Functional data

Framewise displacement (FD)

This measure indexes the movement of the head from one volume to the next, and is calculated as the sum of the absolute values of the differentiated realignment estimates (by backwards differences) at every timepoint (Power et al., 2012). FD for the first volume of a run is 0 by convention. The purpose of this measure is to index head movement, not to precisely calculate or model it.

Framewise displacement (FD) calculations

Differentiating head realignment parameters across frames yields a six dimensional timeseries that represents instantaneous head motion. To express instantaneous head motion as a scalar quantity we used the empirical formula, $FD_i = |\Delta d_{ix}| + |\Delta d_{iy}| + |\Delta d_{iz}| + |\Delta \alpha_i| + |\Delta \beta_i| + |\Delta \gamma_i|$, where $\Delta d_{ix} = d_{(i-1)x} - d_{ix}$, and similarly for the other rigid body parameters $[d_{ix}\ d_{iy}\ d_{iz}\ \alpha_i\ \beta_i\ \gamma_i]$. Rotational displacements were converted from degrees to millimeters by calculating displacement on the surface of a sphere of radius 50 mm, which is approximately the mean distance from the cerebral cortex to the center of the head.

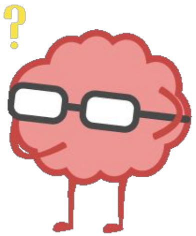
- From Power et al. (2012): "After studying the plots of dozens of healthy adults, values of **0.5 mm for framewise displacement** and **0.5% ΔBOLD for DVARS** were chosen to represent values well above the norm found in still subjects."
- Fair et al. (2013) used an even more stringent FD cut-off of 0.2 mm and DVARS cut-off of 0.4%

Power (2012) https://www.sciencedirect.com/science/article/pii/S1053811911011815

https://fmriprep.readthedocs.io/en/stable/outputs.html#functional-derivatives

Quality Check for fMRI data

Soyeon Kim, Mina Kwon



Quality Check with Cocoanlab pipeline!

Emotional Face Matching Task (EFAT) data

Steps

Behavior data

- Accuracy

Anatomical data

- Raw data

Functional data

- Outlier detection (spiking)
- Realignment (motion outliers)
- Coregistration

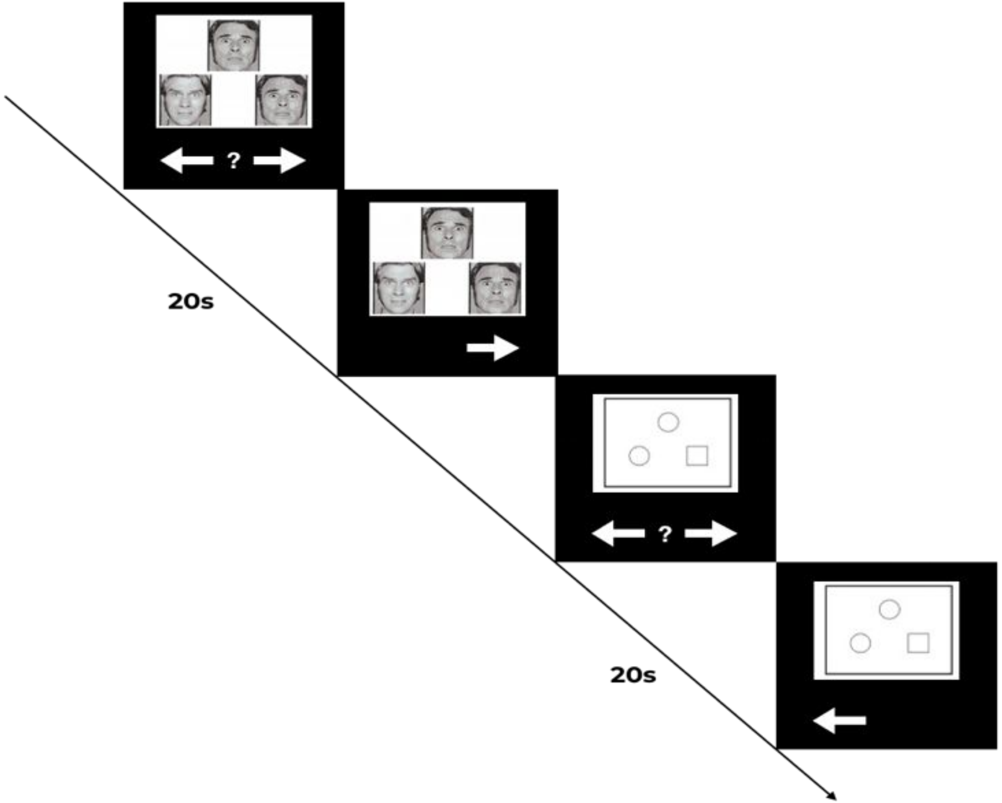
Tips

Making checklist!

Quality Checklist - Cocoanlab

Subject				Done?	Pass/Fail	%Spikes	Global SNR	FD	Notes
RDPT003	behavior		accuracy	✔					
	func	run-01	outlier detection (spiking)	✔		1.64	299.36		
			realignment (motion outliers)	✔				0.05	
			coregistration	✔					
		run-02	outlier detection (spiking)	✔		1.23	276.47		
			realignment (motion outliers)	✔				0.06	
			coregistration	✔					
RDPT004	behavior		accuracy	✔					
	func	run-01	outlier detection (spiking)	✔		2.05	567.39		
			realignment (motion outliers)	✔				0.04	
			coregistration	✔					
		run-02	outlier detection (spiking)	✔		3.69	356.87		
			realignment (motion outliers)	✔				0.05	
			coregistration	✔					
RDPT005	behavior		accuracy	✔					
	func	run-01	outlier detection (spiking)	✔		4.92	400.38		
			realignment (motion outliers)	✔				0.07	
			coregistration	✔					
		run-02	outlier detection (spiking)	✔		4.51	277.81		
			realignment (motion outliers)	✔				0.09	
			coregistration	✔					
RDPT006	behavior		accuracy	✔					
	func	run-01	outlier detection (spiking)						
			realignment (motion outliers)	✔				0.07	
			coregistration						
		run-02	outlier detection (spiking)						
			realignment (motion outliers)	✔	✕			0.25	
			coregistration						
RDPT007	behavior		accuracy	✔					
	func	run-01	outlier detection (spiking)	✔		5.33	432.92		
			realignment (motion outliers)	✔				0.09	
			coregistration	✔					
		run-02	outlier detection (spiking)	✔		3.28	363.77		
			realignment (motion outliers)	✔				0.09	

EFAT data



Healthy Control	Patient Group
41	110

Behavior data

	ID	Shapes_Acc	Angry_Acc	Happy_Acc	Fear_Acc	Sad_Acc	Shapes_RT	Angry_RT	Happy_RT	Fear_RT	Sad_RT	Emotions_A	Emotions_RT
2	RDPT003	0.95	1.00	1.00	1.00	0.92	1105.92	2179.49	1553.48	1935.20	2312.38	0.98	1995.14
3	RDPT004	0.93	0.88	1.00	1.00	0.92	849.73	1808.19	1496.69	2171.14	2222.75	0.95	1924.69
4	RDPT005	0.95	0.83	1.00	0.96	0.79	905.65	1336.12	1157.71	1169.26	1651.56	0.90	1328.66
5	RDPT006	0.94	0.88	1.00	1.00	0.63	741.44	1104.62	894.70	893.71	1832.75	0.88	1181.44
6	RDPT007	0.90	0.92	0.92	1.00	0.75	824.11	1613.30	1314.42	1351.64	2055.28	0.90	1583.66
7	RDPT009	0.85	0.88	0.96	0.96	0.54	1190.95	2060.34	1631.30	2257.74	2721.67	0.83	2167.76
8	RDPT010	0.93	1.00	1.00	1.00	0.96	870.16	1340.77	1123.76	1381.88	1863.86	0.99	1427.57
9	RDPT011	0.91	0.92	1.00	1.00	0.83	904.81	1699.09	1415.72	1485.91	1629.05	0.94	1557.44
10	RDPT013	0.92	0.67	0.92	0.88	0.79	828.99	1854.49	1728.37	1889.82	1975.46	0.81	1862.04
11	RDPT014	0.84	0.83	0.92	1.00	0.71	1182.53	2062.16	1651.45	1493.18	1939.59	0.86	1786.60
12	RDPT016	0.92	0.88	0.92	0.88	0.96	1092.16	2721.88	1652.62	2523.28	2155.56	0.91	2263.34
13	RDPT017	0.95	0.79	0.96	0.96	0.83	991.12	1612.27	1461.44	1507.76	1893.93	0.89	1618.85
14	RDPT018	0.91	0.96	1.00	1.00	0.96	868.15	1663.77	1130.98	1489.85	1813.38	0.98	1524.50
15	RDPT021	0.91	0.63	0.92	1.00	0.50	1155.98	2246.88	1936.10	2298.06	2733.59	0.76	2303.66
16	RDPT024	0.95	0.79	0.96	0.88	0.83	1220.81	2350.70	1620.61	2202.18	2178.48	0.86	2087.99
17	RDPT027	0.75	0.67	0.96	0.75	0.46	1458.32	2034.97	2111.45	2517.16	2191.11	0.71	2213.67
18	RDPT028	0.89	0.79	0.96	0.83	0.92	1360.20	1940.98	1714.63	1729.60	2132.48	0.88	1879.42
19	RDPT031	0.91	0.75	1.00	0.92	0.83	856.64	1304.25	1127.38	1262.58	1570.58	0.88	1316.20
20	RDPT033	0.97	0.83	1.00	1.00	0.83	1201.90	1768.63	1592.15	1703.80	2037.58	0.92	1775.54
21	RDPT034	0.99	0.96	1.00	1.00	1.00	1033.37	1500.74	1360.09	1656.81	1563.74	0.99	1520.35
22	RDPT037	0.93	0.92	0.96	0.92	0.83	948.18	1743.41	1591.40	1842.24	1886.89	0.91	1765.99
23	RDPT038	0.86	0.88	1.00	1.00	0.92	983.80	1536.45	1262.67	1433.20	1604.80	0.95	1459.28
24	RDPT042	0.88	0.88	0.92	0.92	0.75	659.47	920.21	782.54	845.96	856.54	0.86	851.31
25	RDPT043	0.93	0.88	1.00	1.00	0.83	868.22	1545.04	1388.38	1656.36	1807.47	0.93	1599.31
26	RDPT044	0.86	0.79	0.96	0.88	0.92	969.72	1194.35	1200.03	1372.11	1492.09	0.89	1314.64
27	RDPT045	0.92	0.92	1.00	0.88	0.83	1240.24	2389.01	1914.34	2399.69	2164.79	0.91	2216.96
28	RDPT047	0.92	0.79	0.96	1.00	0.79	941.16	1873.01	1761.93	1846.14	2209.27	0.89	1922.59
29	RDPT049	0.98	0.96	1.00	0.96	0.88	1054.58	1619.20	1640.80	1767.06	1750.38	0.95	1694.36
30	RDPT051	0.94	0.88	1.00	0.96	0.92	1017.70	1726.72	1458.47	1863.80	2440.70	0.94	1872.42
31	RDPT053	0.89	0.83	0.83	0.92	0.71	1567.24	2445.25	2185.34	2156.46	2242.53	0.82	2257.40
32	RDPT057	0.92	0.96	1.00	0.92	1.00	991.35	1351.30	1027.55	1562.84	1870.43	0.97	1453.03
33	RDPT058	0.91	0.83	1.00	1.00	0.71	1135.58	2268.25	1961.58	2185.48	2646.26	0.89	2265.39
34	RDPT060	0.93	0.83	1.00	1.00	0.92	902.78	1450.08	1154.53	1563.45	1574.31	0.94	1435.59
35	RDPT063	0.94	0.92	1.00	1.00	0.88	864.03	1687.28	1435.52	1650.03	2279.59	0.95	1763.11
36	RDPT066	0.92	0.71	1.00	0.92	0.71	1206.92	2330.92	1845.58	1754.15	2458.21	0.83	2097.21
37	RDPT068	0.97	1.00	1.00	1.00	0.92	932.50	1268.15	1256.60	1448.30	1538.96	0.98	1378.00
38	RDPT069	0.94	0.92	1.00	0.96	0.75	696.96	1582.45	1119.86	1567.50	1945.36	0.91	1553.79
39	RDPT074	0.89	0.79	0.92	0.88	0.96	1371.08	1548.69	1428.34	1338.49	1534.62	0.89	1462.53
40	RDPT075	0.95	0.88	1.00	1.00	0.92	980.99	1627.77	1211.43	1371.47	1845.86	0.95	1514.13
41	RDPT078	0.92	1.00	1.00	0.96	0.96	852.71	1727.78	1267.48	1679.30	1704.36	0.98	1594.73
42	RDPT080	0.90	0.79	1.00	1.00	0.83	617.38	972.23	783.75	858.90	1156.27	0.91	942.79
43	RDPT081	0.97	0.96	1.00	0.92	0.96	1116.09	2201.86	1560.00	2169.50	1950.93	0.96	1970.57
44	RDPT082	0.91	0.71	0.83	0.79	0.71	1078.65	1571.62	1365.67	1974.60	1785.80	0.76	1674.42
45	RDPT083	0.77	0.54	0.96	0.79	0.58	1295.22	2050.08	1601.10	2014.23	2335.23	0.72	2000.16
46	RDPT084	0.91	0.75	1.00	0.96	0.79	938.54	1537.94	1176.45	1625.67	1711.74	0.88	1512.95
47	RDPT086	0.98	0.92	1.00	1.00	1.00	828.95	1178.11	1047.84	1155.57	1309.83	0.98	1172.84
48	RDPT087	0.93	0.83	1.00	0.83	0.88	978.73	1440.41	1078.10	1749.95	1787.06	0.89	1513.88
49	RDPT089	0.94	0.79	1.00	0.88	0.88	1208.11	2574.26	1927.47	2349.40	2614.28	0.89	2366.35
50	RDPT095	0.97	0.92	1.00	1.00	0.79	728.79	1212.30	875.23	1223.02	1139.60	0.93	1112.54
51	RDPT096	0.94	0.83	0.96	0.83	0.63	583.87	905.92	869.65	983.65	1020.05	0.81	944.82
52	RDPT097	0.93	0.75	1.00	0.96	0.83	848.25	2150.13	1159.20	1944.70	2142.43	0.89	1849.12
53	RDPT101	0.95	0.79	1.00	1.00	0.79	859.07	1411.55	1448.15	1656.21	1935.23	0.90	1612.79
54	RDPT102	0.93	0.83	0.88	0.88	0.75	987.83	2328.74	1769.53	2329.06	1983.53	0.83	2102.71
55	RDPT103	0.93	0.96	1.00	0.92	0.88	698.79	1641.33	1435.02	1497.24	1531.48	0.94	1526.27
56	RDPT104	0.94	0.83	1.00	0.92	0.92	721.21	1375.51	1353.69	1417.62	1703.90	0.92	1462.68
57	RDPT105	0.91	0.88	1.00	1.00	0.83	910.69	1748.82	1382.48	1421.80	1753.08	0.93	1576.54
58	RDPT106	0.96	0.88	1.00	1.00	0.83	845.61	1280.13	1146.10	1323.52	1400.95	0.93	1287.68
59	RDPT108	0.99	0.92	1.00	0.96	0.92	1050.11	1371.19	1153.00	1224.02	1583.61	0.95	1332.95
60	RDPT109	0.86	0.83	1.00	1.00	0.92	903.96	1693.70	1484.03	1986.03	2610.14	0.94	1943.48
61	RDPT110	0.92	0.88	1.00	0.96	0.92	832.69	1184.96	1196.25	1377.90	1512.79	0.94	1317.97
62	RDPT113	0.95	0.92	1.00	0.96	0.88	936.36	1734.95	1365.75	1680.81	2390.66	0.94	1793.04
63	RDPT114	0.94	0.96	0.96	1.00	0.88	712.78	1448.43	1248.79	1253.98	1645.45	0.95	1399.16
64	RDPT117	0.86	0.83	1.00	0.83	0.83	907.22	1551.29	1064.63	1240.00	1447.00	0.88	1325.73
65	RDPT118	0.93	0.96	0.96	1.00	0.96	1007.50	1371.70	1076.64	1372.23	1736.39	0.97	1389.24
66	RDPT120	0.93	0.92	1.00	1.00	0.88	811.48	1976.85	1441.74	1562.85	2081.16	0.95	1765.65
67	RDPT121	0.95	0.92	1.00	1.00	0.96	1017.10	1934.18	1466.91	2205.91	2131.72	0.97	1934.68
68	RDPT124	0.90	0.79	1.00	1.00	0.75	737.51	1144.71	1016.46	1092.05	1347.58	0.89	1150.20
69	RDPT125	0.84	0.79	0.79	0.83	0.88	1201.09	1570.58	1704.04	1657.50	2051.53	0.82	1745.91
70	RDPT127	0.94	0.96	1.00	0.83	0.88	1123.55	2011.93	1721.65	2212.93	2082.31	0.92	2007.20
71	RDPT128	0.90	0.88	0.96	1.00	0.96	1037.74	1557.43	1539.67	1902.65	1838.35	0.95	1709.52
72	RDPT129	0.86	0.88	0.96	0.88	0.92	1003.62	1596.56	1146.03	1401.21	2027.16	0.91	1542.74
73	RDPT130	0.48	0.38	0.50	0.46	0.38	1177.52	2683.92	2190.91	2763.93	2807.87	0.43	2611.66
74	RDPT131	0.90	0.96	1.00	1.00	0.88	872.46	1520.70	1242.15	1450.03	1667.26	0.96	1470.04
75	RDPT132	0.95	1.00	1.00	1.00	0.92	832.10	1291.69	973.23	1349.41	1531.51	0.98	1286.46
76	RDPT134	0.92	0.79	1.00	1.00	0.83	1034.85	1603.72	1438.13	1893.34	1756.54	0.91	1672.93
77	RDPT136	0.93	0.96	1.00	1.00	0.83	682.07	1188.28	969.98	1114.98	1185.97	0.95	1114.80

