

# Multiverse4Decoding

Roman Kessler

```
library(targets)
library(tarchetypes)
library(dplyr)
```

Attaching package: 'dplyr'

The following objects are masked from 'package:stats':

filter, lag

The following objects are masked from 'package:base':

intersect, setdiff, setequal, union

```
library(xtable)
library(ggpubr)
```

Loading required package: ggplot2

```
options(dplyr.print_max = 1e9)
base_dir = "/Users/roman/GitHub/m4d/"
manuscript_dir = paste0(base_dir, "manuscript/")
```

## Multiverse for Decoding

In short, decoding accuracies have been calculated for each participant, each experiment, and each variation in the pipeline. Marginal means have been calculated and plotted in the following.

After careful consideration, I re-decided to use the MLM approach similar than Clayson et al (2021, Neuroimage) anyways, despite initial concerns. After doing some simulations, and comparing it to other approaches, the results seem similar and trustworthy.

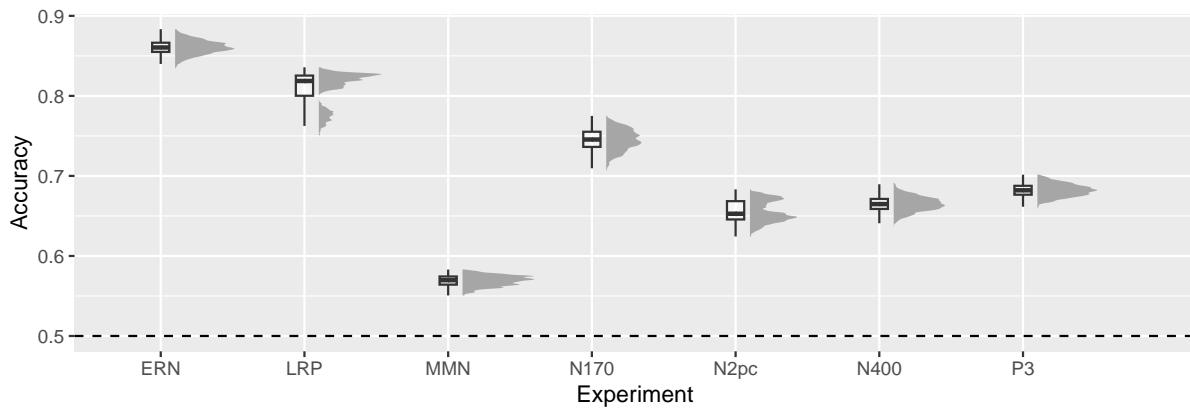
```
#tar_visnetwork()
```

```
#tar_visnetwork(targets_only=TRUE, label=c("description", "branches"))
```

