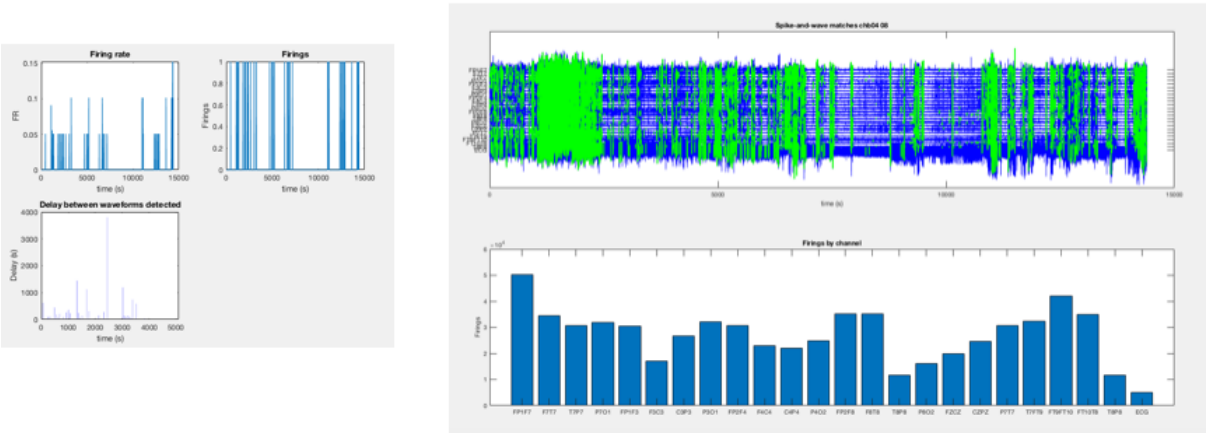


Figure 165, 166. (165) Firing rate, firings by time and delay between firings; (166) Spike-and-wave detections and firings by channel

9.

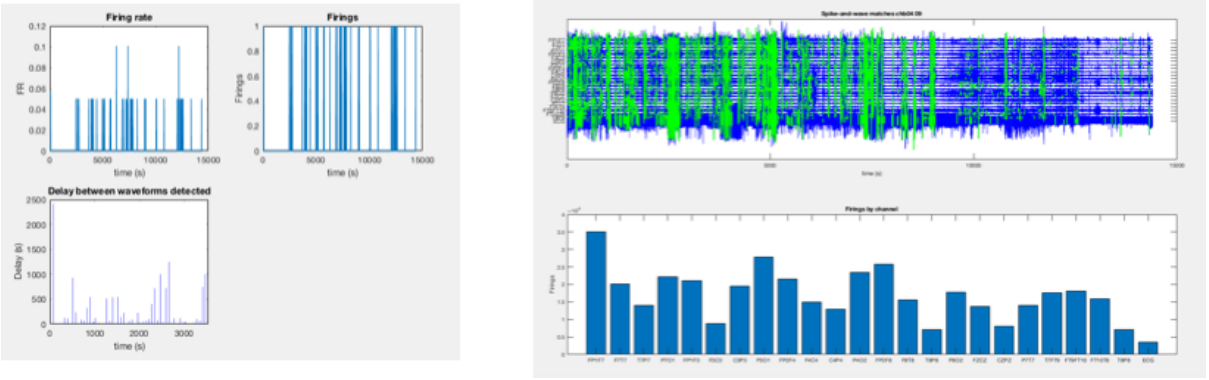


Figure 167, 168. (167) Firing rate, firings by time and delay between firings; (168) Spike-and-wave detections and firings by channel

10.

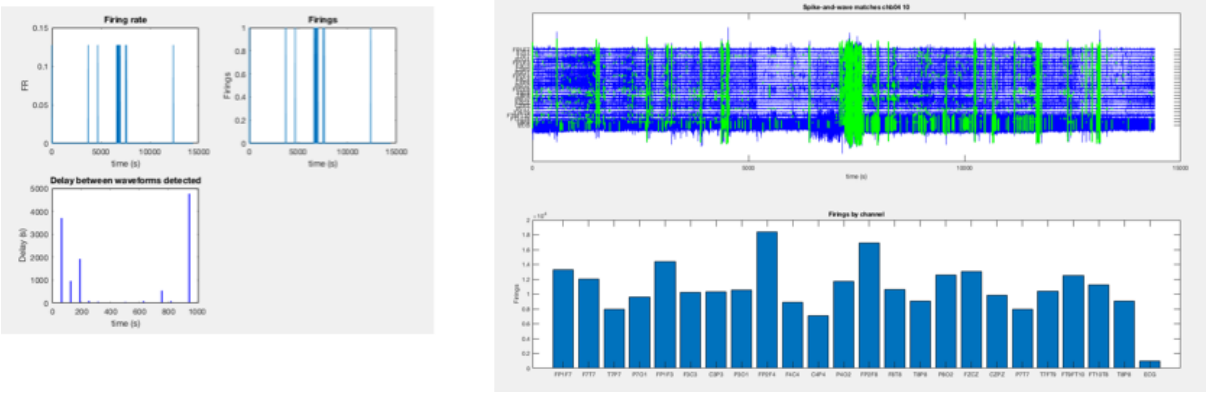


Figure 169, 170. (169) Firing rate, firings by time and delay between firings; (170) Spike-and-wave detections and firings by channel

chb05

Patient overview

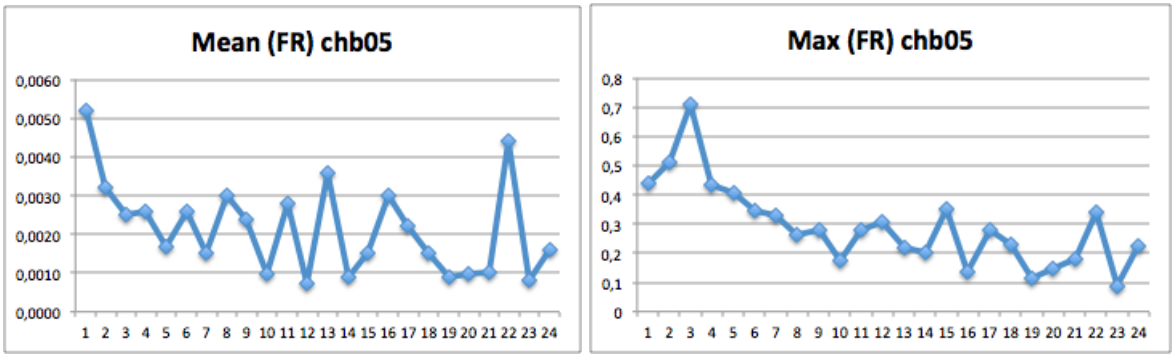


Figure 171, 172. (171) Mean firing rate and (172) Max firing rate

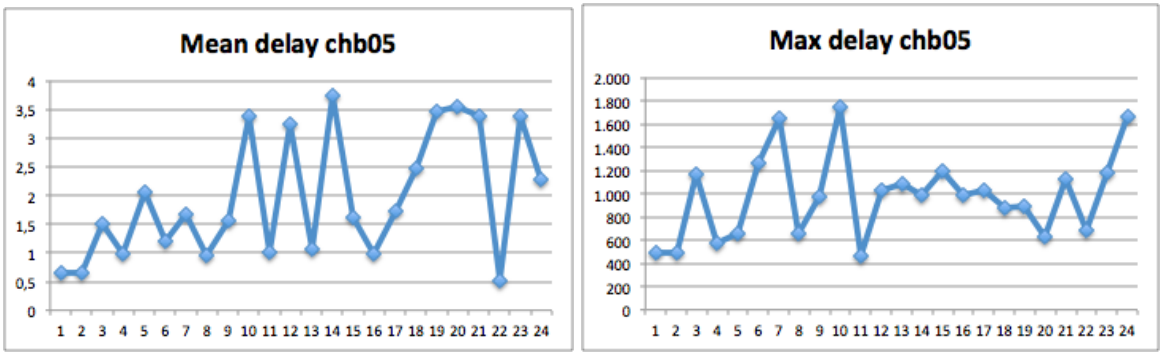


Figure 173, 174. (173) Mean delay and (174) Max delay

The mean firing rates are local maximums in all the seizure recordings (6, 13, 16 and 17, and 22). As for the maximum firing rate, it is quite higher in the first recordings and it has a decreasing tendency.

Considering the mean delays, the seizure files are local minimums, showing that the delay between firings is higher when there are no seizures. Nonetheless, the maximum delays are quite random values.

CHB05	Mean(FR)	Max(FR)	Mean Delay	Max delay
1	0,0052	0,4402	0,6637	488
2	0,0032	0,5091	0,6637	488
3	0,0025	0,7106	1,4934	1173,3000
4	0,0026	0,4315	0,9709	573,1133
5	0,0017	0,4061	2,0511	650,6719
6 (seizure)	0,0026	0,3481	1,1920	1259,7000
7	0,0015	0,3264	1,6800	1648,6000

8	0,0030	0,2614	0,9436	656,3633
9	0,0024	0,2771	1,5505	980,5430
10	0,0010	0,1763	3,3927	1751,2000
11	0,0028	0,2815	1,0114	465,6016
12	0,0007	0,3088	3,2522	1035,6000
13 (seizure)	0,0036	0,2188	1,0663	1081,4000
14	0,0009	0,2006	3,7440	982,4648
15	0,0015	0,3484	1,6137	1188,4000
16 (seizure)	0,0030	0,1364	0,9746	983,6680
17 (seizure)	0,0022	0,2800	1,7233	1023,6000
18	0,0015	0,2272	2,4767	878,3320
19	0,0009	0,1166	3,4650	892,1953
20	0,0010	0,1455	3,5434	634,4336
21	0,0010	0,1810	3,3730	1124,1000
22 (seizure)	0,0044	0,3383	0,5262	685,0898
23	0,0008	0,0890	3,3928	1181,0000
24	0,0016	0,2238	2,2893	1663,9000

Table 6. Parameters obtained for each recording

1.

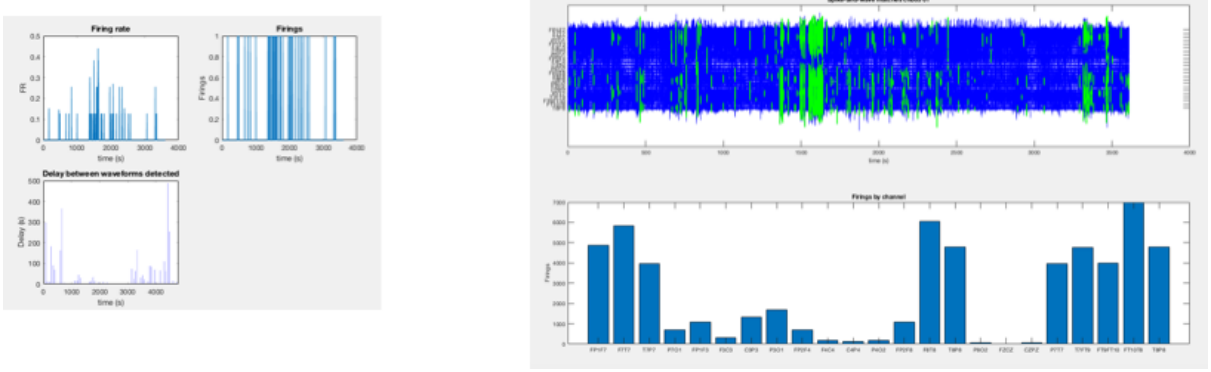


Figure 175, 176. (175) Firing rate, firings by time and delay between firings; (176) Spike-and-wave detections and firings by channel

2.

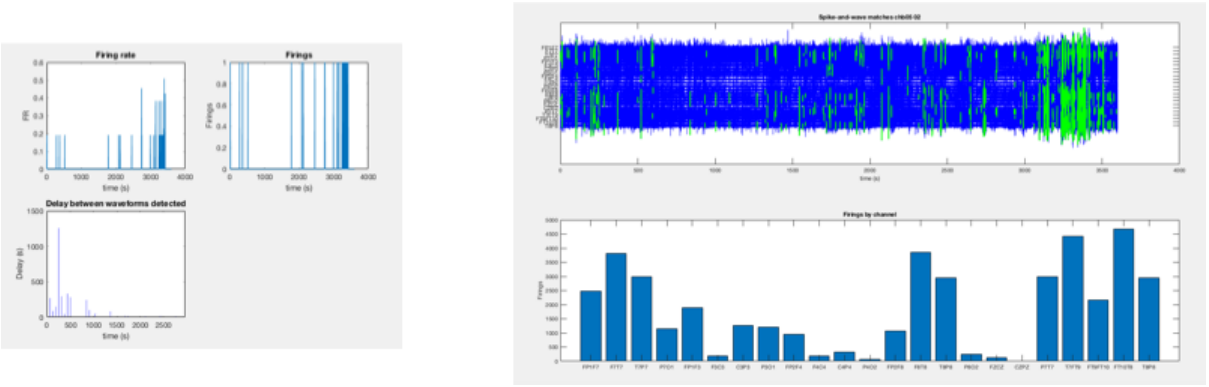


Figure 177, 178. (177) Firing rate, firings by time and delay between firings; (178) Spike-and-wave detections and firings by channel

3.

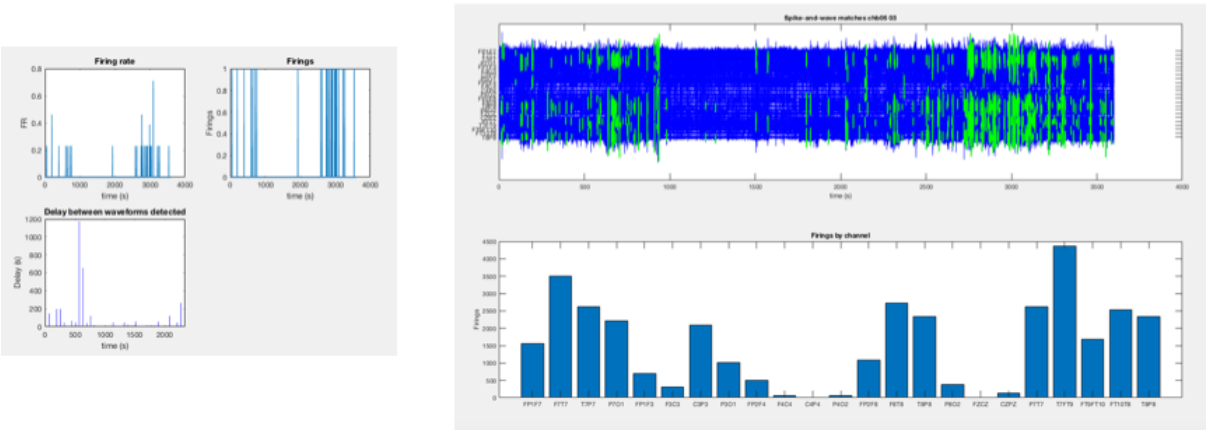


Figure 179, 180. (179) Firing rate, firings by time and delay between firings; (180) Spike-and-wave detections and firings by channel

4.

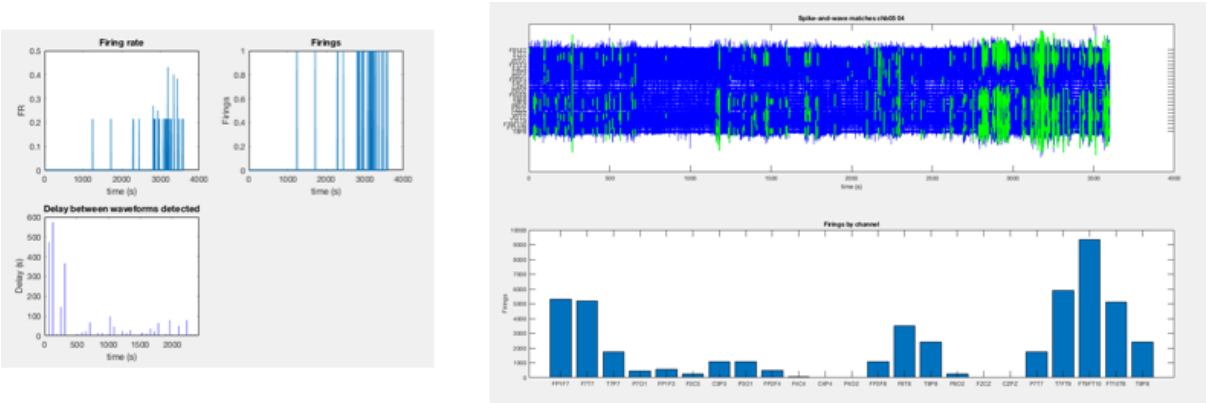


Figure 181, 182. (181) Firing rate, firings by time and delay between firings; (182) Spike-and-wave detections and firings by channel

5.

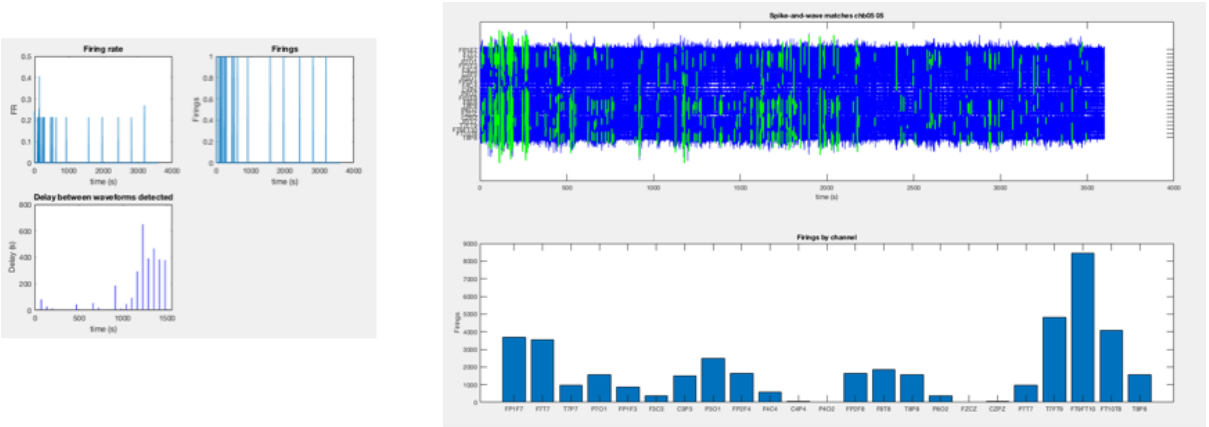


Figure 183, 184. (183) Firing rate, firings by time and delay between firings; (184) Spike-and-wave detections and firings by channel

6.

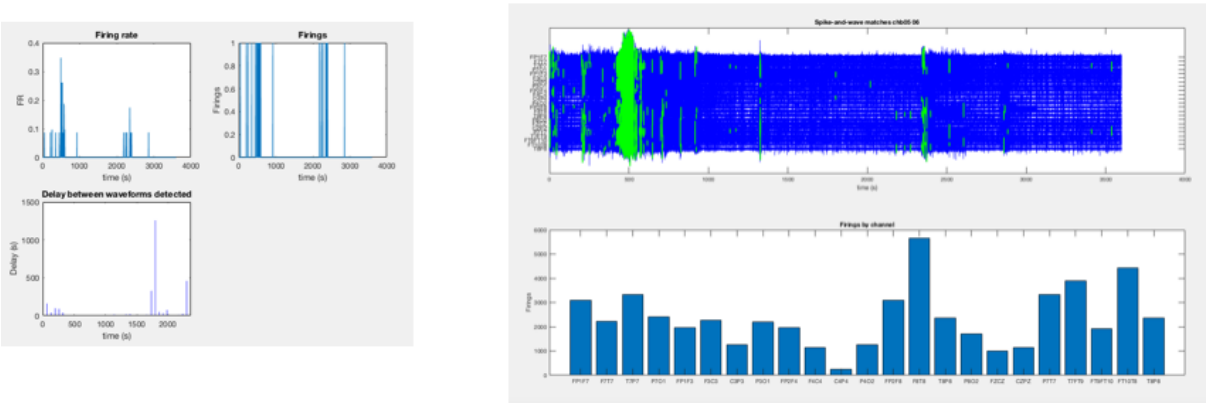


Figure 185, 186. (185) Firing rate, firings by time and delay between firings; (186) Spike-and-wave detections and firings by channel

7.

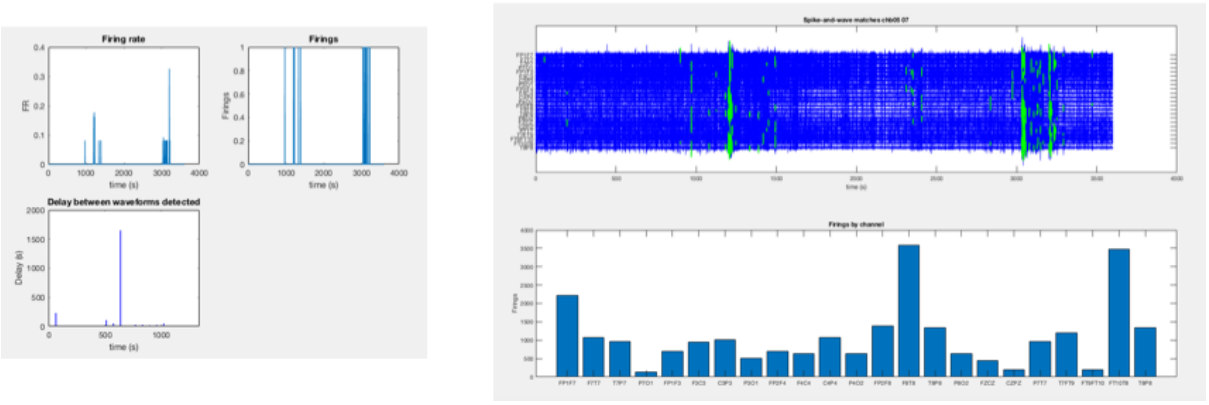


Figure 187, 188. (187) Firing rate, firings by time and delay between firings; (188) Spike-and-wave detections and firings by channel

8.

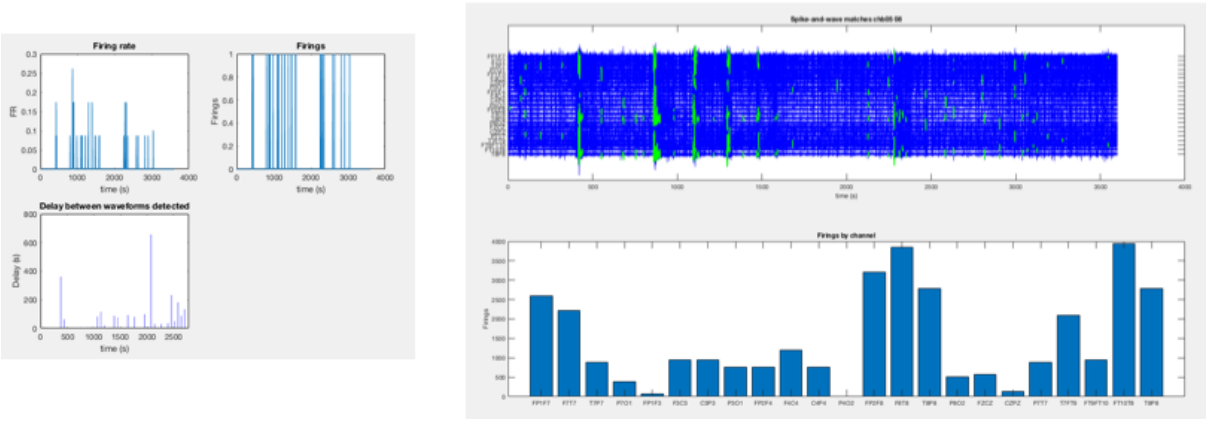


Figure 189, 190. (189) Firing rate, firings by time and delay between firings; (190) Spike-and-wave detections and firings by channel

9.

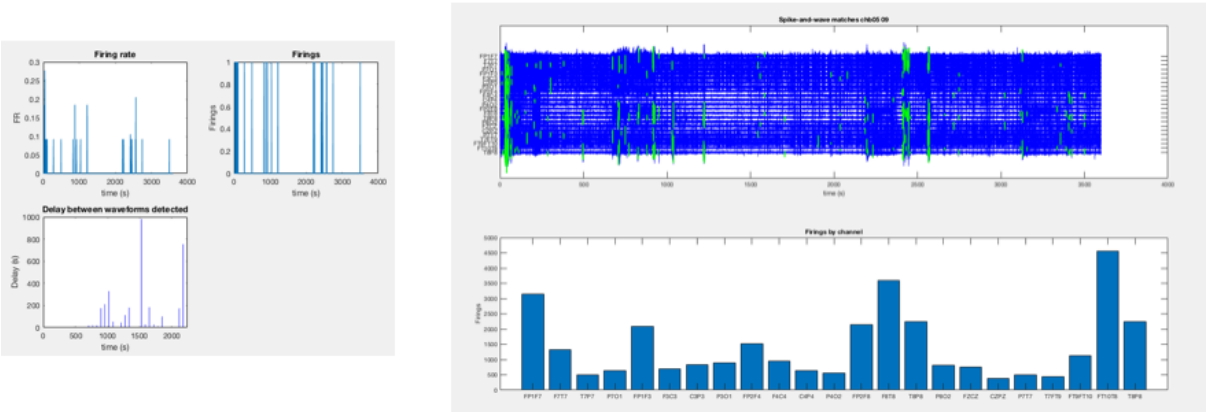


Figure 191, 192. (191) Firing rate, firings by time and delay between firings; (192) Spike-and-wave detections and firings by channel

10.

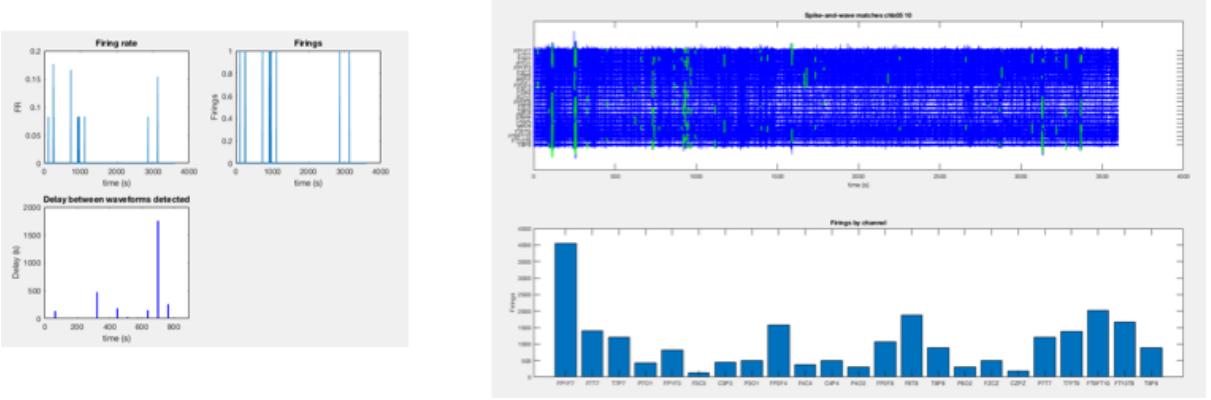


Figure 193, 194. (193) Firing rate, firings by time and delay between firings; (194) Spike-and-wave detections and firings by channel

11.

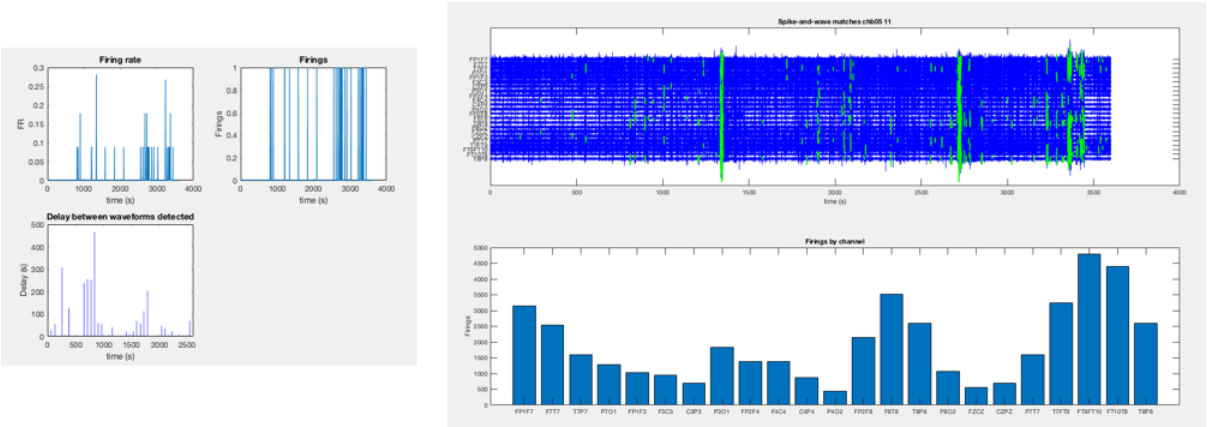


Figure 195, 196. (195) Firing rate, firings by time and delay between firings; (196) Spike-and-wave detections and firings by channel

12.

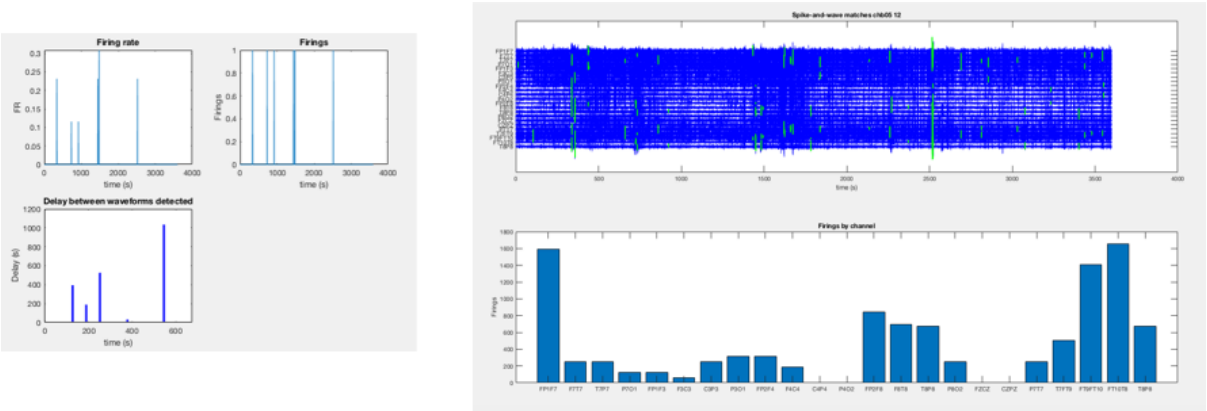


Figure 197, 198. (197) Firing rate, firings by time and delay between firings; (198) Spike-and-wave detections and firings by channel

13.

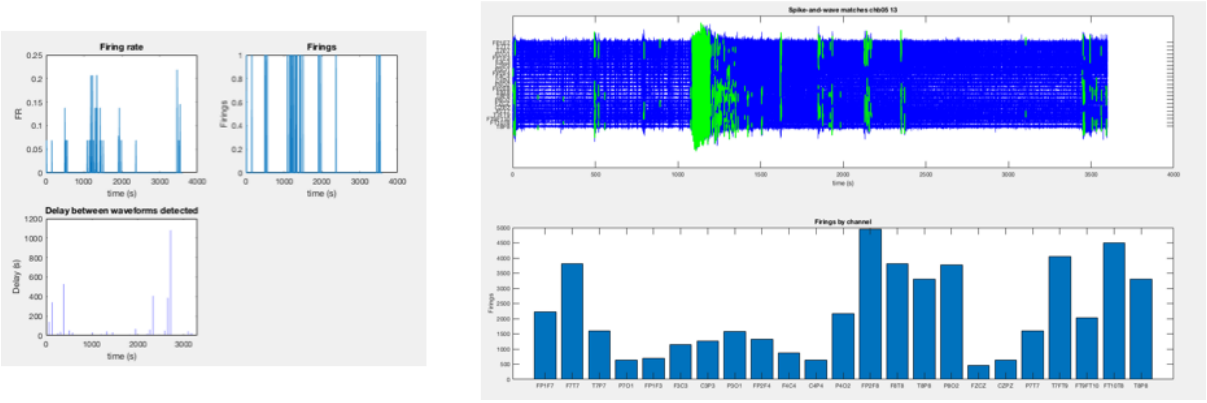


Figure 199, 200. (199) Firing rate, firings by time and delay between firings; (200) Spike-and-wave detections and firings by channel

14.

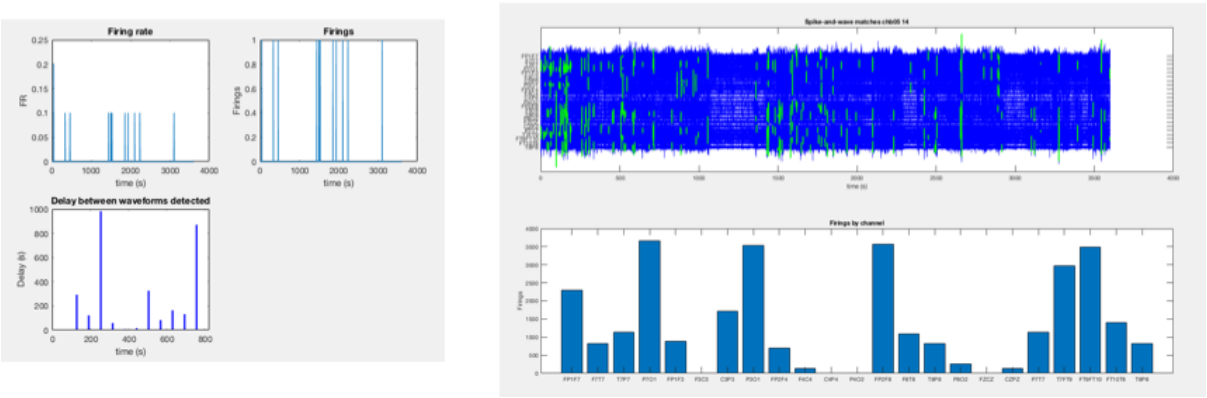


Figure 201, 202. (201) Firing rate, firings by time and delay between firings; (202) Spike-and-wave detections and firings by channel

15.

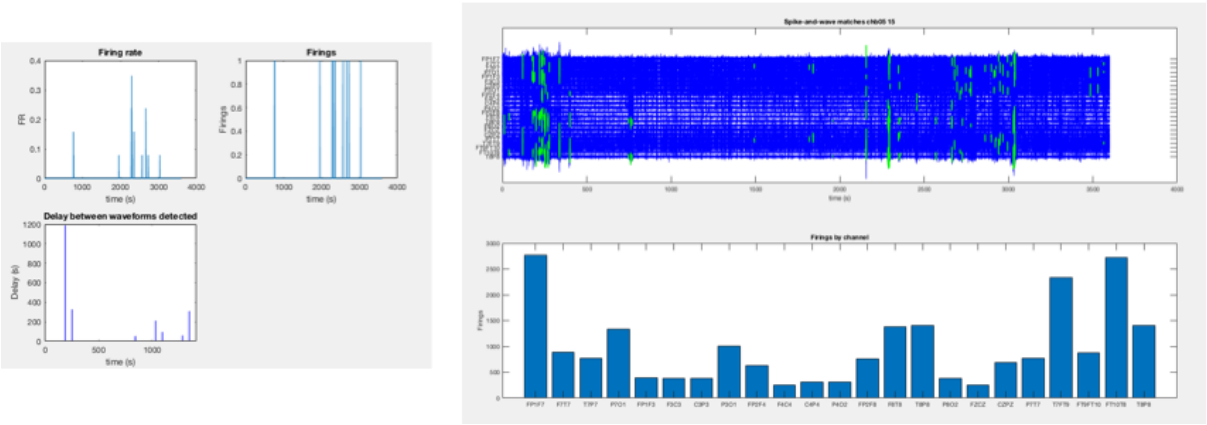


Figure 203, 204. (203) Firing rate, firings by time and delay between firings; (204) Spike-and-wave detections and firings by channel

16.

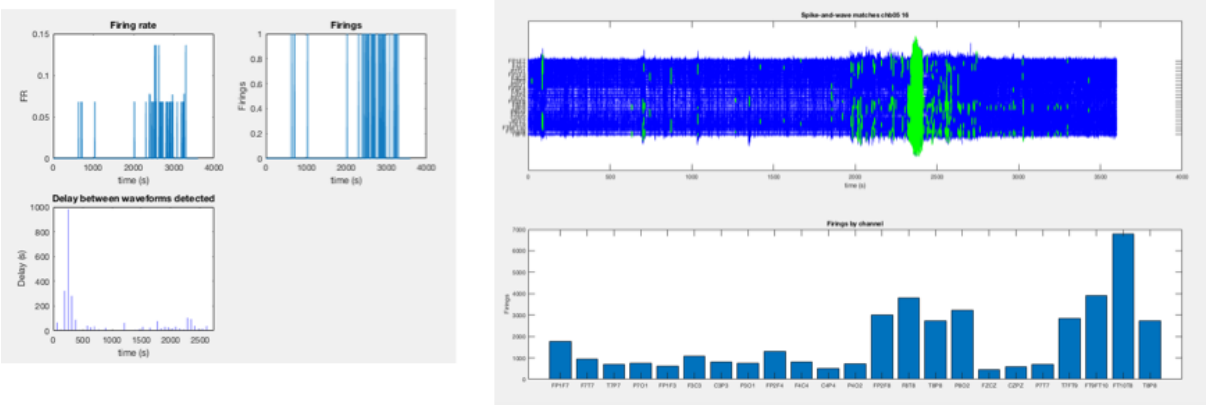


Figure 205, 206. (205) Firing rate, firings by time and delay between firings; (206) Spike-and-wave detections and firings by channel

17.

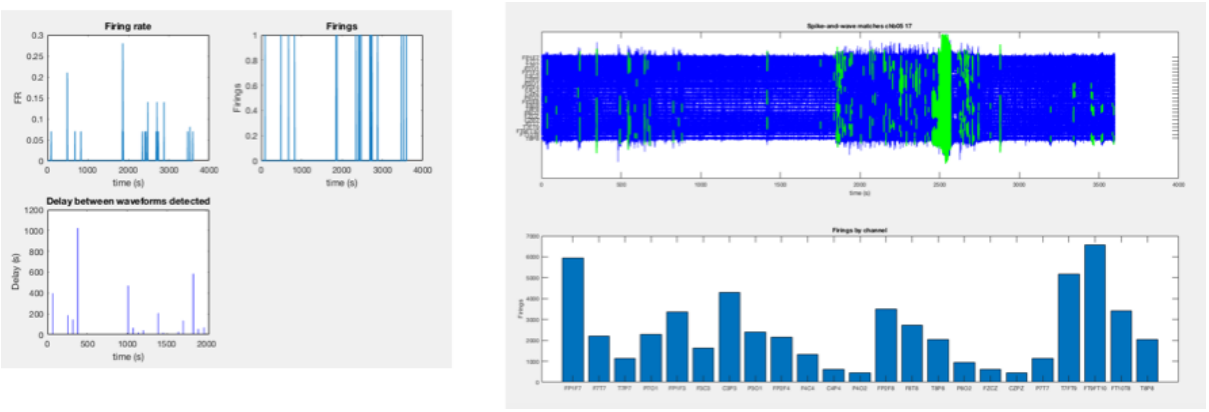


Figure 207, 208. (207) Firing rate, firings by time and delay between firings; (208) Spike-and-wave detections and firings by channel

18.