	Shapes	Angry	Happy	Fear	Sad
Average	0.91	0.85	0.96	0.93	0.83
Std	0.08	0.12	0.08	0.10	0.12
Lower bound	0.76	0.61	0.79	0.74	0.59

accuracy

- lower than Mean - 2*SD
- 3 or more

Behavior data

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	ID	Shapes_Acc	Angry_Acc	Happy_Acc	Fear_Acc	Sad_Acc	Shapes_RT	Angry_RT	Happy_RT	Fear_RT	Sad_RT	Emotions_A	Emotions_RT
2	RDPT003	0.95	1.00	1.00	1.00	0.92	1105.92	2179.49	1553.48	1935.20	2312.38	0.98	1995.14
3	RDPT004	0.93	0.88	1.00	1.00	0.92	849.73	1808.19	1496.69	2171.14	2222.75	0.95	1924.69
4	RDPT005	0.95	0.83	1.00	0.96	0.79	905.65	1336.12	1157.71	1169.26	1651.56	0.90	1328.66
5	RDPT006	0.94	0.88	1.00	1.00	0.63	741.44	1104.62	894.70	893.71	1832.75	0.88	1181.44
6	RDPT007	0.90	0.92	0.92	1.00	0.75	824.11	1613.30	1314.42	1351.64	2055.28	0.90	1583.66
7	RDPT009	0.85	0.88	0.96	0.96	0.54	1190.95	2060.34	1631.30	2257.74	2721.67	0.83	2167.76
8	RDPT010	0.93	1.00	1.00	1.00	0.96	870.16	1340.77	1123.76	1381.88	1863.86	0.99	1427.57
9	RDPT011	0.91	0.92	1.00	1.00	0.83	904.81	1699.09	1415.72	1485.91	1629.05	0.94	1557.44
10	RDPT013	0.92	0.67	0.92	0.88	0.79	828.99	1854.49	1728.37	1889.82	1975.46	0.81	1862.04
11	RDPT014	0.84	0.83	0.92	1.00	0.71	1182.53	2062.16	1651.45	1493.18	1939.59	0.86	1786.60
12	RDPT016	0.92	0.88	0.92	0.88	0.96	1092.16	2721.88	1652.62	2523.28	2155.56	0.91	2263.34
13	RDPT017	0.95	0.79	0.96	0.96	0.83	991.12	1612.27	1461.44	1507.76	1893.93	0.89	1618.85
14	RDPT018	0.91	0.96	1.00	1.00	0.96	868.15	1663.77	1130.98	1489.85	1813.38	0.98	1524.50
15	RDPT021	0.91	0.63	0.92	1.00	0.50	1155.98	2246.88	1936.10	2298.06	2733.59	0.76	2303.66
16	RDPT024	0.95	0.79	0.96	0.88	0.83	1220.81	2350.70	1620.61	2202.18	2178.48	0.86	2087.99
17	RDPT027	0.75	0.67	0.96	0.75	0.46	1458.32	2034.97	2111.45	2517.16	2191.11	0.71	2213.67
18	RDPT028	0.89	0.79	0.96	0.83	0.92	1360.20	1940.98	1714.63	1729.60	2132.48	0.88	1879.42
19	RDPT031	0.91	0.75	1.00	0.92	0.83	856.64	1304.25	1127.38	1262.58	1570.58	0.88	1316.20
20	RDPT033	0.97	0.83	1.00	1.00	0.83	1201.90	1768.63	1592.15	1703.80	2037.58	0.92	1775.54
21	RDPT034	0.99	0.96	1.00	1.00	1.00	1033.37	1500.74	1360.09	1656.81	1563.74	0.99	1520.35
22	RDPT037	0.93	0.92	0.96	0.92	0.83	948.18	1743.41	1591.40	1842.24	1886.89	0.91	1765.99
23	RDPT038	0.86	0.88	1.00	1.00	0.92	983.80	1536.45	1262.67	1433.20	1604.80	0.95	1459.28
24	RDPT042	0.88	0.88	0.92	0.92	0.75	659.47	920.21	782.54	845.96	856.54	0.86	851.31
25	RDPT043	0.93	0.88	1.00	1.00	0.83	868.22	1545.04	1388.38	1656.36	1807.47	0.93	1599.31
26	RDPT044	0.86	0.79	0.96	0.88	0.92	969.72	1194.35	1200.03	1372.11	1492.09	0.89	1314.64
27	RDPT045	0.92	0.92	1.00	0.88	0.83	1240.24	2389.01	1914.34	2399.69	2164.79	0.91	2216.96
28	RDPT047	0.92	0.79	0.96	1.00	0.79	941.16	1873.01	1761.93	1846.14	2209.27	0.89	1922.59
29	RDPT049	0.98	0.96	1.00	0.96	[illegible]	1054.58	[illegible]	1640.80	1767.06	1750.38	[illegible]	1694.36
30	RDPT051	0.94	0.88	1.00	0.96	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.94	[illegible]
31	RDPT053	0.89	0.83	0.83	0.92	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.82	[illegible]
32	RDPT057	0.92	0.96	[illegible]	[illegible]	1.00	991.35	1351.30	[illegible]	1562.84	1870.43	0.97	1453.03
33	RDPT058	0.91	0.83	[illegible]	[illegible]	0.71	1135.58	2268.25	1961.58	2185.48	2646.26	0.89	2265.39
34	RDPT060	0.93	0.83	[illegible]	[illegible]	0.92	902.78	1450.08	1154.53	1563.45	1574.31	0.94	1435.59
35	RDPT063	0.94	0.92	[illegible]	[illegible]	0.88	864.03	1687.28	1435.52	1650.03	2279.59	0.95	1763.11
36	RDPT066	0.92	0.71	1.00	0.92	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.83	2097.21
37	RDPT068	0.97	1.00	1.00	1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
38	RDPT069	0.94	0.92	1.00	0.96	0.75	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
39	RDPT074	0.89	0.79	0.92	0.88	0.96	1371.08	1548.69	1428.34	[illegible]	1534.62	[illegible]	1462.53
40	RDPT075	0.95	0.88	1.00	1.00	0.92	980.99	1627.77	1211.43	1371.47	1845.86	0.95	1514.13
41	RDPT078	0.92	1.00	1.00	0.96	0.96	852.71	1727.78	1267.48	1679.30	1704.36	0.98	1594.73
42	RDPT080	0.90	0.79	1.00	1.00	0.83	617.38	972.23	783.75	858.90	1156.27	0.91	942.79
43	RDPT081	0.97	0.96	1.00	0.92	0.96	1116.09	2201.86	1560.00	2169.50	1950.93	0.96	1970.57
44	RDPT082	0.91	0.71	0.83	0.79	0.71	1078.65	1571.62	1365.67	1974.60	1785.80	0.76	1674.42
45	RDPT083	0.77	0.54	0.96	0.79	0.58	1295.22	2050.08	1601.10	2014.23	2335.23	0.72	2000.16
46	RDPT084	0.91	0.75	1.00	0.96	0.79	938.54	1537.94	1176.45	1625.67	1711.74	0.88	1512.95
47	RDPT086	0.98	0.92	1.00	1.00	1.00	828.95	1178.11	1047.84	1155.57	1309.83	0.98	1172.84
48	RDPT087	0.93	0.83	1.00	0.83	0.88	978.73	1440.41	1078.10	1749.95	1787.06	0.89	1513.88
49	RDPT089	0.94	0.79	1.00	0.88	0.88	1208.11	2574.26	1927.47	2349.40	2614.28	0.89	2366.35
50	RDPT095	0.97	0.92	1.00	1.00	0.79	728.79	1212.30	875.23	1223.02	1139.60	0.93	1112.54
51	RDPT096	0.94	0.83	0.96	0.83	0.63	583.87	905.92	869.65	983.65	1020.05	0.81	944.82
52	RDPT097	0.93	0.75	1.00	0.96	0.83	848.25	2150.13	1159.20	1944.70	2142.43	0.89	1849.12
53	RDPT101	0.95	0.79	1.00	1.00	0.79	859.07	1411.55	1448.15	1656.21	1935.23	0.90	1612.79
54	RDPT102	0.93	0.83	0.88	0.88	0.75	987.83	2328.74	1769.53	2329.06	1983.53	0.83	2102.71
55	RDPT103	0.93	0.96	1.00	0.92	0.88	698.79	1641.33	1435.02	1497.24	1531.48	0.94	1526.27
56	RDPT104	0.94	0.83	1.00	0.92	0.92	721.21	1375.51	1353.69	1417.62	1703.90	0.92	1462.68
57	RDPT105	0.91	0.88	1.00	1.00	0.83	910.69	1748.82	1382.48	1421.80	1753.08	0.93	1576.54
58	RDPT106	0.96	0.88	1.00	1.00	0.83	845.61	1280.13	1146.10	1323.52	1400.95	0.93	1287.68
59	RDPT108	0.99	0.92	1.00	0.96	0.92	1050.11	1371.19	1153.00	1224.02	1583.61	0.95	1332.95
60	RDPT109	0.86	0.83	1.00	1.00	0.92	903.96	1693.70	1484.03	1986.03	2610.14	0.94	1943.48
61	RDPT110	0.92	0.88	1.00	0.96	0.92	832.69	1184.96	1196.25	1377.90	1512.79	0.94	1317.97
62	RDPT113	0.95	0.92	1.00	0.96	0.88	936.36	1734.95	1365.75	1680.81	2390.66	0.94	1793.04
63	RDPT114	0.94	0.96	0.96	1.00	0.88	712.78	1448.43	1248.79	1253.98	1645.45	0.95	1399.16
64	RDPT117	0.86	0.83	1.00	0.83	0.83	907.22	1551.29	1064.63	1240.00	1447.00	0.88	1325.73
65	RDPT118	0.93	0.96	0.96	1.00	0.96	1007.50	1371.70	1076.64	1372.23	1736.39	0.97	1389.24
66	RDPT120	0.93	0.92	1.00	1.00	0.88	811.48	1976.85	1441.74	1562.85	2081.16	0.95	1765.65
67	RDPT121	0.95	0.92	1.00	1.00	0.96	1017.10	1934.18	1466.91	2205.91	2131.72	0.97	1934.68
68	RDPT124	0.90	0.79	1.00	1.00	0.75	737.51	1144.71	1016.46	1092.05	1347.58	0.89	1150.20
69	RDPT125	0.84	0.79	0.79	0.83	0.88	1201.09	1570.58	1704.04	1657.50	2051.53	0.82	1745.91
70	RDPT127	0.94	0.96	1.00	0.83	0.88	1123.55	2011.93	1721.65	2212.93	2082.31	0.92	2007.20
71	RDPT128	0.90	0.88	0.96	1.00	0.96	1037.74	1557.43	1539.67	1902.65	1838.35	0.95	1709.52
72	RDPT129	0.86	0.88	0.96	0.88	0.92	1003.62	1596.56	1146.03	1401.21	2027.16	0.91	1542.74
73	RDPT130	0.48	0.38	0.50	0.46	0.38	1177.52	2683.92	2190.91	2763.93	2807.87	0.43	2611.66
74	RDPT131	0.90	0.96	1.00	1.00	0.88	872.46	1520.70	1242.15	1450.03	1667.26	0.96	1470.04
75	RDPT132	0.95	1.00	1.00	1.00	0.92	832.10	1291.69	973.23	1349.41	1531.51	0.98	1286.46
76	RDPT134	0.92	0.79	1.00	1.00	0.83	1034.85	1603.72	1438.13	1893.34	1756.54	0.91	1672.93
77	RDPT136	0.93	0.96	1.00	1.00	0.83	682.07	1188.28	969.98	1114.98	1185.97	0.95	1114.80

	Shapes	Angry	Happy	Fear	Sad
Average	0.91	0.85	0.96	0.93	0.83
Std	0.08	0.12	0.08	0.10	0.12
Lower bound	0.76	0.61	0.79	0.74	0.59

Healthy control: 2

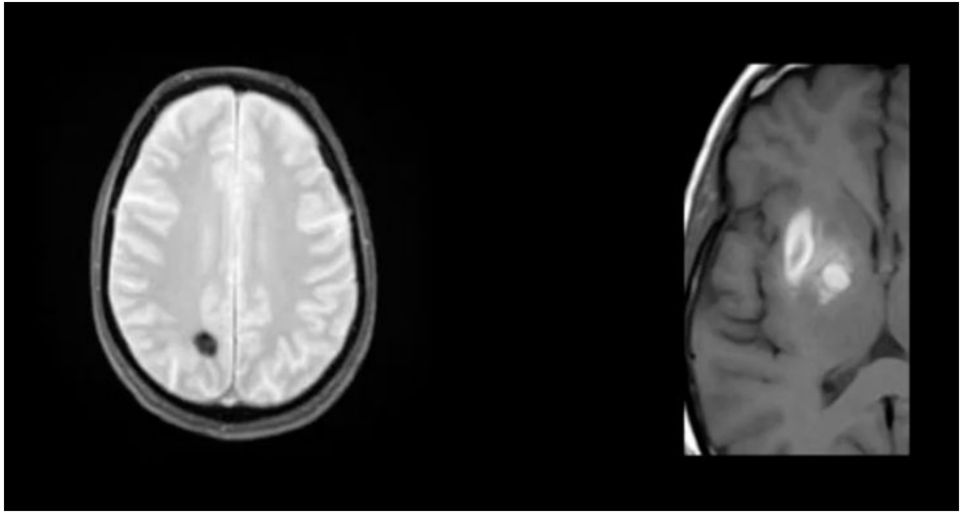
Patient group: 4

accuracy

- lower than Mean - 2*SD
- 3 or more

Anatomical data

Artifacts in raw images



➔ coregistration

https://www.youtube.com/watch?v=fvv2dr3pT7I

Functional data

Steps

PART 1 (a1-a4)

DICOM to NIFTI
in a BIDS format

- a1: Make directory
- a2: Structural
- a3: Functional
- a4: Fieldmap

PART 2 (b1-b3)

Functional images
QC (outlier detection)

b1: Make directories

b2: implicit mask and mean images
- create an implicit mask image
- save mean images and SBRef (before preproc) as png in qc directories

b3: outlier detection
- outlier detection based on 1) mahalanobis distance across global mean for slices and spatial STD for slices, as in scn_session_spike_id.m 2) root-mean-square successive differences between images

PART 3 (b4-b6)

Functional images
Slice timing, motion, distortion correction

b4: slice timing correction
- It works with multi-band sequence
- It reads the actual acquisition timing from dicom header.

b5: motion correction (realignment)
- It uses the first functional image or SBRef (you can choose) as a reference.
- It saves 6 movement parameters for each run

b6: distortion correction (using FSL's topup)

PART 4 (b7-b8)

Structural and functional images
Coregistration, normalization, smoothing

b7: coregistration
- coregistration between T1 and mean functional images or SBRef image (you can choose).

b8: normalization
- segmentation of the coregistered T1 image using SPM12's tissue probability map (TPM.nii)
- warping segmented (and coregistered) T1 image to MNI template
- applying the warping parameter to the functional images

PART 5 (b9-b10)