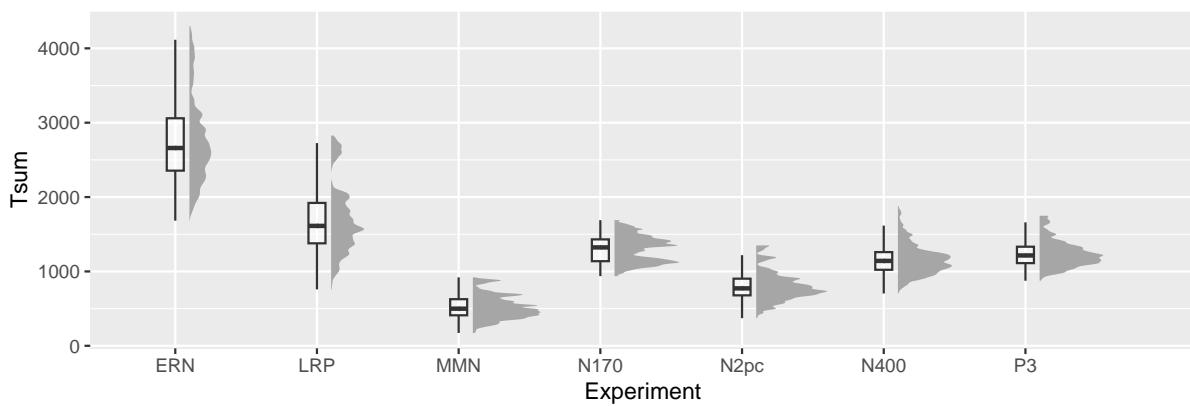
## Overview of decoding performances

### ERPCORE

#### A EEGNet



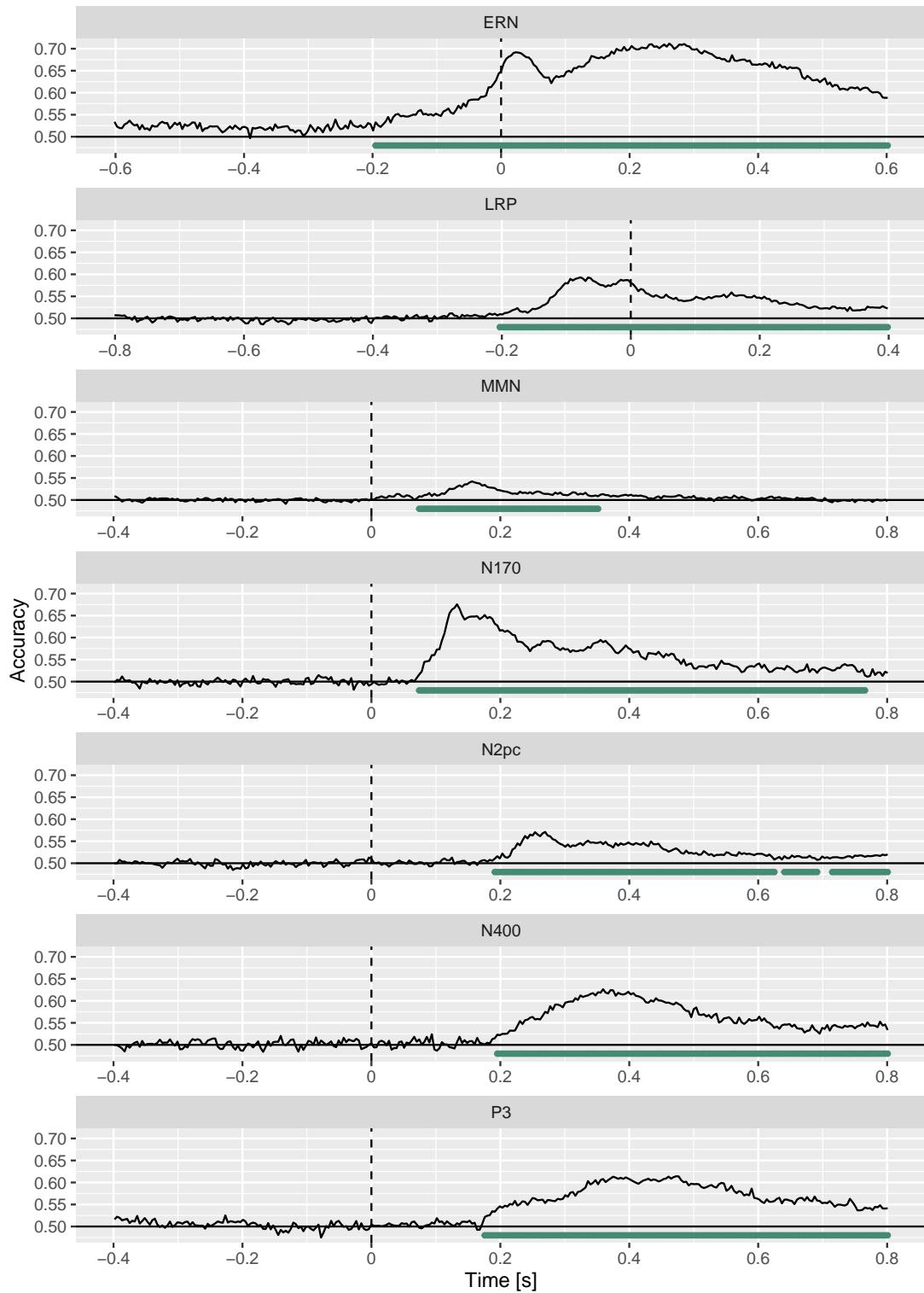
#### B Time-Resolved





## Time-resolved - Example UNIVERSE result

Time-Resolved Decoding Results – Exemplary Single Forking Path



## MLM and LM models -> Are interactions necessary?

### EEGNet

#### Time-resolved

Model fits of models (per experiment) without and with interactions

```
r2s = c()
r2si2 = c()

for (i in 1:7){
  modeli2 <- tar_read(sliding_LMi2_exp, branches=i)[[1]]
  model <- tar_read(sliding_LM_exp, branches=i)[[1]]
  models <- summary(model)
  modeli2s <- summary(modeli2)
  r2s = c(r2s, models$adj.r.squared)
  r2si2 = c(r2si2, modeli2s$adj.r.squared)
}
print("Adj. R2 no interactions:")
```

```
[1] "Adj. R2 no interactions:"
```

```
print(r2s)
```

```
[1] 0.9060015 0.8734629 0.7624970 0.8590996 0.7969701 0.7801203 0.8347194
```

```
print("Adj. R2 2-way interactions:")
```

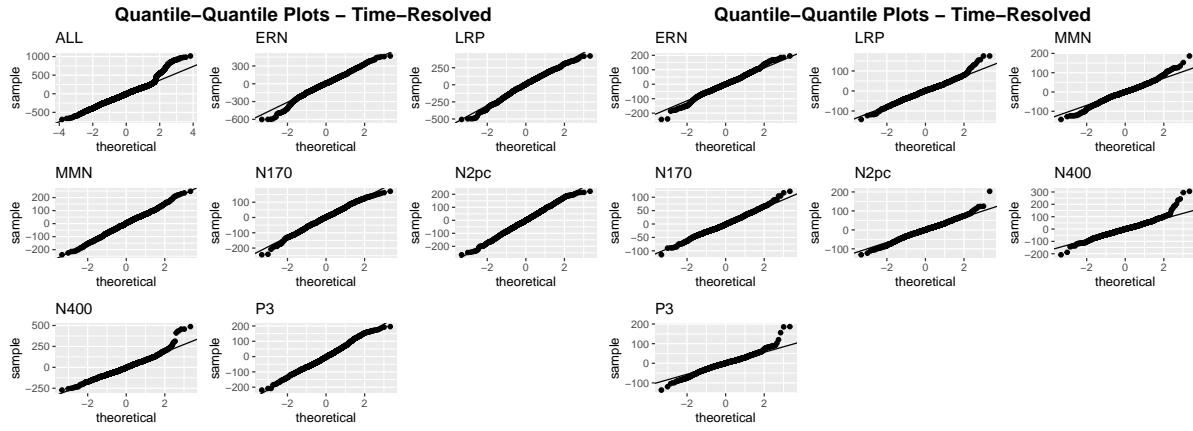
```
[1] "Adj. R2 2-way interactions:"
```

```
print(r2si2)
```

```
[1] 0.9862232 0.9915725 0.9246940 0.9654065 0.9597272 0.9334274 0.9602550
```

```
ggarrange( tar_read(sliding_LM_qq_comb),
           tar_read(sliding_LMi2_qq_comb),
           ncols=2)
```

Warning in as\_grob.default(plot): Cannot convert object of class numeric into a grob.

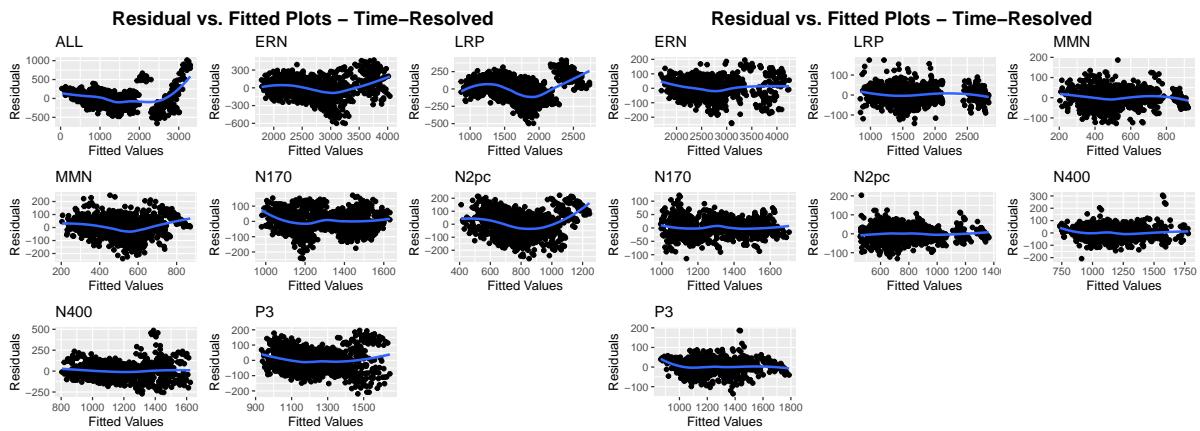


Doesn't really seem to lead to improvement of Normality assumptions when including interactions.

Residual vs Fitted

```
ggarrange( tar_read(sliding_LM_rvf_comb),
           tar_read(sliding_LMi2_rvf_comb),
           ncols=2)
```

Warning in as\_grob.default(plot): Cannot convert object of class numeric into a grob.



Res vs Fitted generally looks better when including 2-way interactions!!

## Influence of analysis choises - (M)LM and EMM

### Estimated Marginal Means & Differences

#### EEGNET

##### Means

```
tar_read(eegnet_HLM_emm_means_comb)
```

	variable	level	emmean	experiment
1		ref average	0.7105222	ALL
2		ref Cz	0.7134084	ALL
3		ref P9P10	0.7132325	ALL
4	hpf	None	0.7114023	ALL
5	hpf	0.1	0.7116057	ALL
6	hpf	0.5	0.7141552	ALL
7	lpf	None	0.7100970	ALL
8	lpf	6	0.7133615	ALL
9	lpf	20	0.7160413	ALL
10	lpf	45	0.7100510	ALL
11	base	200ms	0.7123962	ALL
12	base	400ms	0.7123792	ALL
13	det	offset	0.7118845	ALL
14	det	linear	0.7128910	ALL
15	ar	false	0.7167247	ALL
16	ar	true	0.7080507	ALL
17	emc	None	0.7144621	ALL
18	emc	ica	0.7103133	ALL
19	mac	None	0.7155544	ALL
20	mac	ica	0.7092210	ALL
21	experiment	ERN	0.8606025	ALL
22	experiment	LRP	0.8093122	ALL
23	experiment	MMN	0.5690234	ALL
24	experiment	N170	0.7451850	ALL
25	experiment	N2pc	0.6555816	ALL
26	experiment	N400	0.6648620	ALL
27	experiment	P3	0.6821474	ALL
28		ref average	0.8576382	ERN
29		ref Cz	0.8663069	ERN
30		ref P9P10	0.8578624	ERN