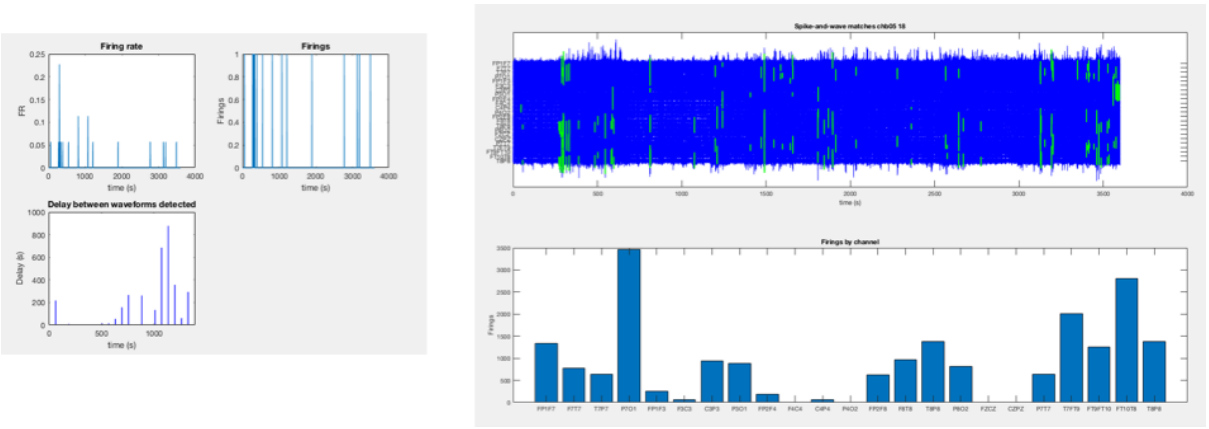


Figure 209, 210. (209) Firing rate, firings by time and delay between firings; (210) Spike-and-wave detections and firings by channel

19.

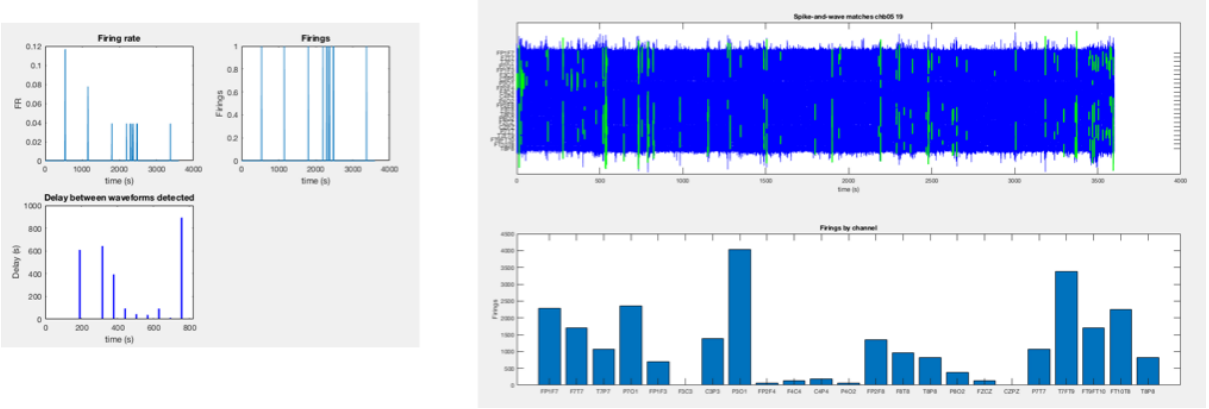


Figure 211, 212. (211) Firing rate, firings by time and delay between firings; (212) Spike-and-wave detections and firings by channel

20.

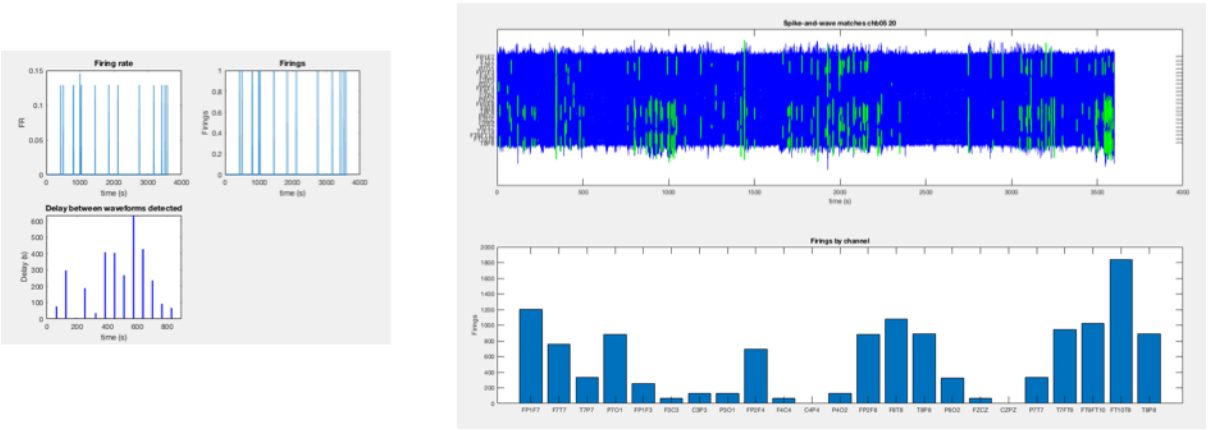


Figure 213, 214. (213) Firing rate, firings by time and delay between firings; (214) Spike-and-wave detections and firings by channel

21.

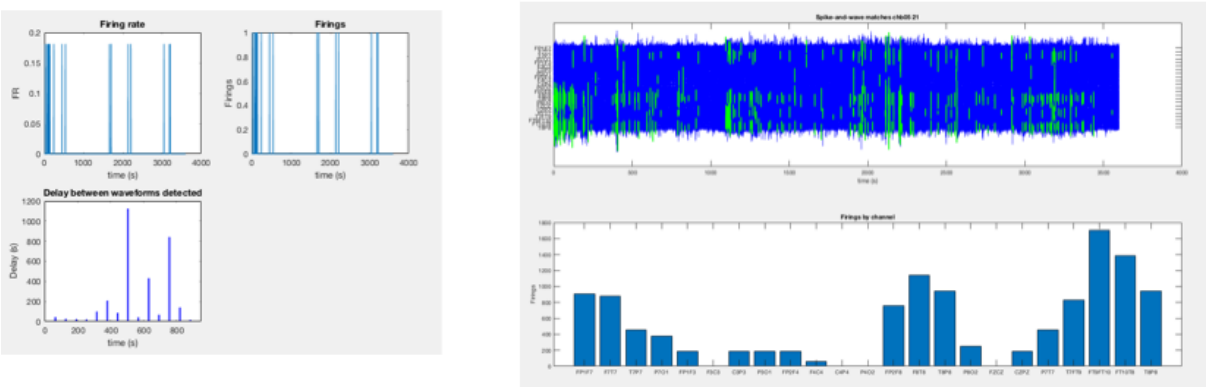


Figure 215, 216. (215) Firing rate, firings by time and delay between firings; (216) Spike-and-wave detections and firings by channel

22.

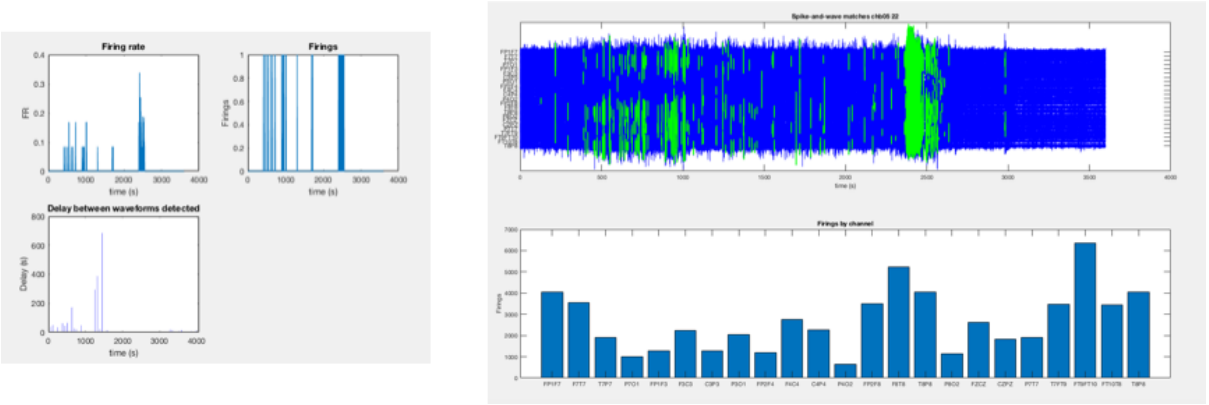


Figure 217, 218. (217) Firing rate, firings by time and delay between firings; (218) Spike-and-wave detections and firings by channel

23.

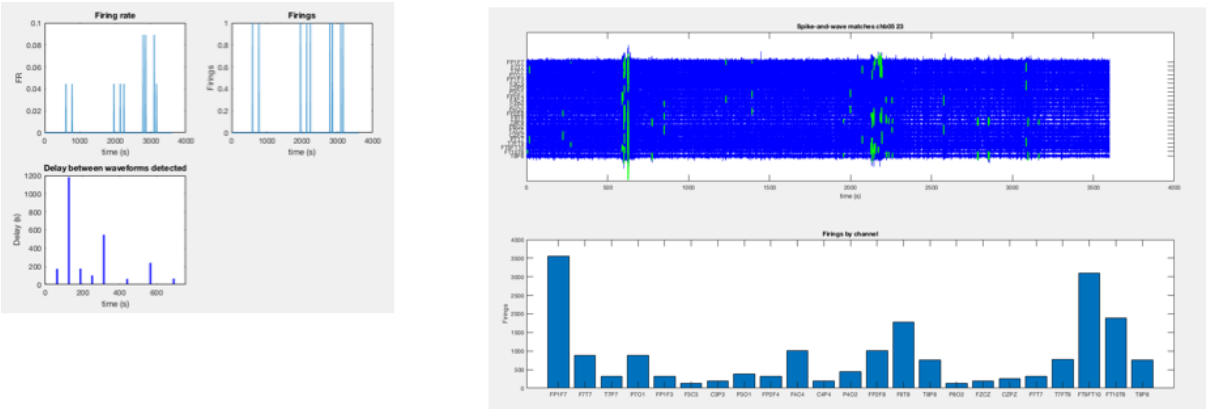


Figure 219, 220. (219) Firing rate, firings by time and delay between firings; (220) Spike-and-wave detections and firings by channel

24.

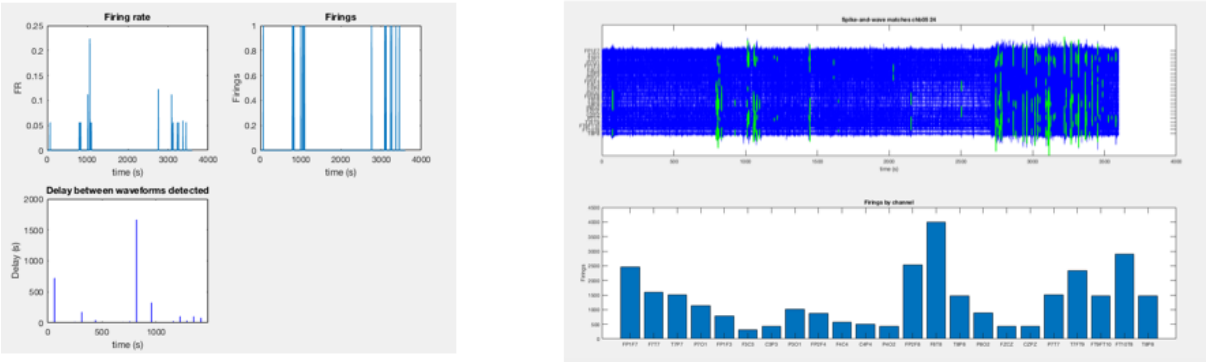


Figure 221, 222. (221) Firing rate, firings by time and delay between firings; (222) Spike-and-wave detections and firings by channel

chb06

Patient overview

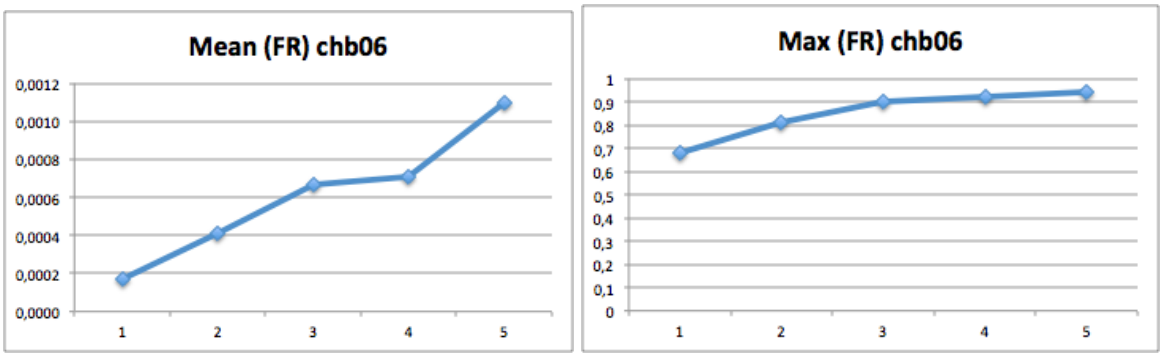


Figure 223, 224. (223) Mean firing rate and (224) Max firing rate

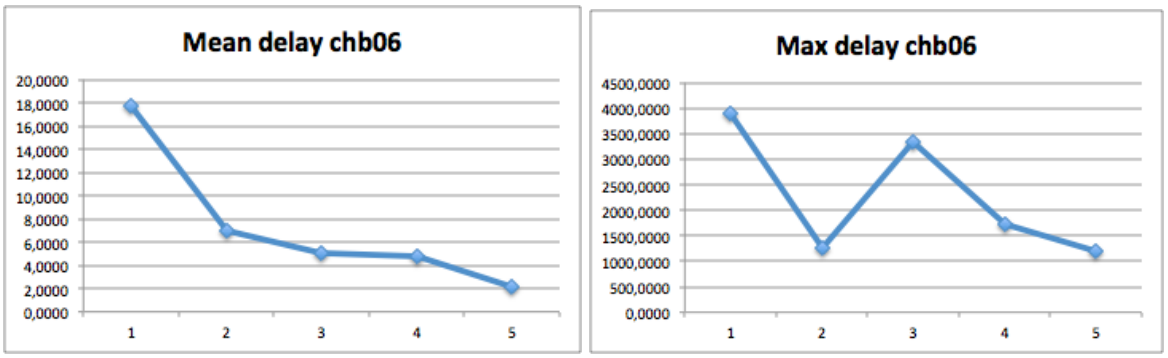


Figure 225, 226. (225) Mean delay and (226) Max delay

As it can be seen on the previous graphs, the recordings with seizures do not show any relevant or characteristic sign differentiating seizure or not.

CHB06	Mean(FR)	Max(FR)	Mean Delay	Max delay
1 (seizure)	0,0002	0,68	17,6778	3889,8000
2	0,0004	0,8100	6,9312	1262,2000
3	0,0007	0,9000	5,0650	3329,9000
4 (seizure)	0,0007	0,9200	4,8122	1725,0000
5	0,0011	0,9400	2,1000	1197,9000

Table 7. Parameters obtained for each recording

1.

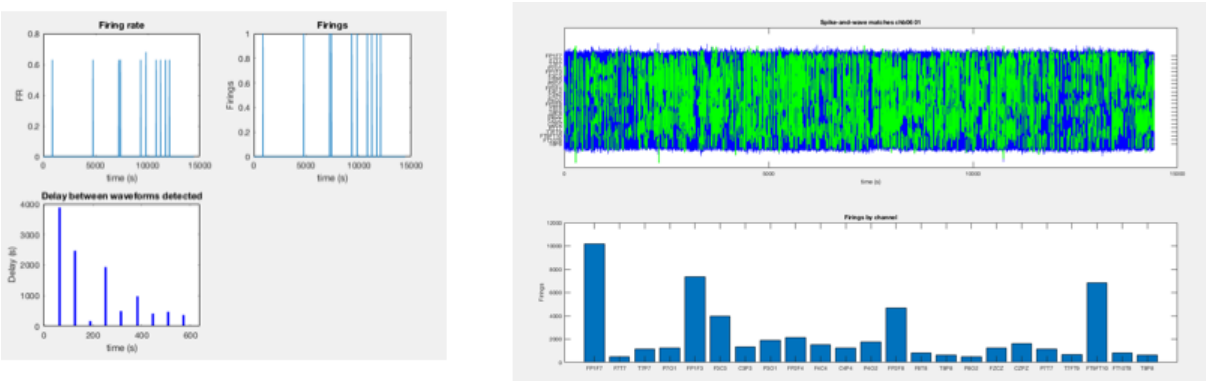


Figure 227, 228. (227) Firing rate, firings by time and delay between firings; (228) Spike-and-wave detections and firings by channel

2.

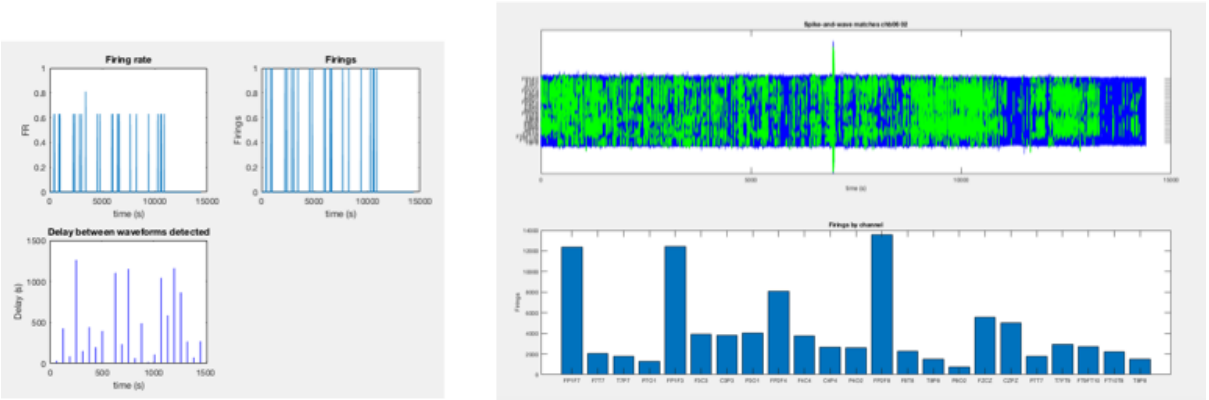


Figure 229, 230. (229) Firing rate, firings by time and delay between firings; (230) Spike-and-wave detections and firings by channel

3.

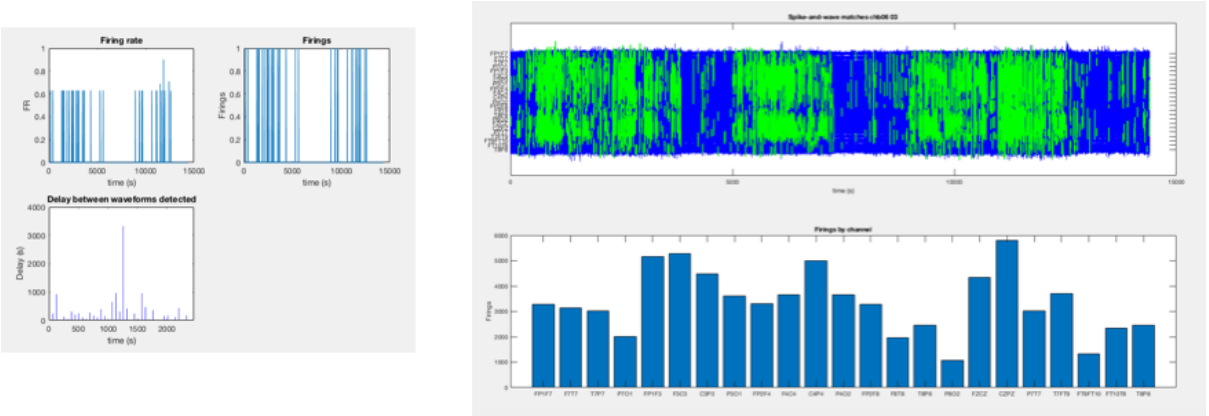
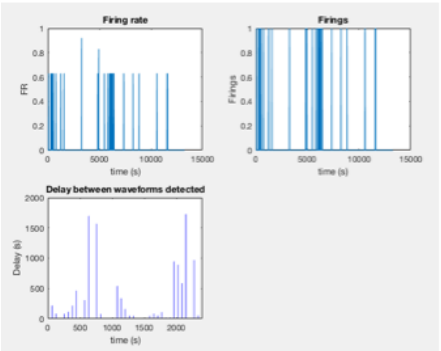


Figure 231, 232. (231) Firing rate, firings by time and delay between firings; (232) Spike-and-wave detections and firings by channel

4.



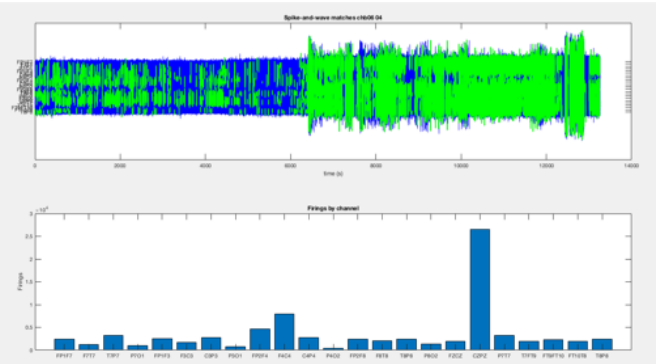
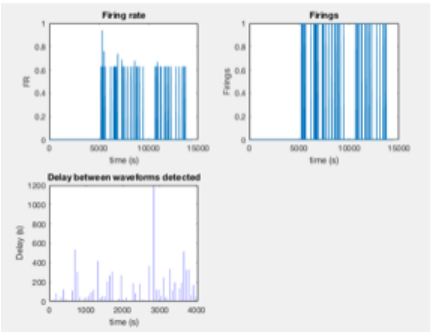


Figure 233, 234. (233) Firing rate, firings by time and delay between firings; (234) Spike-and-wave detections and firings by channel

5.



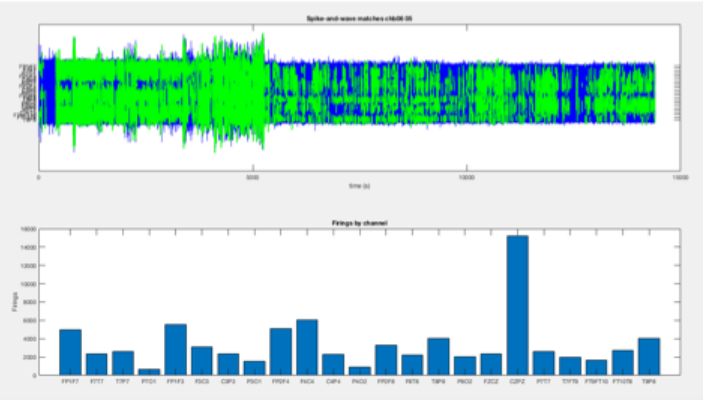


Figure 235, 236. (235) Firing rate, firings by time and delay between firings; (236) Spike-and-wave detections and firings by channel

chb07

Patient overview

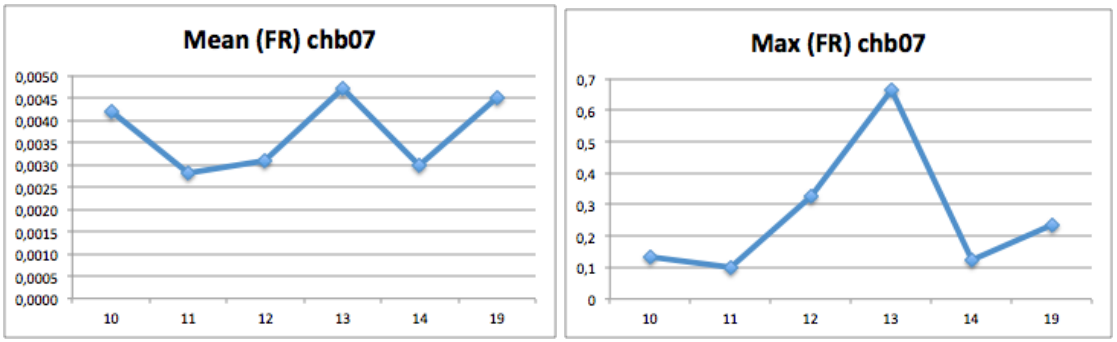


Figure 237, 238. (237) Mean firing rate and (238) Max firing rate

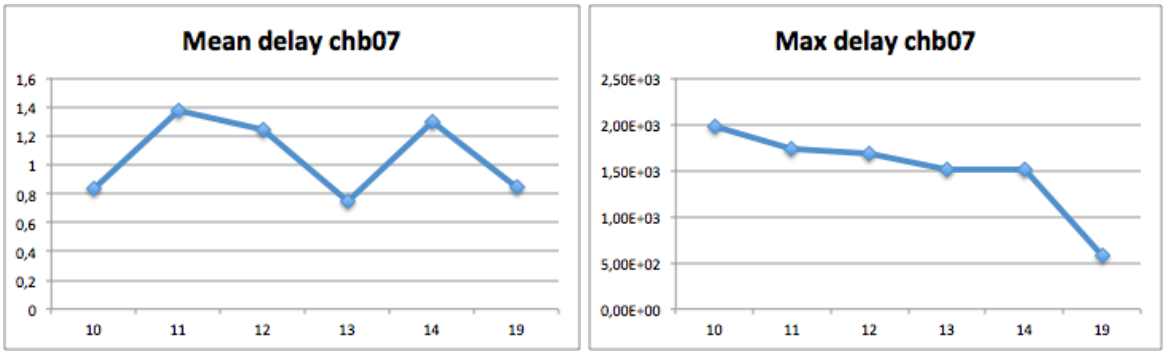


Figure 239, 240. (239) Mean delay and (240) Max delay

Considering that the recordings with seizures are 12, 13 and 19, it can be seen that the tendency of the maximum firing rate is to increase with these. The same happens for the mean firing rate, although other recordings, such as the 10th, show a high mean firing rate value.
As for the delays, the 10, which does not contain any seizure event shows a similar mean delay with the 13 and 19, while the 12 is similar to the non-epileptic recordings.

CHB07	Mean(FR)	Max(FR)	Mean Delay	Max delay
10	0,0042	0,1347	0,8337	1,97E+03
11	0,0028	0,1007	1,3737	1742,3000
12 (seizure)	0,0031	0,3242	1,2421	1689,3000
13 (seizure)	0,0047	0,6632	0,7437	1509,1000
14	0,0030	0,1255	1,2997	1503,3000
19 (seizure)	0,0045	0,2353	0,8442	582,1055

Table 8. Parameters obtained for each recording

10.

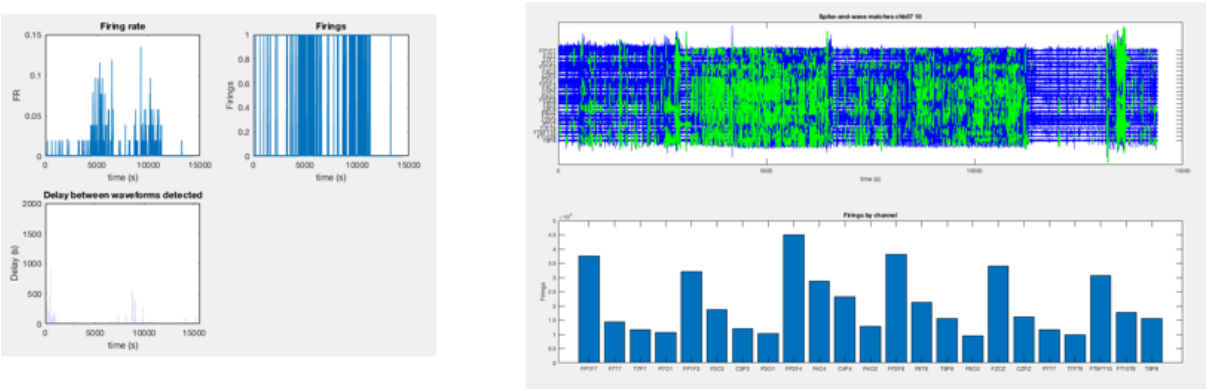


Figure 241, 242. (241) Firing rate, firings by time and delay between firings; (242) Spike-and-wave detections and firings by channel

11.

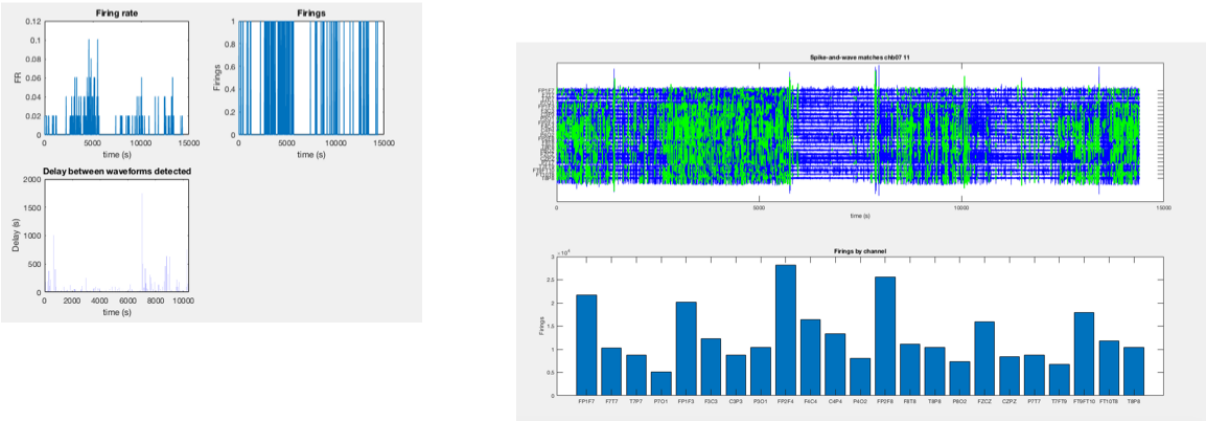


Figure 243, 244. (243) Firing rate, firings by time and delay between firings; (244) Spike-and-wave detections and firings by channel

12.

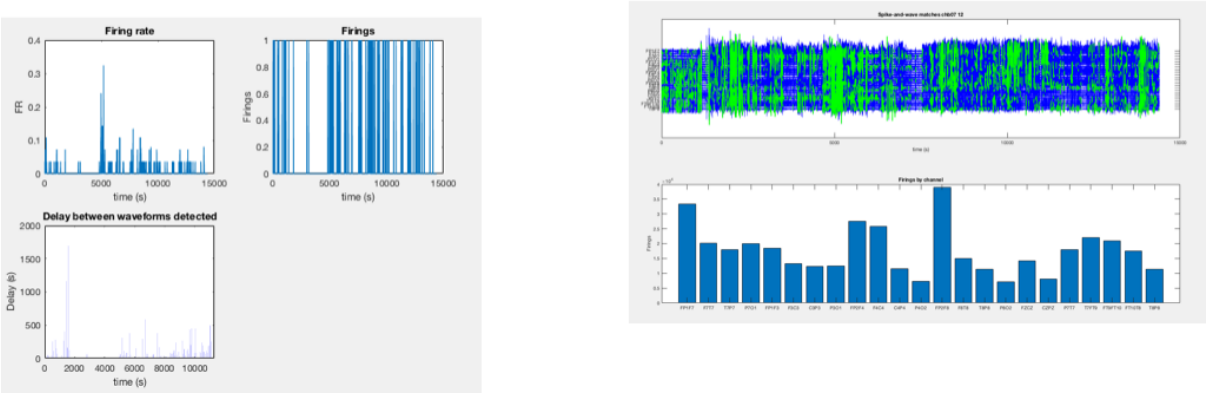


Figure 245, 246. (245) Firing rate, firings by time and delay between firings; (246) Spike-and-wave detections and firings by channel

13.

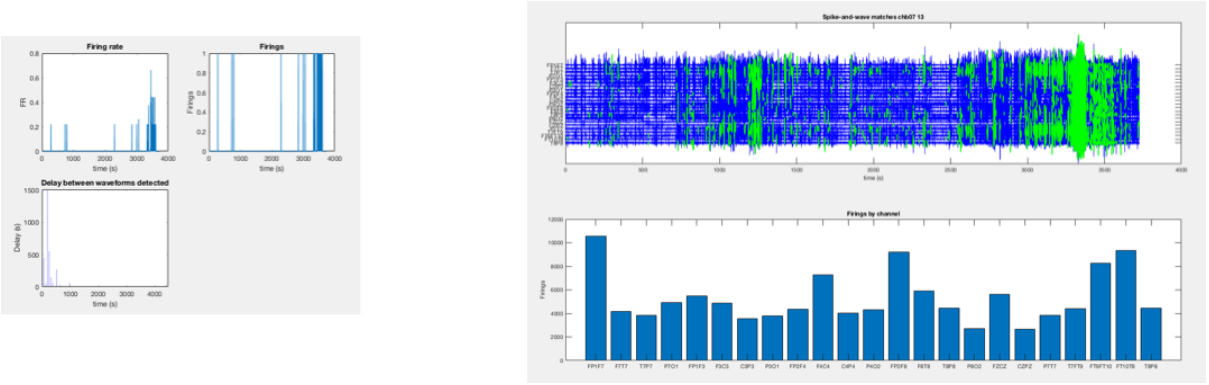


Figure 247, 248. (247) Firing rate, firings by time and delay between firings; (248) Spike-and-wave detections and firings by channel

14.

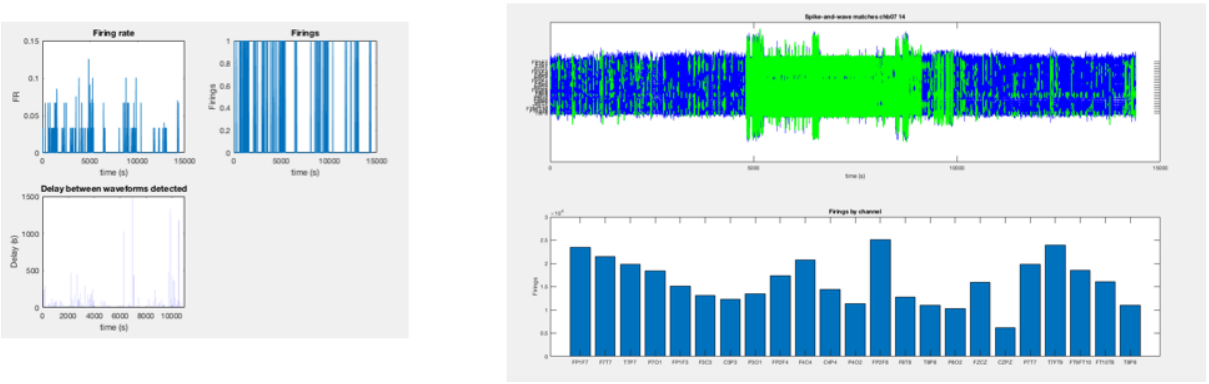


Figure 249, 250. (249) Firing rate, firings by time and delay between firings; (250) Spike-and-wave detections and firings by channel

19.

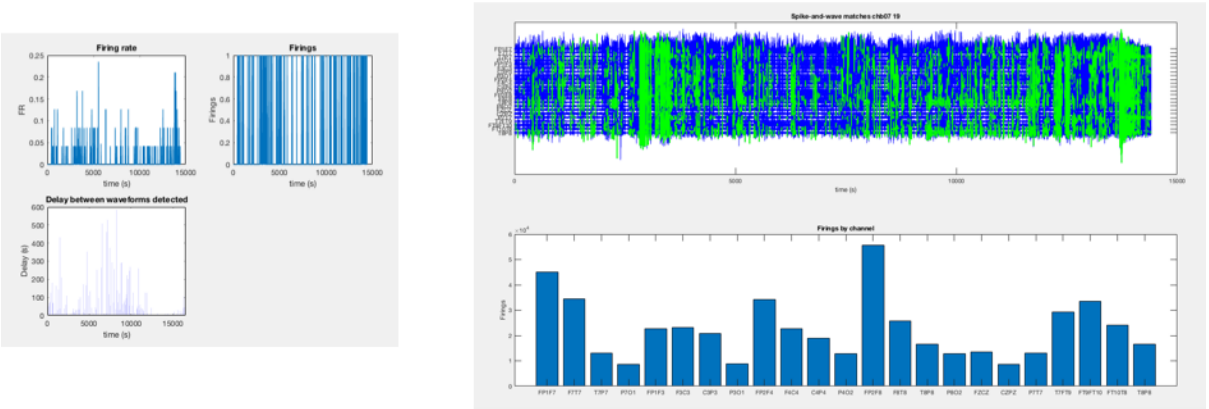
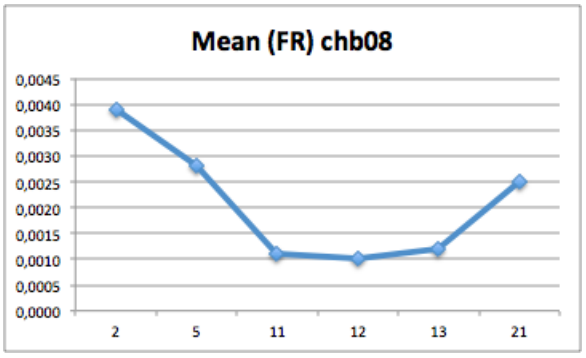


Figure 251, 252. (251) Firing rate, firings by time and delay between firings; (252) Spike-and-wave detections and firings by channel

chb08

Patient overview



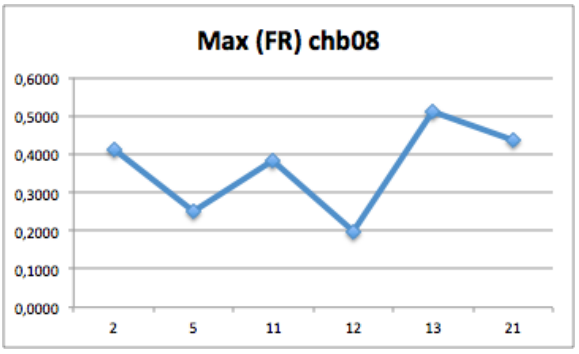
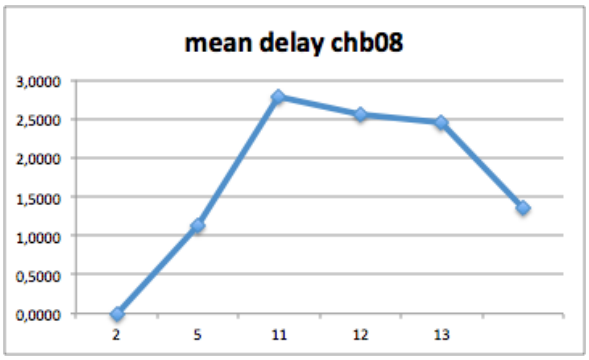


Figure 253, 254. (253) Mean firing rate and (254) Max firing rate



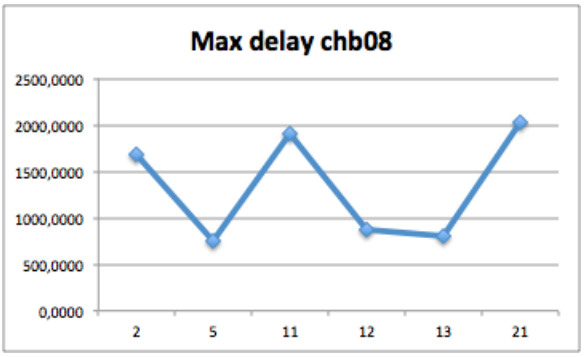


Figure 255, 256. (255) Mean delay and (256) Max delay

Considering all recordings with seizures, all the studied results show diverse values, although with the mean firing rate and the mean delay of 11, 12 and 13, a similar tendency can be seen. Considering that the 2 and 5 are close together, as well as the 11, 12 and 13 and the recording 21 is after some time, it leads to understand that with different time periods the epileptic seizures can be slightly different.