Functional images
Smoothing and ICA-AROMA

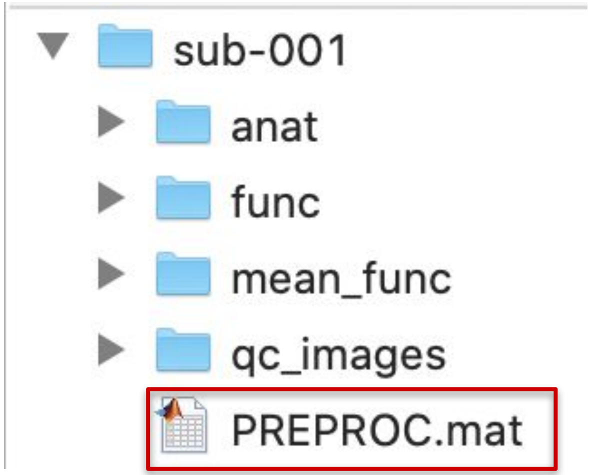
b9: smoothing
- smoothing functional images with the FWHM 5 mm smoothing kernel.

b10: ICA-AROMA
- A data-driven method to identify and remove motion-related independent components from functional MRI data.
- https://github.com/rhr-pruim/ICA-AROMA

Functional data

Steps

```
%% PART3:

% B-1. Preproc directories
SY_b1_preproc_directories(subject_code, study_imaging_dir, run_n, func_tasks); %'forced_save', 'no_save'
```



PREPROC

1x1 struct with 11 fields

Field ▲	Value
study_imaging_dir	'/data/EFAT/imaging/HC'
study_rawdata_dir	'/data/EFAT/imaging/HC'
subject_code	'sub-001'
subject_dir	'/data/EFAT/imaging/HC/sub-001'
anat_nii_files	*1x1 cell*
func_bold_files	*2x1 cell*
preproc_outputdir	'/data/EFAT/imaging/HC/sub-001'
preproc_func_dir	'/data/EFAT/imaging/HC/sub-001/func'
preproc_mean_func_dir	'/data/EFAT/imaging/HC/sub-001/mean_func'
preproc_anat_dir	'/data/EFAT/imaging/HC/sub-001/anat'
qcdir	'/data/EFAT/imaging/HC/sub-001/qc_images'

Functional data

Steps

PART 1 (a1-a4)

DICOM to NIFTI
in a [illegible]IDS format

- a1: [illegible]ectory
- a2: S[illegible]ral
- a3[illegible]l
- [illegible]ieldma[illegible]

PART 2 (b1-b3)

Functional images
QC (outlier detection)

b1: Make directories

b2: implicit mask and mean images
- create an implicit mask image
- save mean images and SBRef (before preproc) as png in qc directories

b3: outlier detection
- outlier detection based on 1) mahalanobis distance across global mean for slices and spatial STD for slices, as in scn_session_spike_id.m 2) root-mean-square successive differences between images

PART 3 (b4-b6)

Functional images
Slice timing, motion, distortion correction

b4: slice timing correction
- It works with multi-band sequence
- It reads the actual acquisition timing from dicom header.

b5: motion correction (realignment)
- It uses the first functional image or SBRef (you can choose) as a reference.
- It saves 6 movement parameters for each run

b6: distortion correction (using FSL's topup)

PART 4 (b7-b8)

Structural and functional images
Coregistration, normalization, smoothing

b7: coregistration
- coregistration between T1 and mean functional images or SBRef image (you can choose).

b8: normalization
- segmentation of the coregistered T1 image using SPM12's tissue probability map (TPM.nii)
- warping segmented (and coregistered) T1 image to MNI template
- applying the warping parameter to the functional images

PART 5 (b9-b10)

Functional images
Smoothing and ICA-AROMA

b9: smoothing
- smoothing functional images with the FWHM 5 mm smoothing kernel.

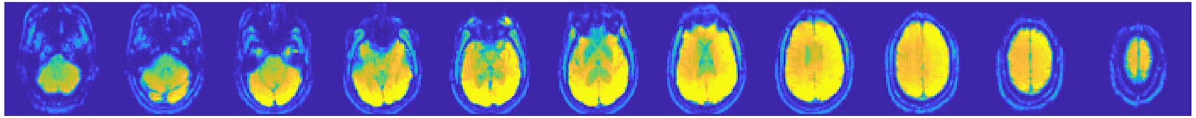
b10: ICA-AROMA
- A data-driven method to identify and remove motion-related independent components from functional MRI data.
- https://github.com/rhr-pruim/ICA-AROMA

Functional data

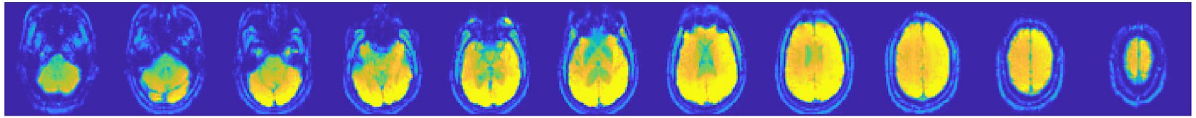
Steps

```
%% B-2. Implicit mask and save means

% This step creates an implicit mask image (implicit_mask.nii) and also
% saves mean images and SBRef as png in qc directories
humanfmri_b2_functional_implicitmask_savemean(preproc_subject_dir);
```

Run 1



Run 2



Functional data

Steps

PART 1 (a1-a4)

~~DICOM to NIFTI~~
~~in a BIDS format~~

- ~~a1: ... ectory~~
- ~~a2: S... ral~~
- ~~a3 ... l~~
- ~~... ieldma...~~

PART 2 (b1-b3)

Functional images
QC (outlier detection)

b1: Make directories

b2: implicit mask and mean images
- create an implicit mask image
- save mean images and SBRef (before preproc) as png in qc directories

b3: outlier detection
- outlier detection based on 1) mahalanobis distance across global mean for slices and spatial STD for slices, as in scn_session_spike_id.m 2) root-mean-square successive differences between images

PART 3 (b4-b6)

Functional images
Slice timing, motion, distortion correction

b4: slice timing correction
- It works with multi-band sequence
- It reads the actual acquisition timing from dicom header.

b5: motion correction (realignment)
- It uses the first functional image or SBRef (you can choose) as a reference.
- It saves 6 movement parameters for each run

b6: distortion correction (using FSL's topup)

PART 4 (b7-b8)

Structural and functional images
Coregistration, normalization, smoothing

b7: coregistration
- coregistration between T1 and mean functional images or SBRef image (you can choose).

b8: normalization
- segmentation of the coregistered T1 image using SPM12's tissue probability map (TPM.nii)
- warping segmented (and coregistered) T1 image to MNI template
- applying the warping parameter to the functional images

PART 5 (b9-b10)

Functional images
Smoothing and ICA-AROMA

b9: smoothing
- smoothing functional images with the FWHM 5 mm smoothing kernel.

b10: ICA-AROMA
- A data-driven method to identify and remove motion-related independent components from functional MRI data.
- https://github.com/rhr-pruim/ICA-AROMA

Functional data

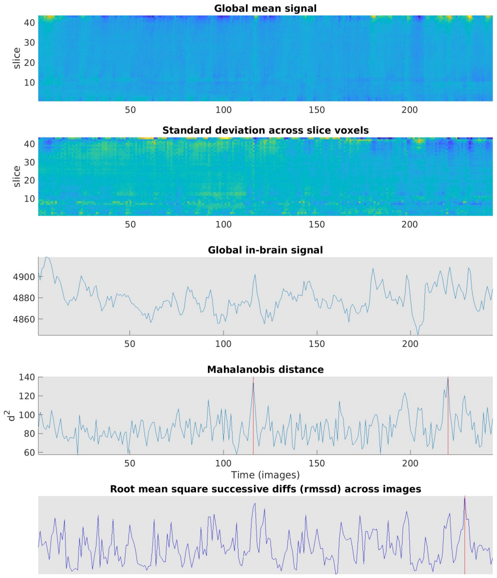
Spiking artifacts

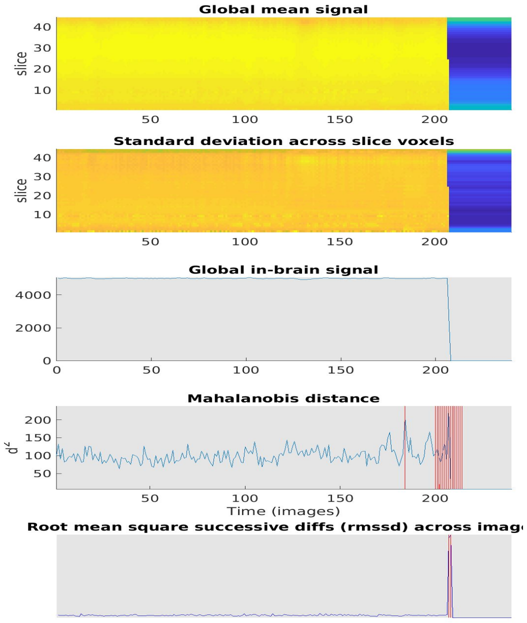
```
%% B-3. Spike identification

% Detecting outliers based on mahalanobis distance across global mean for
% slices and spatial STD for slices, and also RMSSD (root-mean-squared
% successive differences) between images
humanfmri_b3_spike_id(preproc_subject_dir);
```

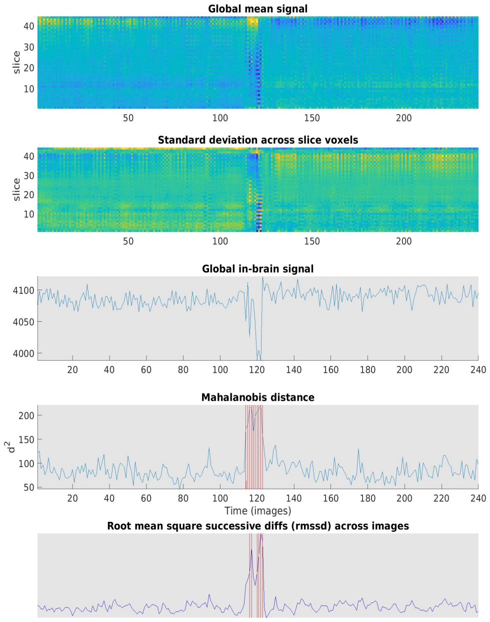
qc_images
- mean_before_preproc.png
- qc_diary_sub-001_task-EFAT_run-01_bold.txt
- qc_diary_sub-001_task-EFAT_run-02_bold.txt
- qc_spike_plot_sub-001_task-EFAT_run-01_bold.png
- qc_spike_plot_sub-001_task-EFAT_run-02_bold.png

Functional data

Spiking artifacts







Functional data

Spiking artifacts

qc_diary_sub-003_task-EFAT_run-01_bold.txt

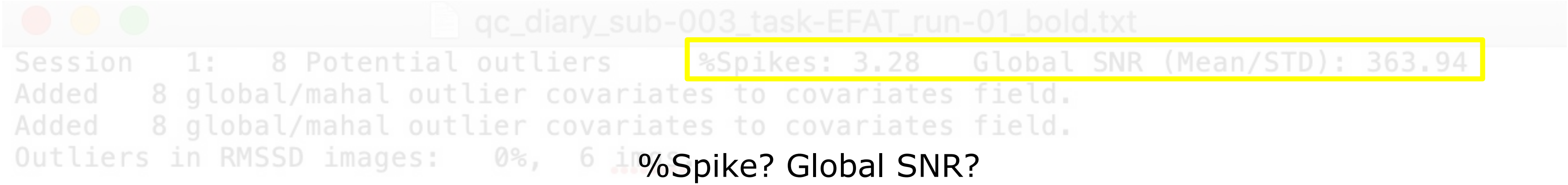
```
Session   1:   8 Potential outliers      %Spikes: 3.28   Global SNR (Mean/STD): 363.94
Added   8 global/mahal outlier covariates to covariates field.
Added   8 global/mahal outlier covariates to covariates field.
Outliers in RMSSD images:   0%,   6 imgs.
```

qc_diary_sub-042_task-EFAT_run-01_bold.txt

```
Session   1:   8 Potential outliers      %Spikes: 3.33   Global SNR (Mean/STD): 108.76
Added   8 global/mahal outlier covariates to covariates field.
Added   8 global/mahal outlier covariates to covariates field.
Outliers in RMSSD images:   0%,   7 imgs.
```

Functional data

Spiking artifacts



%Spike? Global SNR?

➡️ No absolute standard!

Functional data

Spiking artifacts

qc_diary_sub-003_task-EFAT_run-01_bold.txt

```
Session   1:   8 Potential outliers      %Spikes: 3.28   Global SNR (Mean/STD): 363.94
Added   8 global/mahal outlier covariates to covariates field.
Added   8 global/mahal outlier covariates to covariates field.
Outliers in RMSSD images:   0%,   imgs.
```

Healthy control: 5

Patient group: 5

qc_diary_sub-042_task-EFAT_run-01_bold.txt

```
Session   1:   8 Potential outliers      %Spikes: 3.33   Global SNR (Mean/STD): 108.76
Added   8 global/mahal outlier covariates to covariates field.
Added   8 global/mahal outlier covariates to covariates field.
Outliers in RMSSD images:   0%,   7 imgs.
```

Functional data

Steps

PART 1 (a1-a4)

DICOM to NIFTI
in a BIDS format

- a1: ...ectory
- a2: S... ...ral
- a3 ...ic... ...l
- ...Fieldma...

PART 2 (b1-b3)

Functional images
QC (outlier detection)

b1: Make directories

b2: implicit mask and mean images
- create an implicit mask image
- save mean images and SBRef (before preproc) as png in qc directories

b3: outlier detection
- outlier detection based on 1) mahalanobis distance across global mean for slices and spatial STD for slices, as in scn_session_spike_id.m 2) root-mean-square successive differences between images

PART 3 (b4-b6)

Functional images
Slice timing, motion, distortion correction

b4: slice timing correction
- It works with multi-band sequence
- It reads the actual acquisition timing from dicom header.

b5: motion correction (realignment)
- It uses the first functional image or SBRef (you can choose) as a reference.
- It saves 6 movement parameters for each run

b6: distortion correction (using FSL's topup)

PART 4 (b7-b8)

Structural and functional images
Coregistration, normalization, smoothing

b7: coregistration
- coregistration between T1 and mean functional images or SBRef image (you can choose).

b8: normalization
- segmentation of the coregistered T1 image using SPM12's tissue probability map (TPM.nii)
- warping segmented (and coregistered) T1 image to MNI template
- applying the warping parameter to the functional images

PART 5 (b9-b10)

Functional images
Smoothing and ICA-AROMA

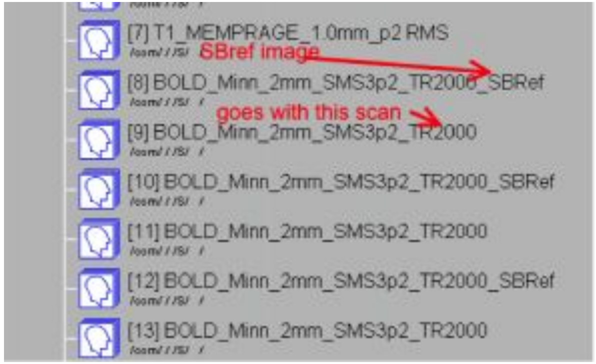
b9: smoothing
- smoothing functional images with the FWHM 5 mm smoothing kernel.

b10: ICA-AROMA
- A data-driven method to identify and remove motion-related independent components from functional MRI data.
- https://github.com/rhr-pruim/ICA-AROMA

Functional data

Motion artifacts

```
%% B-5. Motion correction

% It uses the first functional image or SBRef as a reference
% It saves 6 movement parameters for each run
use_st_corrected_data = false;
use_sbref = false;
SY_humanfmri_b5_motion_correction(preproc_subject_dir, use_st_corrected_data, use_sbref);
```



- qc_images
  - mean_before_preproc.png
  - mean_r_func_bold.png
  - qc_diary_sub-001_task-EFAT_run-01_bold.txt
  - qc_diary_sub-001_task-EFAT_run-02_bold.txt
  - qc_mvmt_sub-001_task-EFAT_run-01_bold.png
  - qc_mvmt_sub-001_task-EFAT_run-02_bold.png
  - qc_spike_plot_sub-001_task-EFAT_run-01_bold.png
  - qc_spike_plot_sub-001_task-EFAT_run-02_bold.png

http://cbs.fas.harvard.edu/science/core-facilities/neuroimaging/information-investigators/scannerfaq#refSMS