31	hpf	None	0.8586448	ERN
32	hpf	0.1	0.8593912	ERN
33	hpf	0.5	0.8637714	ERN
34	lpf	None	0.8590975	ERN
35	lpf	6	0.8617545	ERN
36	lpf	20	0.8632799	ERN
37	lpf	45	0.8582780	ERN
38	emc	None	0.8612553	ERN
39	emc	ica	0.8599497	ERN
40	mac	None	0.8622704	ERN
41	mac	ica	0.8589345	ERN
42	base	200ms	0.8606576	ERN
43	base	400ms	0.8605474	ERN
44	det	offset	0.8611706	ERN
45	det	linear	0.8600344	ERN
46	ar	false	0.8647126	ERN
47	ar	true	0.8564923	ERN
48	ref	average	0.8113611	LRP
49	ref	Cz	0.8104640	LRP
50	ref	P9P10	0.8061115	LRP
51	hpf	None	0.8084858	LRP
52	hpf	0.1	0.8088995	LRP
53	hpf	0.5	0.8105512	LRP
54	lpf	None	0.7957306	LRP
55	lpf	6	0.8204024	LRP
56	lpf	20	0.8213273	LRP
57	lpf	45	0.7997884	LRP
58	emc	None	0.8100374	LRP
59	emc	ica	0.8085870	LRP
60	mac	None	0.8209771	LRP
61	mac	ica	0.7976473	LRP
62	base	200ms	0.8094956	LRP
63	base	400ms	0.8091288	LRP
64	det	offset	0.8074219	LRP
65	det	linear	0.8112024	LRP
66	ar	false	0.8147546	LRP
67	ar	true	0.8038698	LRP
68	ref	average	0.5681232	MMN
69	ref	Cz	0.5687673	MMN
70	ref	P9P10	0.5701797	MMN
71	hpf	None	0.5683575	MMN
72	hpf	0.1	0.5683820	MMN
73	hpf	0.5	0.5703307	MMN

74	lpf	None	0.5667797	MMN
75	lpf	6	0.5695414	MMN
76	lpf	20	0.5721475	MMN
77	lpf	45	0.5676250	MMN
78	emc	None	0.5694156	MMN
79	emc	ica	0.5686312	MMN
80	mac	None	0.5716890	MMN
81	mac	ica	0.5663578	MMN
82	base	200ms	0.5693025	MMN
83	base	400ms	0.5687444	MMN
84	det	offset	0.5668377	MMN
85	det	linear	0.5712092	MMN
86	ar	false	0.5723430	MMN
87	ar	true	0.5657038	MMN
88	ref	average	0.7406108	N170
89	ref	Cz	0.7436471	N170
90	ref	P9P10	0.7512972	N170
91	hpf	None	0.7430969	N170
92	hpf	0.1	0.7443819	N170
93	hpf	0.5	0.7480762	N170
94	lpf	None	0.7511621	N170
95	lpf	6	0.7331087	N170
96	lpf	20	0.7455393	N170
97	lpf	45	0.7509299	N170
98	emc	None	0.7457658	N170
99	emc	ica	0.7446042	N170
100	mac	None	0.7431274	N170
101	mac	ica	0.7472426	N170
102	base	200ms	0.7449419	N170
103	base	400ms	0.7454281	N170
104	det	offset	0.7403353	N170
105	det	linear	0.7500347	N170
106	ar	false	0.7510943	N170
107	ar	true	0.7392757	N170
108	ref	average	0.6550156	N2pc
109	ref	Cz	0.6565307	N2pc
110	ref	P9P10	0.6551984	N2pc
111	hpf	None	0.6553028	N2pc
112	hpf	0.1	0.6549374	N2pc
113	hpf	0.5	0.6565044	N2pc
114	lpf	None	0.6537630	N2pc
115	lpf	6	0.6584872	N2pc
116	lpf	20	0.6595031	N2pc

117	lpf	45	0.6505729	N2pc
118	emc	None	0.6653170	N2pc
119	emc	ica	0.6458461	N2pc
120	mac	None	0.6598520	N2pc
121	mac	ica	0.6513111	N2pc
122	base	200ms	0.6552955	N2pc
123	base	400ms	0.6558676	N2pc
124	det	offset	0.6563763	N2pc
125	det	linear	0.6547868	N2pc
126	ar	false	0.6591314	N2pc
127	ar	true	0.6520317	N2pc
128	ref	average	0.6614567	N400
129	ref	Cz	0.6660536	N400
130	ref	P9P10	0.6670757	N400
131	hpf	None	0.6652528	N400
132	hpf	0.1	0.6642453	N400
133	hpf	0.5	0.6650879	N400
134	lpf	None	0.6636813	N400
135	lpf	6	0.6665603	N400
136	lpf	20	0.6671680	N400
137	lpf	45	0.6620385	N400
138	emc	None	0.6666341	N400
139	emc	ica	0.6630899	N400
140	mac	None	0.6675564	N400
141	mac	ica	0.6621676	N400
142	base	200ms	0.6649353	N400
143	base	400ms	0.6647888	N400
144	det	offset	0.6693866	N400
145	det	linear	0.6603375	N400
146	ar	false	0.6679897	N400
147	ar	true	0.6617343	N400
148	ref	average	0.6794499	P3
149	ref	Cz	0.6820892	P3
150	ref	P9P10	0.6849030	P3
151	hpf	None	0.6806753	P3
152	hpf	0.1	0.6810022	P3
153	hpf	0.5	0.6847646	P3
154	lpf	None	0.6804650	P3
155	lpf	6	0.6836762	P3
156	lpf	20	0.6833241	P3
157	lpf	45	0.6811241	P3
158	emc	None	0.6828095	P3
159	emc	ica	0.6814852	P3

```

160      mac    None 0.6834085      P3
161      mac    ica 0.6808862      P3
162      base   200ms 0.6821452     P3
163      base   400ms 0.6821495     P3
164      det    offset 0.6816629     P3
165      det    linear 0.6826318     P3
166      ar     false 0.6870475     P3
167      ar     true 0.6772472      P3