CHB08	Mean(FR)	Max(FR)	Mean Delay	Max delay
2 (seizure)	0,0039	0,4109	0,.8097	1685,3000
5 (seizure)	0,0028	0,2500	1,1256	749,7227
11 (seizure)	0,0011	0,3816	2,7850	1911,6000
12 (seizure)	0,0010	0,1987	2,5650	875,8984
13 (seizure)	0,0012	0,5101	2,4559	806,4219
21 (seizure)	0,0025	0,4355	1,3654	2035,7000

Table 9. Parameters obtained for each recording

2.

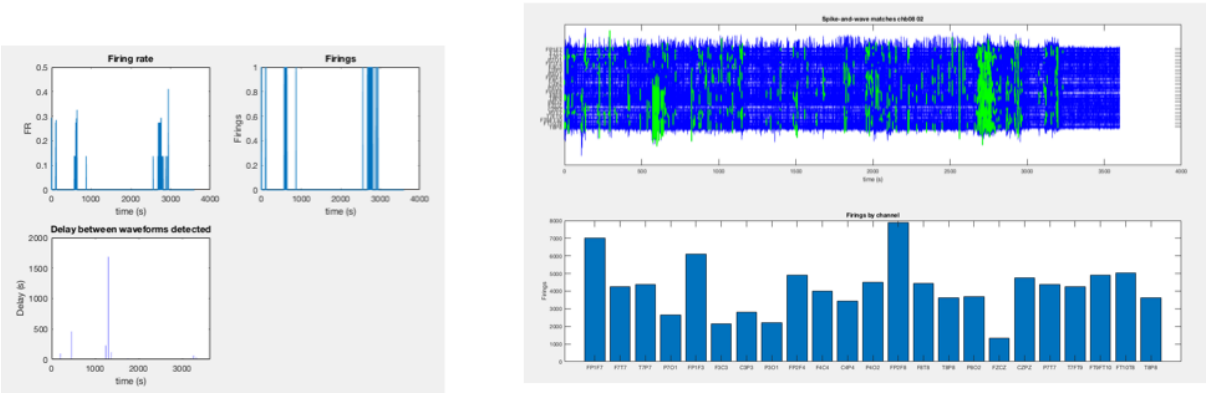


Figure 257, 258. (257) Firing rate, firings by time and delay between firings; (258) Spike-and-wave detections and firings by channel

5.

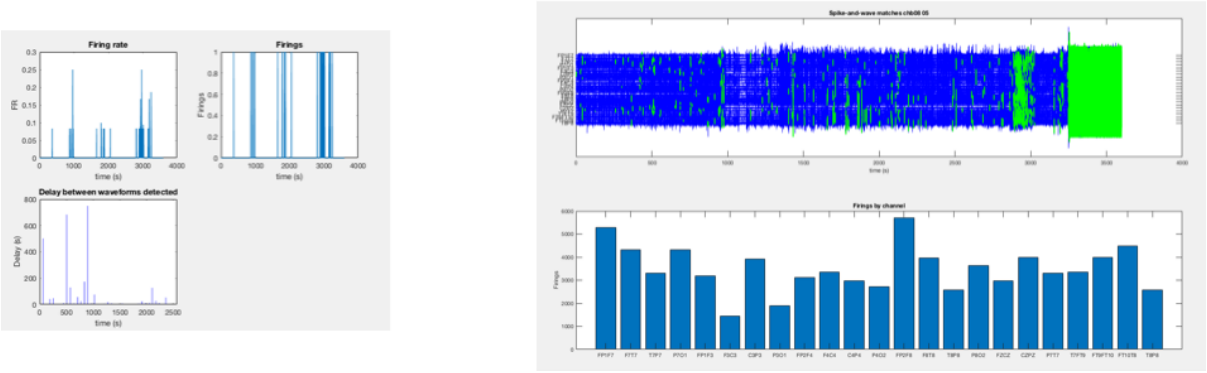


Figure 259, 260. (259) Firing rate, firings by time and delay between firings; (260) Spike-and-wave detections and firings by channel

11.

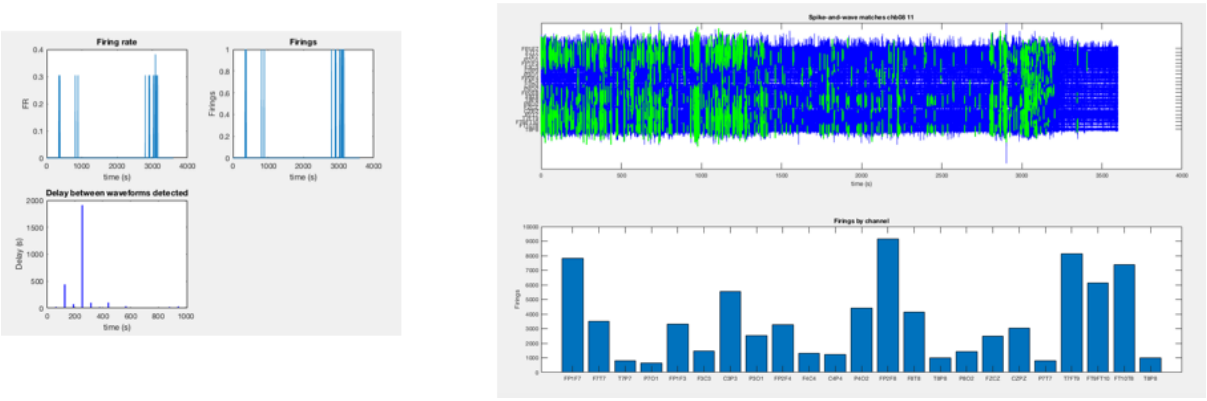
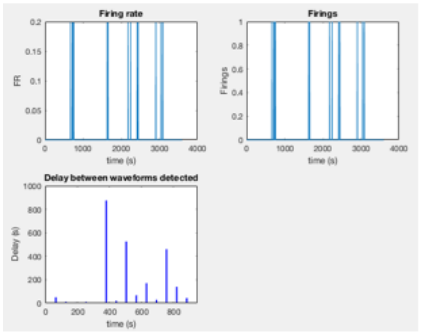


Figure 261, 262. (261) Firing rate, firings by time and delay between firings; (262) Spike-and-wave detections and firings by channel

12.



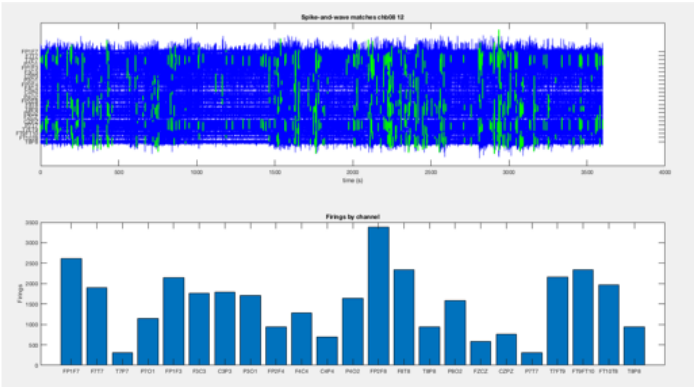
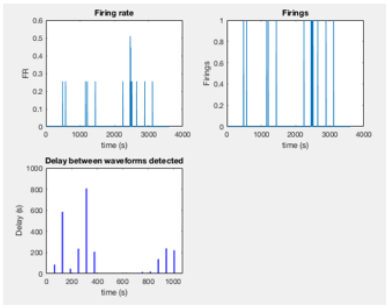


Figure 263, 264. (263) Firing rate, firings by time and delay between firings; (264) Spike-and-wave detections and firings by channel

13.



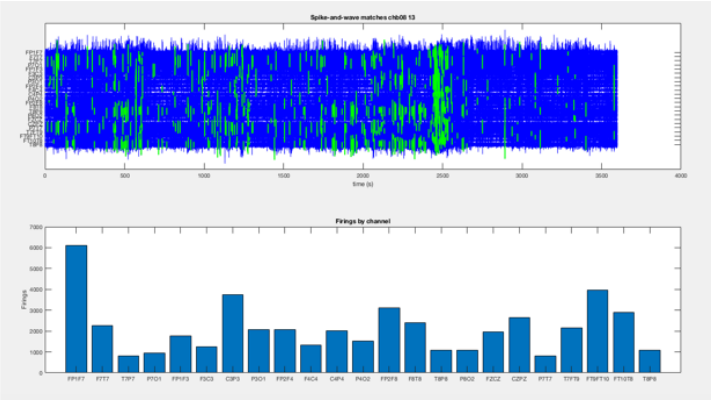
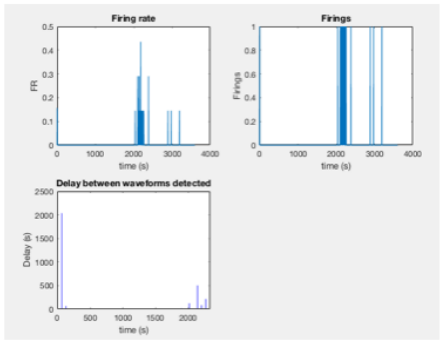


Figure 265, 266. (265) Firing rate, firings by time and delay between firings; (266) Spike-and-wave detections and firings by channel

21.



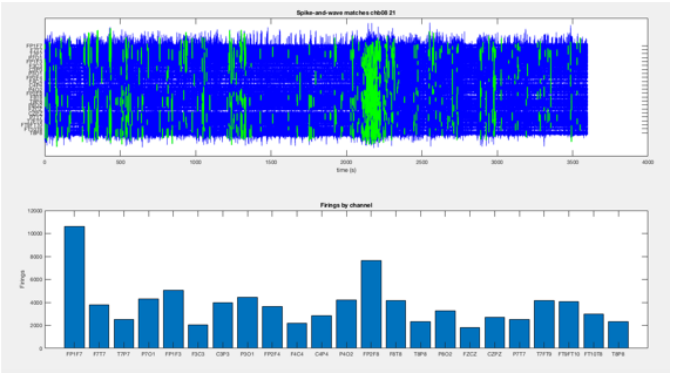


Figure 267, 268. (267) Firing rate, firings by time and delay between firings; (268) Spike-and-wave detections and firings by channel

chb09

Patient overview

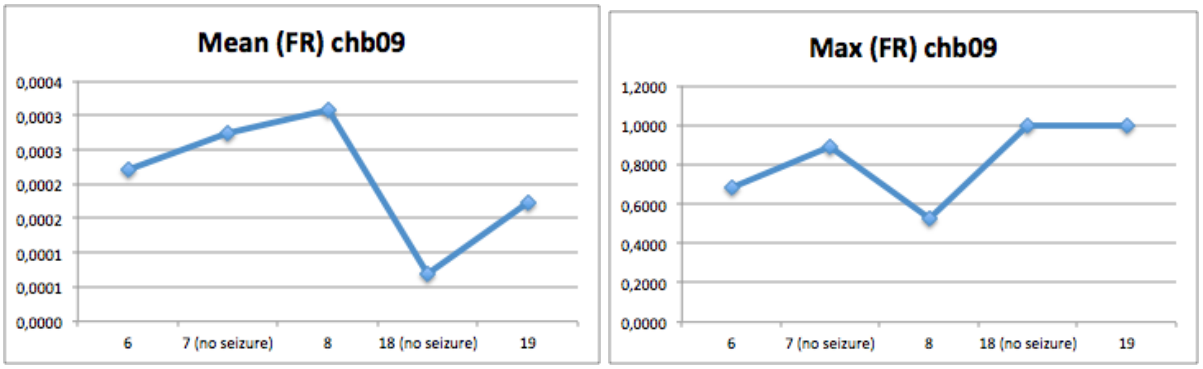


Figure 269, 270. (269) Mean firing rate and (270) Max firing rate

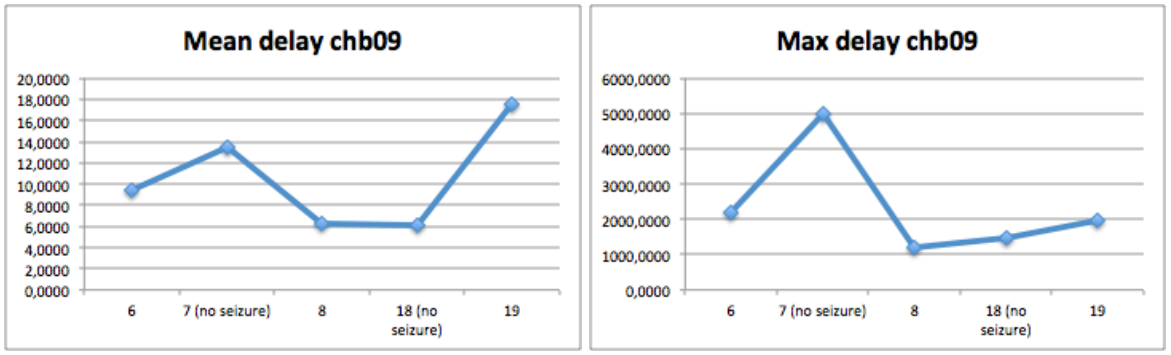


Figure 271, 272. (271) Mean delay and (272) Max delay

As for the mean firing rates, it can clearly be seen a decrease after the recording 8, as the others do not contain any seizures, until the 19th. Nonetheless, when it is approximately one hour between seizures, as seen on recording 7, the mean firing rate maintains a similar value to the others, while the delay increases.

CHB09	Mean(FR)	Max(FR)	Mean Delay	Max delay
6	0,0002	0,6848	9,3912	2195,1000
7 (no seizure)	0,0003	0,8929	13,4056	4999,5000
8	0,0003	0,5250	6,3026	1199,8000
18 (no seizure)	0,0001	1,0000	6,0656	1484,4000
19	0,0002	1,0000	17,5732	1966,2000

Table 10. Parameters obtained for each recording

6.

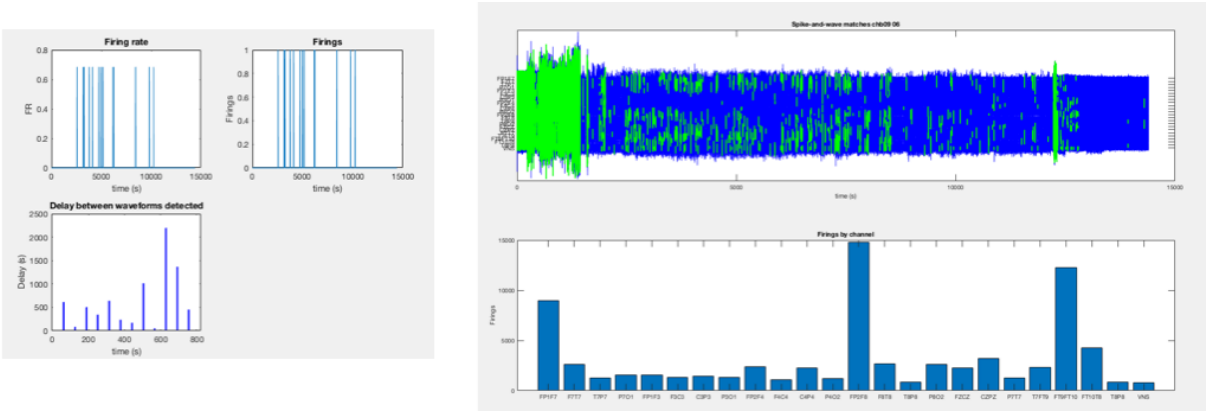


Figure 273, 274. (273) Firing rate, firings by time and delay between firings; (274) Spike-and-wave detections and firings by channel

7.

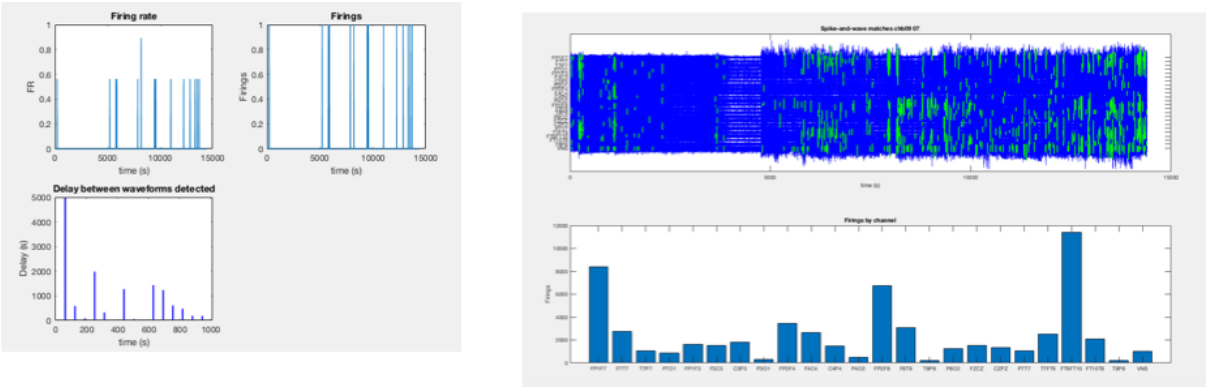


Figure 275, 276. (275) Firing rate, firings by time and delay between firings; (276) Spike-and-wave detections and firings by channel

8.

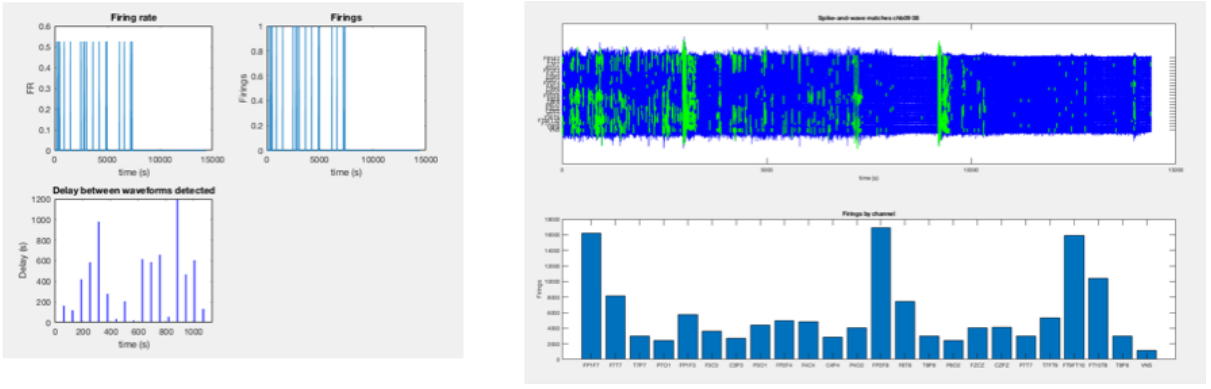


Figure 277, 278. (277) Firing rate, firings by time and delay between firings; (278) Spike-and-wave detections and firings by channel

18.

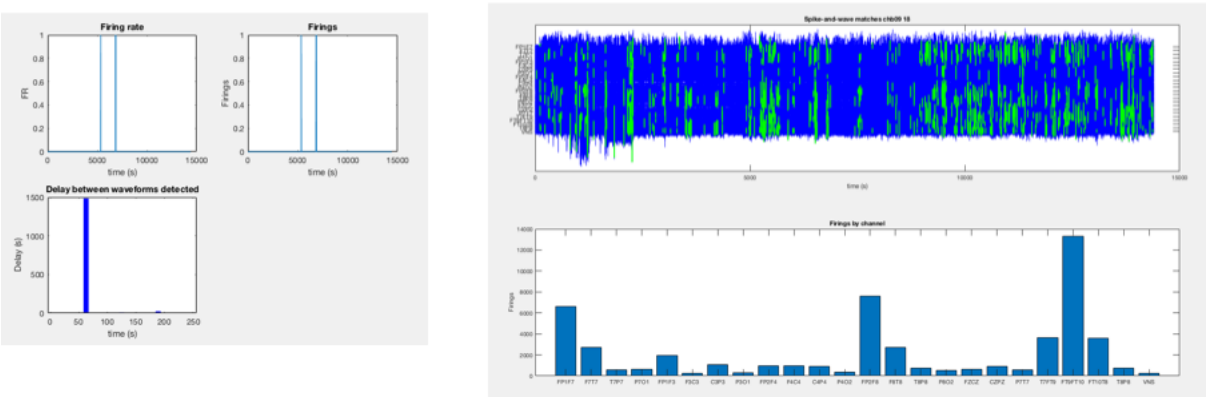


Figure 279, 280. (279) Firing rate, firings by time and delay between firings; (280) Spike-and-wave detections and firings by channel

19.

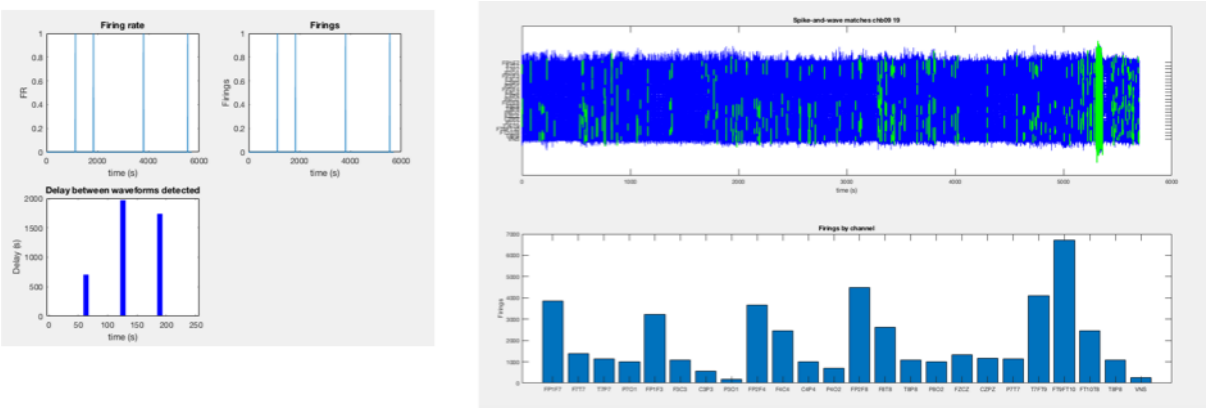


Figure 281, 282. (281) Firing rate, firings by time and delay between firings; (282) Spike-and-wave detections and firings by channel

chb10

Patient overview

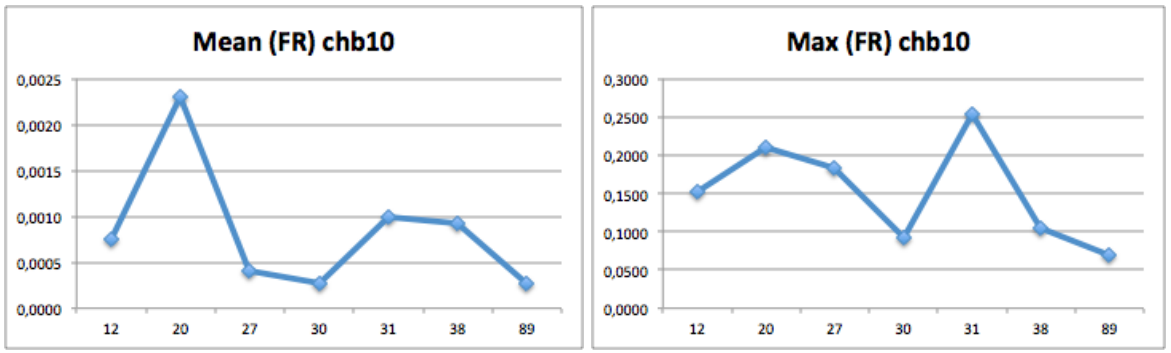


Figure 283, 284. (283) Mean firing rate and (284) Max firing rate

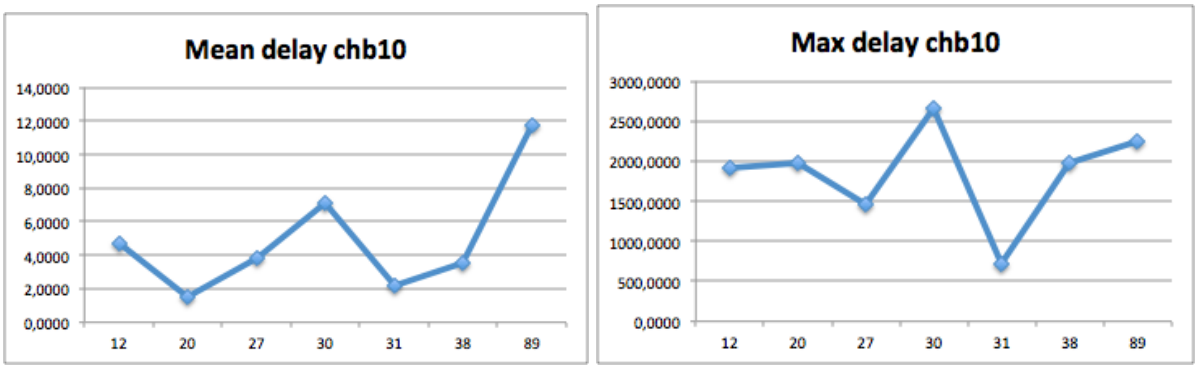


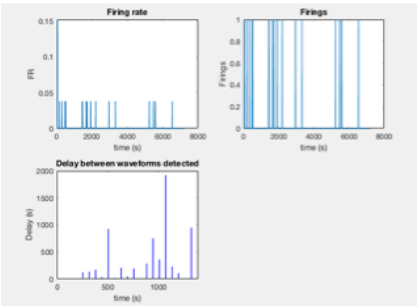
Figure 285, 286. (285) Mean delay and (286) Max delay

Also considering all recordings with seizures, as also seen before, the results tend to slightly differ, showing that with the same patient, the epileptic seizures can be different.

CHB10	Mean(FR)	Max(FR)	Mean Delay	Max delay
12(seizure)	0,0008	0,1516	4,6927	1917,9000
20(seizure)	0,0023	0,2099	1,5135	1980,3000
27(seizure)	0,0004	0,1841	3,8179	1465,5000
30(seizure)	0,0003	0,0914	7,1168	2668,2000
31(seizure)	0,0010	0,2538	2,1430	721,5547
38(seizure)	0,0009	0,1049	3,5107	1986,1000
89(seizure)	0,0003	0,0692	11,7067	2239,3000

Table 11. Parameters obtained for each recording

12.



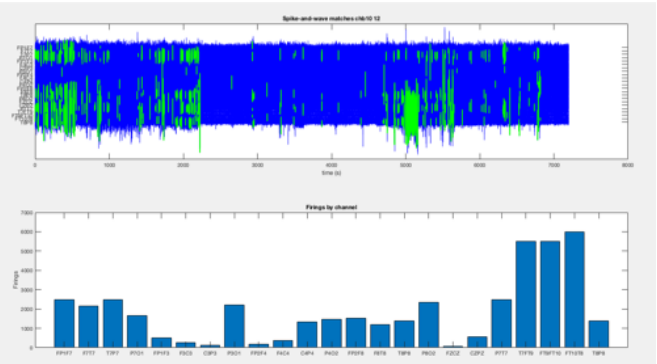
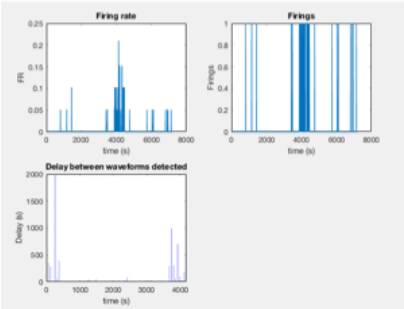


Figure 287, 288. (287) Firing rate, firings by time and delay between firings; (288) Spike-and-wave detections and firings by channel

20.



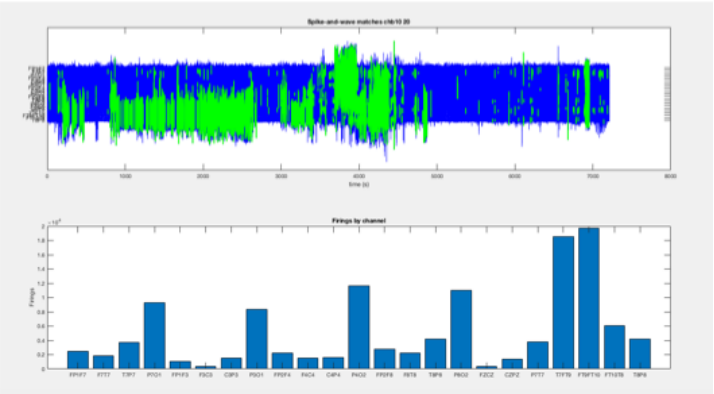
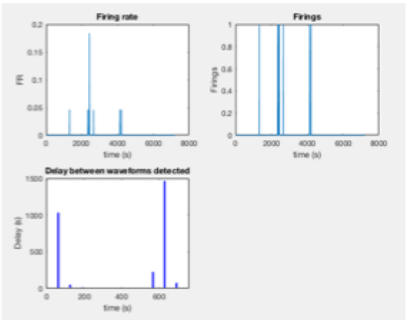


Figure 289, 290. (289) Firing rate, firings by time and delay between firings; (290) Spike-and-wave detections and firings by channel

27.



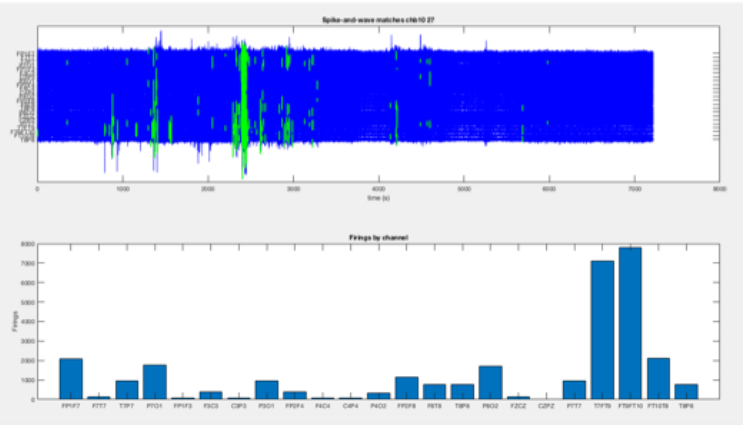


Figure 291, 292. (291) Firing rate, firings by time and delay between firings; (292) Spike-and-wave detections and firings by channel

30.

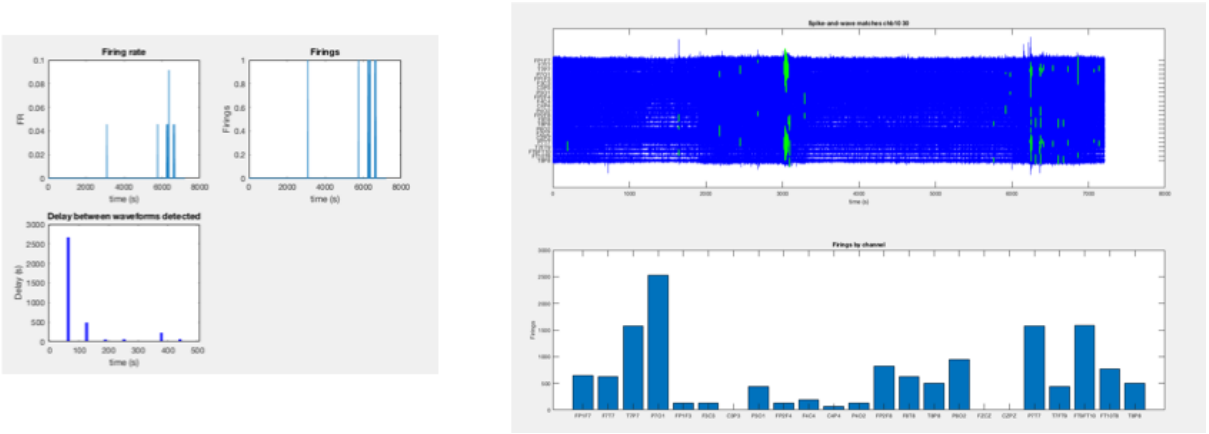


Figure 293, 294. (293) Firing rate, firings by time and delay between firings; (294) Spike-and-wave detections and firings by channel

31.

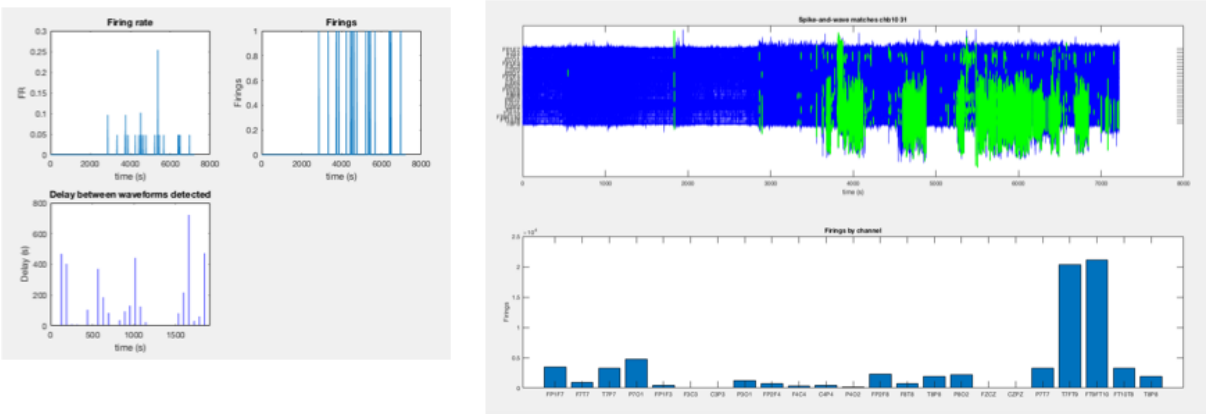


Figure 295, 296. (295) Firing rate, firings by time and delay between firings; (296) Spike-and-wave detections and firings by channel

38.

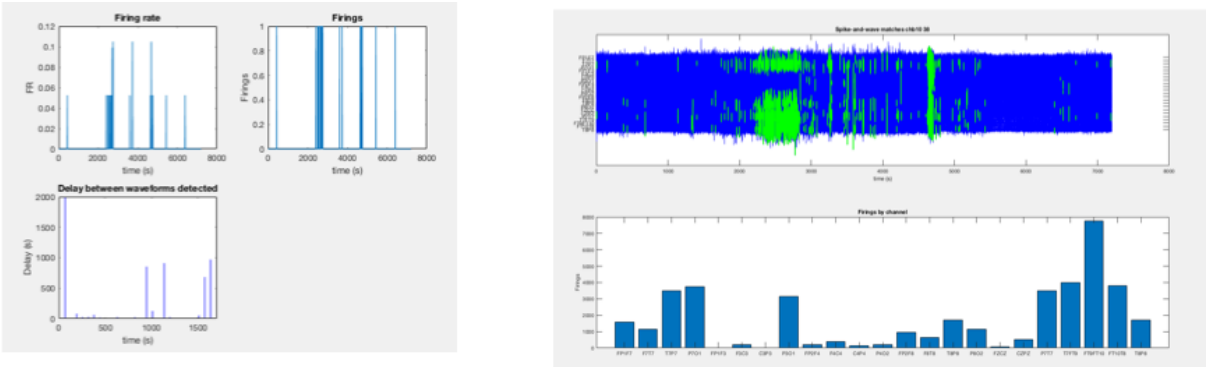


Figure 297, 298. (297) Firing rate, firings by time and delay between firings; (298) Spike-and-wave detections and firings by channel

89.