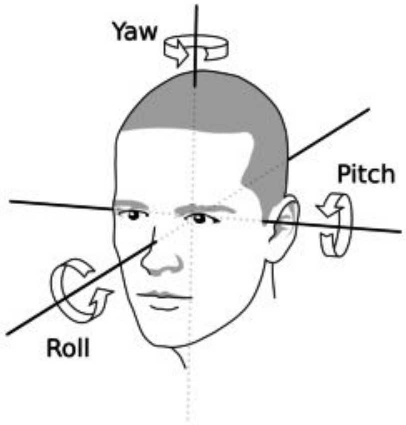
Functional data

6 motion parameters

- x, y, z, pitch, roll, yaw

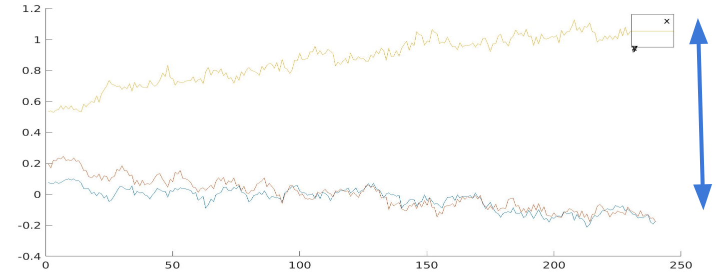
Framewise Displacement

- > 0.2mm

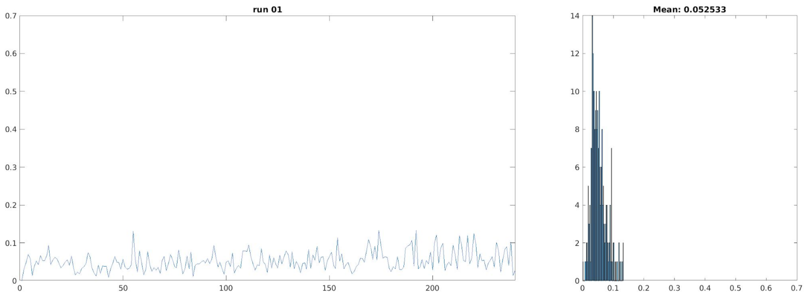


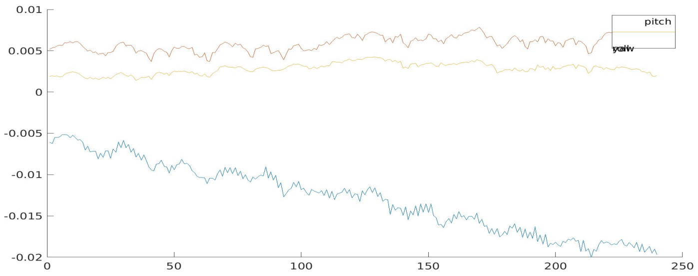
Functional data

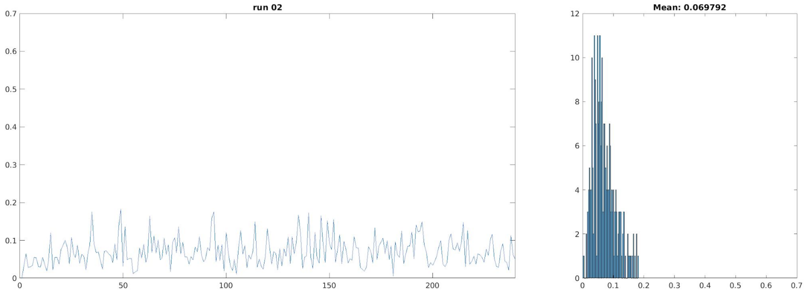
Motion artifacts



> voxel size

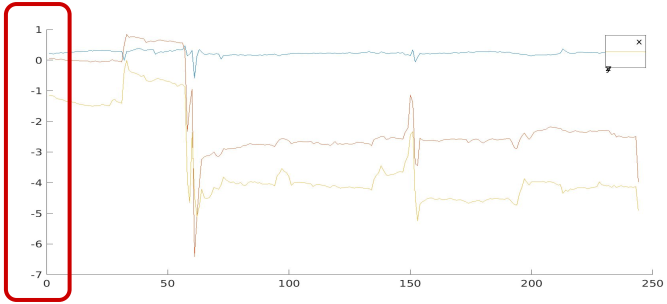


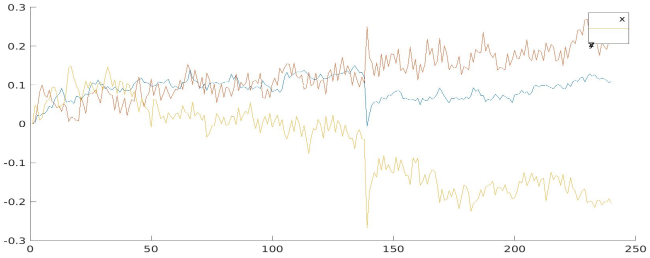


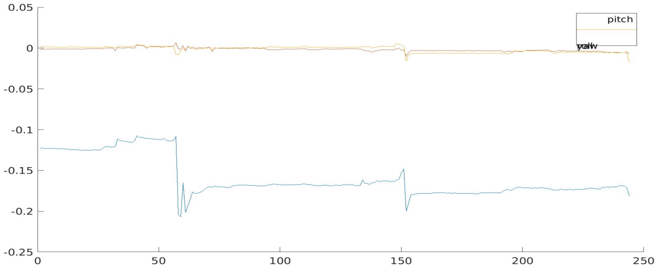


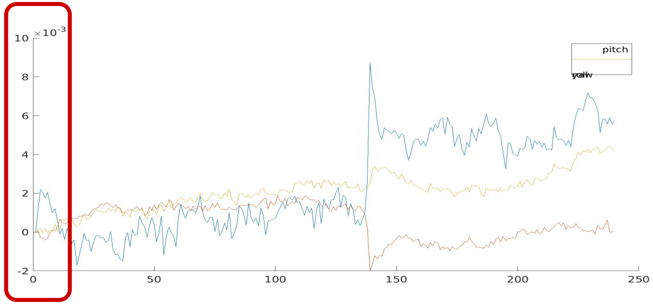
Functional data

Motion artifacts



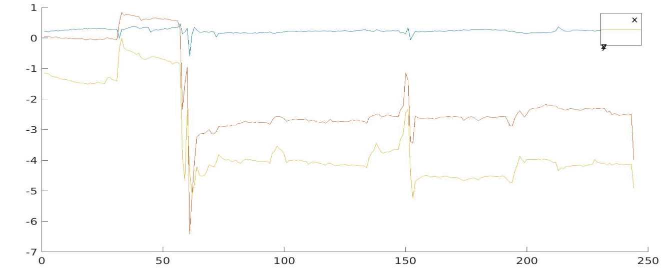


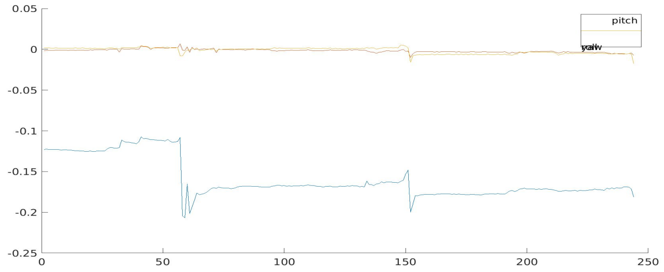


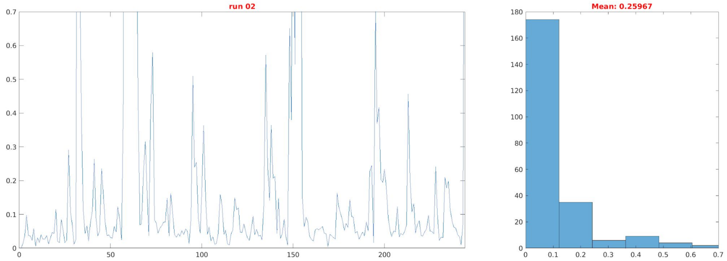


Functional data

Motion artifacts

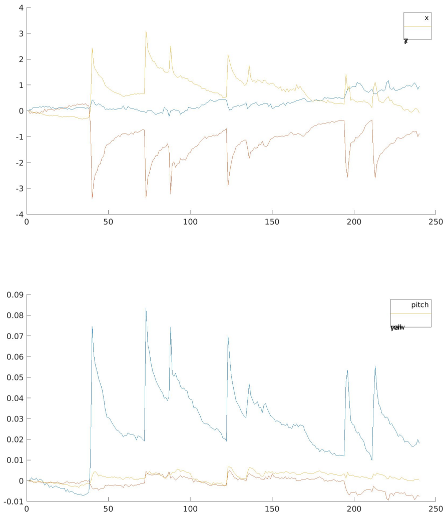


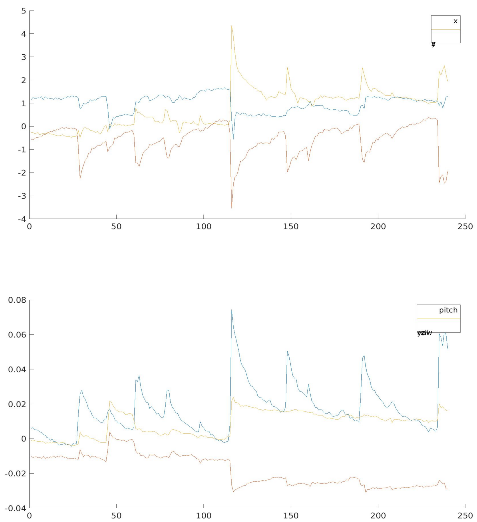


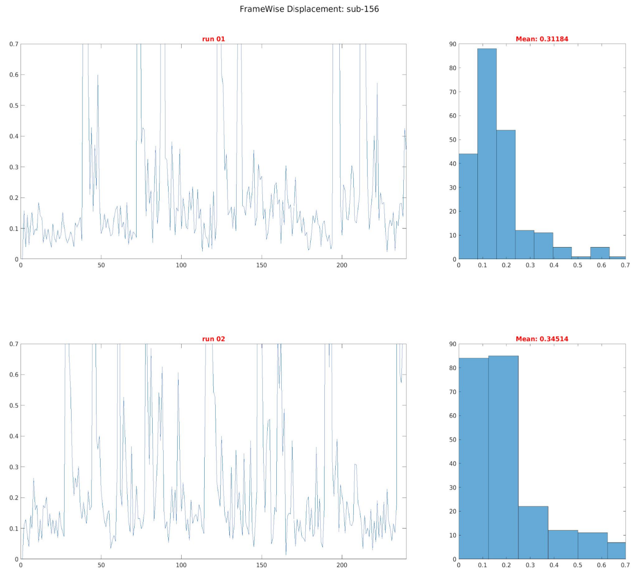


Functional data

Motion artifacts

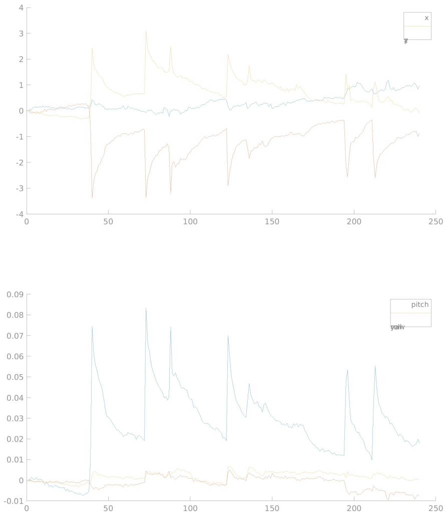


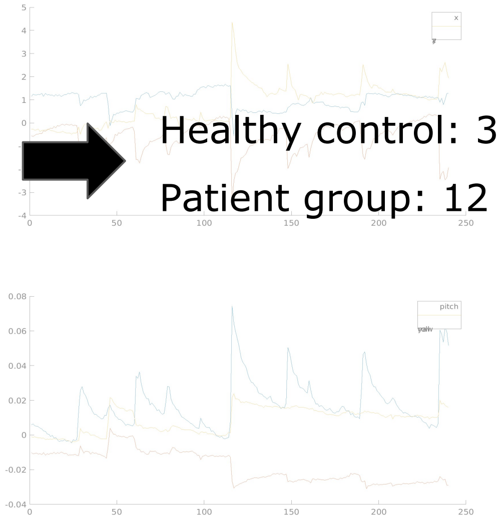




Functional data

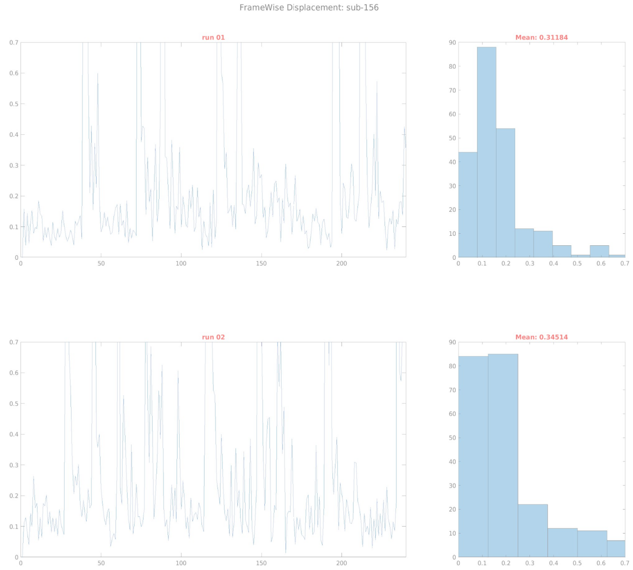
Motion artifacts





Healthy control: 3

Patient group: 12



Functional data

Steps

PART 1 (a1-a4)

DICOM to NIFTI
in a BIDS format

- a1: ... ectory
- a2: S... ural
- a3 ... ic... al
- ... Fieldma...

PART 2 (b1-b3)

Functional images
QC (outlier detection)

b1: Make directories

b2: implicit mask and mean images
- create an implicit mask image
- save mean images and SBRef (before preproc) as png in qc directories

b3: outlier detection
- outlier detection based on 1) mahalanobis distance across global mean for slices and spatial STD for slices, as in scn_session_spike_id.m 2) root-mean-square successive differences between images

PART 3 (b4-b6)

Functional images
Slice timing, motion, distortion correction

b4: slice timing correction
- It works with multi-band sequence
- It reads the actual acquisition timing from dicom header.

b5: motion correction (realignment)
- It uses the first functional image or SBRef (you can choose) as a reference.
- It saves 6 movement parameters for each run

b6: distortion correction (using FSL's topup)

PART 4 (b7-b8)

Structural and functional images
Coregistration, normalization, smoothing

b7: coregistration
- coregistration between T1 and mean functional images or SBRef image (you can choose).

b8: normalization
- segmentation of the coregistered T1 image using SPM12's tissue probability map (TPM.nii)
- warping segmented (and coregistered) T1 image to MNI template
- applying the warping parameter to the functional images

PART 5 (b9-b10)

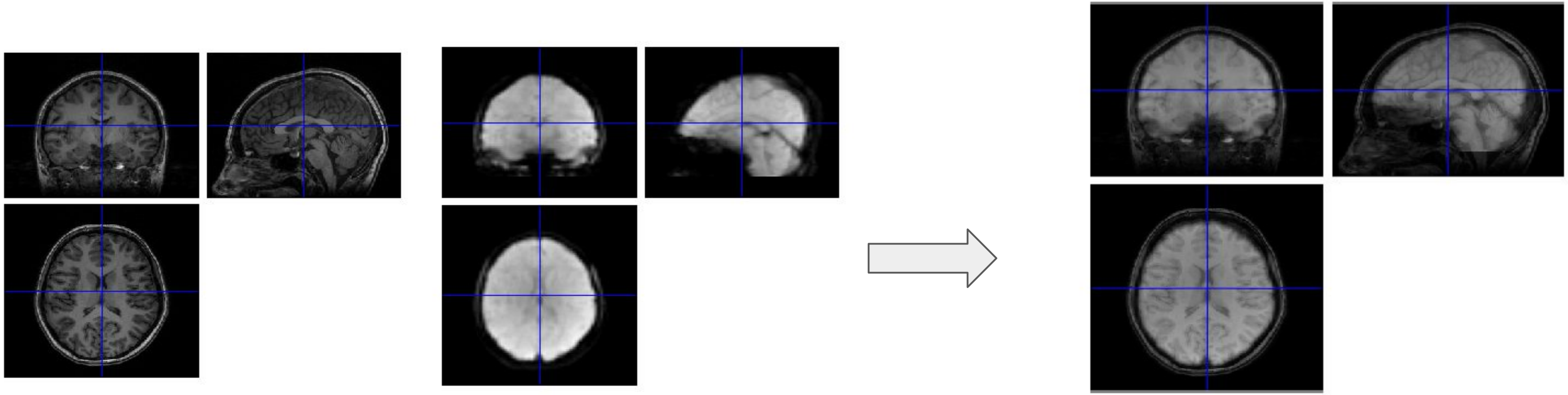
Functional images
Smoothing and ICA-AROMA

b9: smoothing
- smoothing functional images with the FWHM 5 mm smoothing kernel.