```

### Contrasts / Pairwise differences

```
tar_read(eegnet_HLM_emm_contrasts_comb)
```

	variable	level.1	level.2	estimate	SE	df	z.ratio
1		ref	average	Cz -2.886187e-03	0.0006228951	Inf	-4.63350482
2		ref	average	P9P10 -2.710340e-03	0.0007826088	Inf	-3.46321131
3		ref	Cz	P9P10 1.758475e-04	0.0007199230	Inf	0.24425880
4		hpf	None	0.1 -2.033732e-04	0.0002348125	Inf	-0.86610897
5		hpf	None	0.5 -2.752911e-03	0.0005471096	Inf	-5.03173588
6		hpf	0.1	0.5 -2.549538e-03	0.0004536607	Inf	-5.61992237
7		lpf	None	6 -3.264511e-03	0.0010657672	Inf	-3.06306200
8		lpf	None	20 -5.944277e-03	0.0009041907	Inf	-6.57414146
9		lpf	None	45 4.606729e-05	0.0005308075	Inf	0.08678718
10		lpf	6	20 -2.679767e-03	0.0006213412	Inf	-4.31287467
11		lpf	6	45 3.310578e-03	0.0011538558	Inf	2.86914373
12		lpf	20	45 5.990345e-03	0.0010146231	Inf	5.90400967
13		base	200ms	400ms 1.699533e-05	0.0001253259	Inf	0.13560914
14		det	offset	linear -1.006510e-03	0.0010021962	Inf	-1.00430422
15		ar	false	true 8.674032e-03	0.0011444232	Inf	7.57939241
16		emc	None	ica 4.148783e-03	0.0009416235	Inf	4.40598929
17		mac	None	ica 6.333398e-03	0.0009420739	Inf	6.72282433
18	experiment		ERN	LRP 5.129029e-02	0.0131774043	Inf	3.89229115
19	experiment		ERN	MMN 2.915791e-01	0.0127619725	Inf	22.84749142
20	experiment		ERN	N170 1.154175e-01	0.0183730812	Inf	6.28187904
21	experiment		ERN	N2pc 2.050209e-01	0.0206321535	Inf	9.93696184
22	experiment		ERN	N400 1.957405e-01	0.0139013392	Inf	14.08069103
23	experiment		ERN	P3 1.784551e-01	0.0175204109	Inf	10.18555595
24	experiment		LRP	MMN 2.402888e-01	0.0119832004	Inf	20.05213593
25	experiment		LRP	N170 6.412718e-02	0.0122794709	Inf	5.22230801
26	experiment		LRP	N2pc 1.537306e-01	0.0174365553	Inf	8.81657104
27	experiment		LRP	N400 1.444502e-01	0.0160614511	Inf	8.99359388

28	experiment	LRP	P3	1.271648e-01	0.0142312328	Inf	8.93561597
29	experiment	MMN	N170	-1.761616e-01	0.0155507752	Inf	-11.32815447
30	experiment	MMN	N2pc	-8.655813e-02	0.0186152302	Inf	-4.64985571
31	experiment	MMN	N400	-9.583859e-02	0.0139042209	Inf	-6.89276980
32	experiment	MMN	P3	-1.131239e-01	0.0158627725	Inf	-7.13140981
33	experiment	N170	N2pc	8.960345e-02	0.0178046540	Inf	5.03258580
34	experiment	N170	N400	8.032299e-02	0.0179929065	Inf	4.46414753
35	experiment	N170	P3	6.303765e-02	0.0174846257	Inf	3.60531892
36	experiment	N2pc	N400	-9.280460e-03	0.0206027734	Inf	-0.45044711
37	experiment	N2pc	P3	-2.656580e-02	0.0174041765	Inf	-1.52640357
38	experiment	N400	P3	-1.728534e-02	0.0168314590	Inf	-1.02696607
39	ref	average	Cz	-8.668743e-03	0.0020901803	Inf	-4.14736629
40	ref	average	P9P10	-2.242005e-04	0.0019960564	Inf	-0.11232174
41	ref	Cz	P9P10	8.444543e-03	0.0019542885	Inf	4.32103186
42	hpf	None	0.1	-7.463742e-04	0.0007069720	Inf	-1.05573380
43	hpf	None	0.5	-5.126607e-03	0.0012666115	Inf	-4.04749774
44	hpf	0.1	0.5	-4.380233e-03	0.0009229824	Inf	-4.74573831
45	lpf	None	6	-2.656985e-03	0.0020776874	Inf	-1.27881835
46	lpf	None	20	-4.182389e-03	0.0017139697	Inf	-2.44017686
47	lpf	None	45	8.195330e-04	0.0010062962	Inf	0.81440535
48	lpf	6	20	-1.525405e-03	0.0008553290	Inf	-1.78341256
49	lpf	6	45	3.476518e-03	0.0019669523	Inf	1.76746418
50	lpf	20	45	5.001922e-03	0.0015567914	Inf	3.21296893
51	emc	None	ica	1.305649e-03	0.0014398418	Inf	0.90679999
52	mac	None	ica	3.335886e-03	0.0014422723	Inf	2.31293794
53	base	200ms	400ms	1.101584e-04	0.0002988495	Inf	0.36860843
54	det	offset	linear	1.136157e-03	0.0029299213	Inf	0.38777727
55	ar	false	true	8.220273e-03	0.0021901222	Inf	3.75333974
56	ref	average	Cz	8.971237e-04	0.0009866377	Inf	0.90927371
57	ref	average	P9P10	5.249660e-03	0.0011275582	Inf	4.65577735
58	ref	Cz	P9P10	4.352536e-03	0.0010691781	Inf	4.07091789
59	hpf	None	0.1	-4.136931e-04	0.0002861598	Inf	-1.44567160
60	hpf	None	0.5	-2.065396e-03	0.0007041180	Inf	-2.93330990
61	hpf	0.1	0.5	-1.651703e-03	0.0006574348	Inf	-2.51234521
62	lpf	None	6	-2.467182e-02	0.0035372192	Inf	-6.97491916
63	lpf	None	20	-2.559673e-02	0.0032832169	Inf	-7.79623408
64	lpf	None	45	-4.057769e-03	0.0012794295	Inf	-3.17154584
65	lpf	6	20	-9.249094e-04	0.0007250103	Inf	-1.27571891
66	lpf	6	45	2.061405e-02	0.0032780847	Inf	6.28844308
67	lpf	20	45	2.153896e-02	0.0030380341	Inf	7.08976852
68	emc	None	ica	1.450361e-03	0.0009184169	Inf	1.57919667
69	mac	None	ica	2.332986e-02	0.0031323652	Inf	7.44800038
70	base	200ms	400ms	3.668204e-04	0.0002309462	Inf	1.58833745