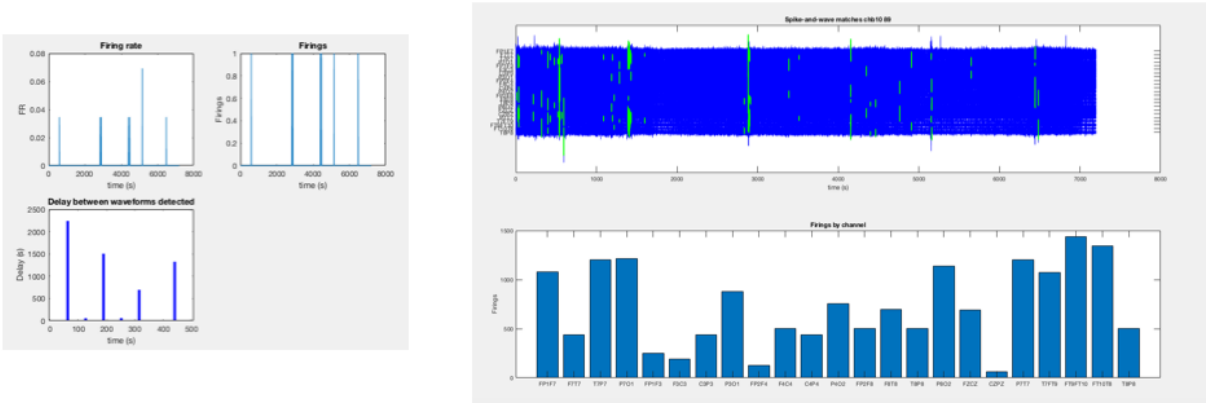


Figure 299, 300. (299) Firing rate, firings by time and delay between firings; (300) Spike-and-wave detections and firings by channel

chb11

Patient overview

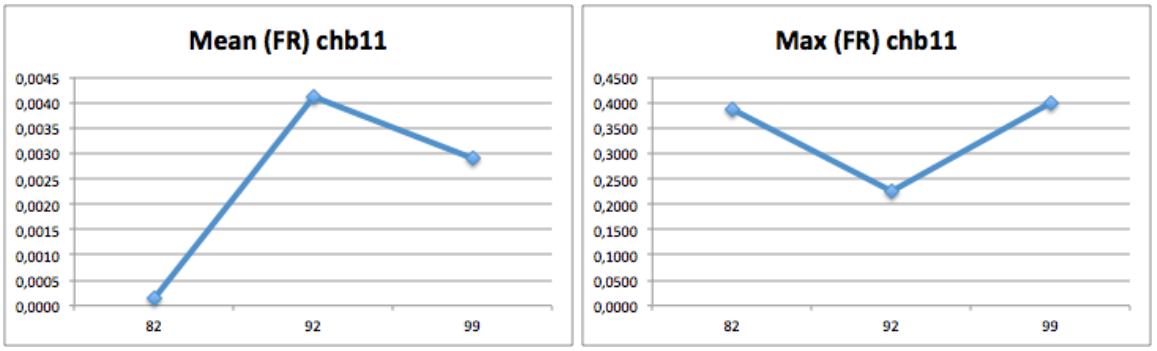


Figure 301, 302. (301) Mean firing rate and (302) Max firing rate

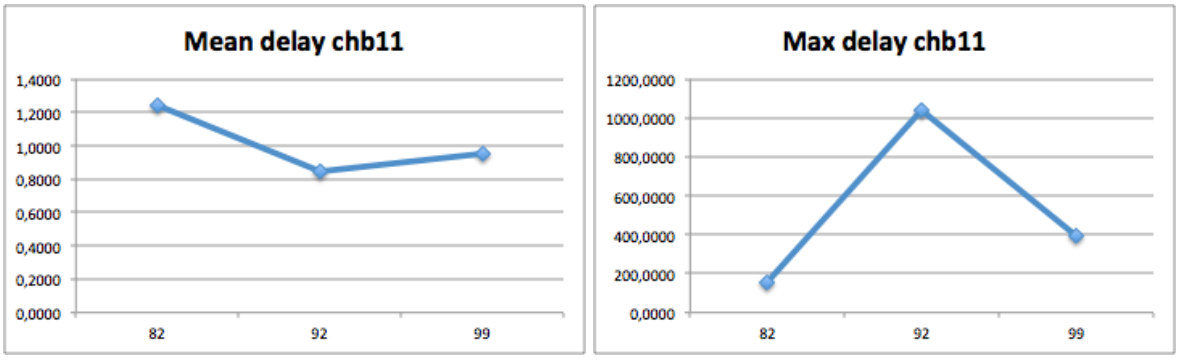


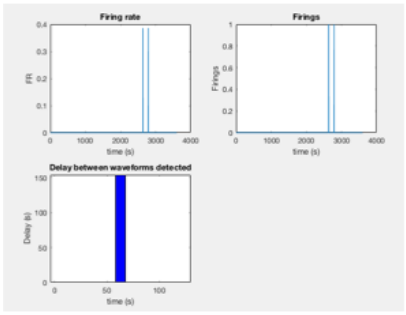
Figure 303, 304. (303) Mean delay and (304) Max delay

All the seizure recordings show not similar values, as they are far in time.

CHB11	Mean(FR)	Max(FR)	Mean Delay	Max delay
82(seizure)	0,0001	0,3865	1,2376	154,2148
92(seizure)	0,0041	0,2254	0,8451	1035,6000
99(seizure)	0,0029	0,3980	0,9504	390,1484

Table 12. Parameters obtained for each recording

82.



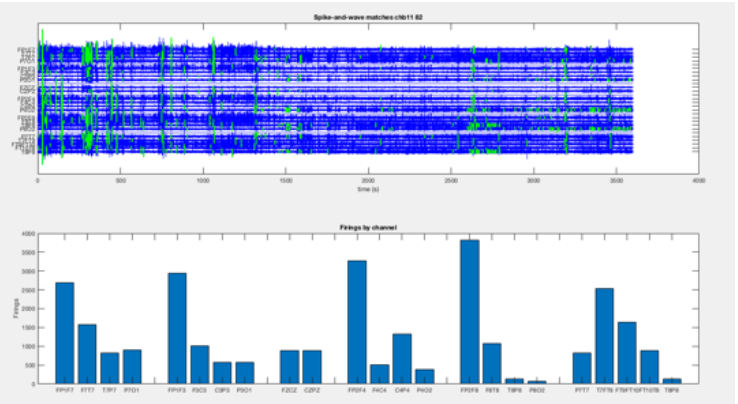
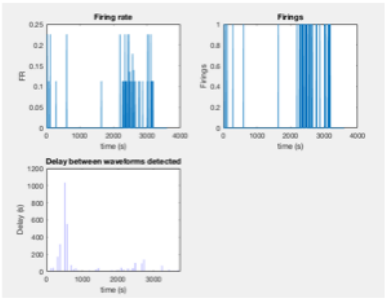


Figure 305, 306 (305) Firing rate, firings by time and delay between firings; (306) Spike-and-wave detections and firings by channel

92.



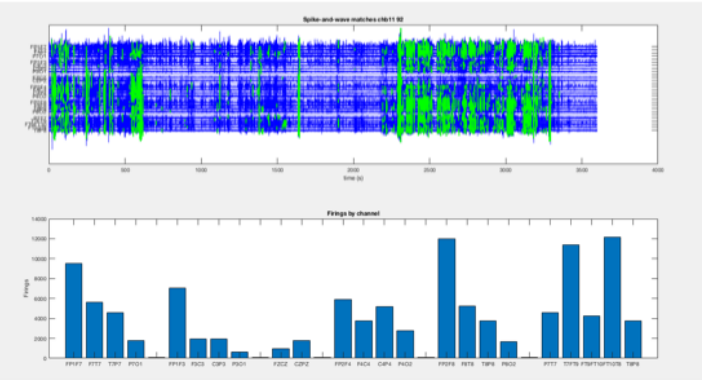
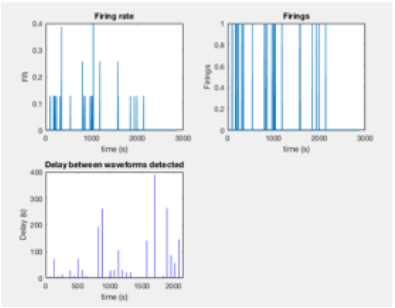


Figure 307, 308. (307) Firing rate, firings by time and delay between firings; (308) Spike-and-wave detections and firings by channel

99.



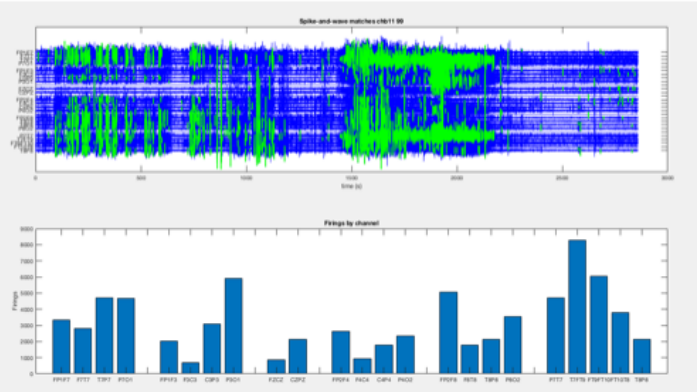


Figure 309, 310. (309) Firing rate, firings by time and delay between firings; (310) Spike-and-wave detections and firings by channel

chb12

Patient overview

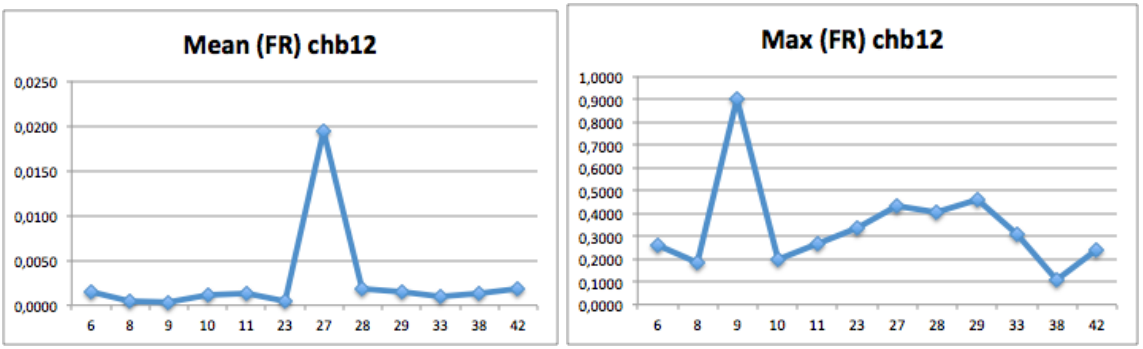


Figure 311, 312. (311) Mean firing rate and (312) Max firing rate

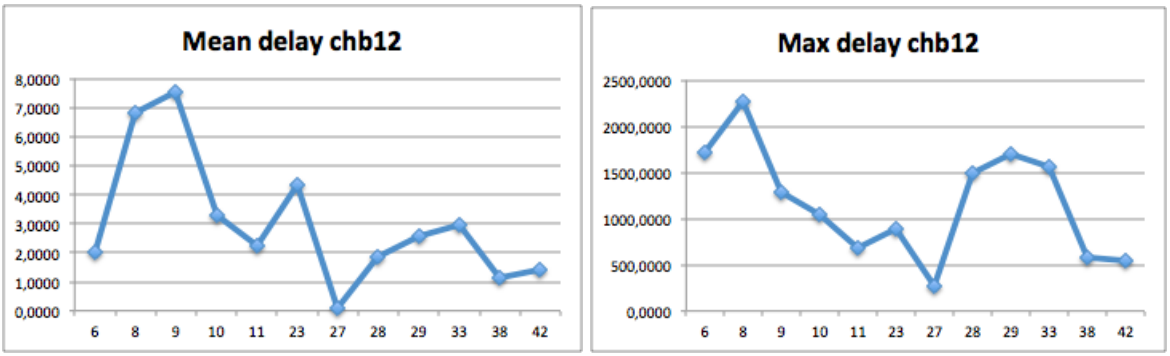


Figure 313, 314. (313) Mean delay and (314) Max delay

As well as before, all the recordings containing seizures show dissimilar values in all the analyses but when the seizures are close in time, the mean firing rate stays around the same values, as it is shown from 6 to 11, although it can be seen a peak on the maximum firing rate on 9. As for the delay, the values are diverse to each other.

CHB12	Mean(FR)	Max(FR)	Mean Delay	Max delay
6(seizure)	0,0015	0,2603	2,0220	1714,3000
8(seizure)	0,0004	0,1856	6,8125	2275,1000
9(seizure)	0,0003	0,9040	7,5255	1292,8000
10(seizure)	0,0012	0,1950	3,2960	1051,0000
11(seizure)	0,0014	0,2652	2,2505	683,5273
23(seizure)	0,0004	0,3387	4,3105	885,1484
27(seizure)	0,0194	0,4350	0,0869	271,4961
28(seizure)	0,0018	0,4021	1,8798	1500,8000
29(seizure)	0,0015	0,4621	2,5803	1697,8000
33(seizure)	0,0010	0,3058	2,9479	1563,5000
38(seizure)	0,0014	0,1073	1,1135	574,3477
42(seizure)	0,0018	0,2387	1,4298	541,5625

Table 13. Parameters obtained for each recording

6.

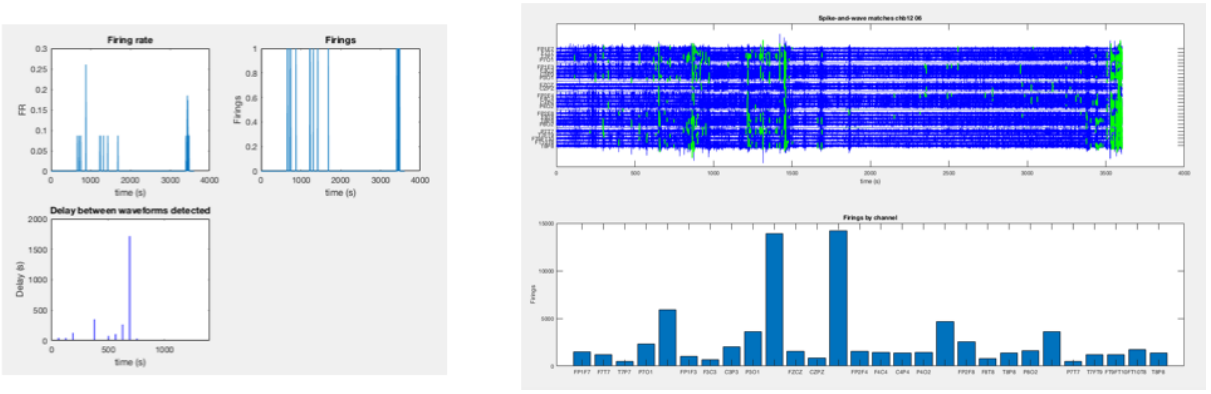


Figure 315, 316. (315) Firing rate, firings by time and delay between firings; (316) Spike-and-wave detections and firings by channel

8.

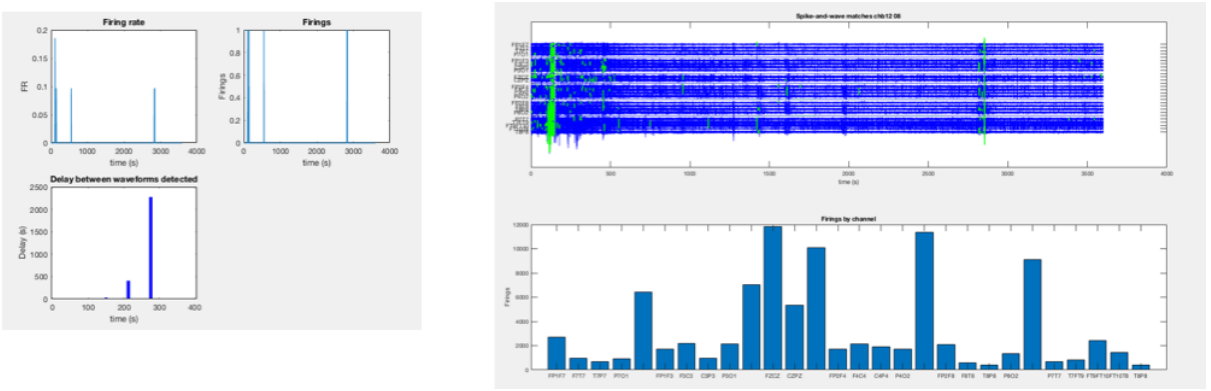


Figure 317, 318. (317) Firing rate, firings by time and delay between firings; (318) Spike-and-wave detections and firings by channel

9.

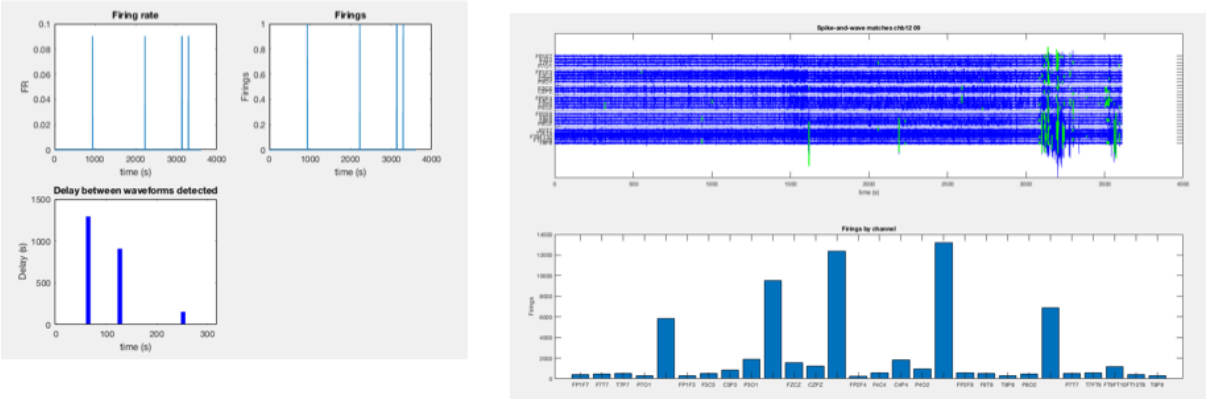


Figure 319, 320. (319) Firing rate, firings by time and delay between firings; (320) Spike-and-wave detections and firings by channel

10.

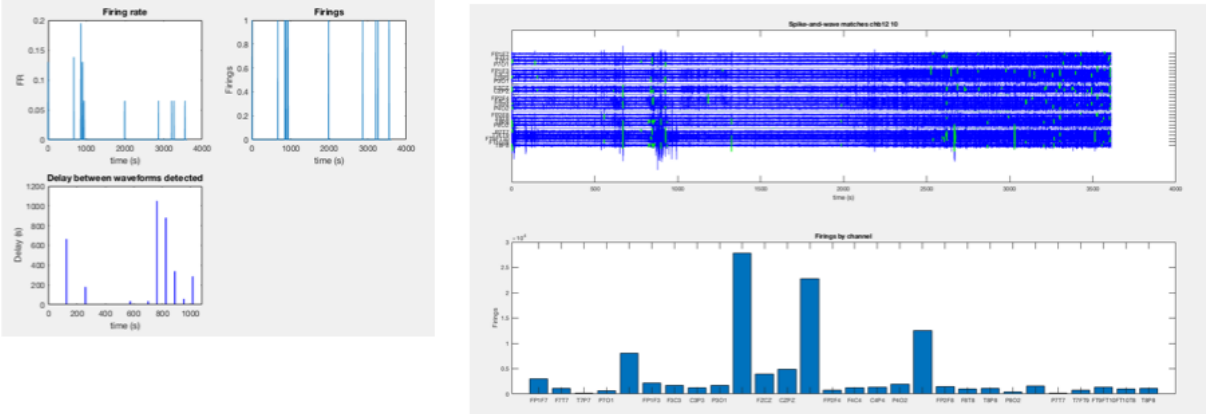


Figure 321, 322. (321) Firing rate, firings by time and delay between firings; (322) Spike-and-wave detections and firings by channel

11.

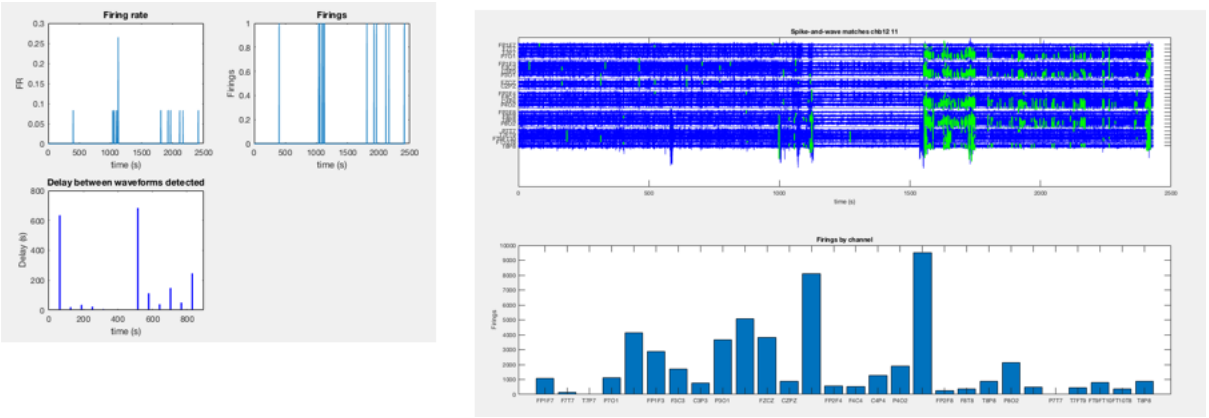


Figure 323, 324. (323) Firing rate, firings by time and delay between firings; (324) Spike-and-wave detections and firings by channel

23.

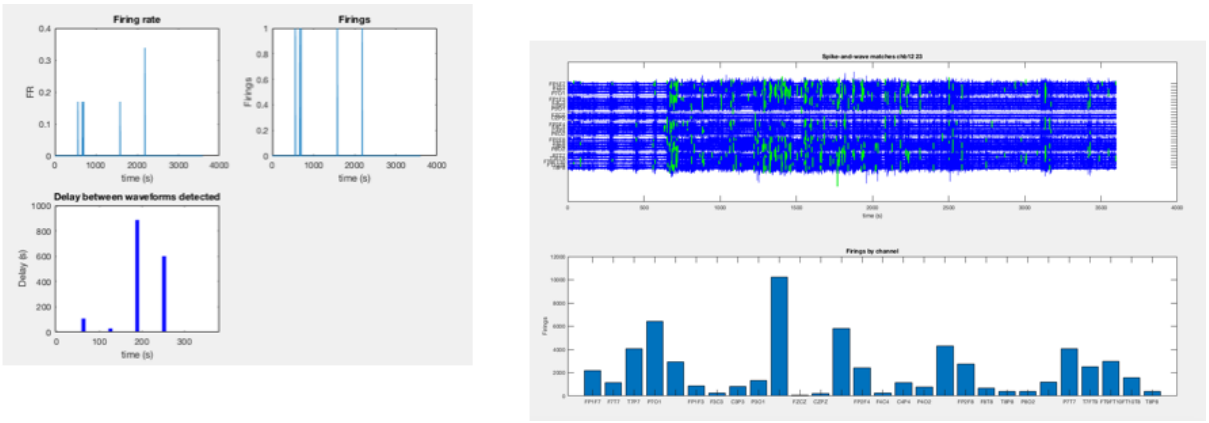


Figure 325, 326. (325) Firing rate, firings by time and delay between firings; (326) Spike-and-wave detections and firings by channel

27.

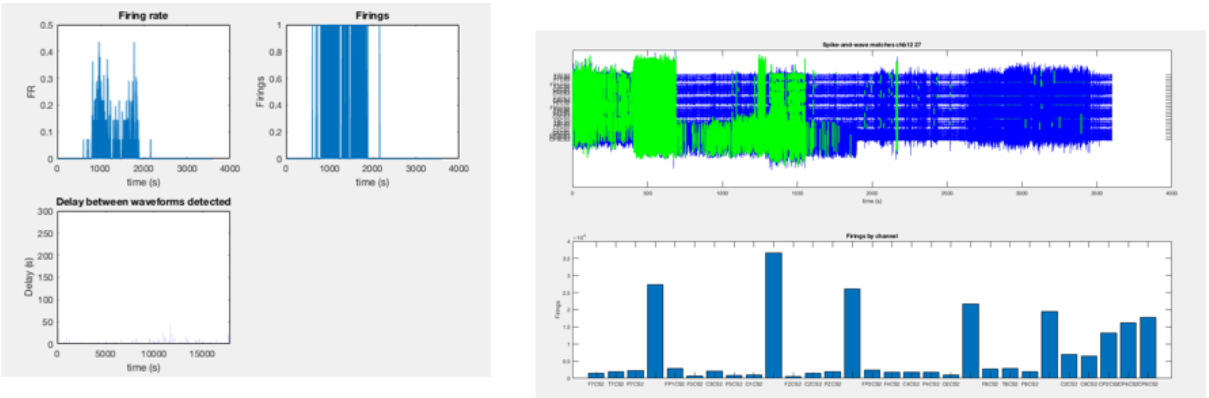


Figure 327, 328. (327) Firing rate, firings by time and delay between firings; (328) Spike-and-wave detections and firings by channel

28.

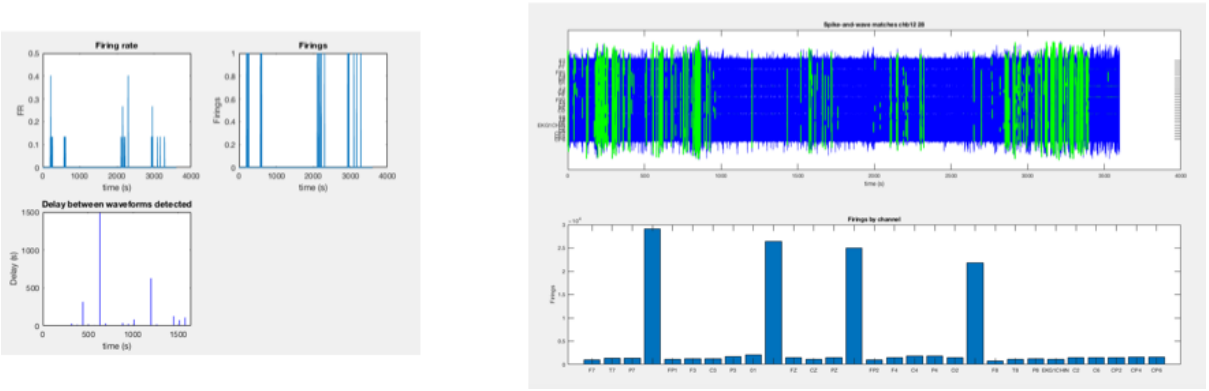


Figure 329, 330. (329) Firing rate, firings by time and delay between firings; (330) Spike-and-wave detections and firings by channel

29.

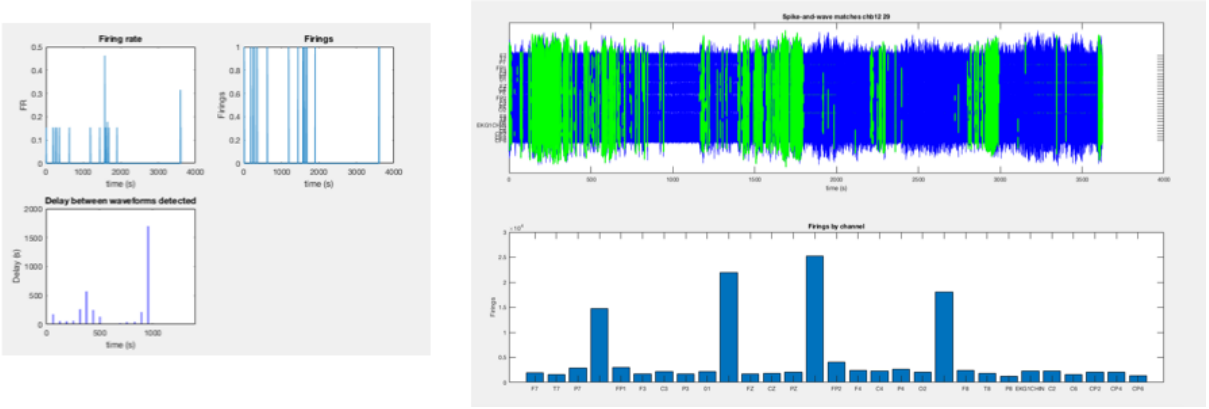


Figure 331, 332. (331) Firing rate, firings by time and delay between firings; (332) Spike-and-wave detections and firings by channel

33.

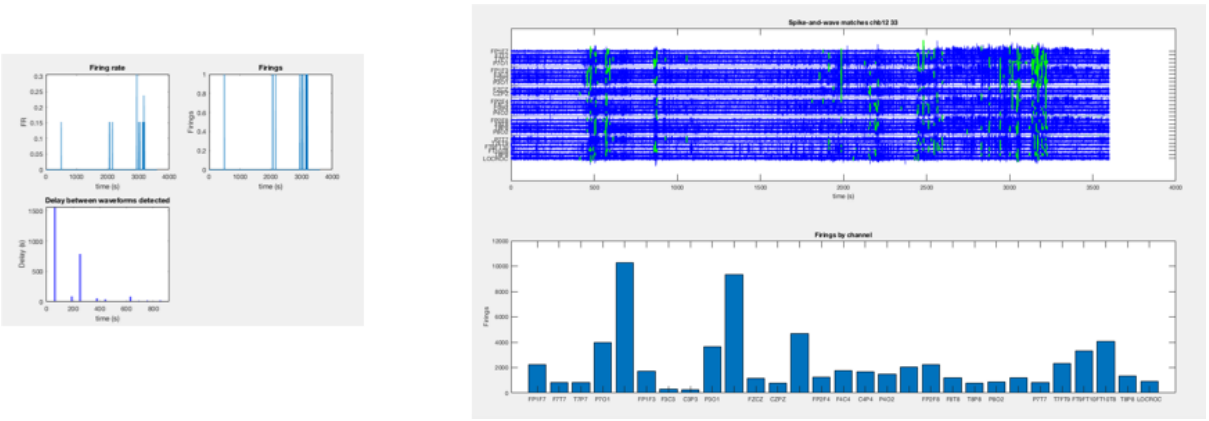
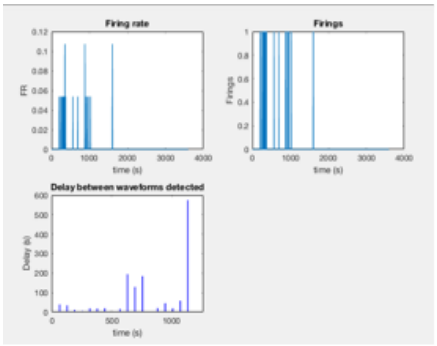


Figure 333, 334. (333) Firing rate, firings by time and delay between firings; (334) Spike-and-wave detections and firings by channel

38.



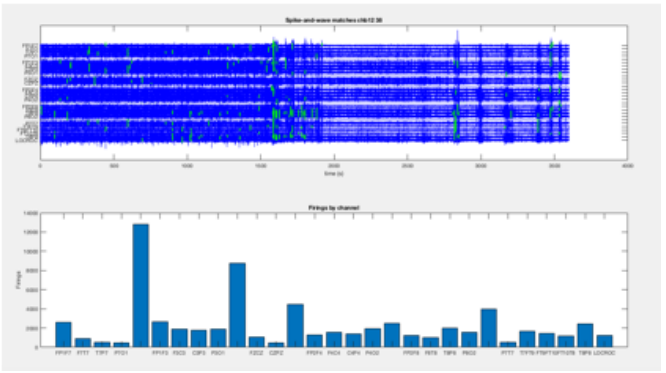
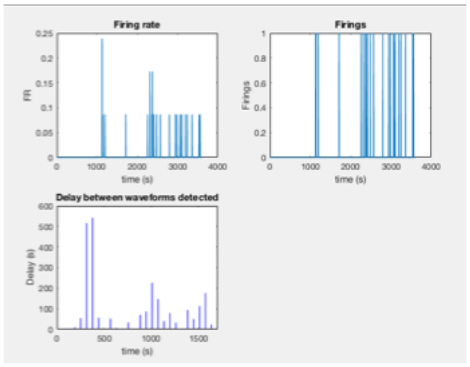


Figure 335, 336. (335) Firing rate, firings by time and delay between firings; (336) Spike-and-wave detections and firings by channel

42.



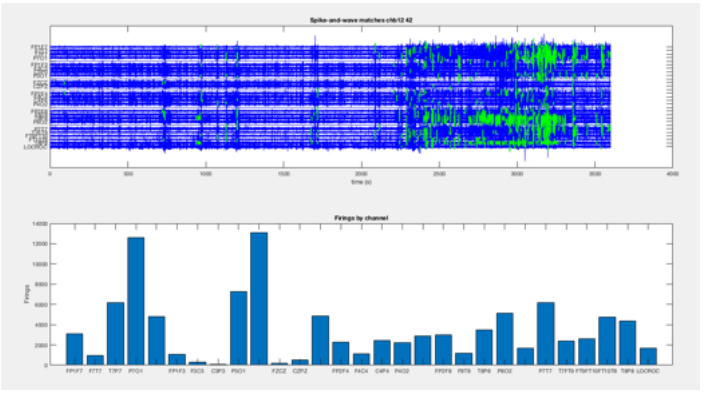


Figure 337, 338. (337) Firing rate, firings by time and delay between firings; (338) Spike-and-wave detections and firings by channel

chb13

Patient overview

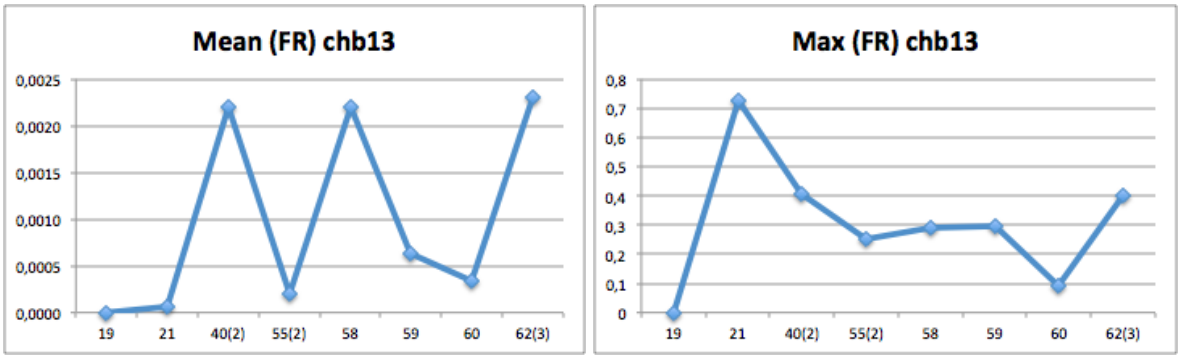


Figure 339, 340. (339) Mean firing rate and (340) Max firing rate

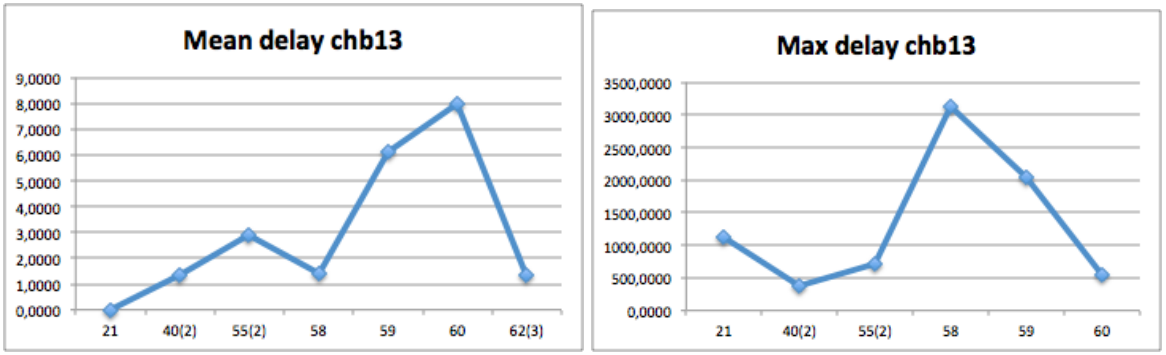


Figure 341, 342. (341) Mean delay and (342) Max delay

Although some recordings, such as 40, 55 and 62 contain more than one seizure, the results do not greatly vary with the others containing only one seizure.

CHB13	Mean(FR)	Max(FR)	Mean Delay	Max delay
19(seizure)	0,0000	0	NaN	NaN
21(seizure)	0,0001	0,7241	0,0039	0.0039
40 (2 seizures)	0,0022	0,4083	1,3385	1117,3000
55 (2 seizures)	0,0002	0,2520	2,9128	375,4883
58(seizure)	0,0022	0,2917	1,4182	726,4844
59(seizure)	0,0006	0,2957	6,0905	3124,9000
60(seizure)	0,0003	0,0928	7,9942	2042,1000
62 (3 seizures)	0,0023	0,3994	1,3219	539,4648

Table 14. Parameters obtained for each recording

19.

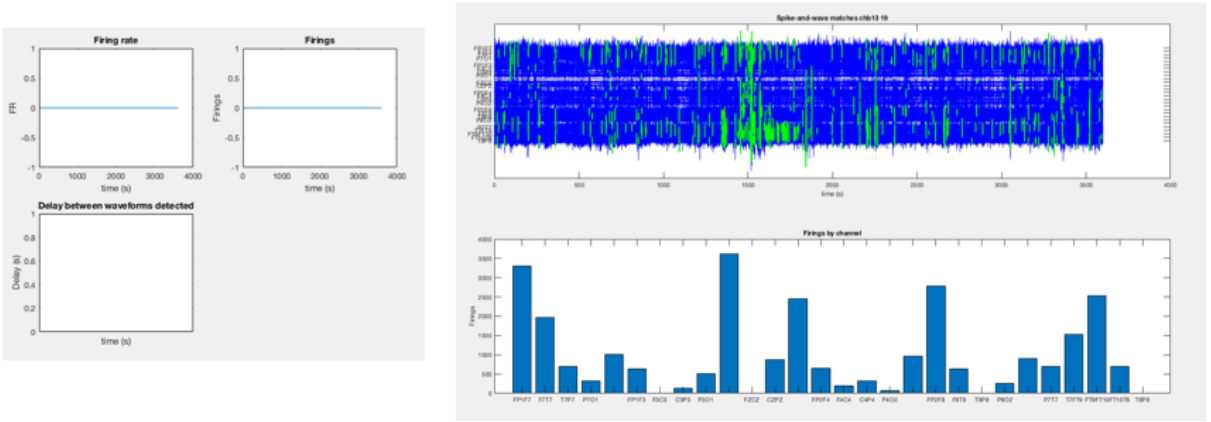


Figure 343, 344. (343) Firing rate, firings by time and delay between firings; (344) Spike-and-wave detections and firings by channel

21.