b10: ICA-AROMA
- A data-driven method to identify and remove motion-related independent components from functional MRI data.
- https://github.com/rhr-pruim/ICA-AROMA

Functional data

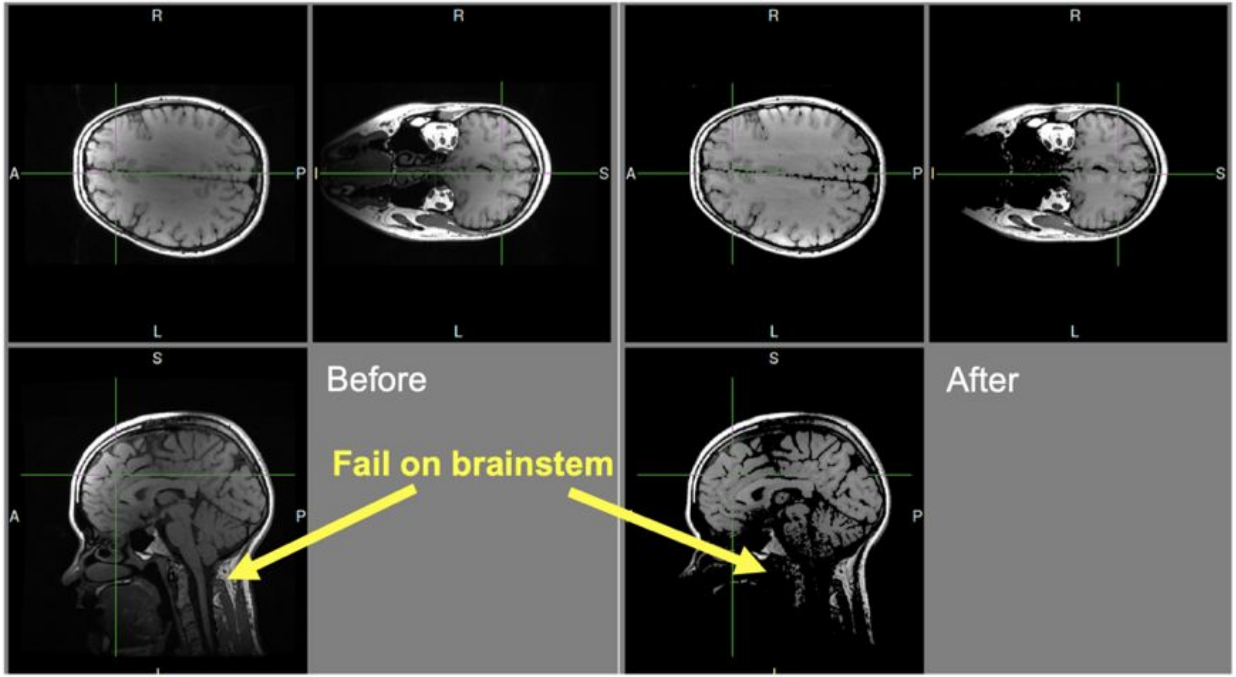
Co-registration



Anatomical image

Anatomical data

Homogeneity correction



http://www.umich.edu/~nii/events/QC_lecture_nii_slides.pdf

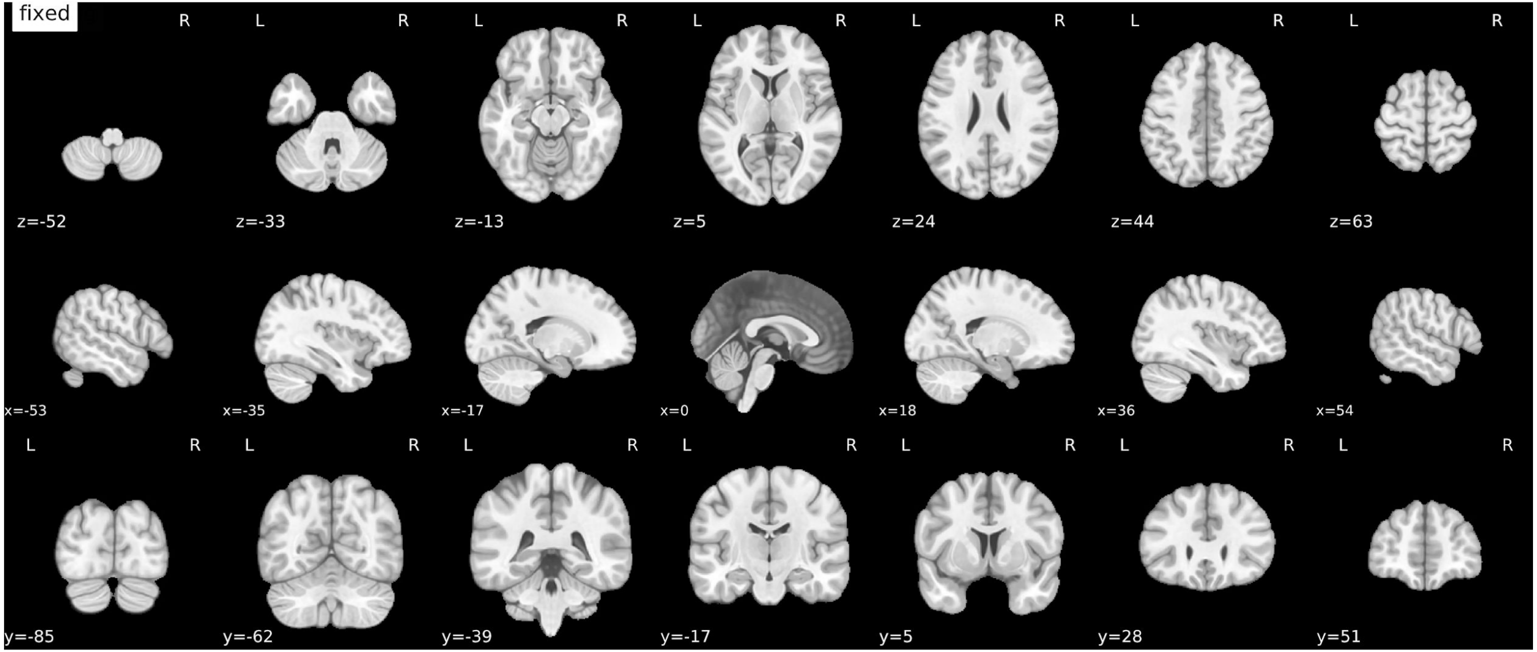
Anatomical data

Skull stripping

http://www.umich.edu/~nii/events/QC_lecture_nii_slides.pdf

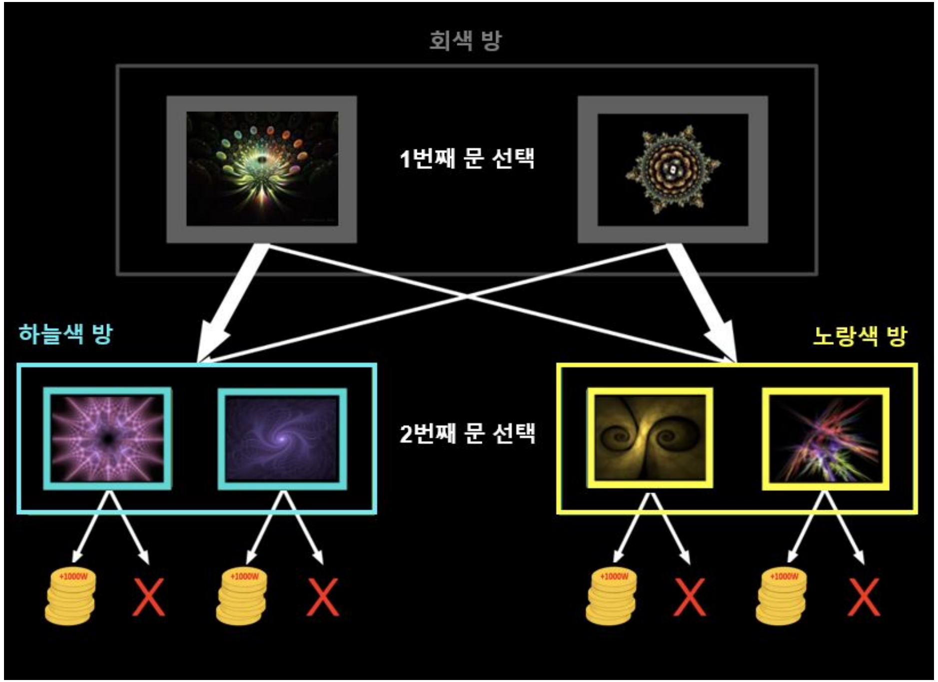
Anatomical data

T1 Normalization



Quality Check with fmriprep output!

Two-step (yonsei) data



Healthy Control	Alcohol	Gaming
30	22	24

Steps

Behavior data

- Parameters

Anatomical data

- Homogeneity Check
- Skull Stripping
- T1 Normalization
- surface reconstruction

Functional data

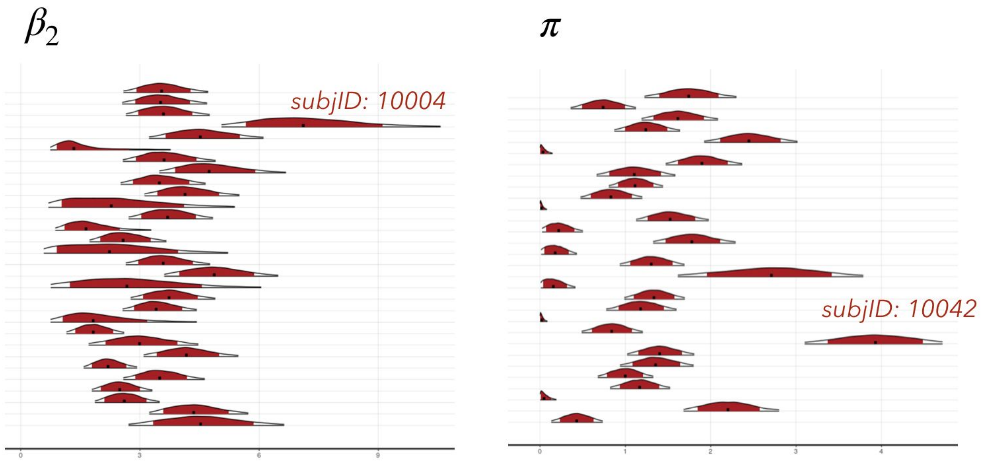
- co-registration
- Outlier detection with motion index

Behavior data

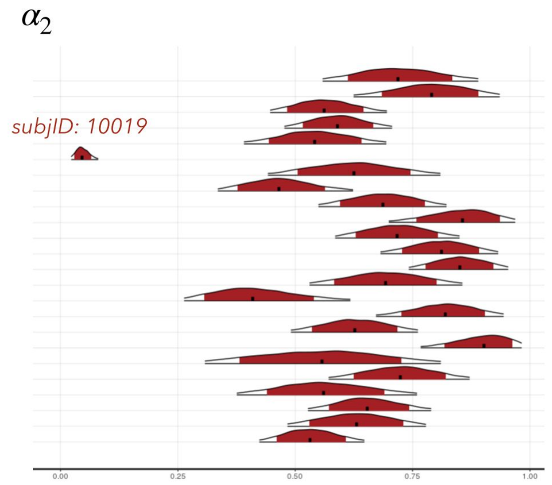
Behavior data

3 outliers

Posterior distribution: Healthy



Posterior distribution: Gaming



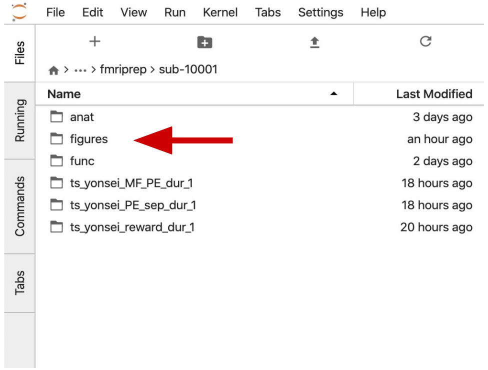
Things to check with fmriprep!

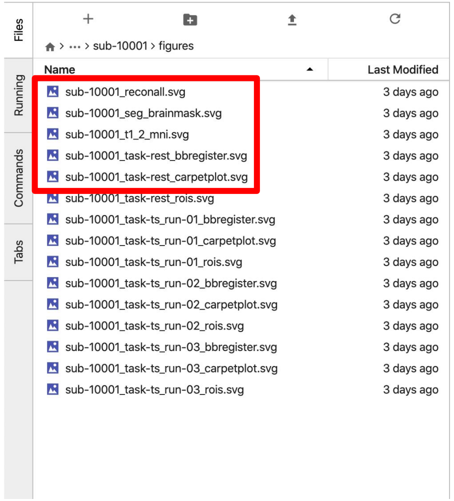
Anatomical data

1. Homogeneity & Skull stripping check
   file name: *_seg_brainmask.svg
2. T1 Normalization (T1 to MNI registration)
   file name: *_t1_2.svg
3. Surface reconstruction
   file name: *_reconall.svg

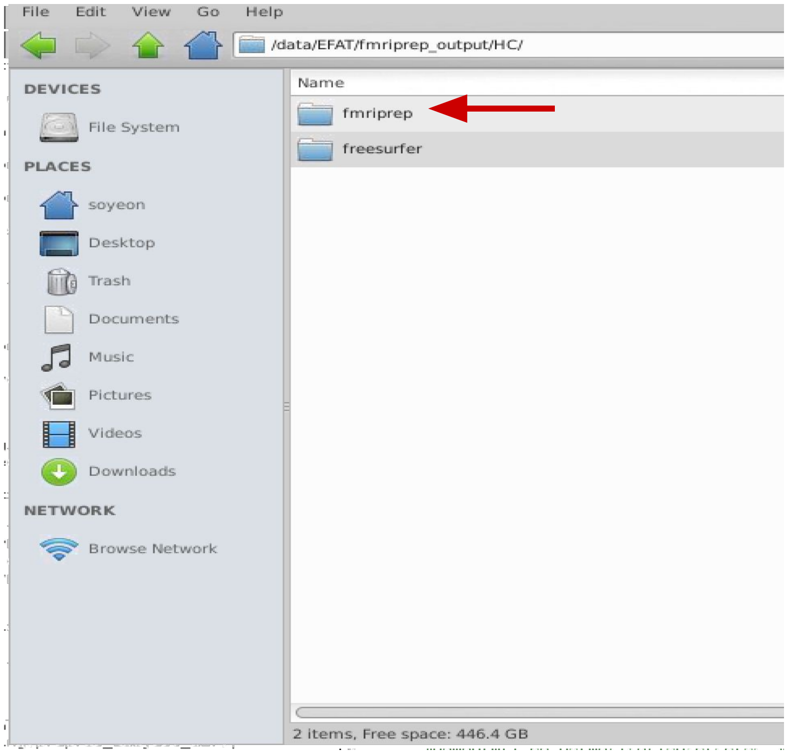
Functional data

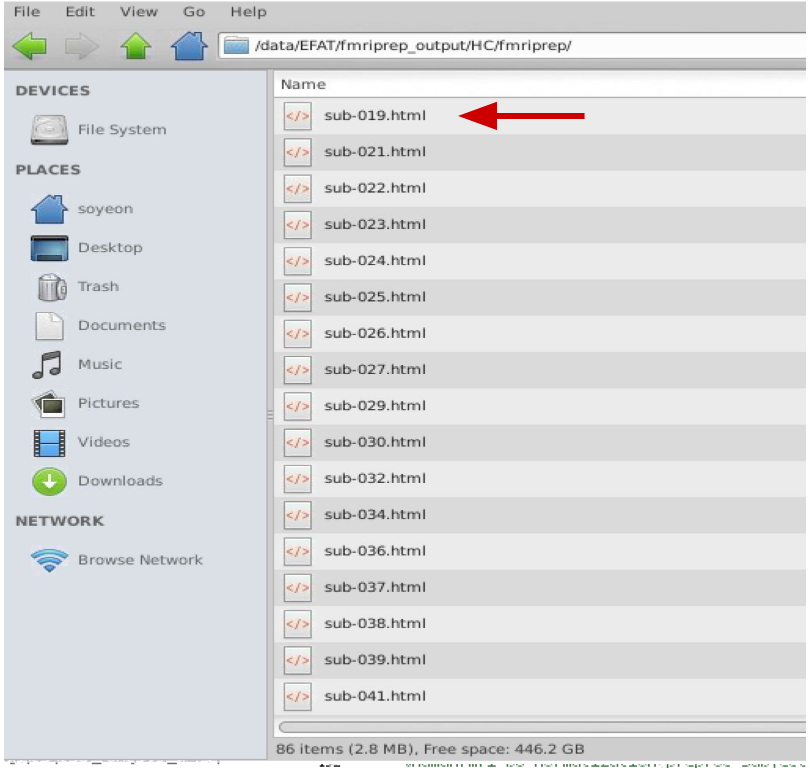
1. co-registration
   file name: *_bbregister.svg
2. outlier detection (with motion index)
   file name: *_carpetplot.svg





Where to go?