71	det	offset	linear	-3.780489e-03	0.0013003306	Inf	-2.90732941
72	ar	false	true	1.088474e-02	0.0010791678	Inf	10.08623596
73	ref	average	Cz	-6.440694e-04	0.0006817542	Inf	-0.94472369
74	ref	average	P9P10	-2.056493e-03	0.0007462967	Inf	-2.75559757
75	ref	Cz	P9P10	-1.412424e-03	0.0007339597	Inf	-1.92438889
76	hpf	None	0.1	-2.448645e-05	0.0002638211	Inf	-0.09281459
77	hpf	None	0.5	-1.973136e-03	0.0003542106	Inf	-5.57051769
78	hpf	0.1	0.5	-1.948650e-03	0.0003065463	Inf	-6.35678709
79	lpf	None	6	-2.761659e-03	0.0017134256	Inf	-1.61177621
80	lpf	None	20	-5.367771e-03	0.0015645166	Inf	-3.43094565
81	lpf	None	45	-8.453012e-04	0.0007382264	Inf	-1.14504326
82	lpf	6	20	-2.606113e-03	0.0008784316	Inf	-2.96677938
83	lpf	6	45	1.916357e-03	0.0016771149	Inf	1.14265127
84	lpf	20	45	4.522470e-03	0.0015403394	Inf	2.93602185
85	emc	None	ica	7.844059e-04	0.0005267458	Inf	1.48915450
86	mac	None	ica	5.331146e-03	0.0015148568	Inf	3.51924127
87	base	200ms	400ms	5.581183e-04	0.0002712839	Inf	2.05732191
88	det	offset	linear	-4.371523e-03	0.0007018664	Inf	-6.22842645
89	ar	false	true	6.639234e-03	0.0013705825	Inf	4.84409662
90	ref	average	Cz	-3.036296e-03	0.0015566629	Inf	-1.95051581
91	ref	average	P9P10	-1.068644e-02	0.0021737939	Inf	-4.91603276
92	ref	Cz	P9P10	-7.650146e-03	0.0020589586	Inf	-3.71554162
93	hpf	None	0.1	-1.284993e-03	0.0004798036	Inf	-2.67816553
94	hpf	None	0.5	-4.979248e-03	0.0012072429	Inf	-4.12447907
95	hpf	0.1	0.5	-3.694255e-03	0.0010502091	Inf	-3.51763729
96	lpf	None	6	1.805339e-02	0.0044073126	Inf	4.09623436
97	lpf	None	20	5.622830e-03	0.0021877608	Inf	2.57013013
98	lpf	None	45	2.322049e-04	0.0009061894	Inf	0.25624319
99	lpf	6	20	-1.243056e-02	0.0035674944	Inf	-3.48439382
100	lpf	6	45	-1.782118e-02	0.0045813177	Inf	-3.88996827
101	lpf	20	45	-5.390625e-03	0.0023554029	Inf	-2.28862119
102	emc	None	ica	1.161567e-03	0.0015591793	Inf	0.74498604
103	mac	None	ica	-4.115126e-03	0.0024020490	Inf	-1.71317319
104	base	200ms	400ms	-4.861111e-04	0.0002832769	Inf	-1.71602797
105	det	offset	linear	-9.699436e-03	0.0020131091	Inf	-4.81813712
106	ar	false	true	1.181858e-02	0.0022740148	Inf	5.19722922
107	ref	average	Cz	-1.515066e-03	0.0009122171	Inf	-1.66086142
108	ref	average	P9P10	-1.827861e-04	0.0024239807	Inf	-0.07540740
109	ref	Cz	P9P10	1.332280e-03	0.0024257066	Inf	0.54923384
110	hpf	None	0.1	3.653926e-04	0.0004975885	Inf	0.73432675
111	hpf	None	0.5	-1.201564e-03	0.0008052560	Inf	-1.49215130
112	hpf	0.1	0.5	-1.566956e-03	0.0006522725	Inf	-2.40230330
113	lpf	None	6	-4.724186e-03	0.0025246739	Inf	-1.87120647

114	lpf	None	20	-5.740036e-03	0.0024556404	Inf	-2.33749054
115	lpf	None	45	3.190188e-03	0.0021262658	Inf	1.50037132
116	lpf	6	20	-1.015850e-03	0.0012517204	Inf	-0.81156310
117	lpf	6	45	7.914374e-03	0.0030149664	Inf	2.62502901
118	lpf	20	45	8.930224e-03	0.0027908294	Inf	3.19984608
119	emc	None	ica	1.947097e-02	0.0056053283	Inf	3.47365456
120	mac	None	ica	8.540958e-03	0.0025614394	Inf	3.33443699
121	base	200ms	400ms	-5.721628e-04	0.0002829109	Inf	-2.02241316
122	det	offset	linear	1.589572e-03	0.0021579528	Inf	0.73661129
123	ar	false	true	7.099628e-03	0.0018263012	Inf	3.88743563
124	ref	average	Cz	-4.596897e-03	0.0014527819	Inf	-3.16420289
125	ref	average	P9P10	-5.619032e-03	0.0022539366	Inf	-2.49298586
126	ref	Cz	P9P10	-1.022135e-03	0.0026076133	Inf	-0.39198121
127	hpf	None	0.1	1.007487e-03	0.0008767882	Inf	1.14906543
128	hpf	None	0.5	1.649306e-04	0.0018421320	Inf	0.08953243
129	hpf	0.1	0.5	-8.425564e-04	0.0015650252	Inf	-0.53836603
130	lpf	None	6	-2.879051e-03	0.0020222010	Inf	-1.42372145
131	lpf	None	20	-3.486690e-03	0.0020530467	Inf	-1.69830029
132	lpf	None	45	1.642795e-03	0.0018860540	Inf	0.87102231
133	lpf	6	20	-6.076389e-04	0.0010041854	Inf	-0.60510630
134	lpf	6	45	4.521846e-03	0.0024133399	Inf	1.87368805
135	lpf	20	45	5.129485e-03	0.0024950227	Inf	2.05588713
136	emc	None	ica	3.544198e-03	0.0017508834	Inf	2.02423447
137	mac	None	ica	5.388817e-03	0.0018512300	Inf	2.91093840
138	base	200ms	400ms	1.464844e-04	0.0003545339	Inf	0.41317452
139	det	offset	linear	9.049117e-03	0.0035986506	Inf	2.51458632
140	ar	false	true	6.255425e-03	0.0023522763	Inf	2.65930722
141	ref	average	Cz	-2.639364e-03	0.0017147135	Inf	-1.53924463
142	ref	average	P9P10	-5.453084e-03	0.0019929401	Inf	-2.73620075
143	ref	Cz	P9P10	-2.813721e-03	0.0020837626	Inf	-1.35030770
144	hpf	None	0.1	-3.269450e-04	0.0008125994	Inf	-0.40234459
145	hpf	None	0.5	-4.089355e-03	0.0015846379	Inf	-2.58062457
146	hpf	0.1	0.5	-3.762410e-03	0.0014161708	Inf	-2.65674904
147	lpf	None	6	-3.211263e-03	0.0023216841	Inf	-1.38316105
148	lpf	None	20	-2.859158e-03	0.0020342060	Inf	-1.40554003
149	lpf	None	45	-6.591797e-04	0.0012671187	Inf	-0.52021936
150	lpf	6	20	3.521050e-04	0.0012654112	Inf	0.27825346
151	lpf	6	45	2.552083e-03	0.0022971708	Inf	1.11096805
152	lpf	20	45	2.199978e-03	0.0019234855	Inf	1.14374573
153	emc	None	ica	1.324327e-03	0.0018846019	Inf	0.70270931
154	mac	None	ica	2.522244e-03	0.0016258141	Inf	1.55137290
155	base	200ms	400ms	-4.340277e-06	0.0002916982	Inf	-0.01487934
156	det	offset	linear	-9.689670e-04	0.0028709038	Inf	-0.33751289

	ar	false	true	9.800347e-03	0.0021004762	Inf	4.66577404
	p.value	significance	experiment				
1	1.072635e-05	***	ALL				
2	1.547911e-03	**	ALL				
3	9.676455e-01		ALL				
4	6.617106e-01		ALL				
5	1.454218e-06	***	ALL				
6	5.726306e-08	***	ALL				
7	1.175868e-02	*	ALL				
8	2.935741e-10	***	ALL				
9	9.997659e-01		ALL				
10	9.490867e-05	***	ALL				
11	2.143139e-02	*	ALL				
12	2.126578e-08	***	ALL				
13	8.921303e-01		ALL				
14	3.152320e-01		ALL				
15	3.471770e-14	***	ALL				
16	1.053022e-05	***	ALL				
17	1.782354e-11	***	ALL				
18	1.917620e-03	**	ALL				
19	0.000000e+00	***	ALL				
20	7.017240e-09	***	ALL				
21	6.028511e-14	***	ALL				
22	0.000000e+00	***	ALL				
23	6.372680e-14	***	ALL				
24	0.000000e+00	***	ALL				
25	3.676828e-06	***	ALL				
26	5.317968e-14	***	ALL				
27	4.718448e-14	***	ALL				
28	4.862777e-14	***	ALL				
29	0.000000e+00	***	ALL				
30	6.799833e-05	***	ALL				
31	1.149233e-10	***	ALL				
32	2.090905e-11	***	ALL				
33	1.003022e-05	***	ALL				
34	1.630562e-04	***	ALL				
35	5.772597e-03	**	ALL				
36	9.993738e-01		ALL				
37	7.289464e-01		ALL				
38	9.479547e-01		ALL				
39	9.966093e-05	***	ERN				
40	9.930687e-01		ERN				
41	4.615782e-05	***	ERN				