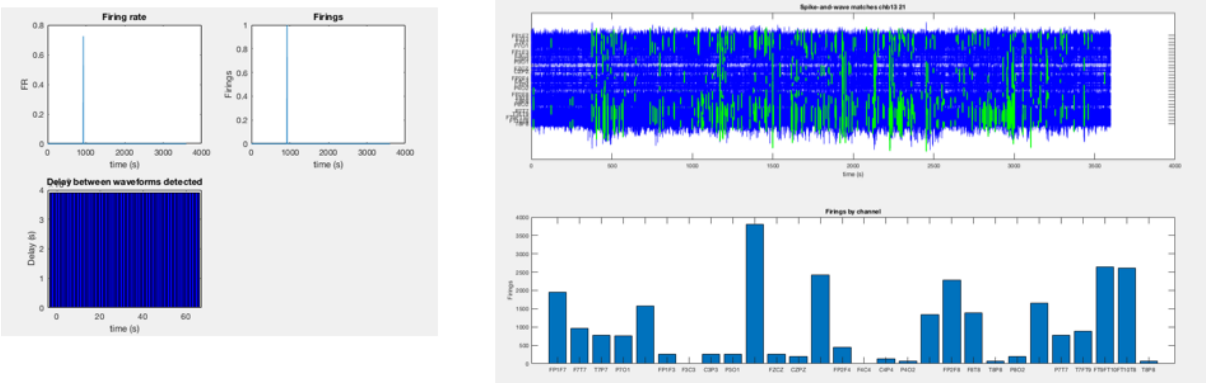


Figure 345, 346. (345) Firing rate, firings by time and delay between firings; (346) Spike-and-wave detections and firings by channel

40.

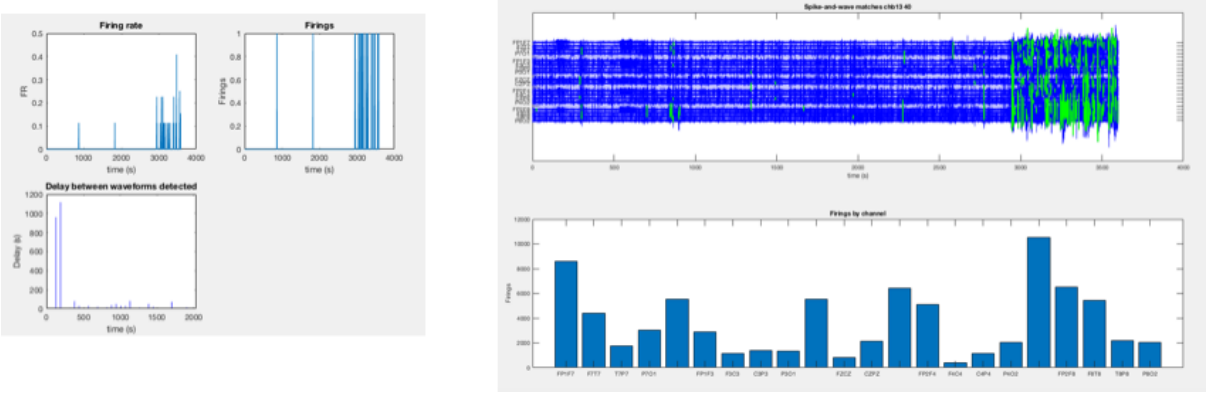


Figure 347, 348. (347) Firing rate, firings by time and delay between firings; (348) Spike-and-wave detections and firings by channel

55.

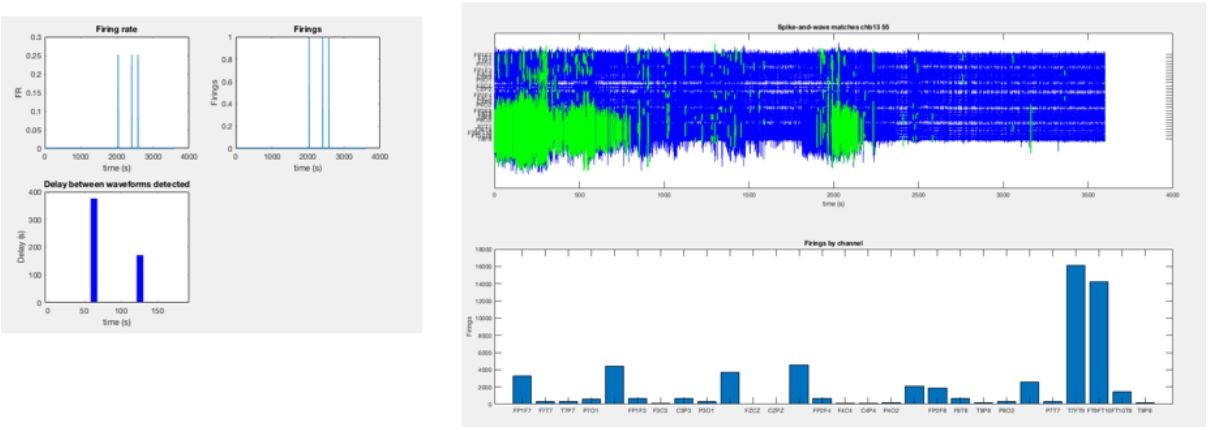


Figure 349, 350. (349) Firing rate, firings by time and delay between firings; (350) Spike-and-wave detections and firings by channel

58.

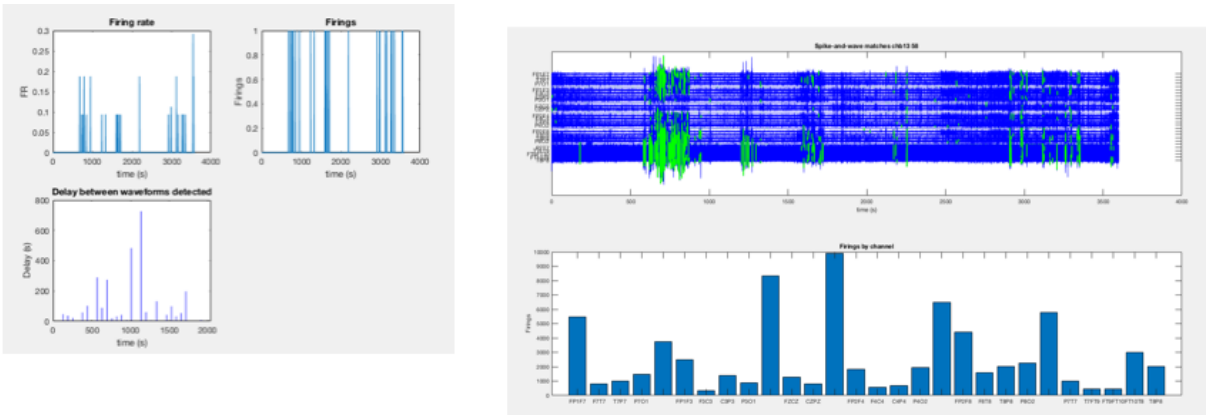


Figure 351, 352. (351) Firing rate, firings by time and delay between firings; (352) Spike-and-wave detections and firings by channel

59.

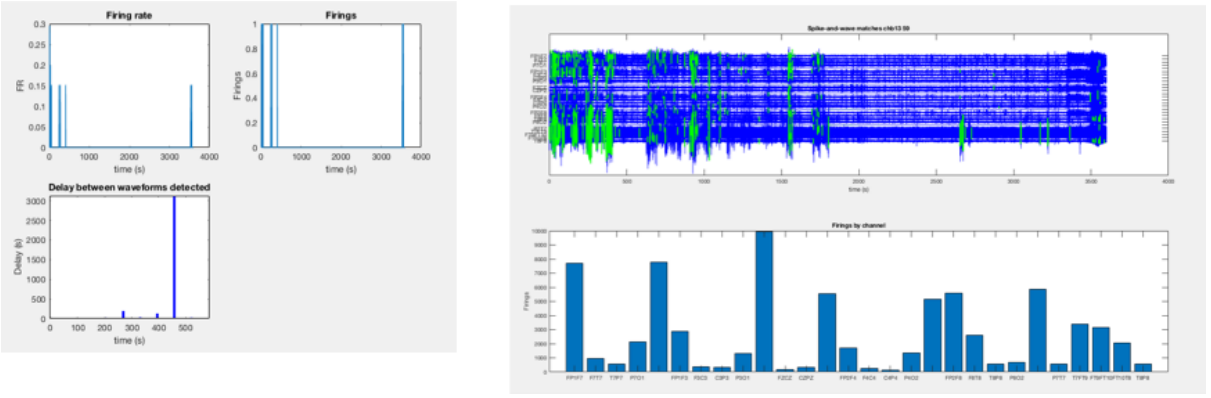
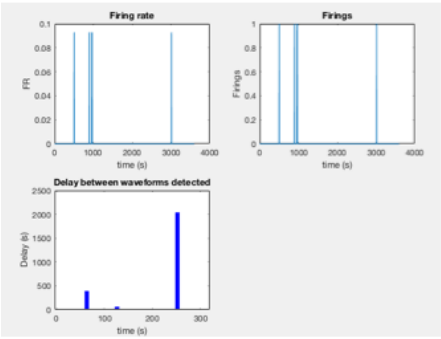


Figure 353, 354. (353) Firing rate, firings by time and delay between firings; (354) Spike-and-wave detections and firings by channel

60.



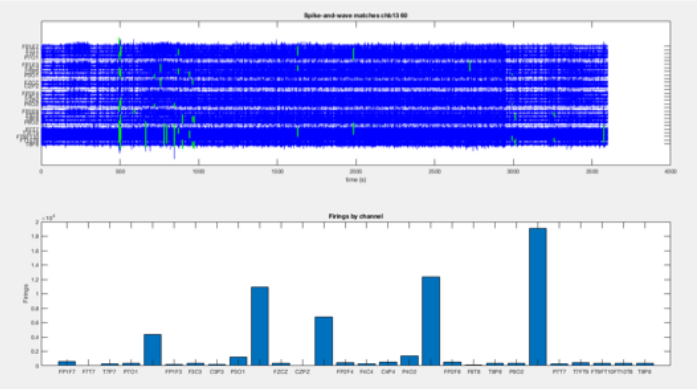
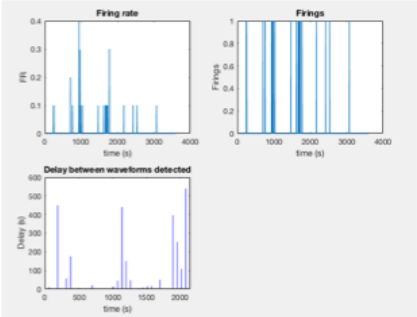


Figure 355, 356. (355) Firing rate, firings by time and delay between firings; (356) Spike-and-wave detections and firings by channel

62.



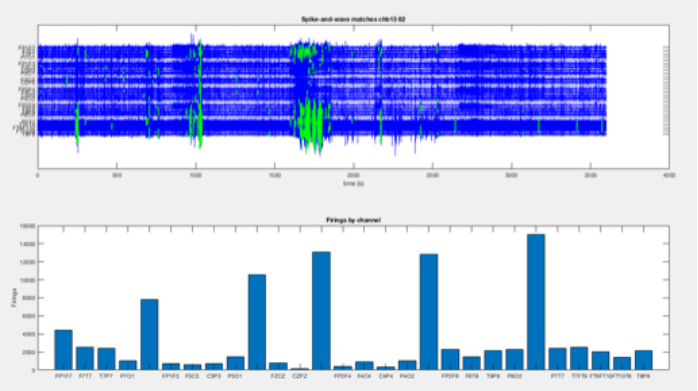
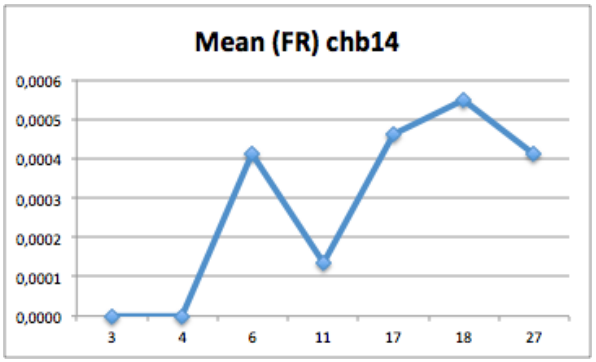


Figure 357, 358. (357) Firing rate, firings by time and delay between firings; (358) Spike-and-wave detections and firings by channel

chb14

Patient overview



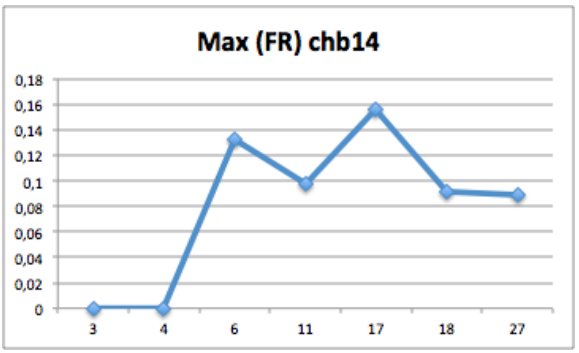
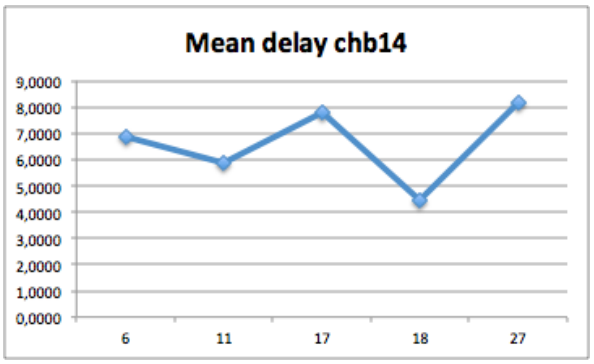


Figure 359, 360. (359) Mean firing rate and (360) Max firing rate



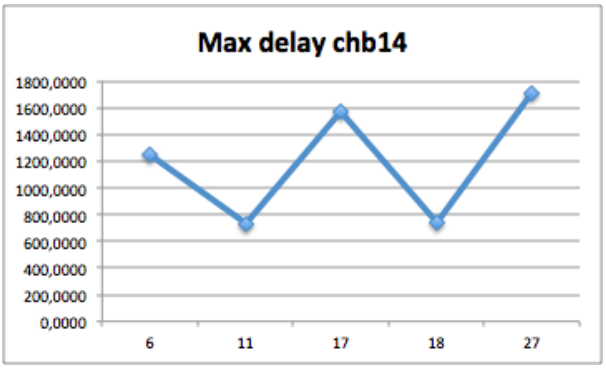


Figure 361, 362. (361) Mean delay and (362) Max delay

Although not all the values could be obtained (of 3 and 4), the obtained results show resemblant values. Therefore, as they are close in time (except 27), it could still be accepted that the seizures are more alike.

CHB14	Mean(FR)	Max(FR)	Mean Delay	Max delay
3(seizure)	0,0000	0	NaN	NaN
4(seizure)	0,0000	0	NaN	NaN
6(seizure)	0,0004	0,1318	6,8884	1250,3000
11(seizure)	0,0001	0,0972	5,8714	733,4414
17(seizure)	0,0005	0,1554	7,7968	1569,8000
18(seizure)	0,0005	0,0908	4,4557	744,4609
27(seizure)	0,0004	0,0884	8,1425	1710,7000

Table 15. Parameters obtained for each recording

3.

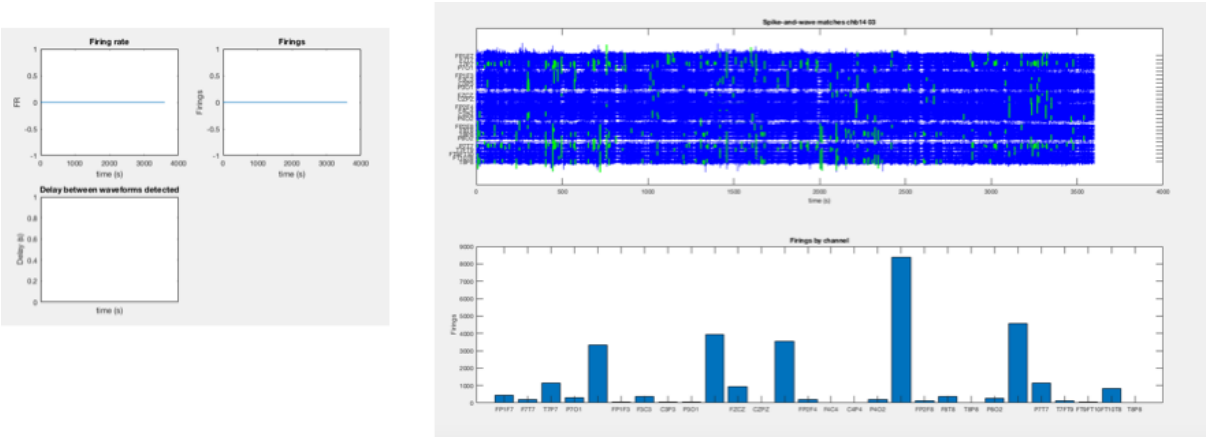


Figure 363, 364. (363) Firing rate, firings by time and delay between firings; (364) Spike-and-wave detections and firings by channel

4.

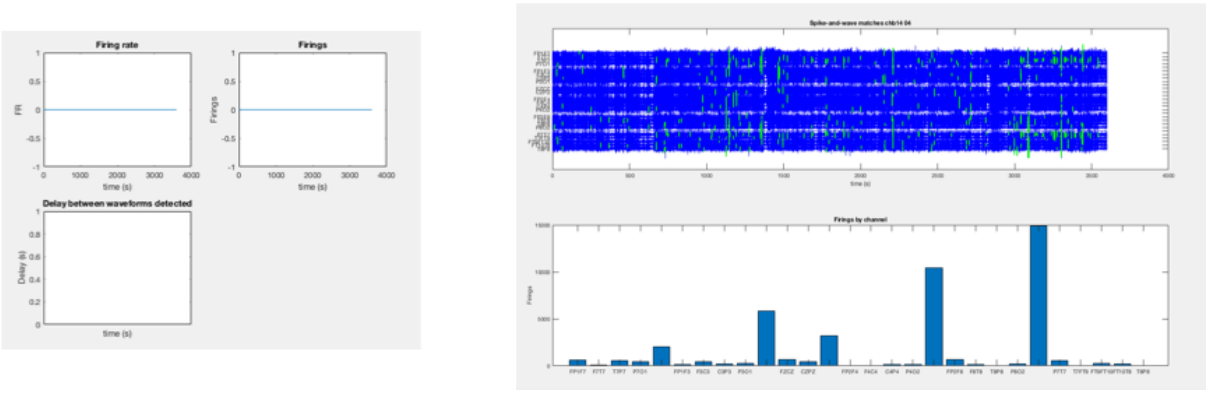


Figure 365, 366. (365) Firing rate, firings by time and delay between firings; (366) Spike-and-wave detections and firings by channel

6.

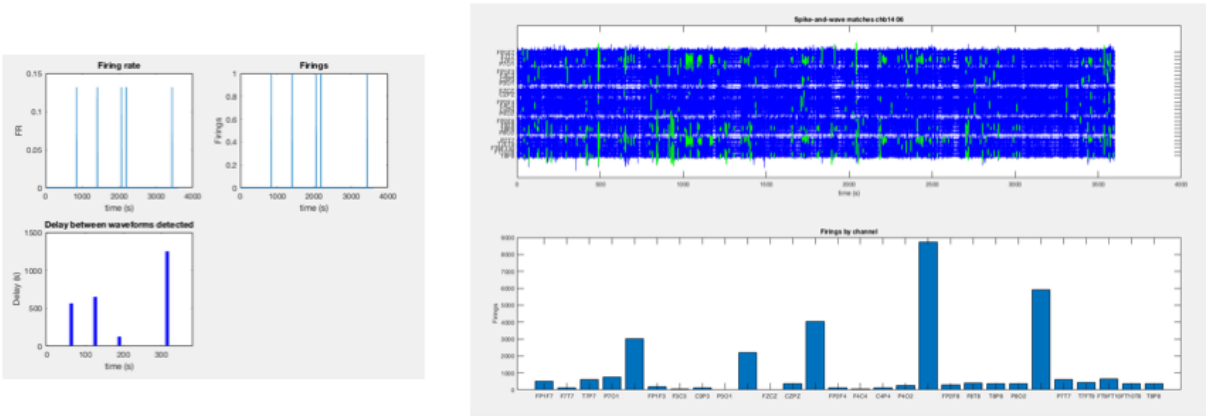


Figure 367, 368. (367) Firing rate, firings by time and delay between firings; (368) Spike-and-wave detections and firings by channel

11.

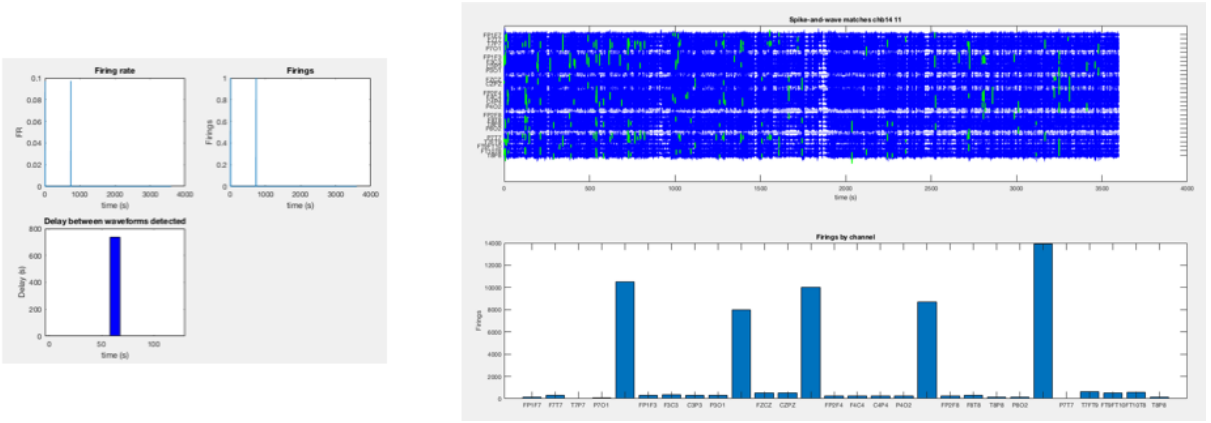


Figure 369, 370. (369) Firing rate, firings by time and delay between firings; (370) Spike-and-wave detections and firings by channel

17.

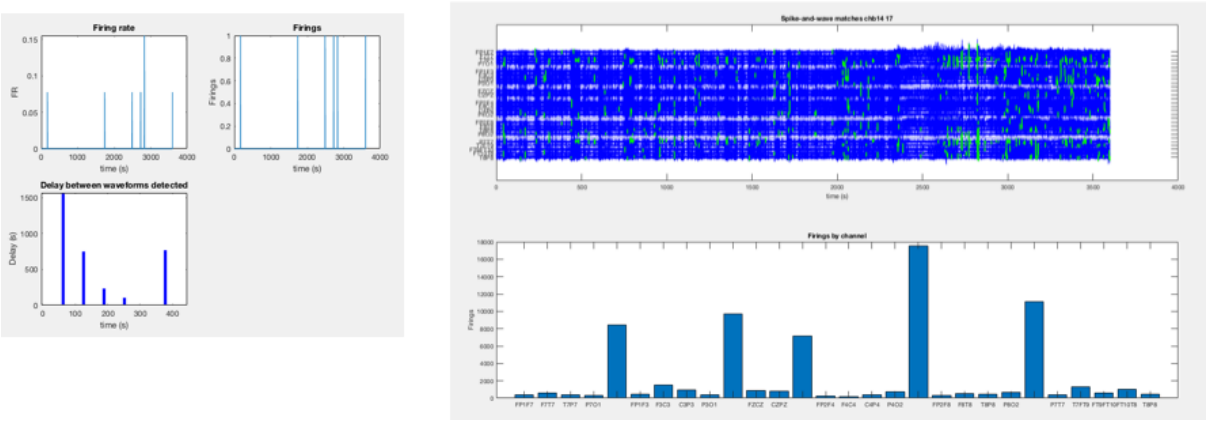


Figure 371, 372. (371) Firing rate, firings by time and delay between firings; (372) Spike-and-wave detections and firings by channel

18.

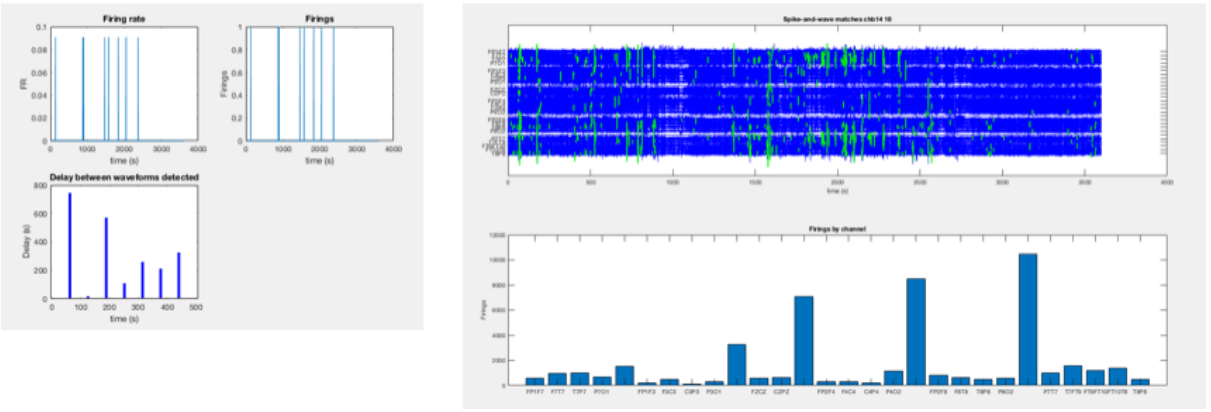


Figure 373, 374. (373) Firing rate, firings by time and delay between firings; (374) Spike-and-wave detections and firings by channel

27.

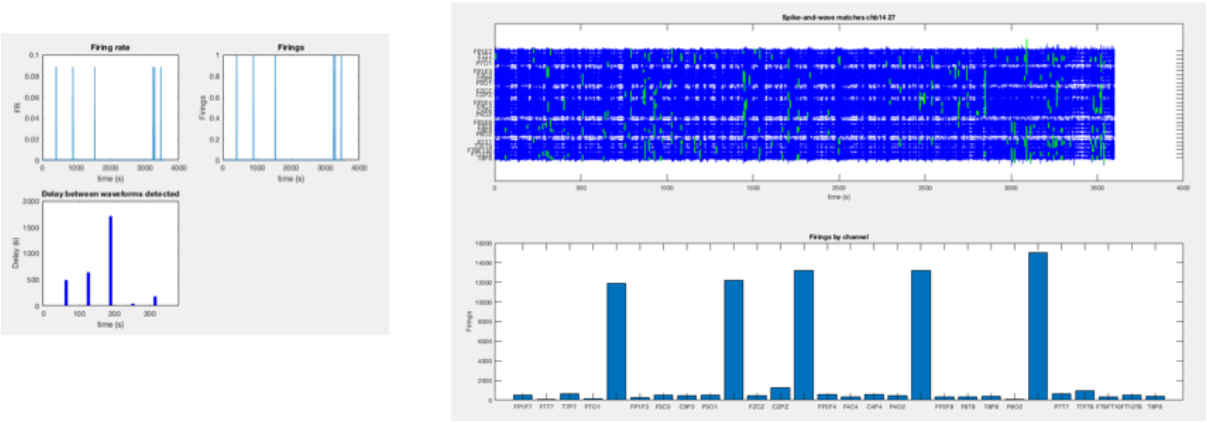


Figure 375, 376. (375) Firing rate, firings by time and delay between firings; (376) Spike-and-wave detections and firings by channel

chb15

Patient overview

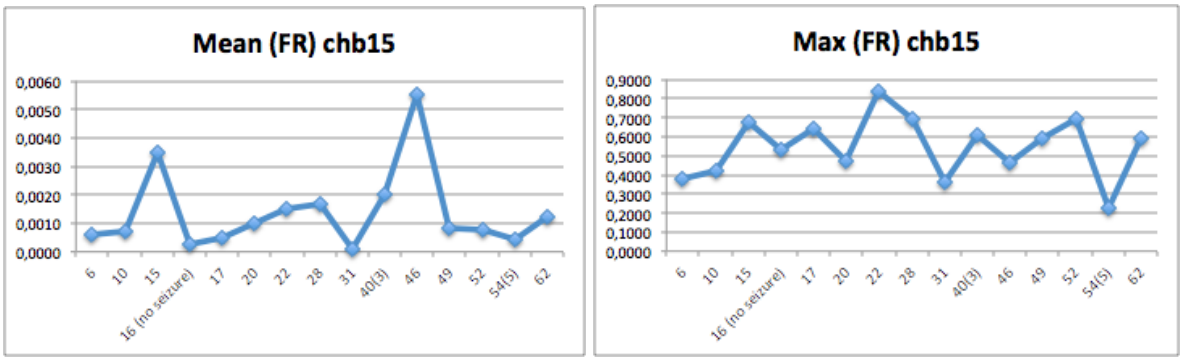


Figure 377, 378. (377) Mean firing rate and (378) Max firing rate

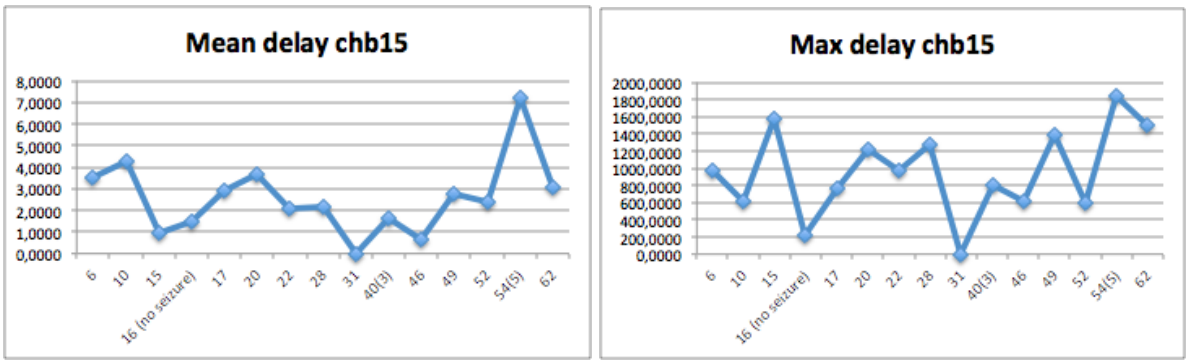


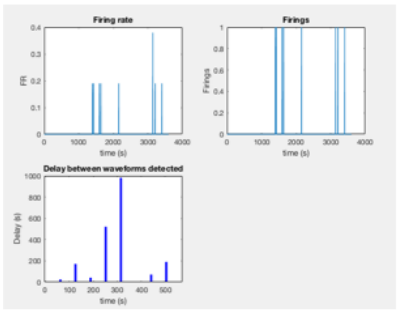
Figure 379, 380. (379) Mean delay and (380) Max delay

Considering the mean firing rate, there can be seen two peaks in 15 and 46, while the maximum firing rates stay alike. Regarding the delays, the mean delay is greatest on 54, which contains 5 seizures, which could be the increased firing detection time between seizures.

CHB15	Mean(FR)	Max(FR)	Mean Delay	Max delay
6(seizure)	0,0006	0,3795	3,5454	982,3867
10(seizure)	0,0007	0,4242	4,2809	621,1406
15(seizure)	0,0035	0,6783	0,9667	1576,8000
16 (no seizure)	0,0003	0,5339	1,4728	225,4375
17(seizure)	0,0005	0,6386	2,9148	761,9258
20(seizure)	0,0010	0,4684	3,6458	1223,5000
22(seizure)	0,0015	0,8375	2,0637	982,2891
28(seizure)	0,0017	0,6954	2,1888	1274,9000
31(seizure)	0,0001	0,3642	0,0039	0,0039
40 (3 seizures)	0,0020	0,6086	1,6660	798,0898
46(seizure)	0,0055	0,4600	0,6310	619,5039
49(seizure)	0,0008	0,5942	2,7601	1388,5000
52(seizure)	0,0008	0,6959	2,4081	589,2305
54 (5 seizures)	0,0004	0,2234	7,1877	1847,7000
62(seizure)	0,0012	0,5943	3,0462	1509,2000

Table 16. Parameters obtained for each recording

6.



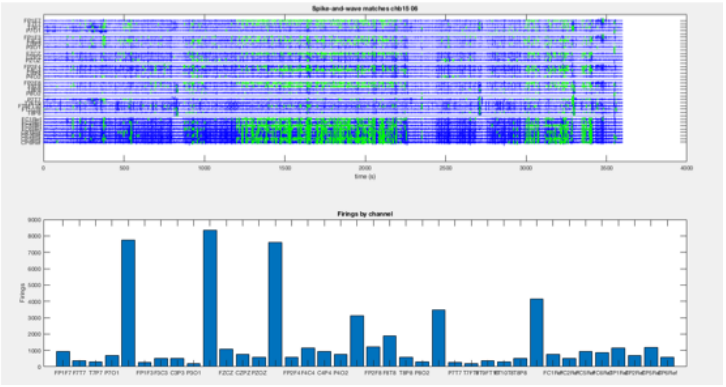


Figure 381, 382. (381) Firing rate, firings by time and delay between firings; (382) Spike-and-wave detections and firings by channel

10.

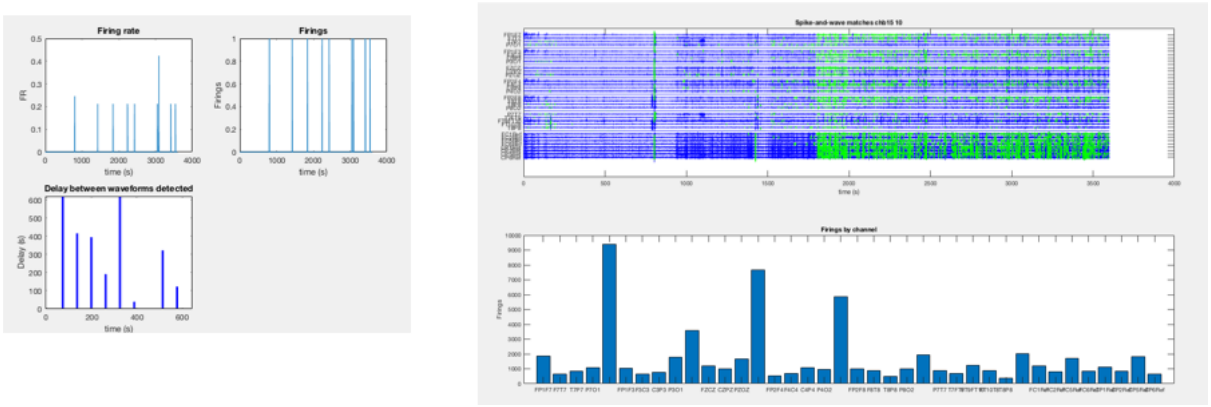


Figure 383, 384. (383) Firing rate, firings by time and delay between firings; (384) Spike-and-wave detections and firings by channel

15.

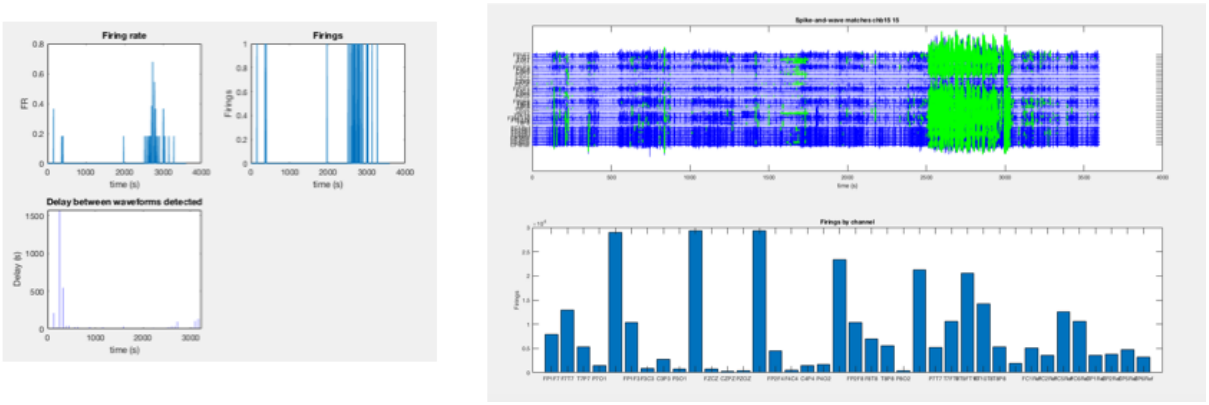


Figure 385, 386. (385) Firing rate, firings by time and delay between firings; (386) Spike-and-wave detections and firings by channel

16.

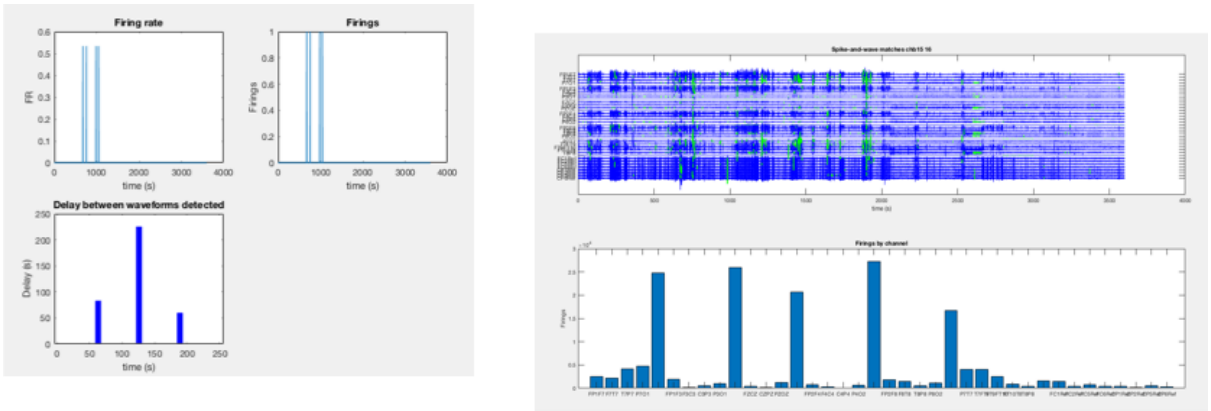


Figure 387, 388. (387) Firing rate, firings by time and delay between firings; (388) Spike-and-wave detections and firings by channel

17.