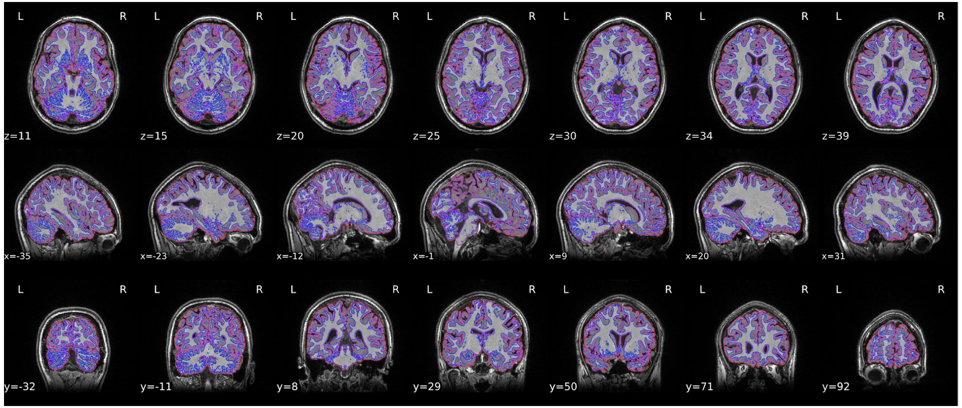


Sample data: https://fmriprep.readthedocs.io/en/stable/_static/sample_report.html

Anatomical data

Anatomical data

1. Homogeneity & Skull stripping check



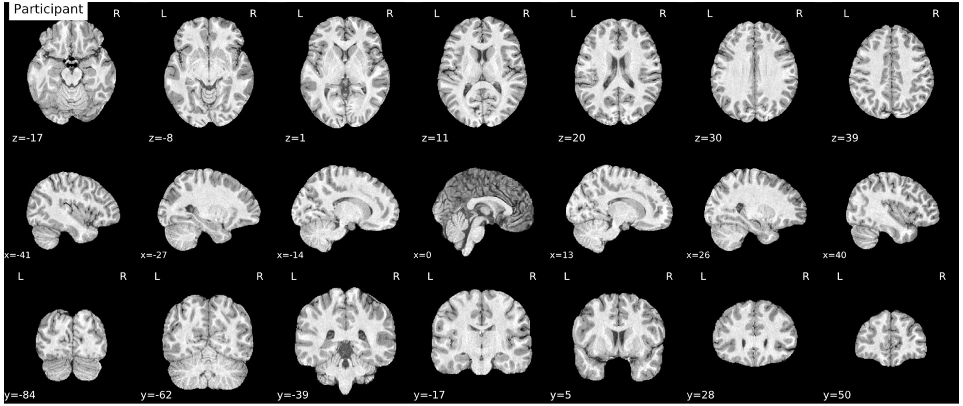
1) **homogeneity: visually check if color of brain is homogeneous. Filter out those with holes etc.**

2) **Skull segmentation: Visually check if brain is properly segmented.**

file name: *_seg_brainmask.svg

Anatomical data

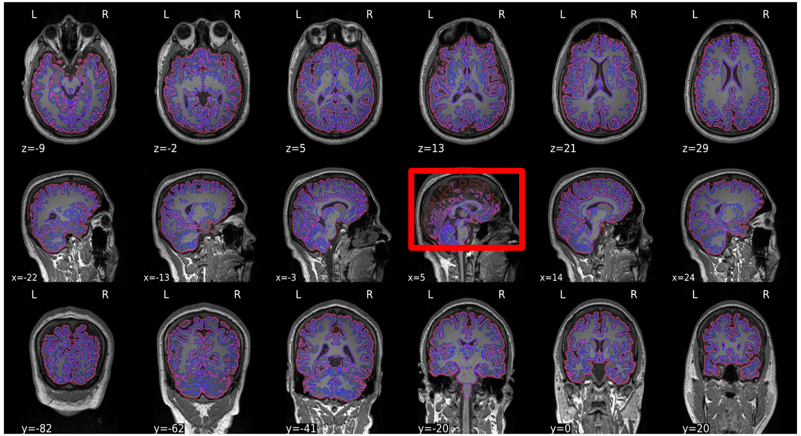
2. T1 Normalization (T1 to MNI registration)

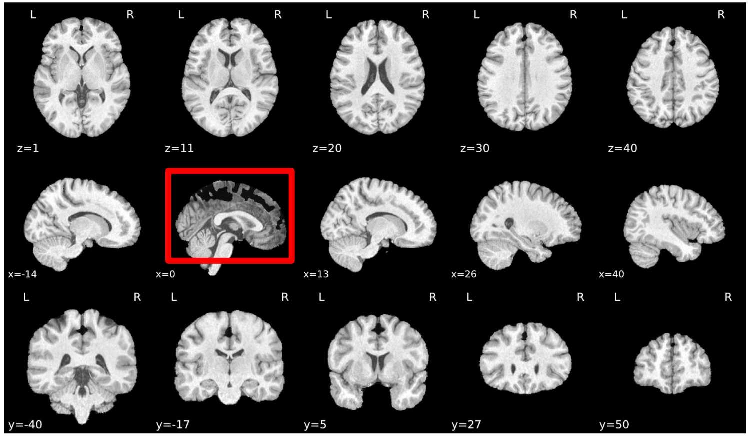


⇒ visually check if T1 image and MNI is matched!

file name: *t1_2_mni.svg

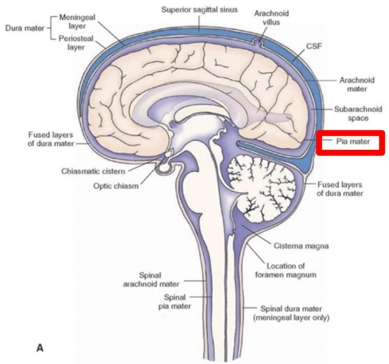
Anatomical data

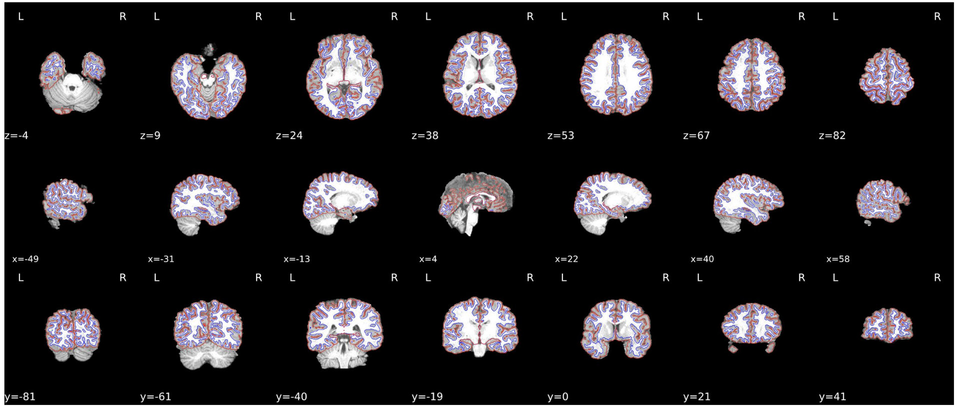




Anatomical data

3. Surface reconstruction





Surfaces (white matter and pial) reconstructed with FreeSurfer overlaid on the participant’s T1w template

⇒ visually check if red line (pia mater) & blue line (white matter) is correctly drawn

file name: *reconall.svg

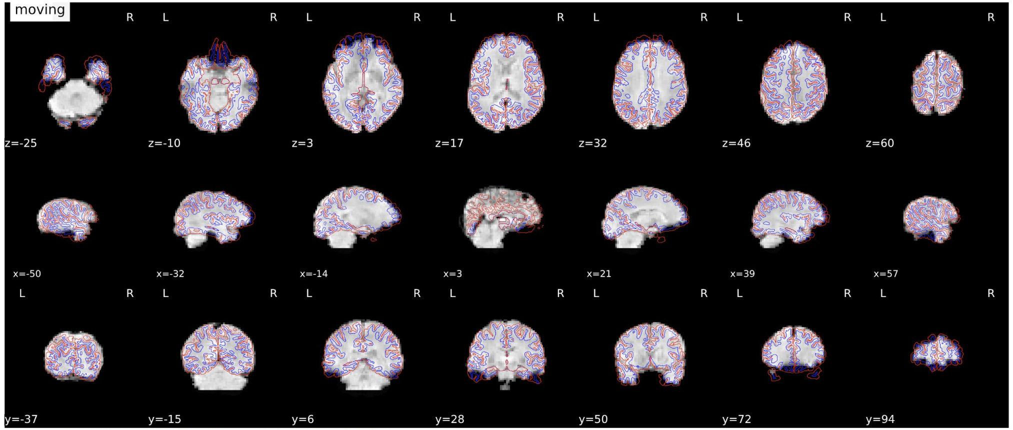
Functional image

Functional data

1. Co-registration (EPI to T1 image)

Alignment of functional and anatomical MRI data (surface driven)

bbregister was used to generate transformations from EPI-space to T1w-space. Note that Nearest Neighbor interpolation is used in the reportlets in order to highlight potential spin-history and other artifacts, whereas final images are resampled using Lanczos interpolation.



Get figure file: sub-003/figures/sub-003_task-EFAT_run-1_desc-bbregister_bold.svg

fixed: T1w-space
- red line: Pia mater
- blue line: white matter

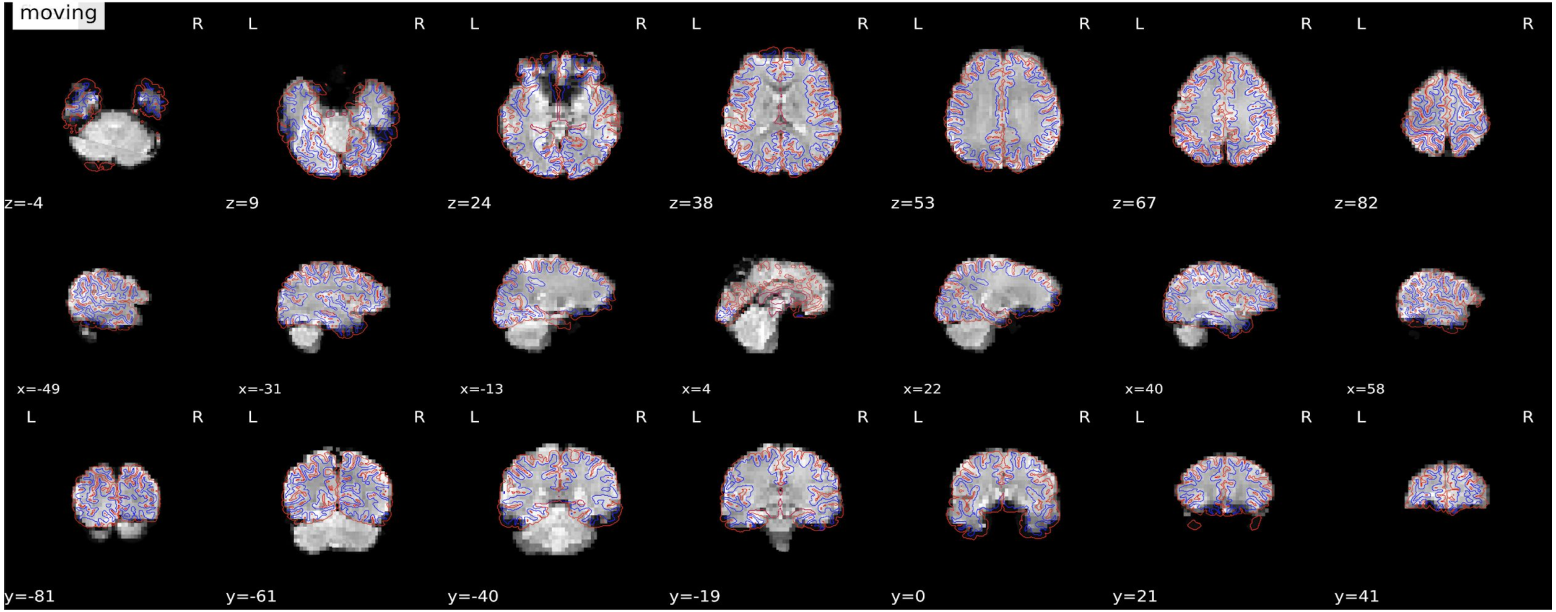
moving: EPI-space

⇒ **visually check if the lines are aligned with EPI-space!**

https://fmriprep.readthedocs.io/en/stable/outputs.html

Functional data

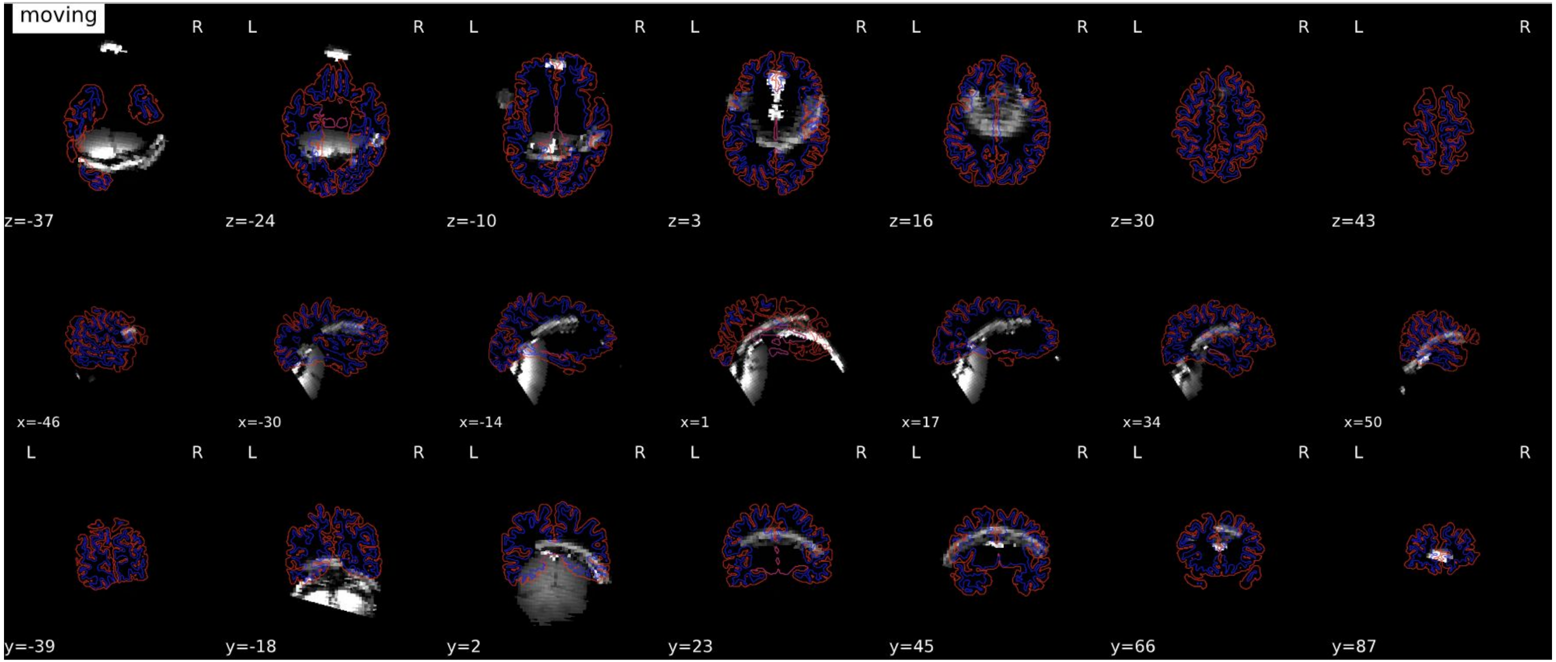
1. Co-registration (EPI to T1 image)



file name: *bbregister_bold.svg

Functional data

1. Co-registration (EPI to T1 image)



file name: *bbregister_bold.svg

Functional data

2. Outlier Detection (with ‘framewise displacement; FD’)

Outlier detection. These confounds can be used to detect potential outlier time points - frames with sudden and large motion or intensity spikes.