42	5.416856e-01		ERN
43	1.530833e-04	***	ERN
44	6.204141e-06	***	ERN
45	5.764612e-01		ERN
46	6.973172e-02	.	ERN
47	8.477018e-01		ERN
48	2.812818e-01		ERN
49	2.891128e-01		ERN
50	7.189784e-03	**	ERN
51	3.645126e-01		ERN
52	2.072605e-02	*	ERN
53	7.124196e-01		ERN
54	6.981809e-01		ERN
55	1.744941e-04	***	ERN
56	6.344234e-01		LRP
57	9.631459e-06	***	LRP
58	1.385470e-04	***	LRP
59	3.174918e-01		LRP
60	9.399289e-03	**	LRP
61	3.215244e-02	*	LRP
62	1.839107e-11	***	LRP
63	6.117329e-14	***	LRP
64	8.256540e-03	**	LRP
65	5.784466e-01		LRP
66	1.923215e-09	***	LRP
67	8.088974e-12	***	LRP
68	1.142910e-01		LRP
69	9.476555e-14	***	LRP
70	1.122101e-01		LRP
71	3.645291e-03	**	LRP
72	6.356018e-24	***	LRP
73	6.119254e-01		MMN
74	1.615041e-02	*	MMN
75	1.317967e-01		MMN
76	9.952619e-01		MMN
77	7.612173e-08	***	MMN
78	6.179640e-10	***	MMN
79	3.718785e-01		MMN
80	3.368994e-03	**	MMN
81	6.615440e-01		MMN
82	1.592284e-02	*	MMN
83	6.630424e-01		MMN
84	1.750479e-02	*	MMN

85	1.364467e-01		MMN
86	4.327829e-04	***	MMN
87	3.965527e-02	*	MMN
88	4.711432e-10	***	MMN
89	1.271890e-06	***	MMN
90	1.247443e-01		N170
91	2.640589e-06	***	N170
92	5.940551e-04	***	N170
93	2.024109e-02	*	N170
94	1.100576e-04	***	N170
95	1.265792e-03	**	N170
96	2.454512e-04	***	N170
97	4.985439e-02	*	N170
98	9.941035e-01		N170
99	2.776223e-03	**	N170
100	5.804045e-04	***	N170
101	1.006371e-01		N170
102	4.562802e-01		N170
103	8.668068e-02	.	N170
104	8.615692e-02	.	N170
105	1.449048e-06	***	N170
106	2.022809e-07	***	N170
107	2.204107e-01		N2pc
108	9.968699e-01		N2pc
109	8.468709e-01		N2pc
110	7.430739e-01		N2pc
111	2.946614e-01		N2pc
112	4.303160e-02	*	N2pc
113	2.404871e-01		N2pc
114	8.966887e-02	.	N2pc
115	4.372270e-01		N2pc
116	8.490434e-01		N2pc
117	4.301714e-02	*	N2pc
118	7.513394e-03	**	N2pc
119	5.134216e-04	***	N2pc
120	8.547226e-04	***	N2pc
121	4.313369e-02	*	N2pc
122	4.613588e-01		N2pc
123	1.013088e-04	***	N2pc
124	4.434658e-03	**	N400
125	3.387473e-02	*	N400
126	9.188027e-01		N400
127	4.838646e-01		N400

128	9.955903e-01		N400
129	8.524007e-01		N400
130	4.844191e-01		N400
131	3.245098e-01		N400
132	8.198603e-01		N400
133	9.304899e-01		N400
134	2.393919e-01		N400
135	1.677959e-01		N400
136	4.294603e-02	*	N400
137	3.603450e-03	**	N400
138	6.794788e-01		N400
139	1.191721e-02	*	N400
140	7.830153e-03	**	N400
141	2.725579e-01		P3
142	1.709998e-02	*	P3
143	3.673390e-01		P3
144	9.146450e-01		P3
145	2.666524e-02	*	P3
146	2.152197e-02	*	P3
147	5.099203e-01		P3
148	4.958130e-01		P3
149	9.542627e-01		P3
150	9.924828e-01		P3
151	6.827647e-01		P3
152	6.623569e-01		P3
153	4.822369e-01		P3
154	1.208123e-01		P3
155	9.881284e-01		P3
156	7.357303e-01		P3
157	3.074574e-06	***	P3

### Omnibus F-Test per facet (Experiment-Model and Preprocessing Step)

```
tar_read(eegnet_HLM_emm_omni_comb)
```

	model	term	df1	df2	F.ratio	Chisq	p.value	experiment	p.fdr
1		ref	2	Inf	11.643	23.286	8.777766e-06	ALL	1.508571e-04
2		hpf	2	Inf	15.803	31.606	1.370610e-07	ALL	4.240023e-06
3		lpf	3	Inf	19.606	58.818	1.051566e-12	ALL	5.421748e-11
4		base	1	Inf	0.018	0.018	8.921303e-01	ALL	1.000000e+00
5		det	1	Inf	1.009	1.009	3.152320e-01	ALL	1.000000e+00