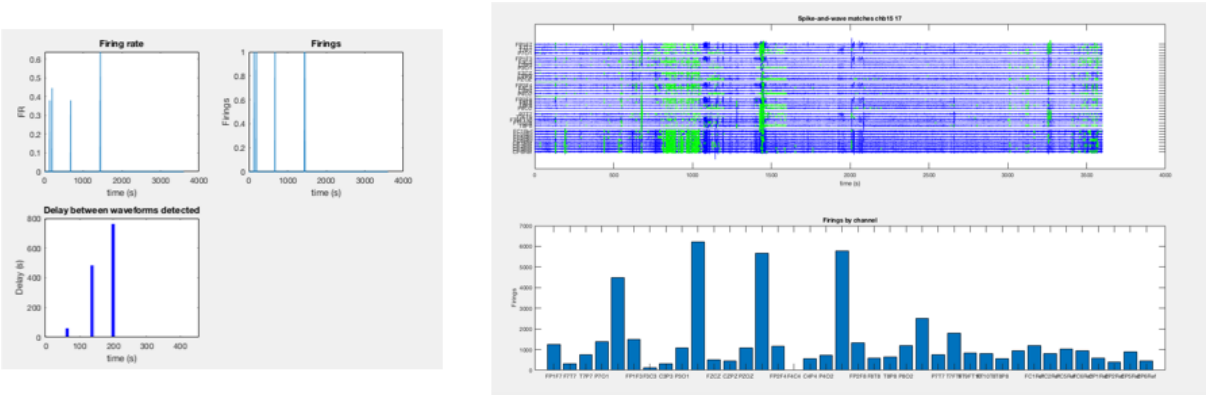


Figure 389, 390. (389) Firing rate, firings by time and delay between firings; (390) Spike-and-wave detections and firings by channel

20.

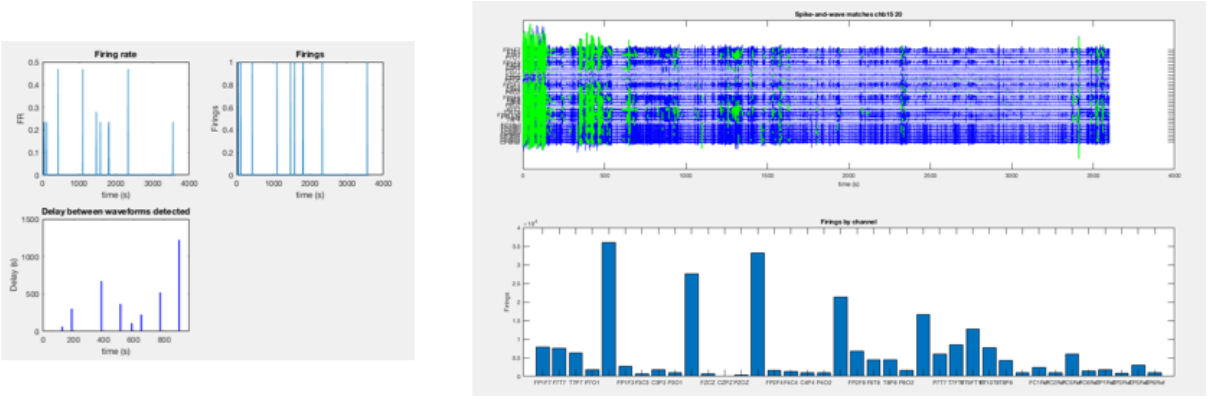


Figure 391, 392. (391) Firing rate, firings by time and delay between firings; (392) Spike-and-wave detections and firings by channel

22.

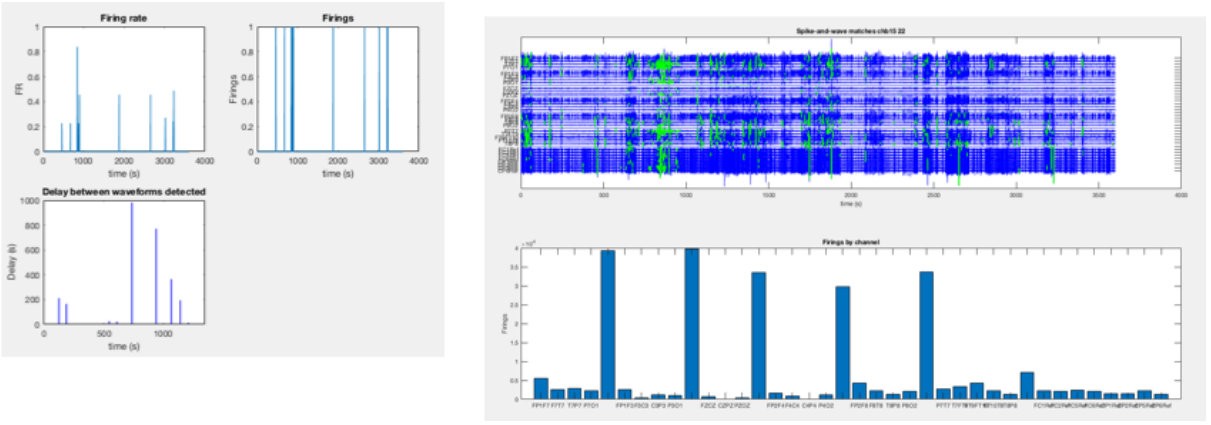


Figure 393, 394. (393) Firing rate, firings by time and delay between firings; (394) Spike-and-wave detections and firings by channel

28.

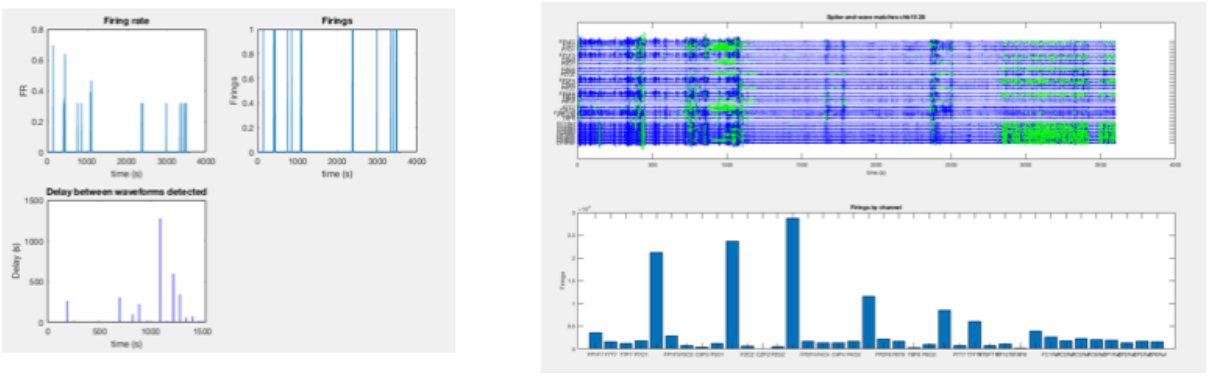


Figure 395, 396. (395) Firing rate, firings by time and delay between firings; (396) Spike-and-wave detections and firings by channel

31.

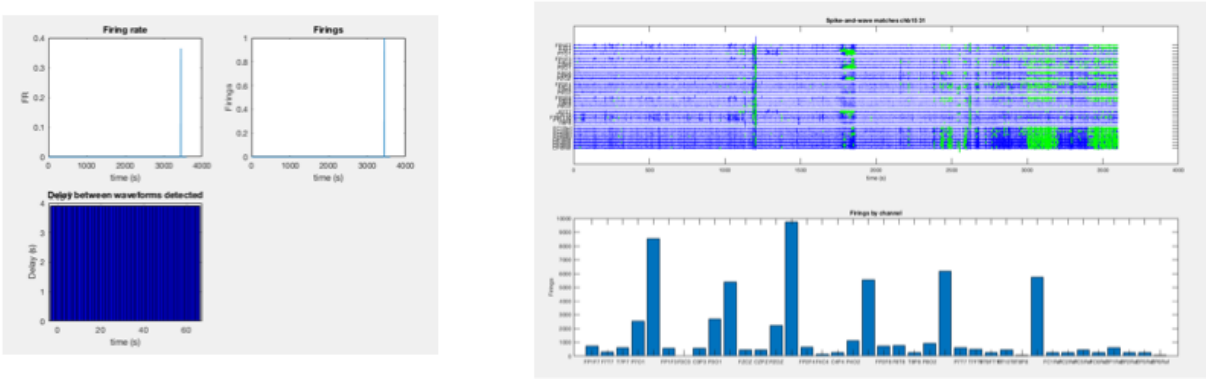


Figure 397, 398. (397) Firing rate, firings by time and delay between firings; (398) Spike-and-wave detections and firings by channel

40.

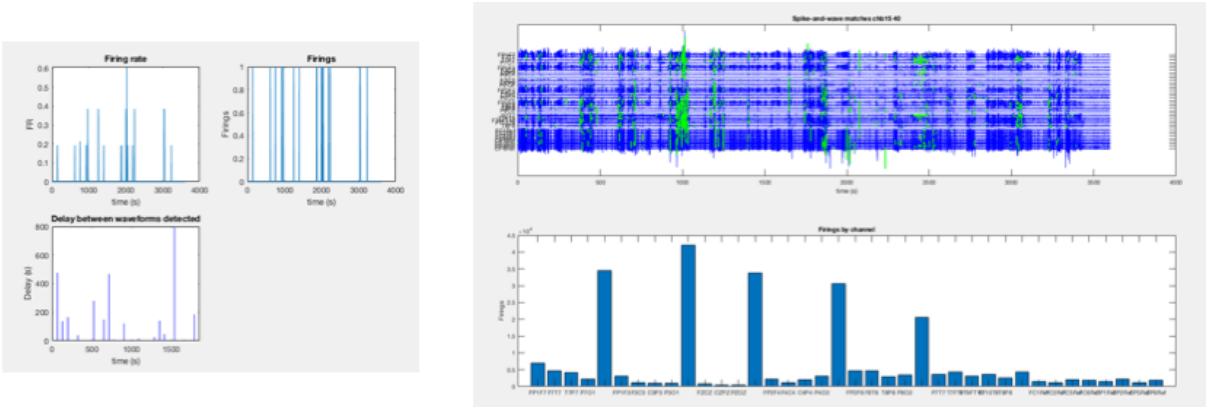


Figure 399, 400. (399) Firing rate, firings by time and delay between firings; (400) Spike-and-wave detections and firings by channel

46.

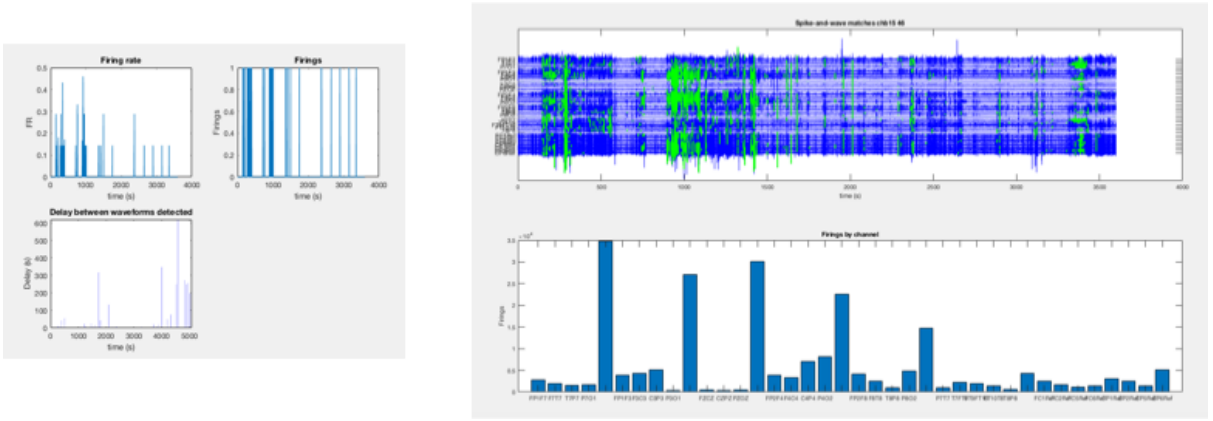


Figure 401, 402. (401) Firing rate, firings by time and delay between firings; (402) Spike-and-wave detections and firings by channel

49.

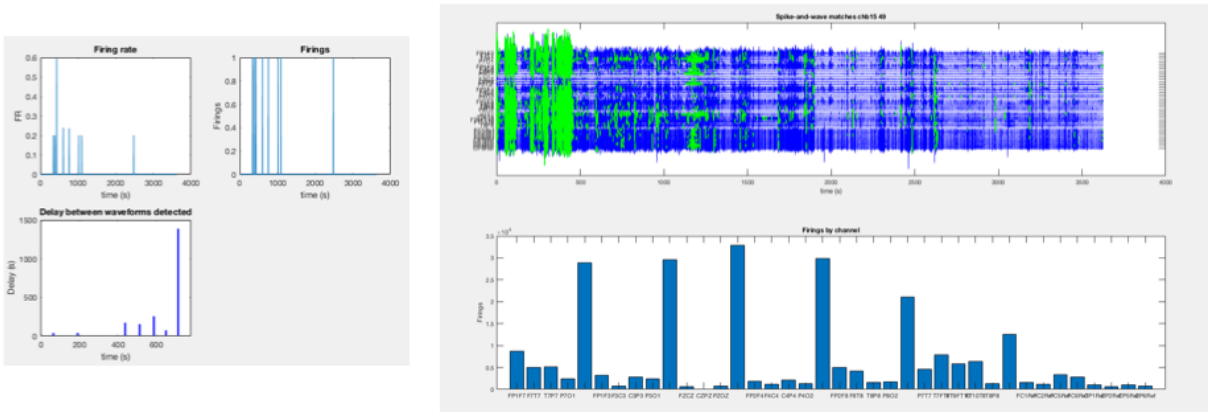


Figure 403, 404. (403) Firing rate, firings by time and delay between firings; (404) Spike-and-wave detections and firings by channel

52.

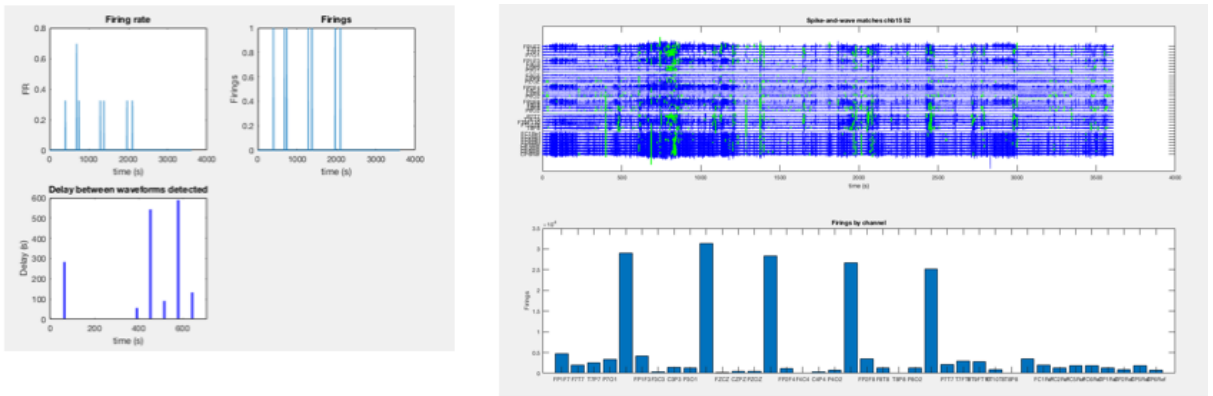


Figure 405, 406. (405) Firing rate, firings by time and delay between firings; (406) Spike-and-wave detections and firings by channel

54.

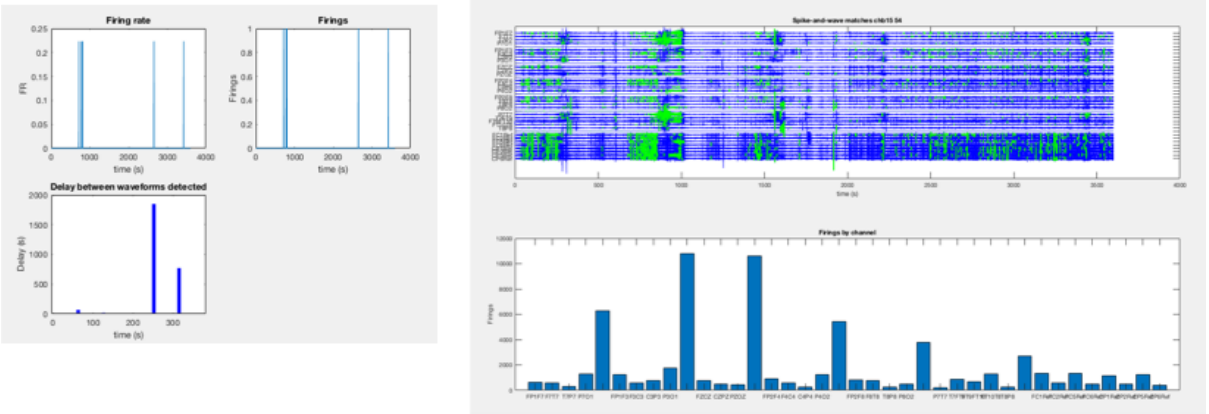


Figure 407, 408. (407) Firing rate, firings by time and delay between firings; (408) Spike-and-wave detections and firings by channel

62.

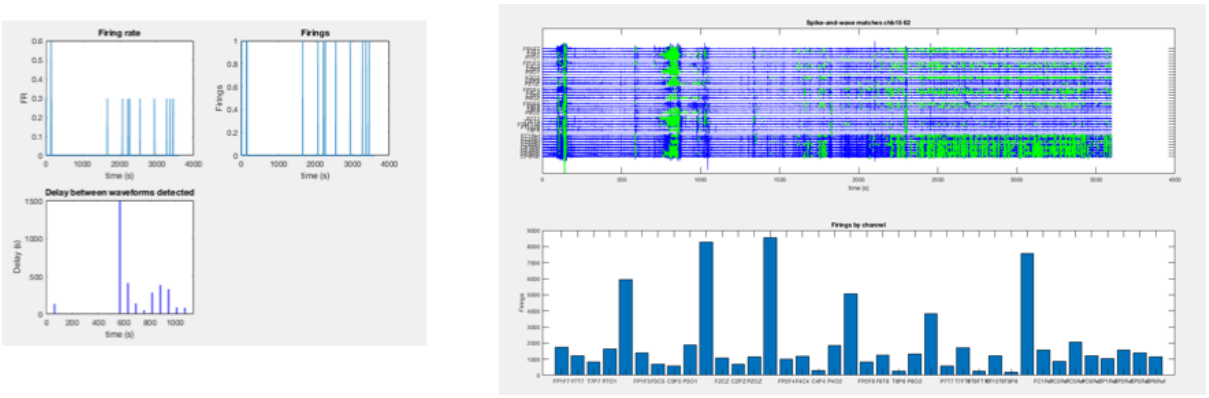


Figure 409, 410. (409) Firing rate, firings by time and delay between firings; (410) Spike-and-wave detections and firings by channel

chb16

Patient overview

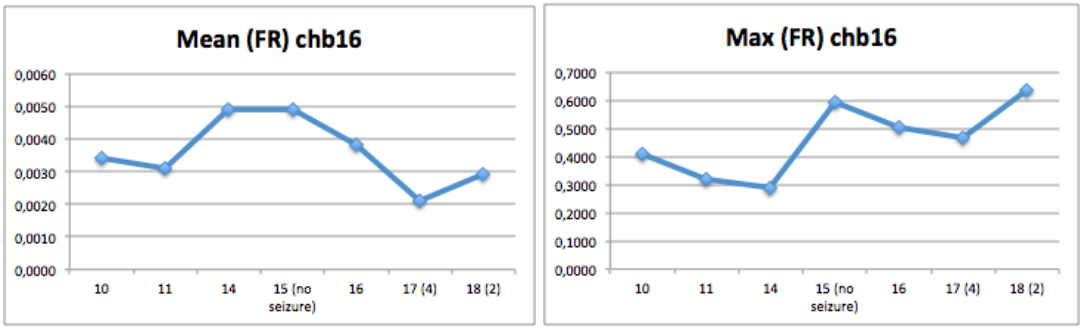


Figure 411, 412. (411) Mean firing rate and (412) Max firing rate

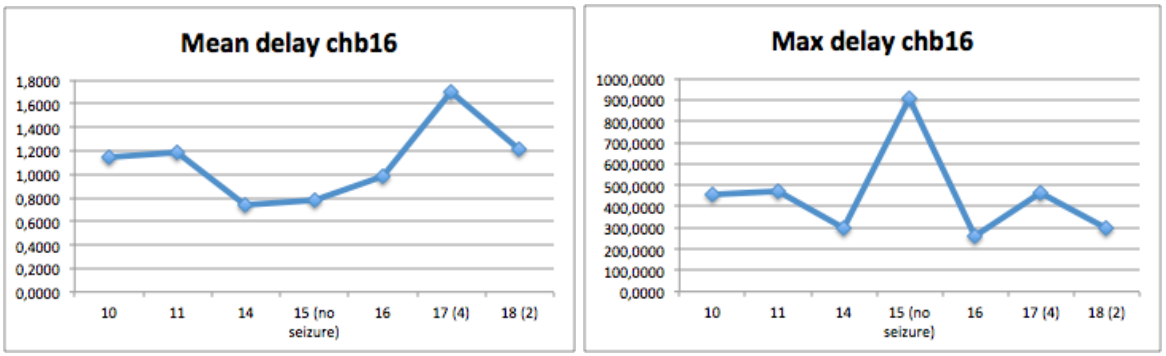


Figure 413, 414. (413) Mean delay and (414) Max delay

Considering that all the recordings contain seizures, except 15, and are successive in time; there is not a very high divergence between them. Moreover, the 15 does not show any remarkable difference with the epileptic recordings, in exception of the maximum delay, which highly increases.

CHB16	Mean(FR)	Max(FR)	Mean Delay	Max delay
10(seizure)	0,0034	0,4079	1,1434	454,3945
11(seizure)	0,0031	0,3182	1,1816	473,2852
14(seizure)	0,0049	0,2897	0,7330	300,2344
15	0,0049	0,5915	0,7756	905,2070
16(seizure)	0,0038	0,5027	0,9820	258,0977
17 (4 seizures)	0,0021	0,4684	1,7026	459,6328
18 (2 seizures)	0,0029	0,6364	1,2134	301,1641

Table 17. Parameters obtained for each recording

10.

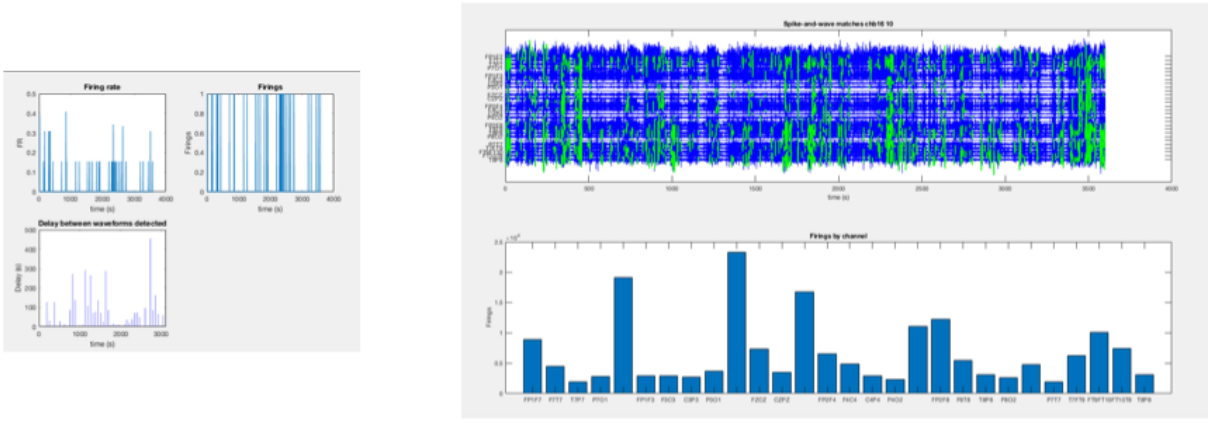


Figure 415, 416. (415) Firing rate, firings by time and delay between firings; (416) Spike-and-wave detections and firings by channel

11.

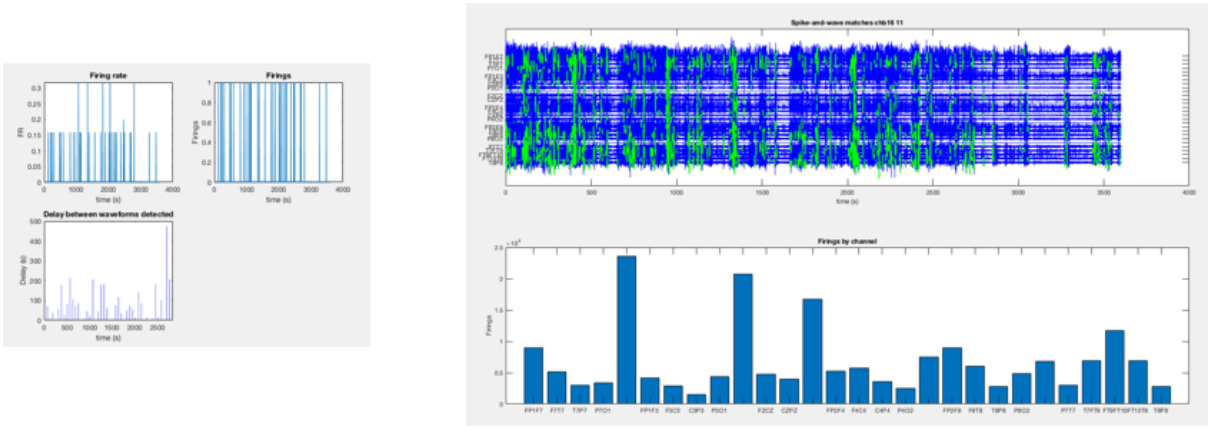


Figure 417, 418. (417) Firing rate, firings by time and delay between firings; (418) Spike-and-wave detections and firings by channel

14.

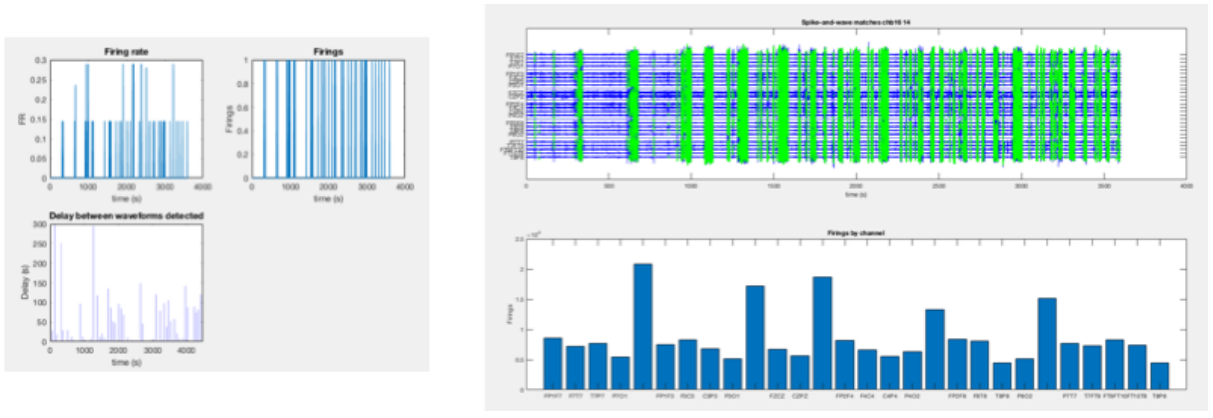


Figure 419, 420. (419) Firing rate, firings by time and delay between firings; (420) Spike-and-wave detections and firings by channel

15.

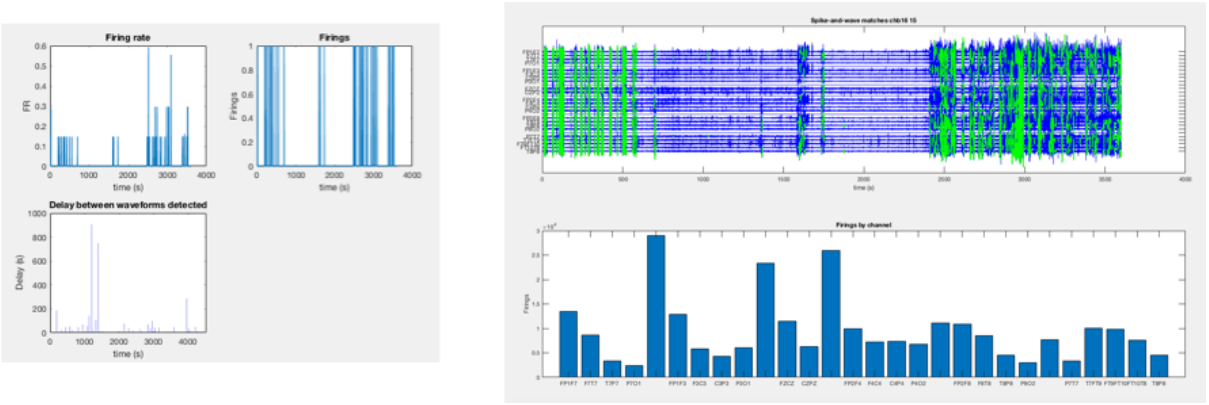


Figure 421, 422. (421) Firing rate, firings by time and delay between firings; (422) Spike-and-wave detections and firings by channel

16.

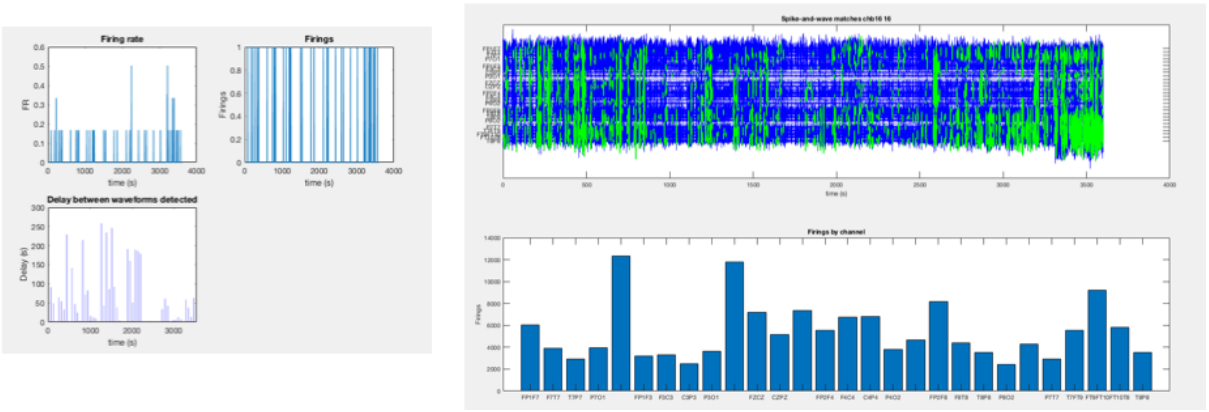


Figure 423, 424. (423) Firing rate, firings by time and delay between firings; (424) Spike-and-wave detections and firings by channel

17.

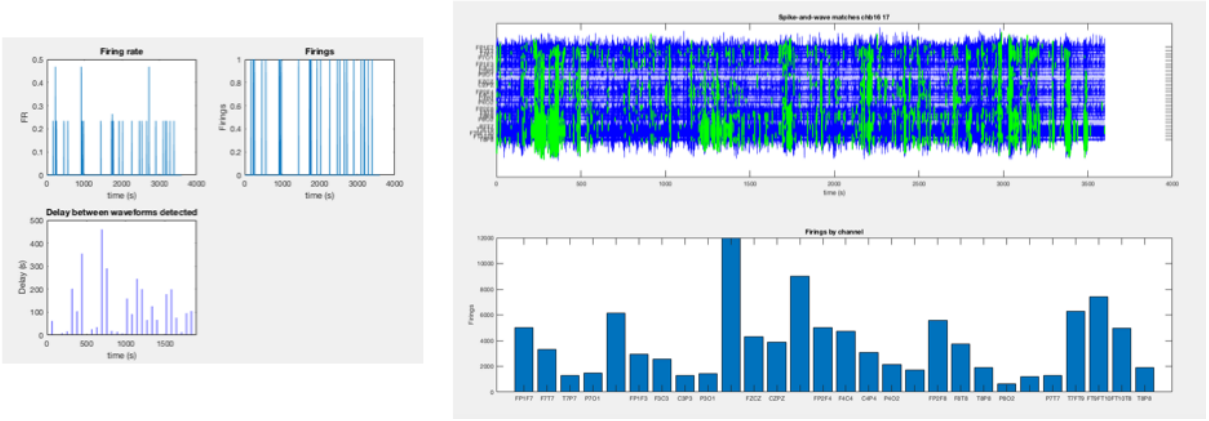
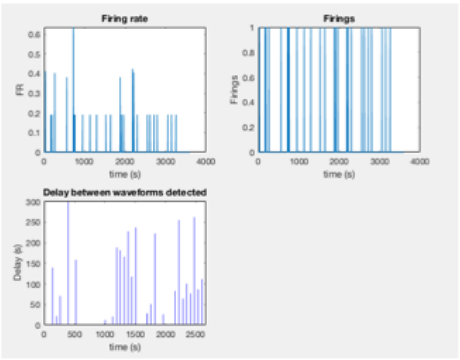


Figure 425, 426. (425) Firing rate, firings by time and delay between firings; (426) Spike-and-wave detections and firings by channel

18.



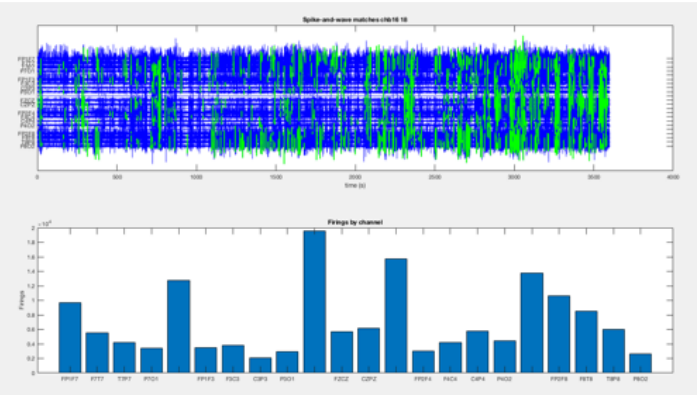
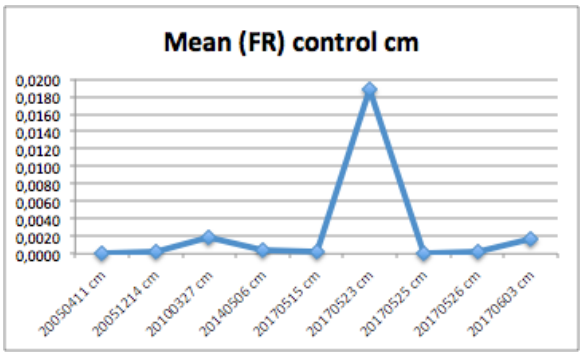


Figure 427, 428. (427) Firing rate, firings by time and delay between firings; (428) Spike-and-wave detections and firings by channel

Control group

Bipolar montage (cm)

Patients overview



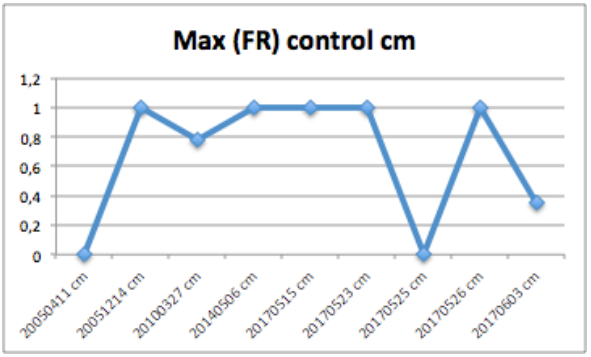
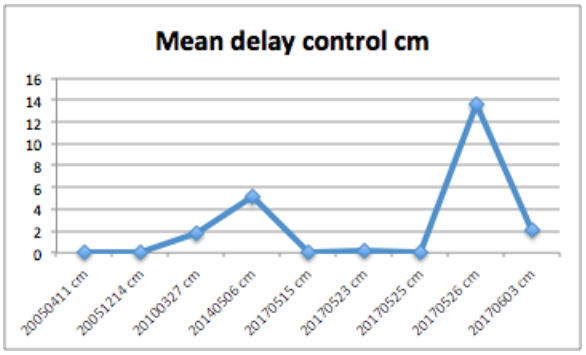


Figure 429, 430. (429) Mean firing rate and (430) Max Firing rate



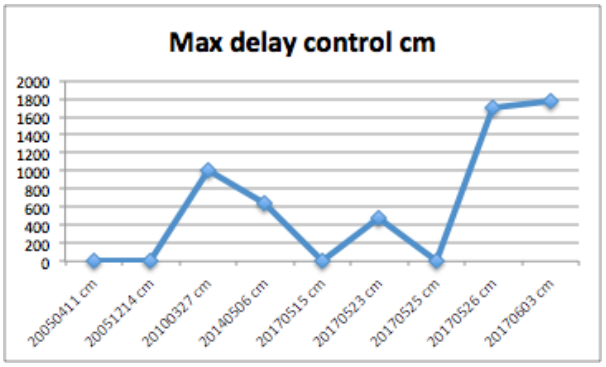


Figure 431, 432. (431) Mean delay and (432) Max delay

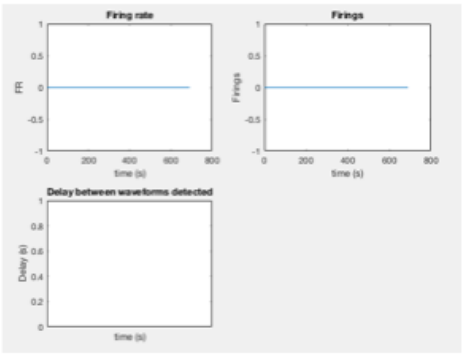
The control group has been studied differentiating bipolar and monopolar montages. It needs to be remarked that the epileptic patients were large recordings and they were analyzed patient by patient, whereas in the control group each recording is a different subject. First of all, the bipolar montage is analyzed. As for the mean firing rates, the values stay fairly low, except with the 6th patient, where there is a peak up to 0,0188, although with the other analysis it shows similar values with the other patients.