- `framewise_displacement` - is a quantification of the estimated bulk-head motion calculated using formula proposed by [Power2012];
- `dvars` - the derivative of RMS variance over voxels (or DVARS) [Power2012];
- `std_dvars` - standardized DVARS;
- `non_steady_state_outlier_XX` - columns indicate non-steady state volumes with a single `1` value and `0` elsewhere (*i.e.*, there is one `non_steady_state_outlier_XX` column per outlier/volume).

Detected outliers can be further removed from time series using methods such as: volume *censoring* - entirely discarding problematic time points [Power2012], regressing signal from outlier points in denoising procedure, or including outlier points in the subsequent first-level analysis when building the design matrix. Averaged value of confound (for example, mean `framewise_displacement`) can also be added as regressors in group level analysis [Yan2013]. *Spike regressors* for outlier censoring can also be generated from within *fMRIPrep* using the command line options `--fd-spike-threshold` and `--dvars-spike-threshold` (default: FD > 0.5 mm or DVARS > 1.5). Spike regressors are stored in separate `motion_outlier_XX` columns.

https://fmriprep.readthedocs.io/en/stable/outputs.html

Functional data

DVARS (DV)

This measure indexes the change in signal intensity from one volume to the next, and is calculated as the root mean square value of the differentiated BOLD timeseries (by backwards differences) within a spatial mask at every timepoint (Smyser et al., 2010). DV for the first volume of a run is set to zero by convention. This paper usually presents DV calculated over the whole-brain mask but it can be calculated over any collection of voxels. Gray matter DV (DV_{GM}), which closely parallels whole-brain DV (DV_{GS}), is presented at several points in the manuscript where indicated (e.g., after global signal regression has made it pointless to plot mean global signal but still informative to plot mean gray matter signal, we use DV_{GM} instead of DV_{GS} so that the same set of voxels is being examined.)

DVARS calculations

DVARS (D referring to temporal derivative of timecourses, VARS referring to RMS variance over voxels) indexes the rate of change of BOLD signal across the entire brain at each frame of data. To calculate DVARS, the volumetric timeseries is differentiated (by backwards differences) and RMS signal change is calculated over the whole brain. DVARS is thus a measure of how much the intensity of a brain image changes in comparison to the previous timepoint (as opposed to the global signal, which is the average value of a brain image at a timepoint). The global measure of signal change is

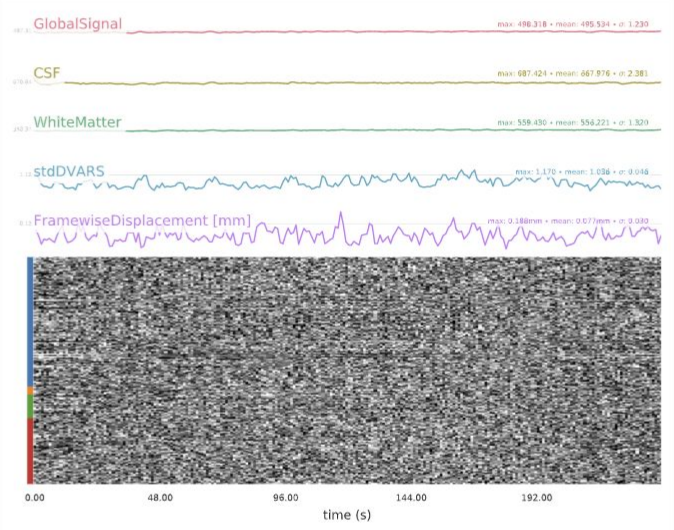
$$\mathrm{DVARS}(\Delta I)_i = \sqrt{\left\langle \left[\Delta I_i\left(\vec{x}\right)\right]^2 \right\rangle} = \sqrt{\left\langle \left[I_i\left(\vec{x}\right) - I_{i-1}\left(\vec{x}\right)\right]^2 \right\rangle}$$

where, as before, $I_i(\vec{x})$ is image intensity at locus $\vec{x}$ on frame i and angle brackets denote the spatial average over the whole brain. A computationally important detail

Power (2012) https://www.sciencedirect.com/science/article/pii/S1053811911011815

Functional data

The visual reports provide several sections per task and run to aid designing a denoising strategy for subsequent analysis. Some of the estimated confounds are plotted with a “carpet” visualization of the BOLD time series [Power2016]. An example of these plots follows:



The figure shows on top several confounds estimated for the BOLD series: global signals (‘GlobalSignal’, ‘WM’, ‘GM’), standardized DVARS (‘stdDVARS’), and framewise-displacement (‘FramewiseDisplacement’). At the bottom, a ‘carpetplot’ summarizing the BOLD series. The color-map on the left-side of the carpetplot denotes signals located in cortical gray matter regions (blue), subcortical gray matter (orange), cerebellum (green) and the union of white-matter and CSF compartments (red).

Criterion

- **stdDVARS > 0.4 ~ 0.5% △BOLD**
- **mean FD > 0.2mm ~ 0.5 mm**

FD: Difference between frames across time
DVARS: Difference between each voxel across time

- D: referring to temporal derivative of timecourses
- VARS: referring to RMS variance over voxels
- → provide a single estimated head motion parameter for each time point

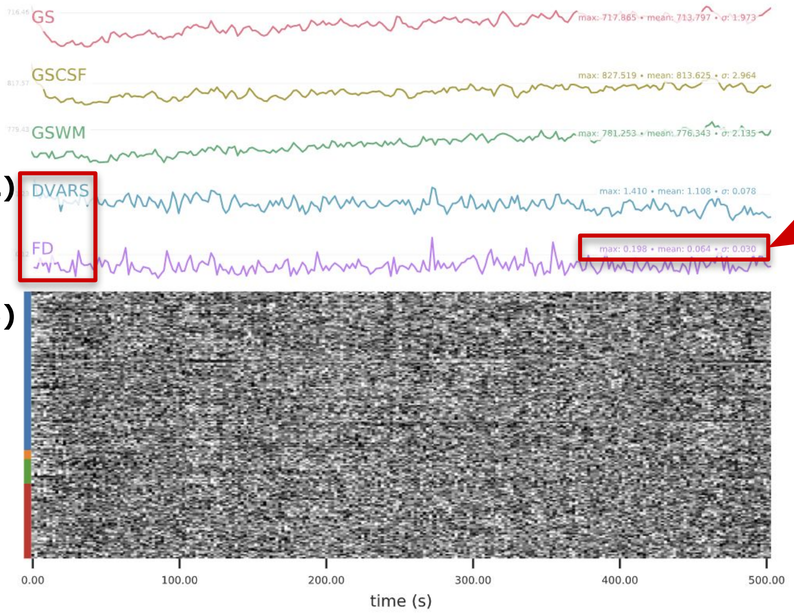
https://fmriprep.readthedocs.io/en/stable/outputs.html#functional-derivatives

Functional data

2. Outlier Detection (with 'framewise displacement; FD')

2)

3)



1) mean FD > 0.2mm

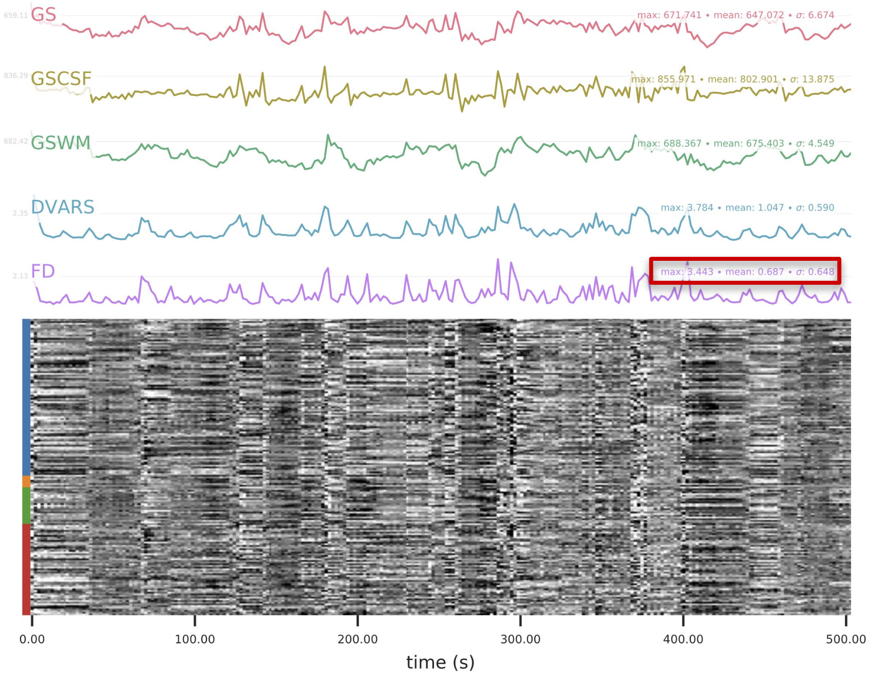
2) Extraordinary spikes in FD & DVARS graph.

3) Patterns in carpet plot

https://fmriprep.readthedocs.io/en/stable/outputs.html

Functional data

2. Outlier Detection (with ‘framewise displacement; FD’)



Functional data

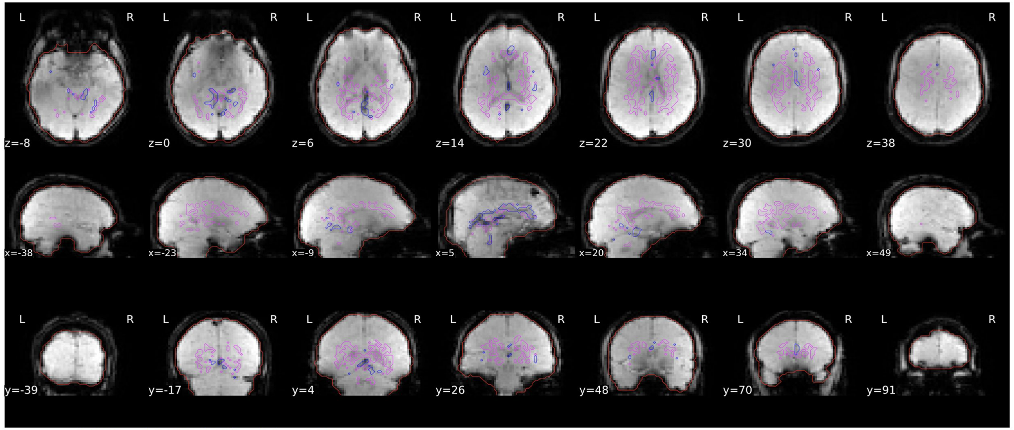
BOLD signal (red)
aCompCor mask (magenta): additional noise components calculated using anatomical
tCompCor mask (blue contour): additional noise components calculated using temporal

* CompCor: component based noise correction method

⇒ **Check what?????**

Brain mask and (temporal/anatomical) CompCor ROIs

Brain mask calculated on the BOLD signal (red contour), along with the masks used for a/tCompCor.
The aCompCor mask (magenta contour) is a conservative CSF and white-matter mask for extracting physiological and movement confounds.
The fCompCor mask (blue contour) contains the top 5% most variable voxels within a heavily-eroded brain-mask.



Get figure file: sub-003/figures/sub-003_task-EFAT_run-1_desc-rois_bold.svg

https://fmriprep.readthedocs.io/en/stable/outputs.html

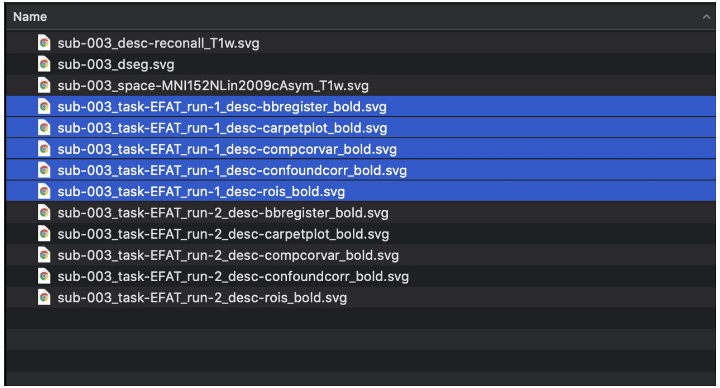
Checking it with fmriprep output!

Functional data

Outlier detection. These confounds can be used to detect potential outlier time points - frames with sudden and large motion or intensity spikes.

- `framewise_displacement` - is a quantification of the estimated bulk-head motion calculated using formula proposed by [Power2012];
- `dvars` - the derivative of RMS variance over voxels (or DVARS) [Power2012];
- `std_dvars` - standardized DVARS;
- `non_steady_state_outlier_XX` - columns indicate non-steady state volumes with a single `1` value and `0` elsewhere (*i.e.*, there is one `non_steady_state_outlier_XX` column per outlier/volume).

Detected outliers can be further removed from time series using methods such as: volume *censoring* - entirely discarding problematic time points [Power2012], regressing signal from outlier points in denoising procedure, or including outlier points in the subsequent first-level analysis when building the design matrix. Averaged value of confound (for example, mean `framewise_displacement`) can also be added as regressors in group level analysis [Yan2013]. *Spike regressors* for outlier censoring can also be generated from within *fMRIPrep* using the command line options `--fd-spike-threshold` and `--dvars-spike-threshold` (default: FD > 0.5 mm or DVARS > 1.5). Spike regressors are stored in separate `motion_outlier_XX` columns.



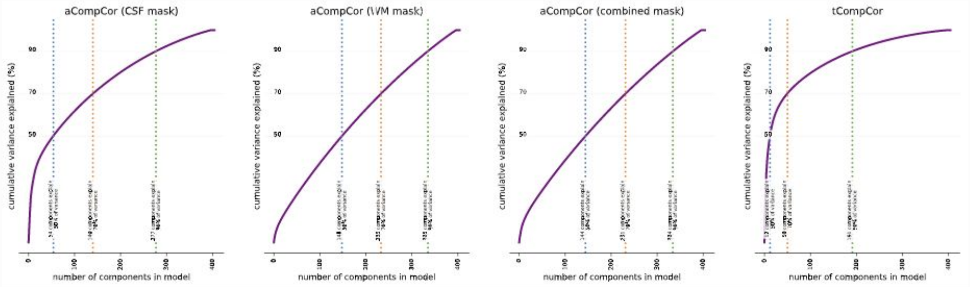
https://fmriprep.readthedocs.io/en/stable/outputs.html

Variance explained by t/aCompCor components

The cumulative variance explained by the first k components of the *t/aCompCor* decomposition, plotted for all values of *k*. The number of components that must be included in the model in order t
some fraction of variance in the decomposition mask can be used as a feature selection criterion for confound regression.

Functional data

Noise components computed during each CompCor decomposition are evaluated according to the fraction of variance that they explain across the nuisance ROI. This is used by *fMRIPrep* to determine whether each component should be saved for use in denoising operations: a component is saved if it contributes to explaining the top 50 percent of variance in the nuisance ROI. *fMRIPrep* can be configured to save all components instead using the command line option `--return-all-components`. *fMRIPrep* reports include a plot of the cumulative variance explained by each component, ordered by descending singular value.



The figure displays the cumulative variance explained by components for each of four CompCor decompositions (left to right: anatomical CSF mask, anatomical white matter mask, anatomical combined mask, temporal). The number of components is plotted on the abscissa and the cumulative variance explained on the ordinate. Dotted lines indicate the minimum number of components necessary to explain 50%, 70%, and 90% of the variance in the nuisance mask. By default, only the components that explain the top 50% of the variance are saved.

Behzadi (2007) https://www.ncbi.nlm.nih.gov/pubmed/17560126

https://fmriprep.readthedocs.io/en/stable/outputs.html#functional-derivatives

Functional data

Framewise displacement (FD)

This measure indexes the movement of the head from one volume to the next, and is calculated as the sum of the absolute values of the differentiated realignment estimates (by backwards differences) at every timepoint (Power et al., 2012). FD for the first volume of a run is 0 by convention. The purpose of this measure is to index head movement, not to precisely calculate or model it.