6	ar	1	Inf	57.447	57.447	3.471770e-14	ALL	2.685005e-12
7	emc	1	Inf	19.413	19.413	1.053022e-05	ALL	1.714502e-04
8	mac	1	Inf	45.196	45.196	1.782354e-11	ALL	7.876807e-10
9	experiment	6	Inf	115.390	692.340	2.758215e-146	ALL	8.532618e-144
10	ref	2	Inf	11.853	23.706	7.118322e-06	ERN	1.295337e-04
11	hpf	2	Inf	11.271	22.542	1.273967e-05	ERN	1.970527e-04
12	lpf	3	Inf	5.982	17.946	4.515690e-04	ERN	5.347429e-03
13	emc	1	Inf	0.822	0.822	3.645126e-01	ERN	1.000000e+00
14	mac	1	Inf	5.350	5.350	2.072605e-02	ERN	1.644017e-01
15	base	1	Inf	0.136	0.136	7.124196e-01	ERN	1.000000e+00
16	det	1	Inf	0.150	0.150	6.981809e-01	ERN	1.000000e+00
17	ar	1	Inf	14.088	14.088	1.744941e-04	ERN	2.346968e-03
18	ref	2	Inf	12.129	24.258	5.400086e-06	LRP	1.074976e-04
19	hpf	2	Inf	4.388	8.776	1.242271e-02	LRP	1.098000e-01
20	lpf	3	Inf	24.059	72.177	1.458449e-15	LRP	1.503918e-13
21	emc	1	Inf	2.494	2.494	1.142910e-01	LRP	7.365883e-01
22	mac	1	Inf	55.473	55.473	9.476555e-14	LRP	5.863200e-12
23	base	1	Inf	2.523	2.523	1.122101e-01	LRP	7.365883e-01
24	det	1	Inf	8.453	8.453	3.645291e-03	LRP	3.524004e-02
25	ar	1	Inf	101.732	101.732	6.356018e-24	LRP	9.831263e-22
26	ref	2	Inf	3.882	7.764	2.061198e-02	MMN	1.644017e-01
27	hpf	2	Inf	21.543	43.086	4.403393e-10	MMN	1.619439e-08
28	lpf	3	Inf	6.280	18.840	2.949130e-04	MMN	3.801342e-03
29	emc	1	Inf	2.218	2.218	1.364467e-01	MMN	8.442036e-01
30	mac	1	Inf	12.385	12.385	4.327829e-04	MMN	5.347429e-03
31	base	1	Inf	4.233	4.233	3.965527e-02	MMN	2.992067e-01
32	det	1	Inf	38.793	38.793	4.711432e-10	MMN	1.619439e-08
33	ar	1	Inf	23.465	23.465	1.271890e-06	MMN	3.278858e-05
34	ref	2	Inf	12.100	24.200	5.559867e-06	N170	1.074976e-04
35	hpf	2	Inf	8.744	17.488	1.593596e-04	N170	2.240834e-03
36	lpf	3	Inf	5.733	17.199	6.428135e-04	N170	6.857111e-03
37	emc	1	Inf	0.555	0.555	4.562802e-01	N170	1.000000e+00
38	mac	1	Inf	2.935	2.935	8.668068e-02	N170	5.829331e-01
39	base	1	Inf	2.945	2.945	8.615692e-02	N170	5.829331e-01
40	det	1	Inf	23.214	23.214	1.449048e-06	N170	3.448209e-05
41	ar	1	Inf	27.011	27.011	2.022809e-07	N170	5.688743e-06
42	ref	2	Inf	1.408	2.816	2.447338e-01	N2pc	1.000000e+00
43	hpf	2	Inf	3.093	6.186	4.537935e-02	N2pc	3.190508e-01
44	lpf	3	Inf	3.573	10.719	1.333967e-02	N2pc	1.146296e-01
45	emc	1	Inf	12.066	12.066	5.134216e-04	N2pc	5.672445e-03
46	mac	1	Inf	11.118	11.118	8.547226e-04	N2pc	8.813698e-03
47	base	1	Inf	4.090	4.090	4.313369e-02	N2pc	3.103147e-01
48	det	1	Inf	0.543	0.543	4.613588e-01	N2pc	1.000000e+00

49	ar	1	Inf	15.112	15.112	1.013088e-04	N2pc	1.492390e-03
50	ref	2	Inf	7.670	15.340	4.667181e-04	N400	5.347429e-03
51	hpf	2	Inf	0.848	1.696	4.282307e-01	N400	1.000000e+00
52	lpf	3	Inf	1.470	4.410	2.204155e-01	N400	1.000000e+00
53	emc	1	Inf	4.098	4.098	4.294603e-02	N400	3.103147e-01
54	mac	1	Inf	8.474	8.474	3.603450e-03	N400	3.524004e-02
55	base	1	Inf	0.171	0.171	6.794788e-01	N400	1.000000e+00
56	det	1	Inf	6.323	6.323	1.191721e-02	N400	1.084301e-01
57	ar	1	Inf	7.072	7.072	7.830153e-03	N400	7.340244e-02
58	ref	2	Inf	3.895	7.790	2.034169e-02	P3	1.644017e-01
59	hpf	2	Inf	3.699	7.398	2.475540e-02	P3	1.914538e-01
60	lpf	3	Inf	0.705	2.115	5.487183e-01	P3	1.000000e+00
61	emc	1	Inf	0.494	0.494	4.822369e-01	P3	1.000000e+00
62	mac	1	Inf	2.407	2.407	1.208123e-01	P3	7.627276e-01
63	base	1	Inf	0.000	0.000	9.881284e-01	P3	1.000000e+00
64	det	1	Inf	0.114	0.114	7.357303e-01	P3	1.000000e+00
65	ar	1	Inf	21.769	21.769	3.074574e-06	P3	6.793775e-05
	sign.unc	sign.fdr						
1	***	***						
2	***	***						
3	***	***						
4								
5								
6	***	***						
7	***	***						
8	***	***						
9	***	***						
10	***	***						
11	***	***						
12	***	**						
13								
14	*							
15								
16								
17	***	**						
18	***	***						
19	*							
20	***	***						
21								
22	***	***						
23								
24	**	*						
25	***	***						

```
26      *
27      ***      ***
28      ***      **
29
30      ***      **
31      *
32      ***      ***
33      ***      ***
34      ***      ***
35      ***      **
36      ***      **
37
38      .
39      .
40      ***      ***
41      ***      ***
42
43      *
44      *
45      ***      **
46      ***      **
47      *
48
49      ***      **
50      ***      **
51
52
53      *
54      **      *
55
56      *
57      **      .
58      *
59      *
60
61
62
63
64
65      ***      ***
```

### Time-resolved

## Means

```
tar_read(sliding_LM_emm_means_comb)
```

	variable	level	emmmean	experiment
1		ref average	1339.8121	ALL
2		ref Cz	1355.1896	ALL
3		ref P9P10	1366.6259	ALL
4	hpf	None	1306.2825	ALL
5	hpf	0.1	1346.6881	ALL
6	hpf	0.5	1408.6571	ALL
7	lpf	None	1183.4106	ALL
8	lpf	6	1639.4605	ALL
9	lpf	20	1370.9505	ALL
10	lpf	45	1221.6819	ALL
11	base	200ms	1328.3105	ALL
12	base	400ms	1379.4412	ALL
13	det	offset	1228.9534	ALL
14	det	linear	1478.7983	ALL
15	ar	false	1395.6957	ALL
16	ar	true	1312.0561	ALL
17	emc	None	1392.1899	ALL
18	emc	ica	1315.5618	ALL
19	mac	None	1379.2992	ALL
20	mac	ica	1328.4525	ALL
21	experiment	ERN	2756.7986	ALL
22	experiment	LRP	1697.0784	ALL
23	experiment	MMN	523.4586	ALL
24	experiment	N170	1300.0328	ALL
25	experiment	N2pc	799.6500	ALL
26	experiment	N400	1161.3261	ALL
27	experiment	P3	1238.7865	ALL
28		ref average	2722.3412	ERN
29		ref Cz	2754.9801	ERN
30		ref P9P10	2793.0744	ERN
31	hpf	None	2663.4905	ERN
32	hpf	0.1	2728.0225	ERN
33	hpf	0.5	2878.8828	ERN
34	lpf	None	2409.4681	ERN
35	lpf	6	3430.3628	ERN
36	lpf	20	2744.4459	ERN
37	lpf	45	2442.9176	ERN