CONTROL cm	Mean(FR)	Max(FR)	Mean Delay	Max delay
20050411 cm	0,0000	0	0	0
20051214 cm	0,0003	1,0000	0,0039	0,0039
20100327 cm	0,0019	0,7778	1,7751	1015,0000
20140506 cm	0,0005	1,0000	5,1430	642,3945
20170515 cm	0,0003	1,0000	0,0039	0,0039
20170523 cm	0,0188	1,0000	0,1597	478,1211

20170525 cm	0,0000	0,0000	0	0
20170526 cm	0,0003	1,0000	13,5541	1695,5000
20170603 cm	0,0017	0,3529	2,0989	1780,8000

Table 18. Parameters obtained for each recording

20050411cm



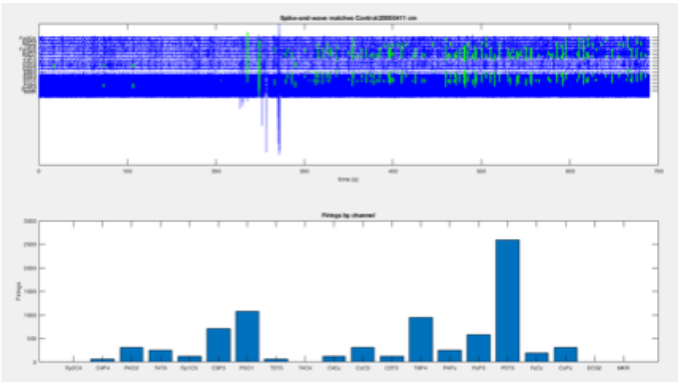
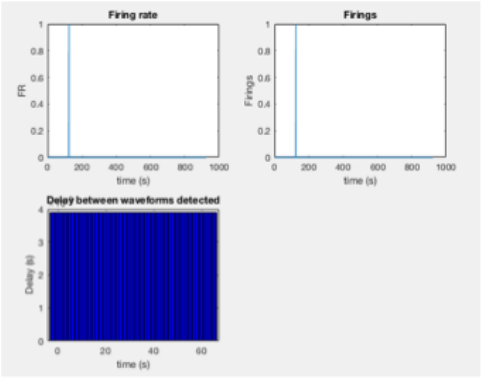


Figure 433, 434. (433) Firing rate, firings by time and delay between firings; (434) Spike-and-wave detections and firings by channel

20051214 cm



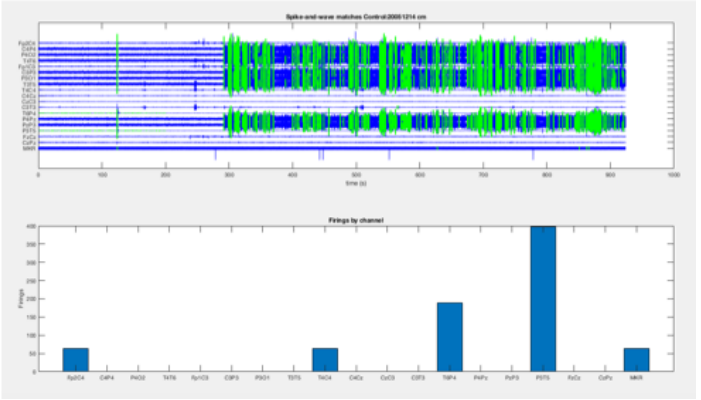
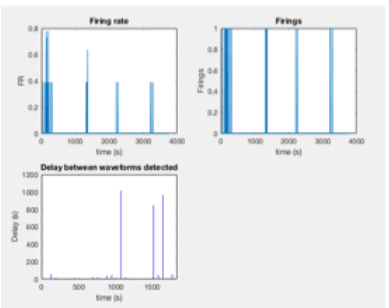


Figure 435, 436. (435) Firing rate, firings by time and delay between firings; (436) Spike-and-wave detections and firings by channel

20100327 cm



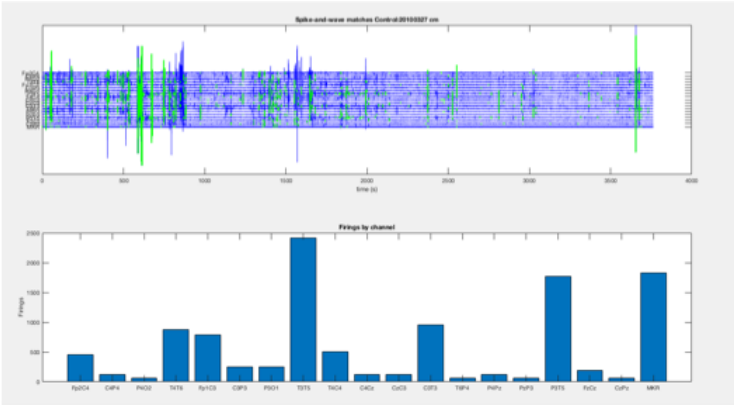
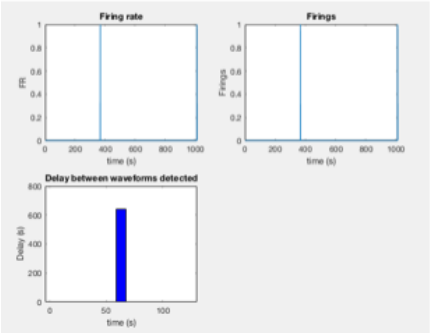


Figure 437, 438. (437) Firing rate, firings by time and delay between firings; (438) Spike-and-wave detections and firings by channel

20140506 cm



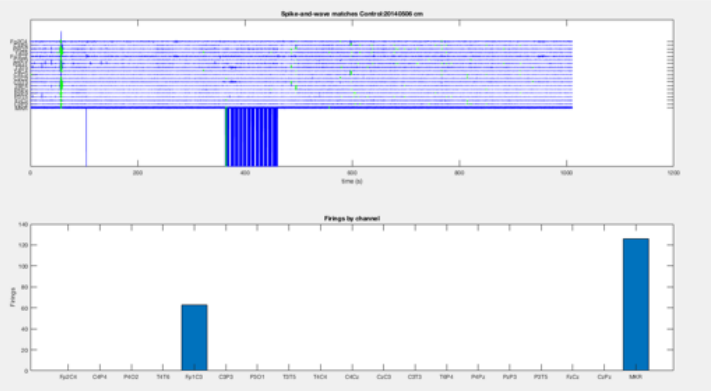
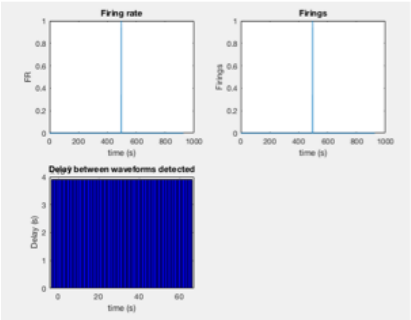


Figure 439, 440. (439) Firing rate, firings by time and delay between firings; (440) Spike-and-wave detections and firings by channel

20170515 cm



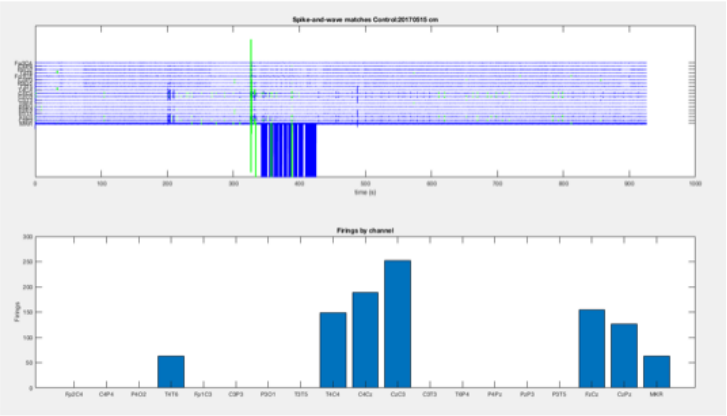
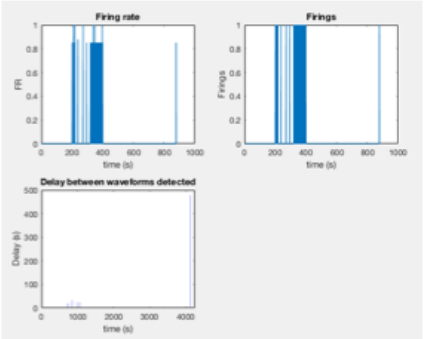


Figure 441, 442. (441) Firing rate, firings by time and delay between firings; (442) Spike-and-wave detections and firings by channel

20170523 cm



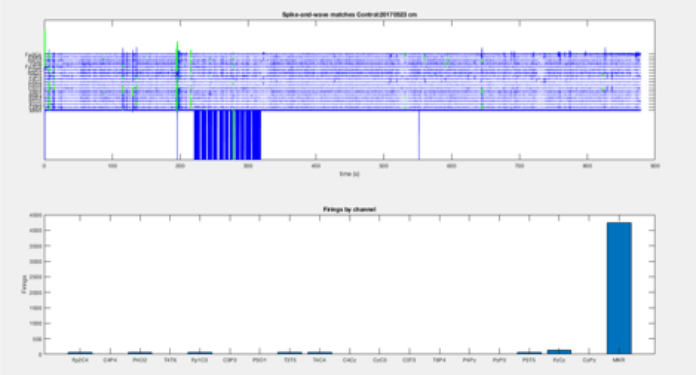
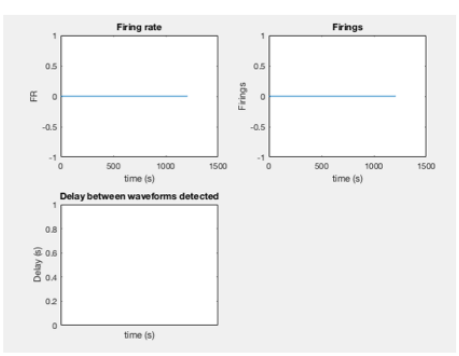


Figure 443, 444. (443) Firing rate, firings by time and delay between firings; (444) Spike-and-wave detections and firings by channel

20170525 cm



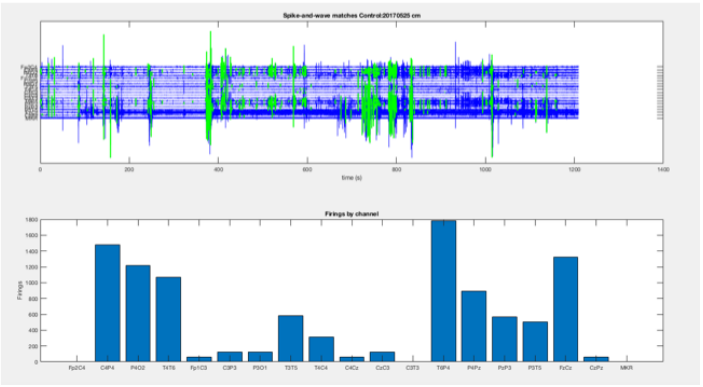
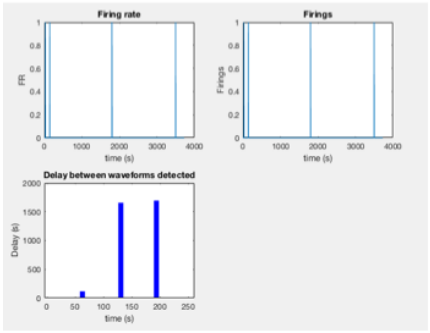


Figure 445, 446. (445) Firing rate, firings by time and delay between firings; (446) Spike-and-wave detections and firings by channel

20170526 cm



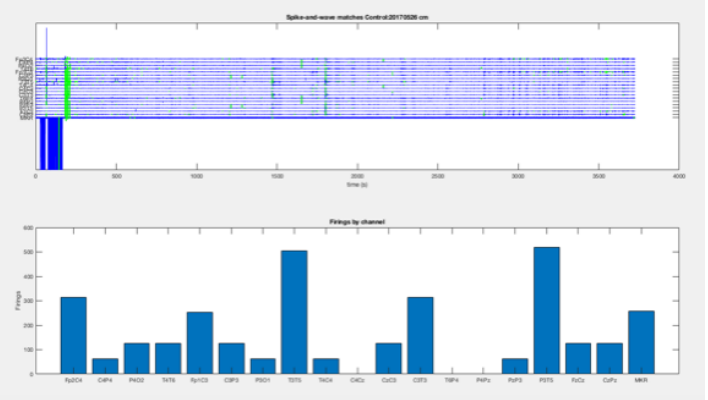
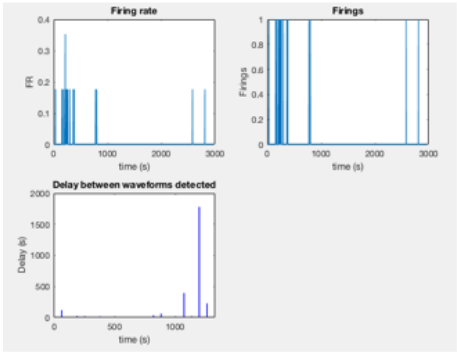


Figure 447, 448. (447) Firing rate, firings by time and delay between firings; (448) Spike-and-wave detections and firings by channel

20170603 cm



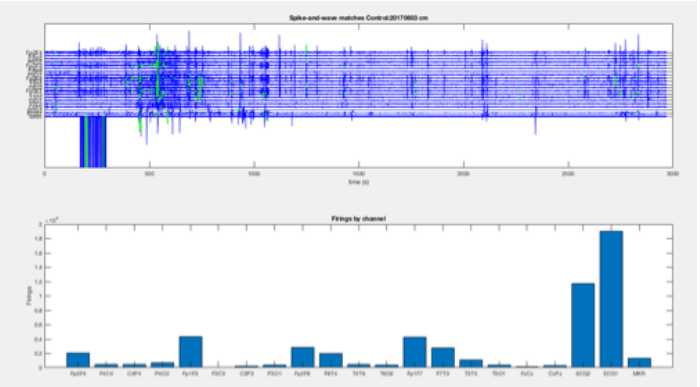
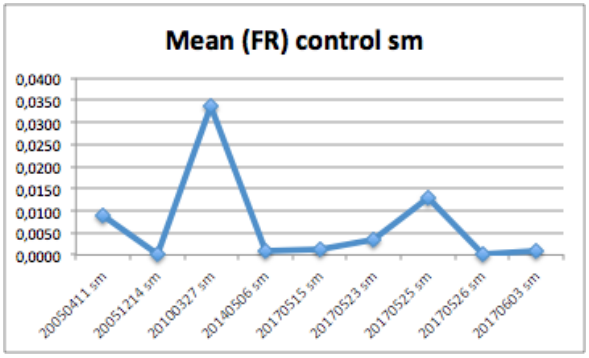


Figure 449, 450. (449) Firing rate, firings by time and delay between firings; (450) Spike-and-wave detections and firings by channel

Monopolar montage (sm)

Patients overview



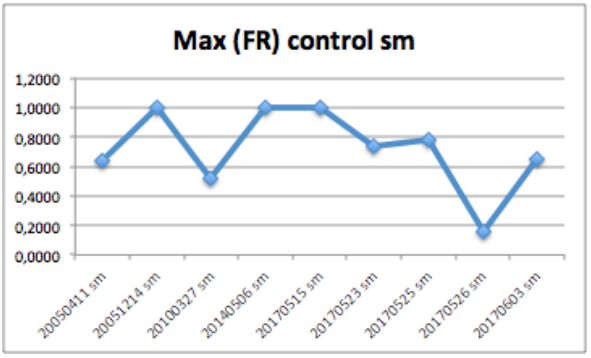
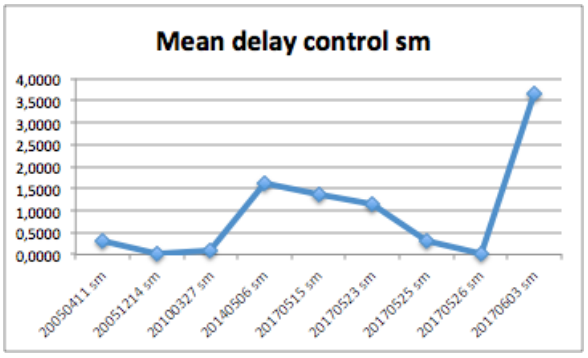


Figure 451, 452. (451) Mean firing rate and (452) Max firing rate



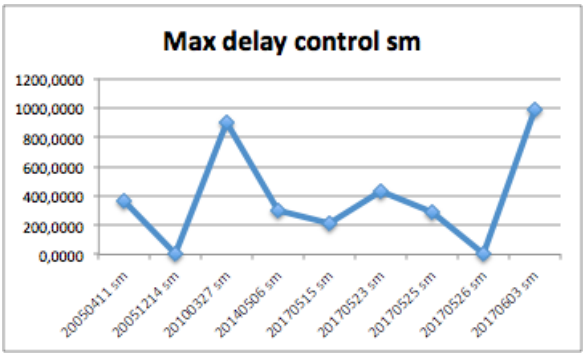


Figure 453, 454. (453) Mean delay and (454) Max delay

As for the control group with monopolar montage, it can be seen that the third patient shows a higher mean firing rate, whereas the 6th shows a lower value than when studied with bipolar montage. All in all, the patients show quite similar values to each other, with some slight variations, especially with the delays. Concretely, the last patient shows significantly higher mean and maximum delay values.

CONTROL sm	Mean(FR)	Max(FR)	Mean Delay	Max delay
20050411 sm	0,0089	0,6389	0,3251	368,2188
20051214 sm	0,0003	1,0000	0,0039	0,0039
20100327 sm	0,0337	0,5206	0,0938	901,1914
20140506 sm	0,0007	1,0000	1,6058	298,3203
20170515 sm	0,0011	1,0000	1	215
20170523 sm	0,0034	0,7340	1,1499	425,8203
20170525 sm	0,0128	0,7857	0,3041	284,0078
20170526 sm	0,0000	0,1537	0,0039	0,0039
20170603 sm	0,0010	0,6466	3,6719	991,8828

Table 19. Parameters obtained for each recording

20050411sm

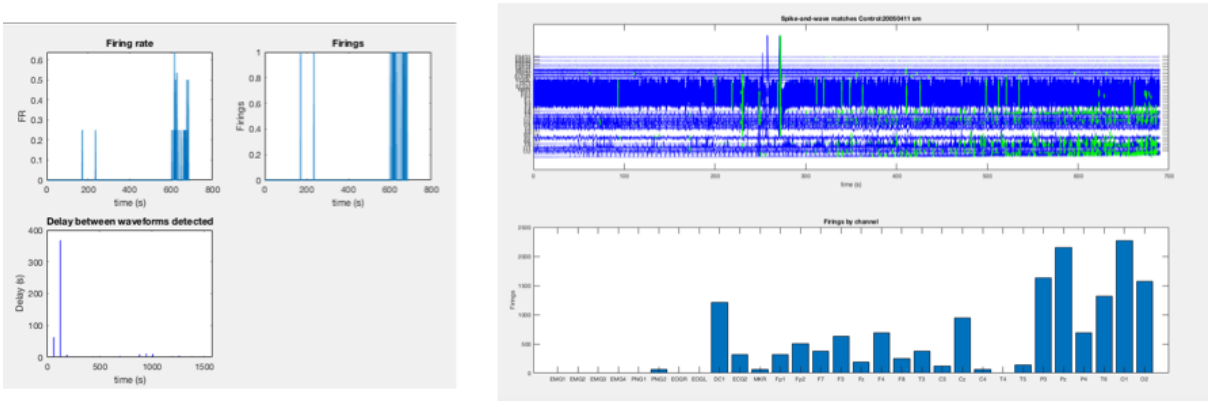


Figure 455, 456. (455) Firing rate, firings by time and delay between firings; (456) Spike-and-wave detections and firings by channel

20051214 sm

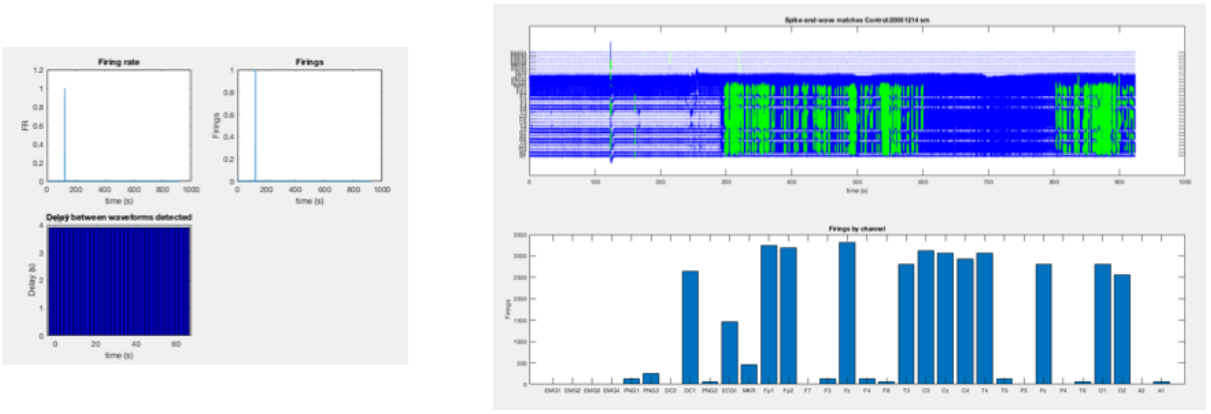


Figure 457, 458. (457) Firing rate, firings by time and delay between firings; (458) Spike-and-wave detections and firings by channel

20100327 sm

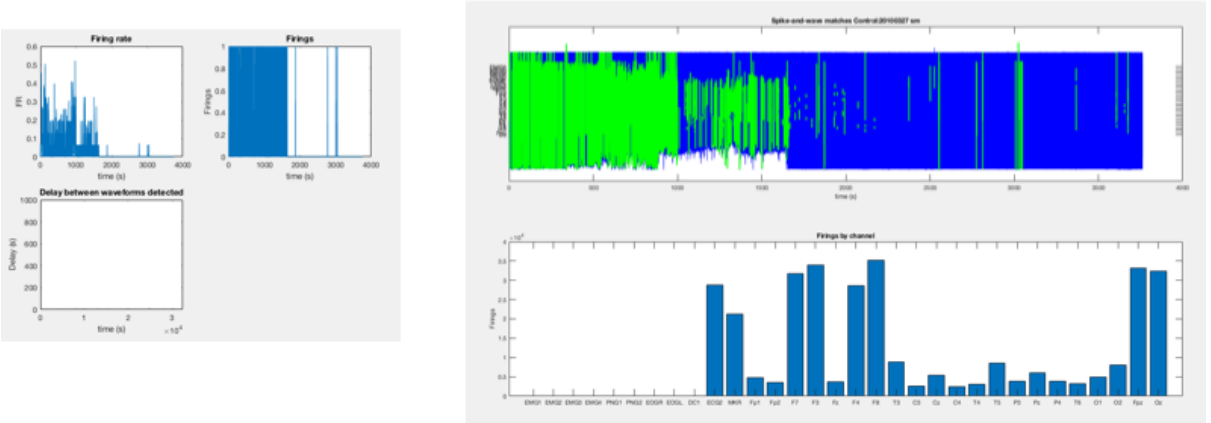


Figure 459, 460. (459) Firing rate, firings by time and delay between firings; (460) Spike-and-wave detections and firings by channel

20140506 sm

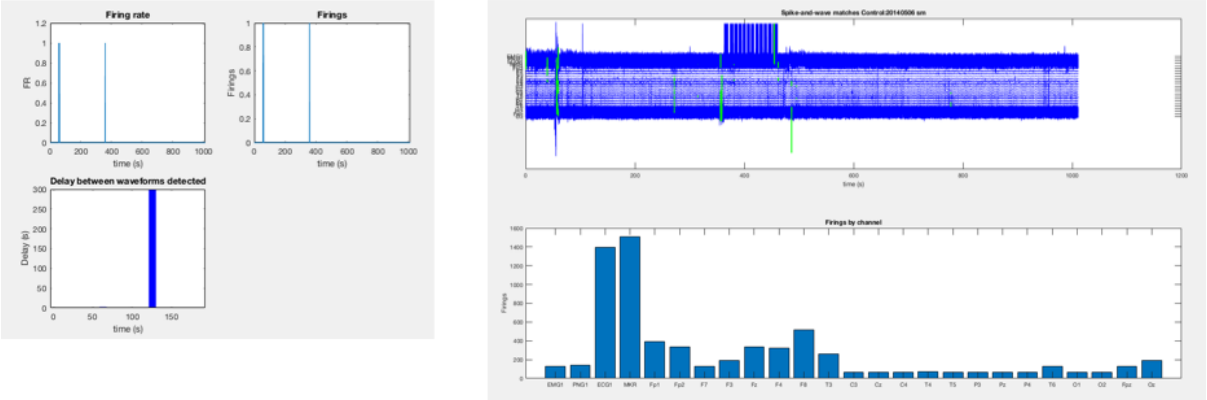


Figure 461, 462. (461) Firing rate, firings by time and delay between firings; (462) Spike-and-wave detections and firings by channel

20170515 sm

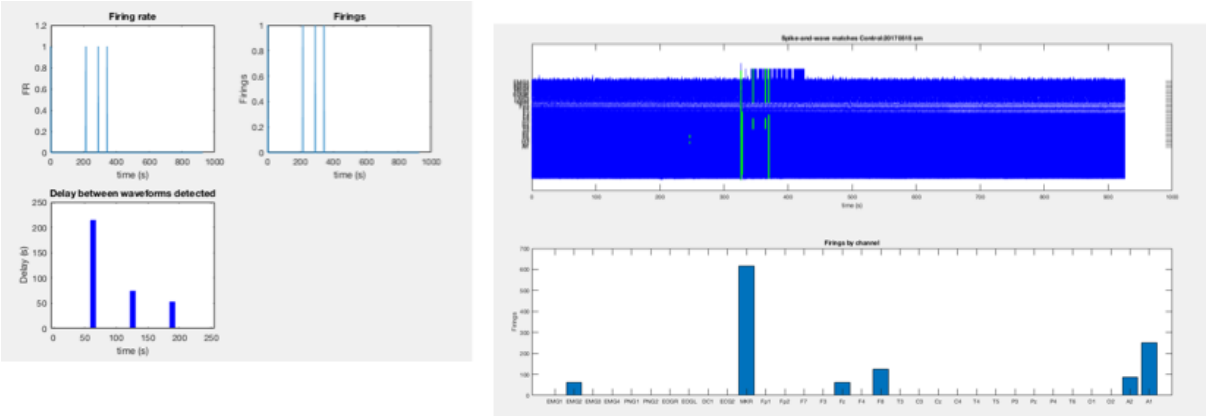


Figure 463, 464. (463) Firing rate, firings by time and delay between firings; (464) Spike-and-wave detections and firings by channel

20170523 sm

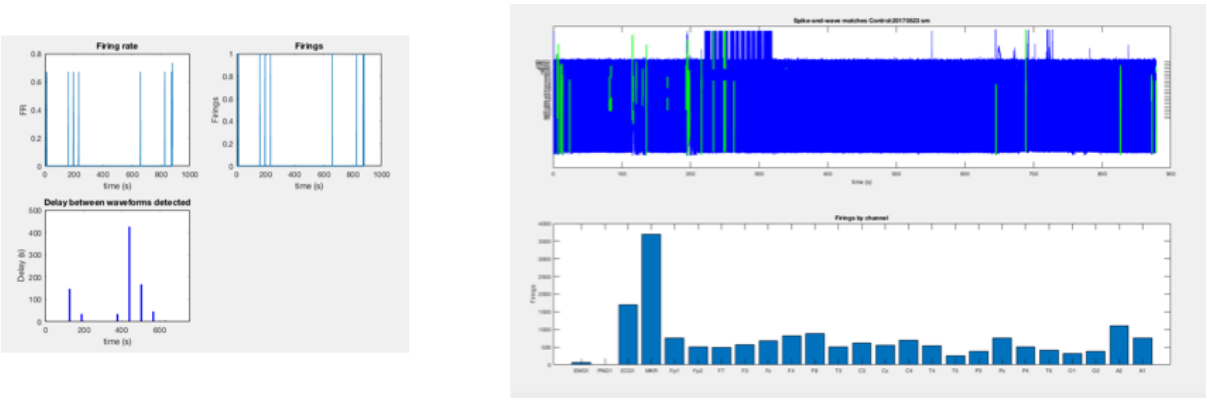
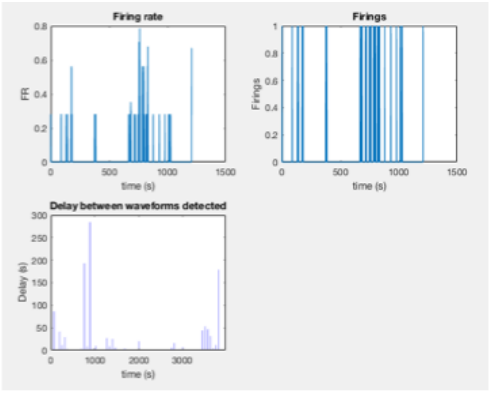


Figure 465, 466. (465) Firing rate, firings by time and delay between firings; (466) Spike-and-wave detections and firings by channel

20170525 sm



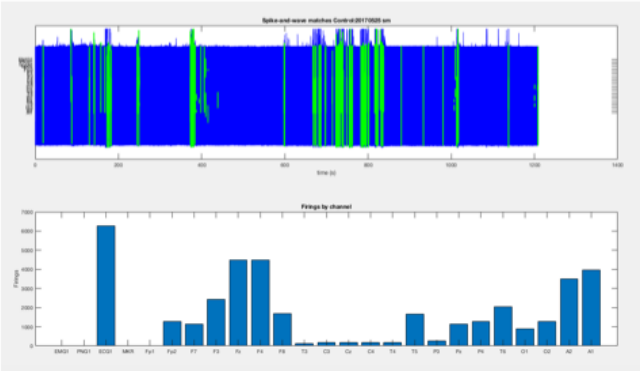
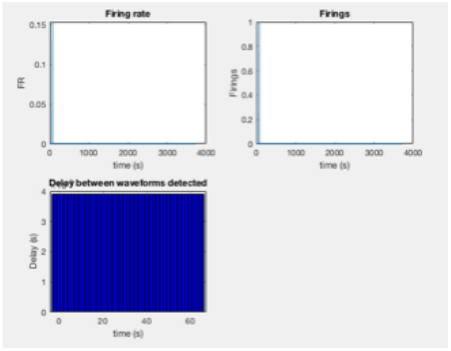


Figure 467, 468. (467) Firing rate, firings by time and delay between firings; (468) Spike-and-wave detections and firings by channel

20170526 sm



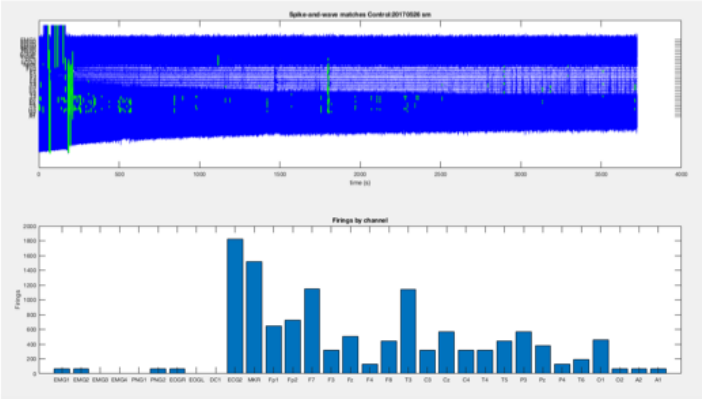
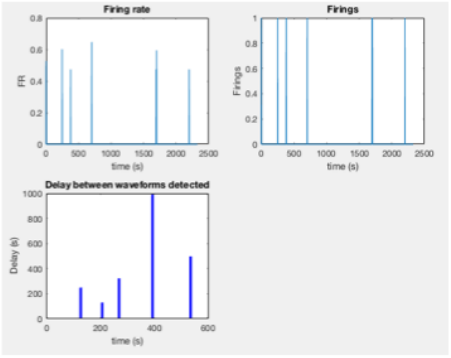


Figure 469, 470. (469) Firing rate, firings by time and delay between firings; (470) Spike-and-wave detections and firings by channel

20170603 sm



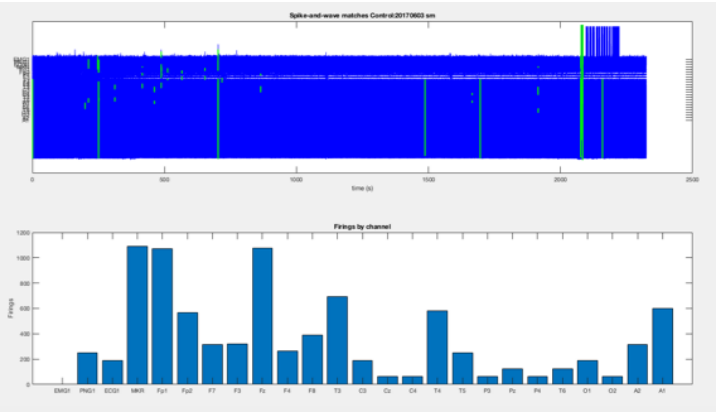


Figure 471, 472. (471) Firing rate, firings by time and delay between firings; (472) Spike-and-wave detections and firings by channel

ADHD

Patients overview

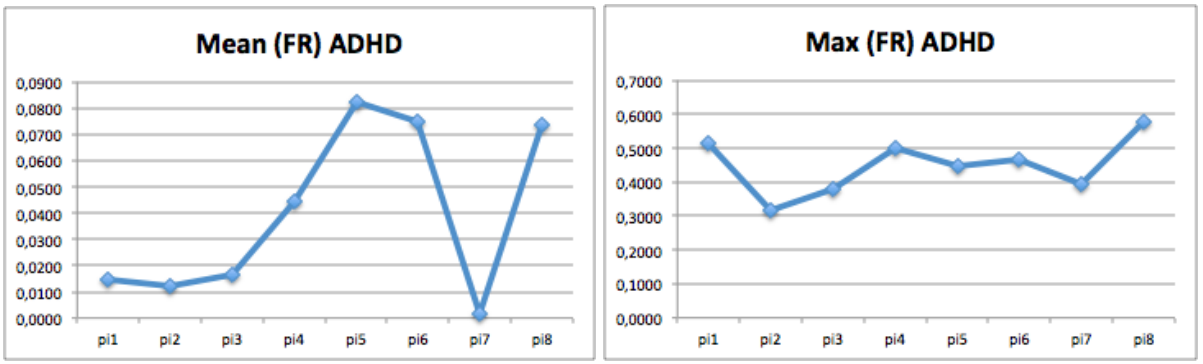


Figure 473, 474. (473) Mean firing rate and (474) Max firing rate

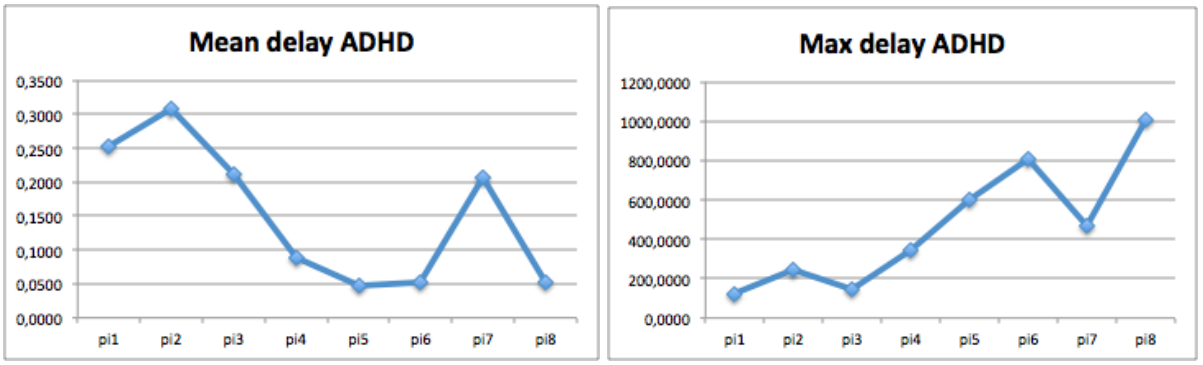


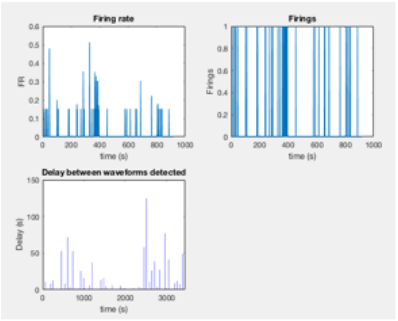
Figure 475, 476. (475) Mean delay and (476) Max delay

The patients with ADHD showed more noise in the signal, even after the filtering process was applied. Moreover, in most of the patients, a lot of the firings detected are seen on the 'status' channel, which could indicate a malfunctioning of the implemented code.