- From Power et al. (2012): "After studying the plots of dozens of healthy adults, values of **0.5 mm for framewise displacement** and **0.5% ΔBOLD for DVARS** were chosen to represent values well above the norm found in still subjects."
  - Also removed *1 TR before* and *2 TRs after* bad frame
- Fair et al. (2013) used an even more stringent FD cut-off of 0.2 mm and DVARS cut-off of 0.4%

Framewise displacement (FD) calculations

Differentiating head realignment parameters across frames yields a six dimensional timeseries that represents instantaneous head motion. To express instantaneous head motion as a scalar quantity we used the empirical formula, $FD_i = |\Delta d_{ix}| + |\Delta d_{iy}| + |\Delta d_{iz}| + |\Delta\alpha_i| + |\Delta\beta_i| + |\Delta\gamma_i|$, where $\Delta d_{ix} = d_{(i-1)x} - d_{ix}$, and similarly for the other rigid body parameters $[d_{ix}\ d_{iy}\ d_{iz}\ \alpha_i\ \beta_i\ \gamma_i]$. Rotational displacements were converted from degrees to millimeters by calculating displacement on the surface of a sphere of radius 50 mm, which is approximately the mean distance from the cerebral cortex to the center of the head.

only large movements are sought. After studying the plots of dozens of healthy adults, values of 0.5 for framewise displacement and 0.5% ΔBOLD for DVARS were chosen to represent values well above the norm found in still subjects (see Figure S5 for examples of still subjects).

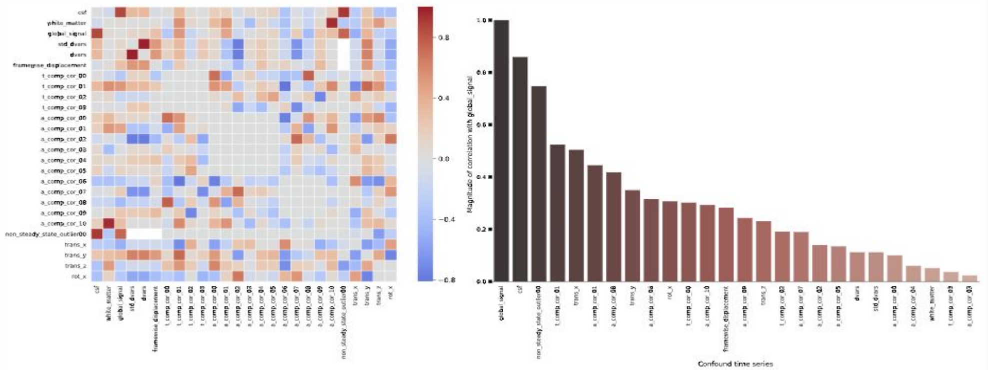
Realizing the artifactual contributions of micromovements to R-fMRI findings, Power and colleagues recently called for the rigorous scrubbing of any time frames in which micromovements occur, as well as their neighboring time points, proposing framewise displacement (FD) > 0.2mm as the threshold for frame removal (Power et al., 2012a, b). Recent work has suggested that the combination of scrubbing and modeling based approaches brings about the greatest reduction in motion-induced artifact (Power et al., 2012b, Satterthwaite et al., 2013) – this combination can be accomplished in a single, integrated regression model (i.e., by modeling motion parameters and spike regressors for each scrubbed time point).

Power (2012) https://www.sciencedirect.com/science/article/pii/S1053811911011815

https://fmriprep.readthedocs.io/en/stable/outputs.html#functional-derivatives

Functional data

Also included is a plot of correlations among confound regressors. This can be used to guide selection of a confound model or to assess the extent to which tissue-specific regressors correlate with global signal.



The left-hand panel shows the matrix of correlations among selected confound time series as a heat-map. Note the zero-correlation blocks near the diagonal; these correspond to each CompCor decomposition. The right-hand panel displays the correlation of selected confound time series with the mean global signal computed across the whole brain; the regressors shown are those with greatest correlation with the global signal. This information can be used to diagnose partial volume effects.

Left: correlation matrix of selected confound time series

Right: correlation of selected confound time series with the mean global signal (regressors with greatest correlation wer shown)

https://fmriprep.readthedocs.io/en/stable/outputs.html#functional-derivatives

Results after Quality Check

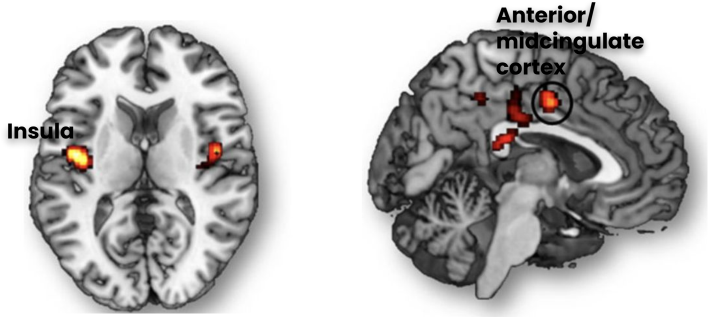
QC results

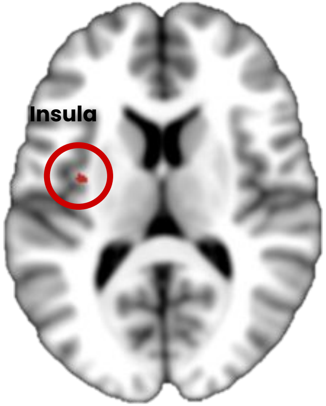
EFAT data

PASS	FAIL		
	behavior	spike & movement	coregistration
108	6	34	2

Second Level Results

angry > shapes contrast





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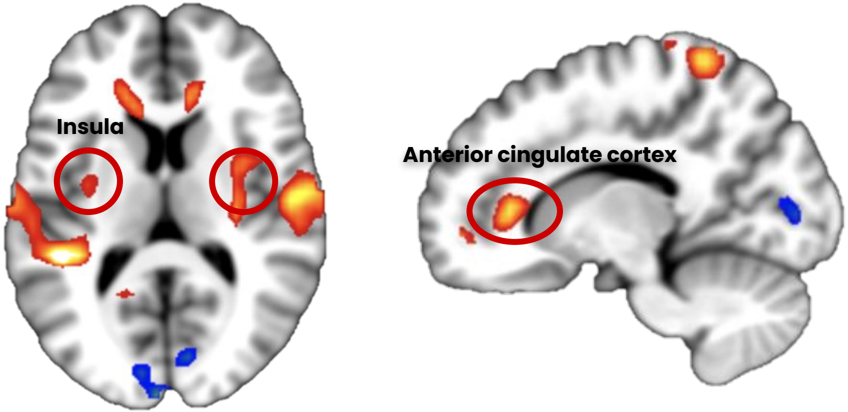

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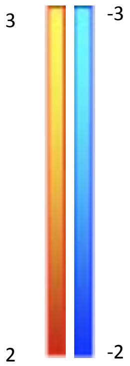
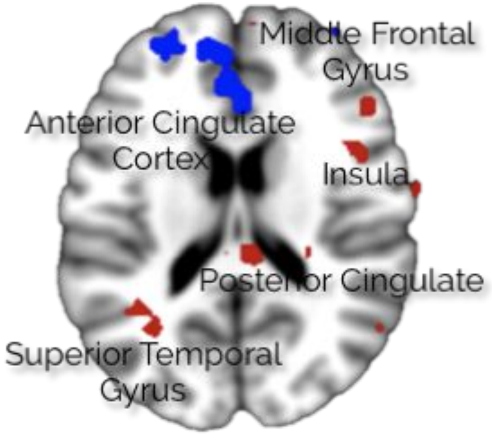


Machine Learning Results



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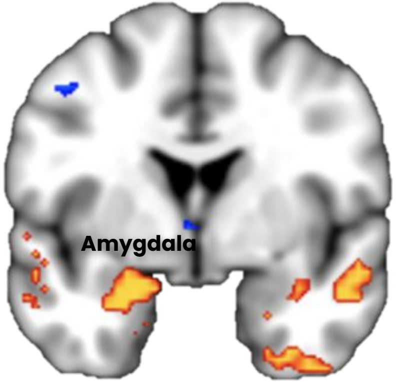
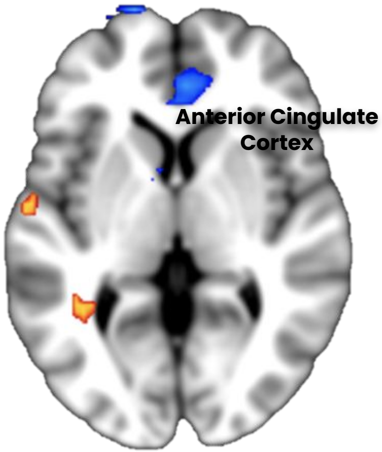




<After>

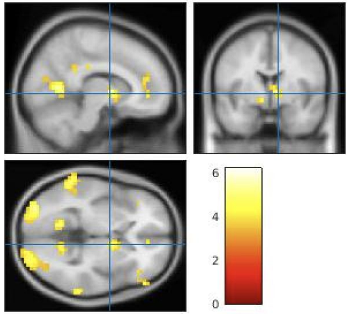
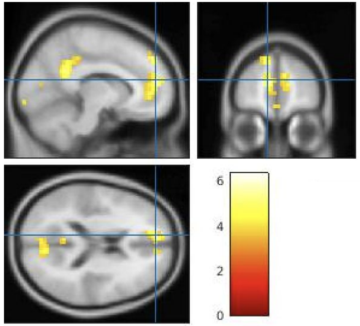
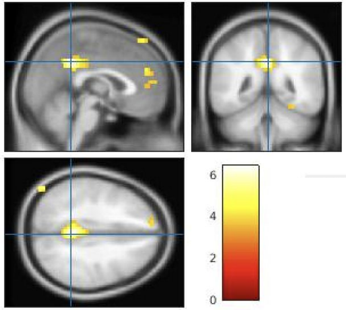
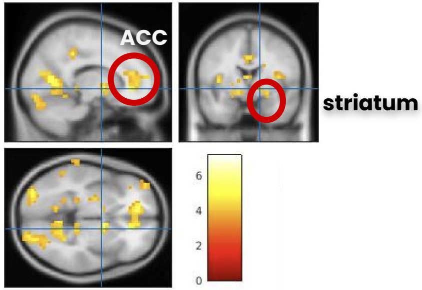
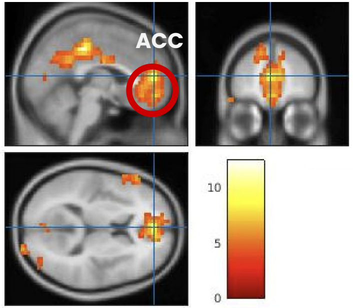
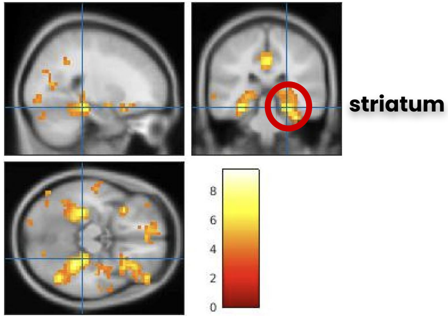
QC results

Two step task (yonsei) data

PASS	FAIL		
	behavior	**spike & movement**	**signal loss**
47	3	21	3

	FAIL	PASS	total
HC	**11**	19	30
AUD	**9**	13	22
GD	**9**	15	24
sum	29	47	76

QC results reward vs non reward ($p < 0.001$)

	Healthy Control	Alcohol Use Disorder	Gaming Disorder
<Before>			
<After>			

QC results

Two step task (yonsei) data

PASS	FAIL		
47	behavior	spike & movement	signal loss
	3	21	3

	FAIL	PASS	total
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AUD	**9**	13	22
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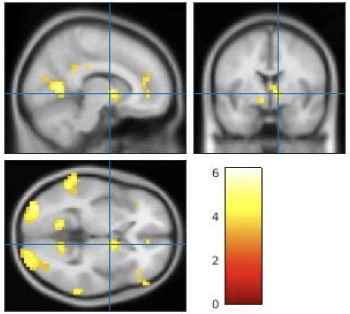
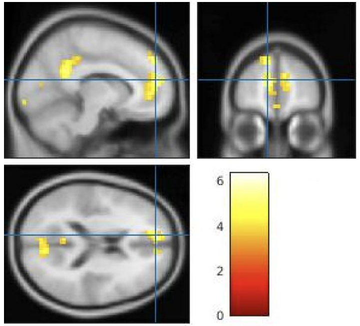
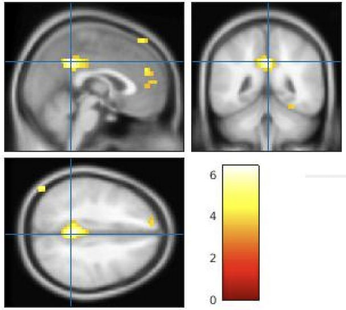
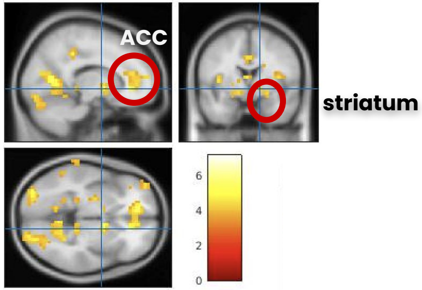
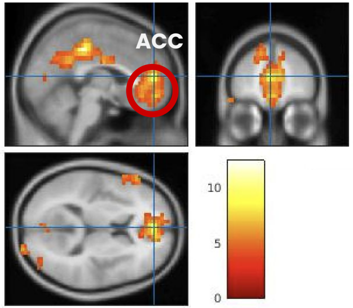
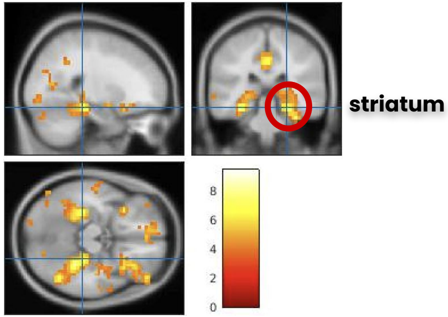
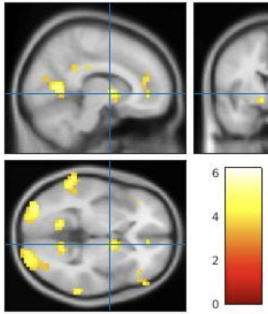
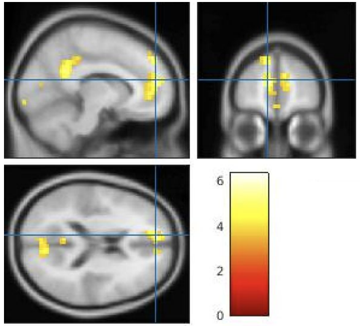
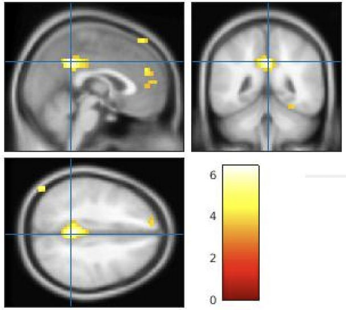
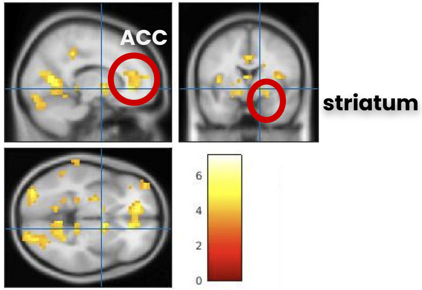
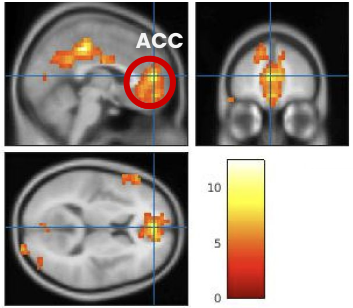
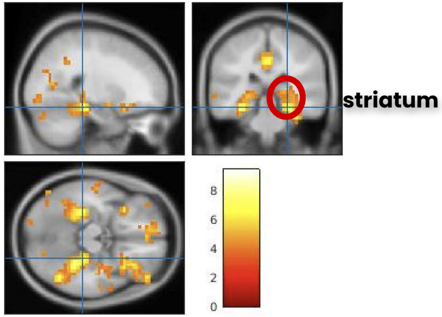
sum	29	47	76

QC results reward vs non reward ($p < 0.001$)

	Healthy Control	Alcohol Use Disorder	Gaming Disorder
‹Before›			
‹After›			

QC results reward prediction error ($p < 0.001$)

	Healthy Control	Alcohol Use Disorder	Gaming Disorder
<Before>			
<After>			


thank you