ADHD	Mean(FR)	Max(FR)	Mean Delay	Max delay
pi1	0,0147	0,5133	0,2537	124,5781
pi2	0,0119	0,3159	0,3077	241,8359
pi3	0,0166	0,3792	0,2104	145,8867
pi4	0,0443	0,4996	0,0879	342,8711
pi5	0,0823	0,4490	0,0472	600,2773
pi6	0,0747	0,4682	0,0515	804,1055
pi7	0,0016	0,3940	0,2061	470,7617
pi8	0,0736	0,5765	0,0529	1005,2000

Table 20. Parameters obtained for each recording

pi1



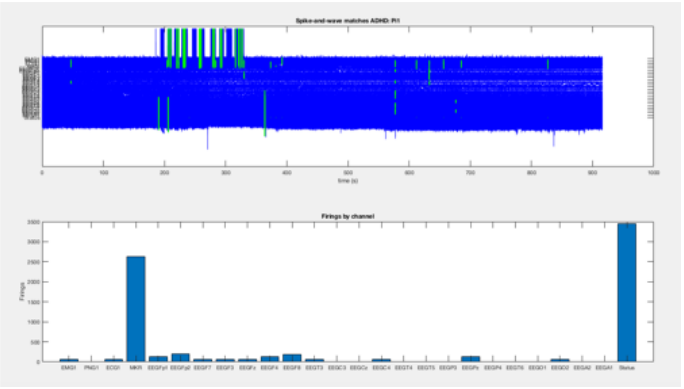
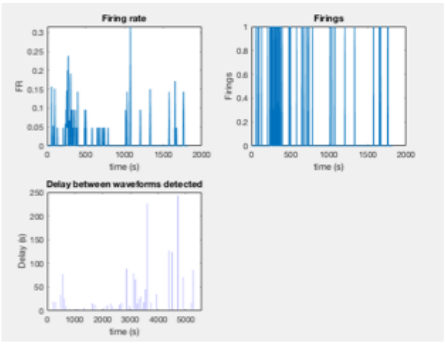


Figure 477, 478. (477) Firing rate, firings by time and delay between firings; (478) Spike-and-wave detections and firings by channel

pi2



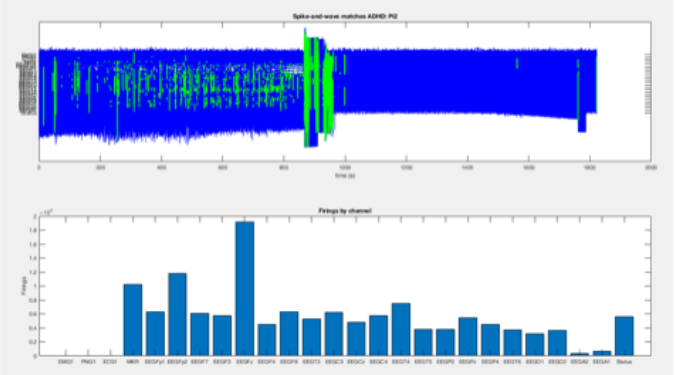
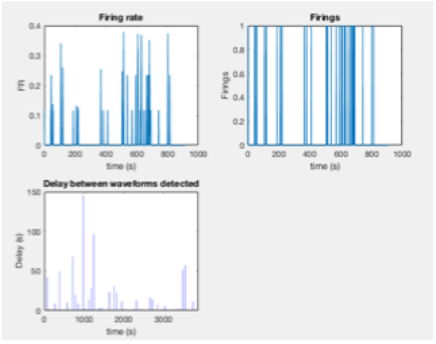


Figure 479, 480. (479) Firing rate, firings by time and delay between firings; (480) Spike-and-wave detections and firings by channel

pi3



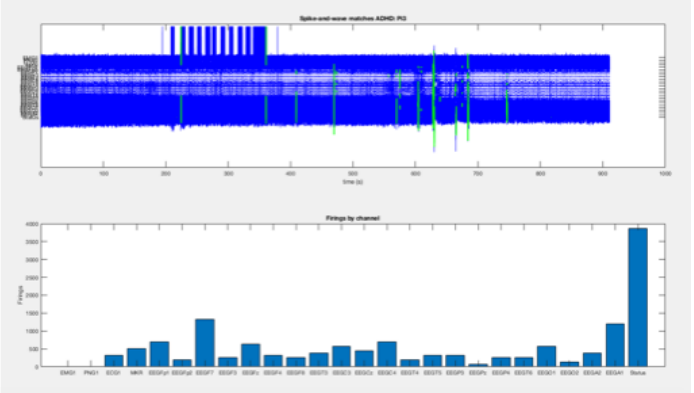
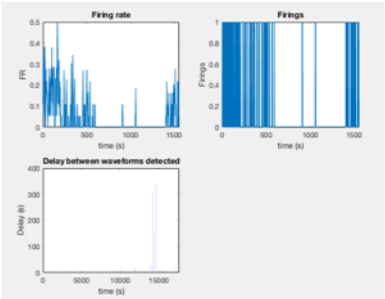


Figure 481, 482. (481) Firing rate, firings by time and delay between firings; (482) Spike-and-wave detections and firings by channel

pi4



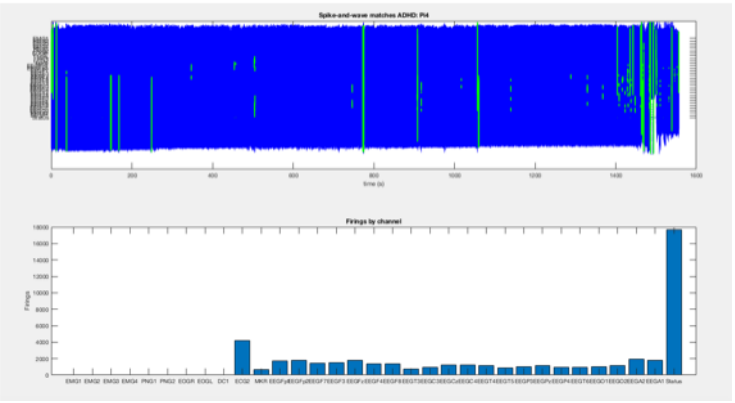
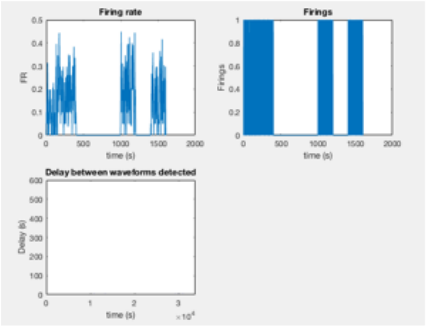


Figure 483, 484. (483) Firing rate, firings by time and delay between firings; (484) Spike-and-wave detections and firings by channel

pi5



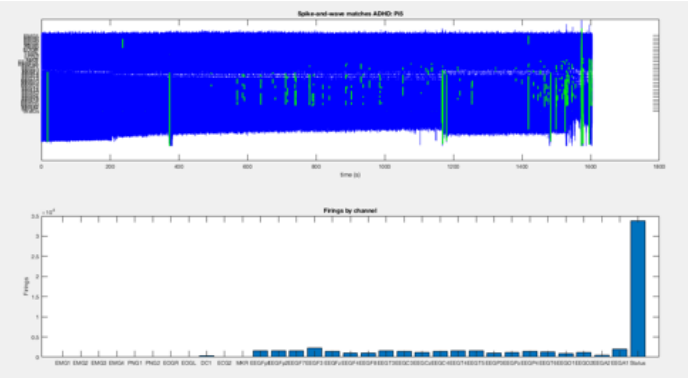
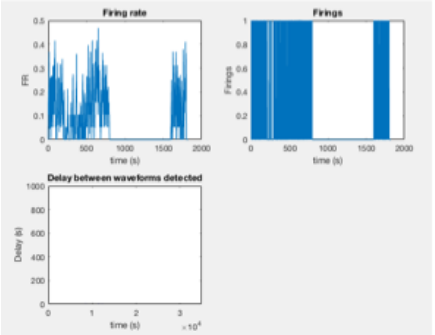


Figure 485, 486. (485) Firing rate, firings by time and delay between firings; (486) Spike-and-wave detections and firings by channel

pi6



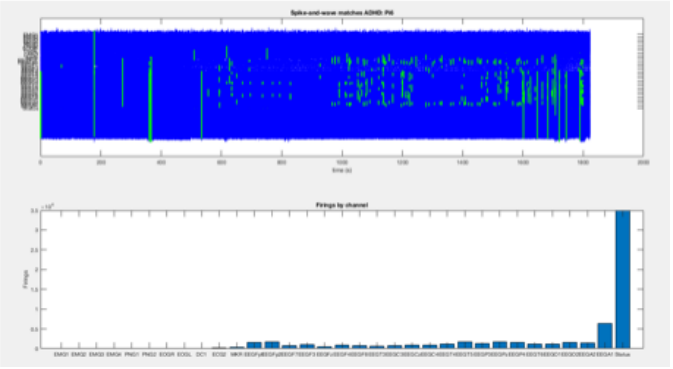


Figure 487, 488. (487) Firing rate, firings by time and delay between firings; (488) Spike-and-wave detections and firings by channel

pi7

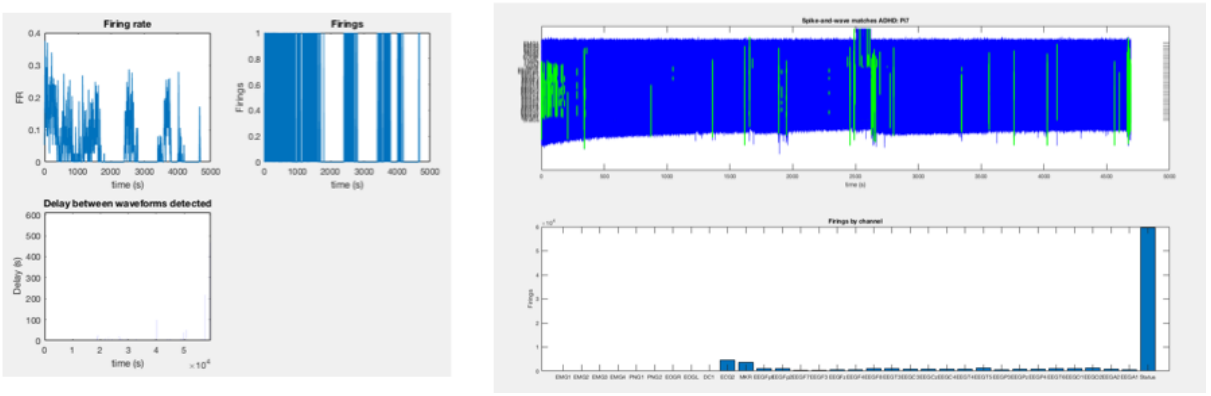


Figure 489, 490. (489) Firing rate, firings by time and delay between firings; (490) Spike-and-wave detections and firings by channel

pi8

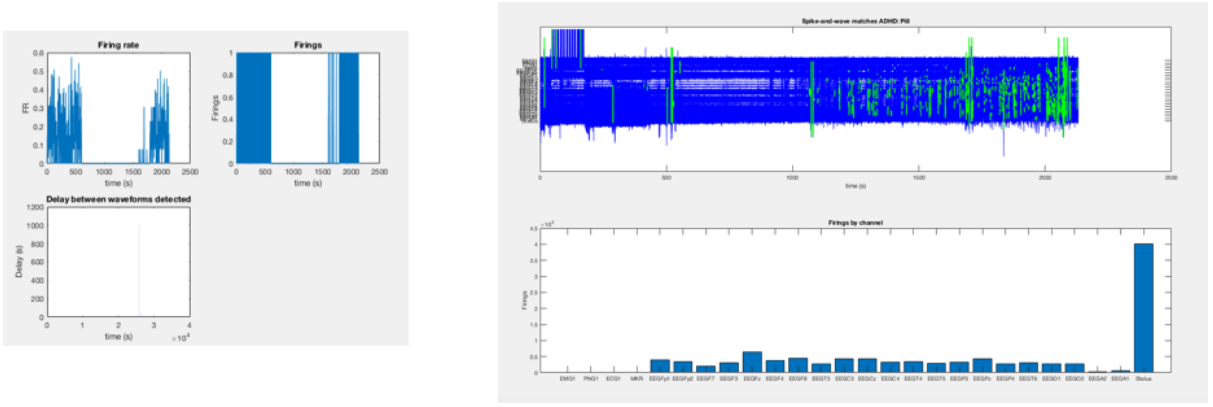


Figure 491, 492. (491) Firing rate, firings by time and delay between firings; (492) Spike-and-wave detections and firings by channel

Firing location evaluation

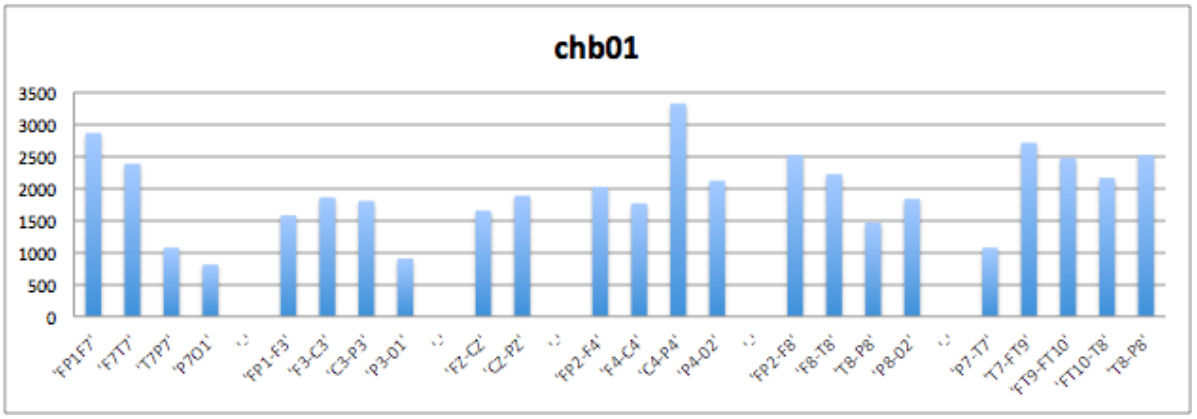


Figure 493. Amount of firings by EEG channel

The first patient shows firings overall the whole scalp.

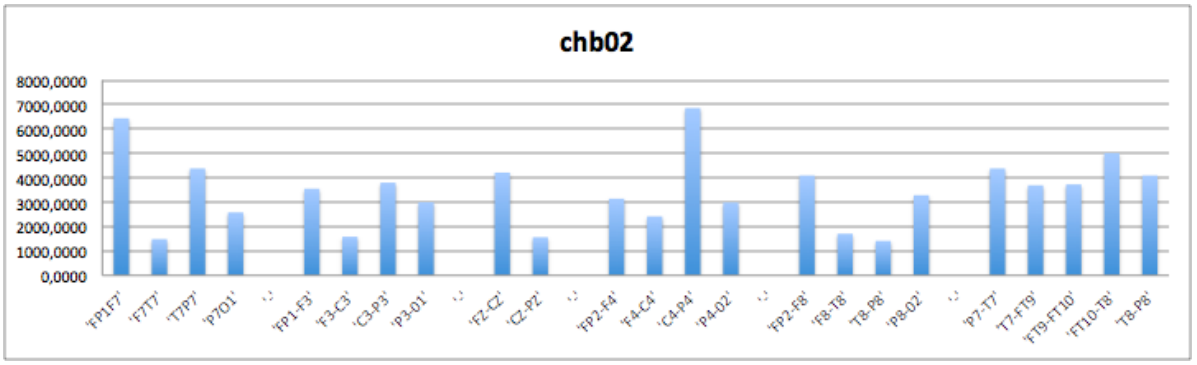


Figure 494. Amount of firings by EEG channel

The second patient also shows firings over all the scalp, with a greater amount on 'FP1F7' and 'C4-P4'. Moreover there can be seen similar values in the region of 'F7-T7, 'T7-FT9', 'FT9-FT10', 'FT10-T8' and 'T8-P8'.

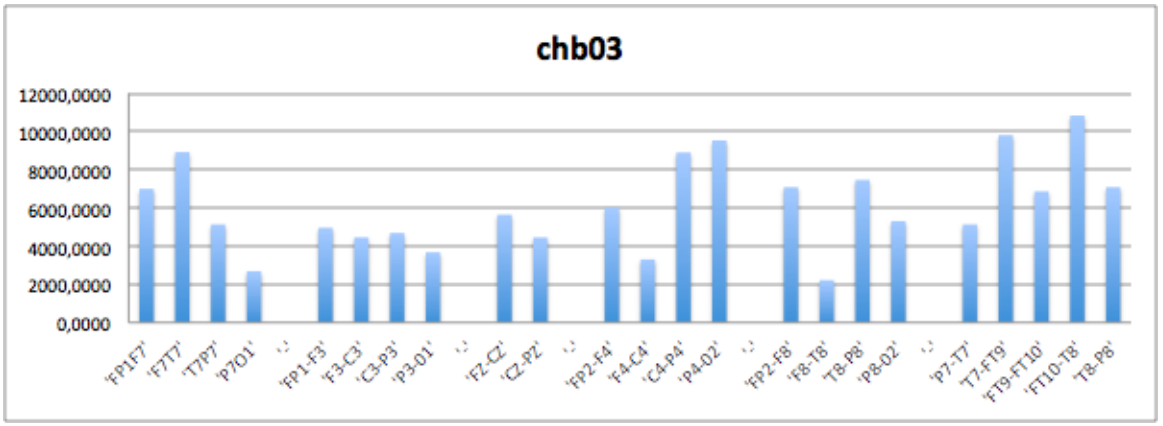


Figure 495. Amount of firings by EEG channel

The third patient shows a greater amount of firings in ‘F7T7’, ‘C4-P4’, ‘P4-02’, ‘T7-FT9’ and ‘FT10-T8’.

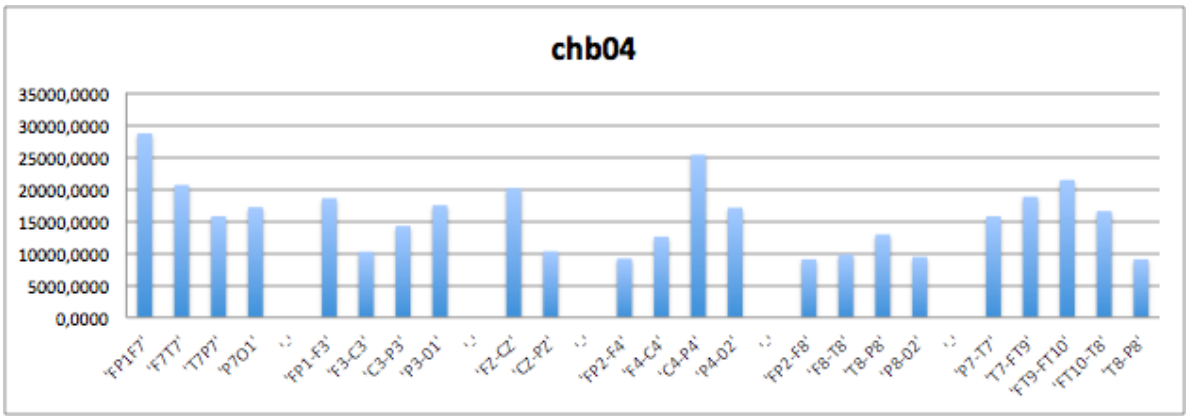


Figure 496. Amount of firings by EEG channel

As for chb04, the firing locations also stay around the same values, with a peak in ‘FP1F7’ and ‘C4-P4’.

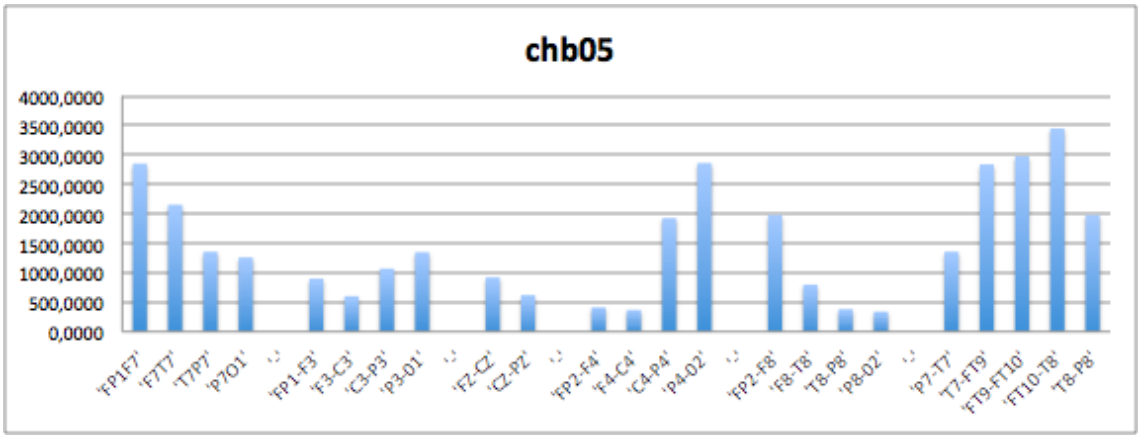


Figure 497. Amount of firings by EEG channel

The patient chb05 shows lower values on most channels in exception of ‘FP1-F7’, ‘C4-P4’, ‘P4-02’, ‘F7-T7, ‘T7-FT9’, ‘FT9-FT10’, ‘FT10-T8’ and ‘T8-P8’.

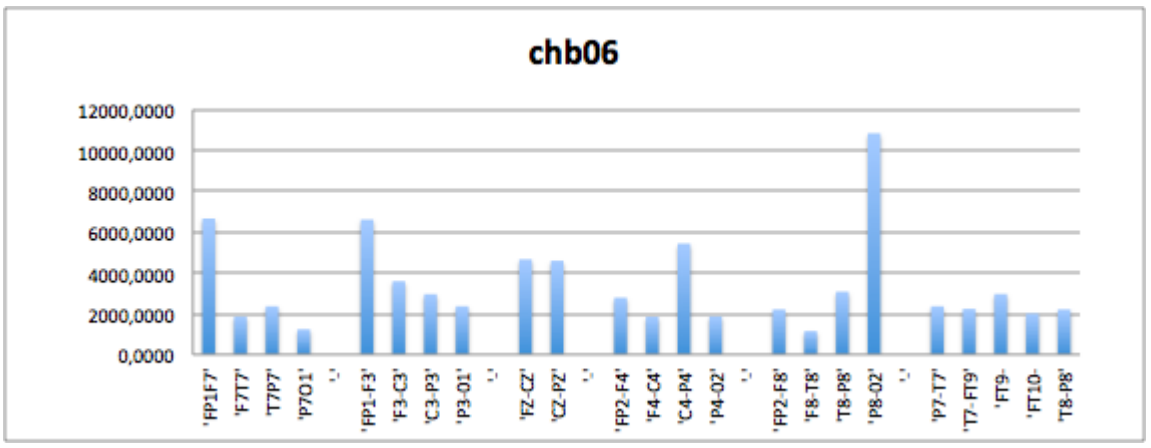


Figure 498. Amount of firings by EEG channel

As for chb06, the amount of firings is relatively quite low in exception for a high peak in 'P8-02' and higher values on 'FP1F7' and 'FP1-F3'.

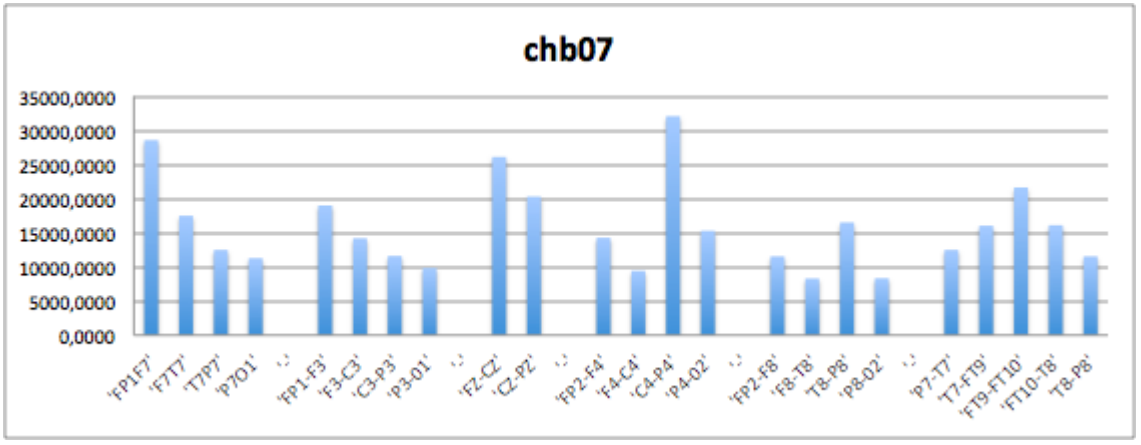


Figure 499. Amount of firings by EEG channel

The patient chb07 shows higher amounts of detections (similarly as chb04), while the other patients have lower detections. Overall, the values are quite constant with the exception of some peaks in 'FP1F7', 'FZ-CZ' and 'C4-P4'.

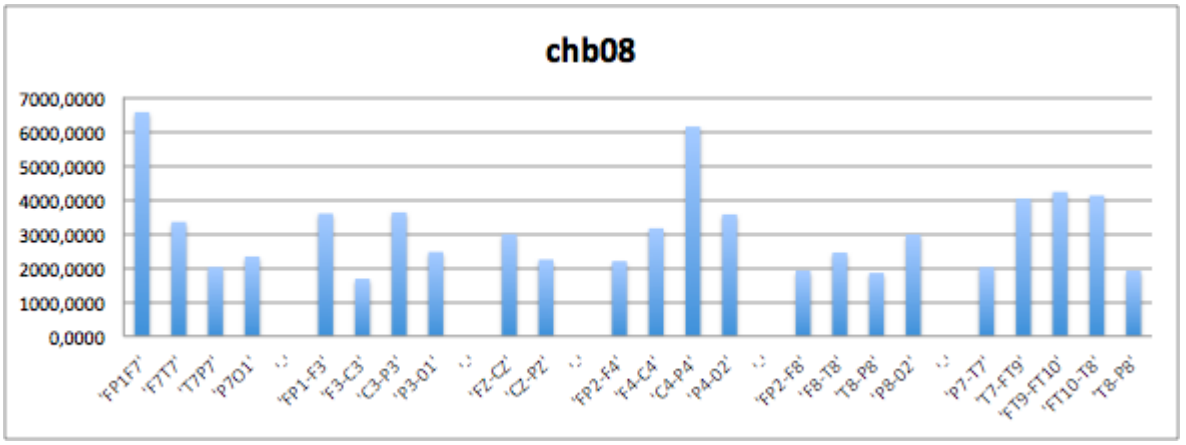


Figure 500. Amount of firings by EEG channel

Likewise, chb08 has constant firing detection values with the exception of 'FP1F7' and 'C4-P4'.

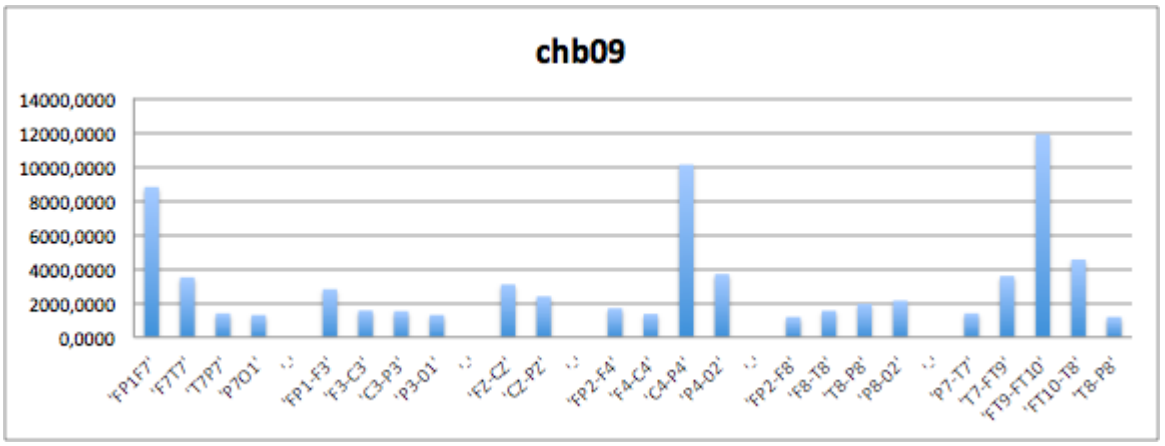


Figure 501. Amount of firings by EEG channel

As for the patient chb09, the detection values are very low, with the clear exception of the channels 'FP1F7', 'C4-P4' and 'FT9-FT10'.

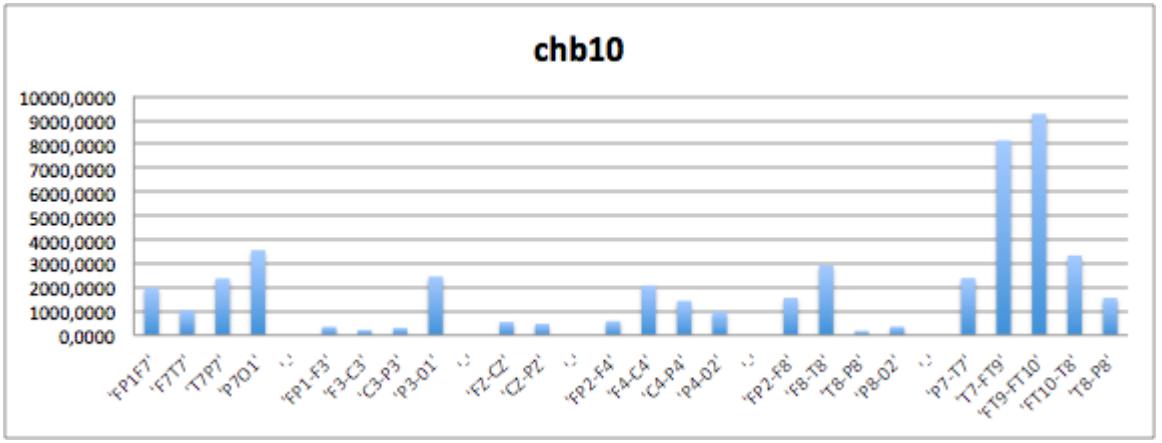


Figure 502. Amount of firings by EEG channel

Similarly, on chb10, the values are low, with clear peaks on 'T7-FT9', 'FT9-FT10', 'FT10-T8' and 'T8-P8'.

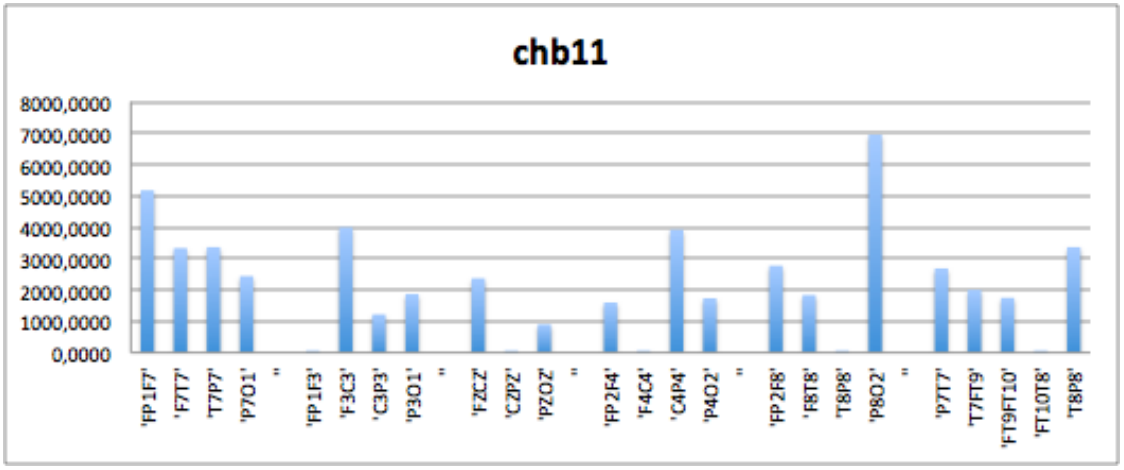


Figure 503. Amount of firings by EEG channel

In chb11, there are some channels like 'CZPZ', 'T8P8' and 'FT10T8' that have no firing detection, and some others with a greater amount like 'P802', 'C4P4', 'F3C3' and 'FP1F7'.

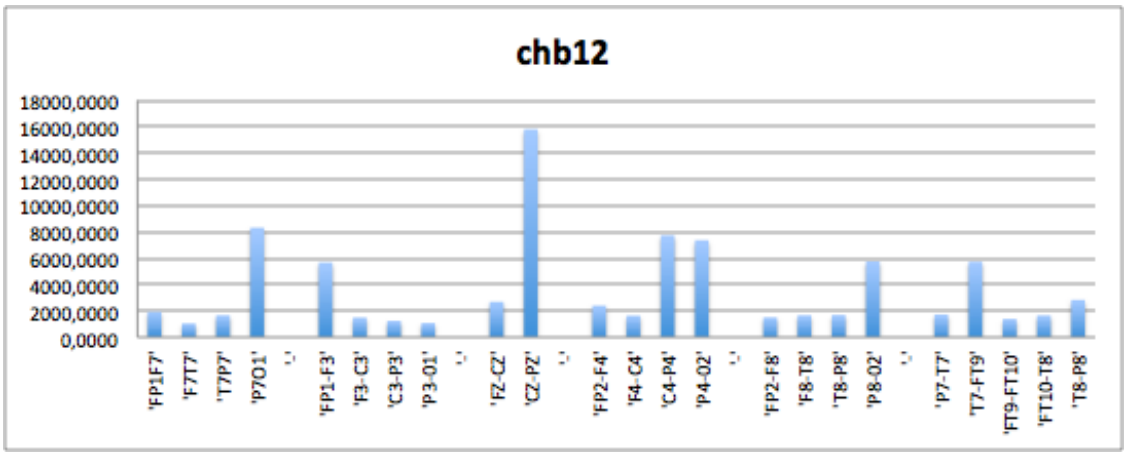


Figure 504. Amount of firings by EEG channel

Regarding the patient chb12, the values are also quite low with the exception of 'CZ-PZ'.

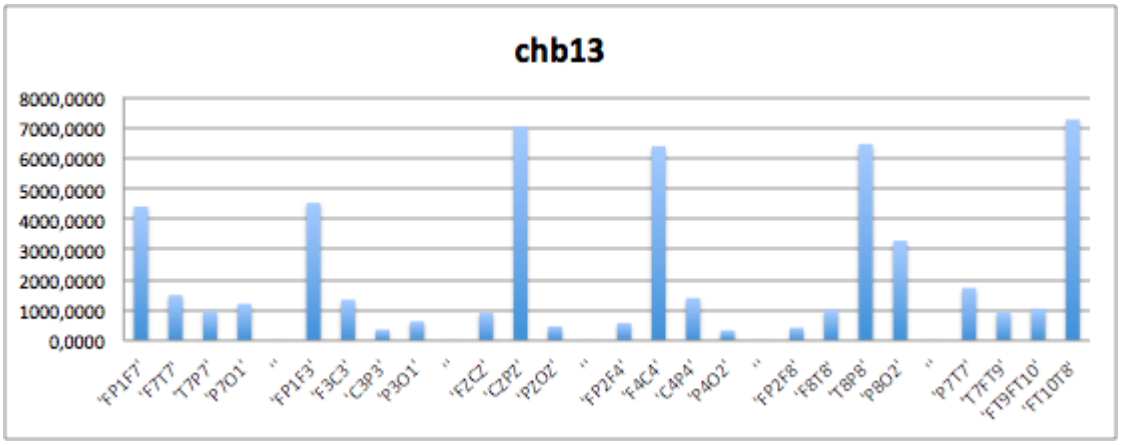


Figure 505. Amount of firings by EEG channel

On chb13, there can be seen some clear peaks on the channels 'FP1F7', 'FP1F3', 'CZPZ', 'F4C4', 'T8P8' and 'FT10T8'.

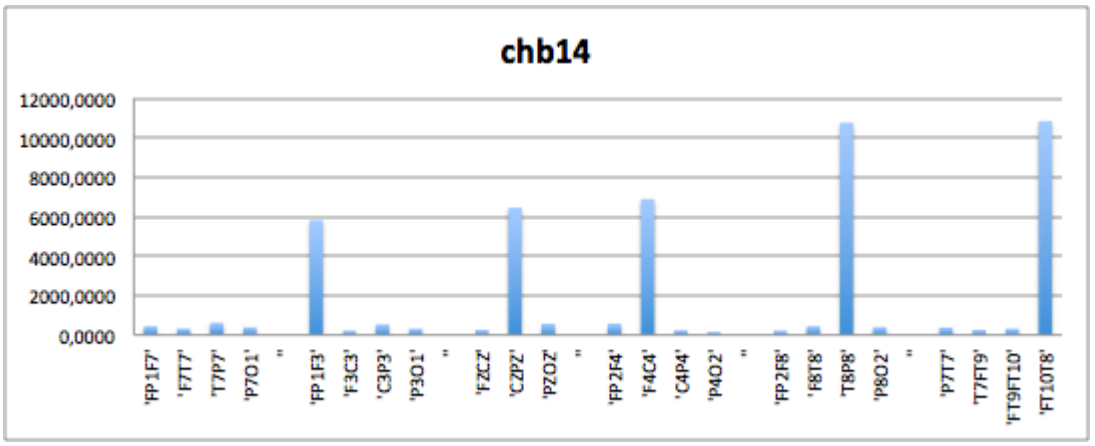


Figure 506. Amount of firings by EEG channel

Likewise, with the subject chb14, all the values are remarkably low, and the peaks are high on the channels 'FP1F3', 'CZPZ', 'F4C4', 'T8P8' and 'FT10T8'.

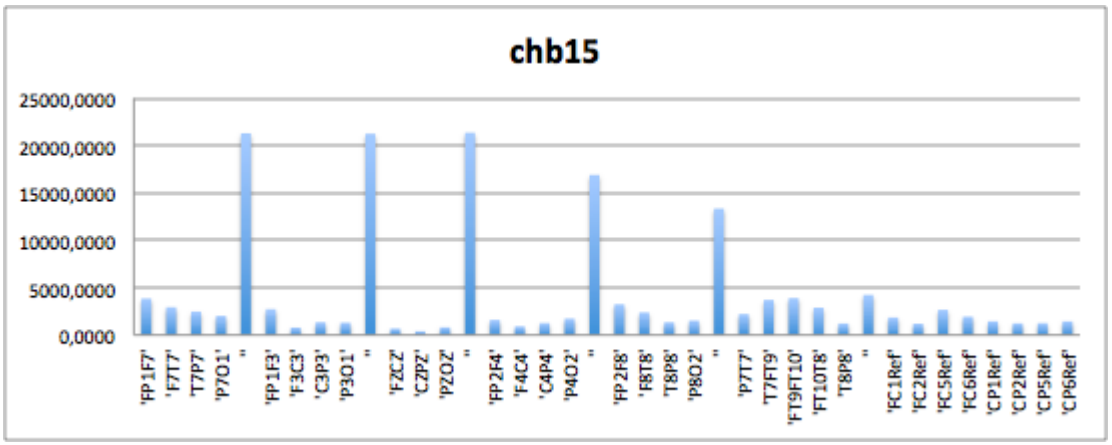


Figure 507. Amount of firings by EEG channel

chb15 also shows some clear peaks where there should not be any detection, so that could be because of a wrong algorithm functioning. But as it has already been mentioned, the same was applied for all the patients and to avoid such bad detections, it should have been done individually for each patient.

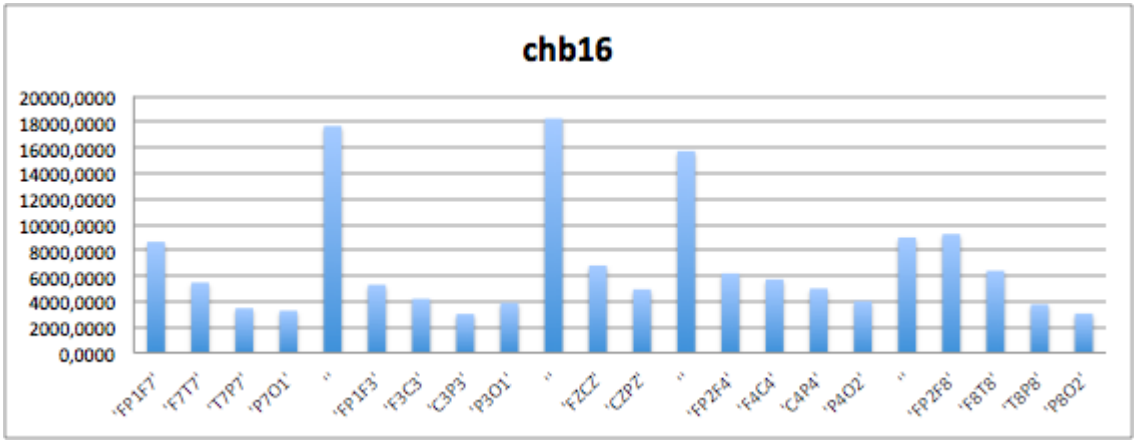


Figure 508. Amount of firings by EEG channel

The patient chb16 shows peaks on the non-specific channels, which could also be an algorithm error as previously seen on chb15.