38	emc	None	2831.5491	ERN
39	emc	ica	2682.0481	ERN
40	mac	None	2810.9096	ERN
41	mac	ica	2702.6876	ERN
42	base	200ms	2753.8428	ERN
43	base	400ms	2759.7544	ERN
44	det	offset	2449.5646	ERN
45	det	linear	3064.0326	ERN
46	ar	false	2812.7329	ERN
47	ar	true	2700.8643	ERN
48	ref	average	1691.2122	LRP
49	ref	Cz	1700.2538	LRP
50	ref	P9P10	1699.7693	LRP
51	hpf	None	1595.1049	LRP
52	hpf	0.1	1676.3718	LRP
53	hpf	0.5	1819.7586	LRP
54	lpf	None	1406.4192	LRP
55	lpf	6	2169.8017	LRP
56	lpf	20	1729.7623	LRP
57	lpf	45	1482.3305	LRP
58	emc	None	1731.2608	LRP
59	emc	ica	1662.8961	LRP
60	mac	None	1752.8861	LRP
61	mac	ica	1641.2708	LRP
62	base	200ms	1674.7058	LRP
63	base	400ms	1719.4510	LRP
64	det	offset	1425.1531	LRP
65	det	linear	1969.0038	LRP
66	ar	false	1750.2527	LRP
67	ar	true	1643.9042	LRP
68	ref	average	528.9033	MMN
69	ref	Cz	540.2208	MMN
70	ref	P9P10	501.2517	MMN
71	hpf	None	480.9967	MMN
72	hpf	0.1	526.6129	MMN
73	hpf	0.5	562.7662	MMN
74	lpf	None	420.7873	MMN
75	lpf	6	662.4957	MMN
76	lpf	20	558.0619	MMN
77	lpf	45	452.4895	MMN
78	emc	None	525.0890	MMN
79	emc	ica	521.8282	MMN
80	mac	None	536.0945	MMN

81	mac	ica	510.8227	MMN
82	base	200ms	538.9324	MMN
83	base	400ms	507.9848	MMN
84	det	offset	447.7955	MMN
85	det	linear	599.1217	MMN
86	ar	false	570.5074	MMN
87	ar	true	476.4098	MMN
88	ref	average	1288.5706	N170
89	ref	Cz	1290.6984	N170
90	ref	P9P10	1320.8295	N170
91	hpf	None	1257.4133	N170
92	hpf	0.1	1281.8746	N170
93	hpf	0.5	1360.8106	N170
94	lpf	None	1230.4009	N170
95	lpf	6	1351.9762	N170
96	lpf	20	1351.6870	N170
97	lpf	45	1266.0671	N170
98	emc	None	1309.9649	N170
99	emc	ica	1290.1007	N170
100	mac	None	1306.5835	N170
101	mac	ica	1293.4821	N170
102	base	200ms	1283.1649	N170
103	base	400ms	1316.9008	N170
104	det	offset	1156.1718	N170
105	det	linear	1443.8939	N170
106	ar	false	1320.2792	N170
107	ar	true	1279.7864	N170
108	ref	average	792.0254	N2pc
109	ref	Cz	805.4867	N2pc
110	ref	P9P10	801.4379	N2pc
111	hpf	None	755.2831	N2pc
112	hpf	0.1	818.4705	N2pc
113	hpf	0.5	825.1963	N2pc
114	lpf	None	672.5147	N2pc
115	lpf	6	1003.2075	N2pc
116	lpf	20	810.1683	N2pc
117	lpf	45	712.7094	N2pc
118	emc	None	865.8022	N2pc
119	emc	ica	733.4978	N2pc
120	mac	None	817.9430	N2pc
121	mac	ica	781.3569	N2pc
122	base	200ms	762.3807	N2pc
123	base	400ms	836.9193	N2pc

124	det	offset	721.4270	N2pc
125	det	linear	877.8730	N2pc
126	ar	false	809.9766	N2pc
127	ar	true	789.3234	N2pc
128	ref	average	1134.1000	N400
129	ref	Cz	1161.2486	N400
130	ref	P9P10	1188.6295	N400
131	hpf	None	1154.7667	N400
132	hpf	0.1	1170.4718	N400
133	hpf	0.5	1158.7397	N400
134	lpf	None	1030.2557	N400
135	lpf	6	1395.5049	N400
136	lpf	20	1163.4216	N400
137	lpf	45	1056.1220	N400
138	emc	None	1208.9209	N400
139	emc	ica	1113.7312	N400
140	mac	None	1174.9274	N400
141	mac	ica	1147.7247	N400
142	base	200ms	1107.4591	N400
143	base	400ms	1215.1931	N400
144	det	offset	1166.5307	N400
145	det	linear	1156.1214	N400
146	ar	false	1232.3465	N400
147	ar	true	1090.3056	N400
148	ref	average	1221.5316	P3
149	ref	Cz	1233.4389	P3
150	ref	P9P10	1261.3891	P3
151	hpf	None	1236.9219	P3
152	hpf	0.1	1224.9925	P3
153	hpf	0.5	1254.4452	P3
154	lpf	None	1114.0282	P3
155	lpf	6	1462.8746	P3
156	lpf	20	1239.1065	P3
157	lpf	45	1139.1368	P3
158	emc	None	1272.7427	P3
159	emc	ica	1204.8304	P3
160	mac	None	1255.7505	P3
161	mac	ica	1221.8226	P3
162	base	200ms	1177.6879	P3
163	base	400ms	1299.8851	P3
164	det	offset	1236.0315	P3
165	det	linear	1241.5415	P3
166	ar	false	1273.7744	P3

167 ar true 1203.7987

P3

### Contrasts / Pairwise differences

```
tar_read(sliding_LM_emm_contrasts_comb)
```

	variable	level.1	level.2	estimate	SE	df	t.ratio	
1		ref	average	Cz	-15.3775551	5.672263	8045	-2.71100891
2		ref	average	P9P10	-26.8138599	5.672263	8045	-4.72718924
3		ref	Cz	P9P10	-11.4363048	5.672263	8045	-2.01618032
4		hpf	None	0.1	-40.4056270	5.672263	8045	-7.12336999
5		hpf	None	0.5	-102.3746072	5.672263	8045	-18.04828337
6		hpf	0.1	0.5	-61.9689803	5.672263	8045	-10.92491338
7		lpf	None	6	-456.0499018	6.549765	8045	-69.62843769
8		lpf	None	20	-187.5399147	6.549765	8045	-28.63307550
9		lpf	None	45	-38.2712680	6.549765	8045	-5.84315136
10		lpf	6	20	268.5099870	6.549765	8045	40.99536219
11		lpf	6	45	417.7786337	6.549765	8045	63.78528633
12		lpf	20	45	149.2686467	6.549765	8045	22.78992414
13		base	200ms	400ms	-51.1306942	4.631383	8045	-11.04004823
14		det	offset	linear	-249.8448290	4.631383	8045	-53.94604959
15		ar	false	true	83.6396050	4.631383	8045	18.05931424
16		emc	None	ica	76.6281654	4.631383	8045	16.54541673
17		mac	None	ica	50.8467454	4.631383	8045	10.97873852
18	experiment		ERN	LRP	1059.7201521	8.664525	8045	122.30563110
19	experiment		ERN	MMN	2233.3399886	8.664525	8045	257.75678251
20	experiment		ERN	N170	1456.7657811	8.664525	8045	168.12991418
21	experiment		ERN	N2pc	1957.1486066	8.664525	8045	225.88066765
22	experiment		ERN	N400	1595.4725396	8.664525	8045	184.13849682
23	experiment		ERN	P3	1518.0120632	8.664525	8045	175.19853995
24	experiment		LRP	MMN	1173.6198365	8.664525	8045	135.45115140
25	experiment		LRP	N170	397.0456290	8.664525	8045	45.82428307
26	experiment		LRP	N2pc	897.4284544	8.664525	8045	103.57503655
27	experiment		LRP	N400	535.7523874	8.664525	8045	61.83286571
28	experiment		LRP	P3	458.2919110	8.664525	8045	52.89290884
29	experiment		MMN	N170	-776.5742075	8.664525	8045	-89.62686833
30	experiment		MMN	N2pc	-276.1913820	8.664525	8045	-31.87611485
31	experiment		MMN	N400	-637.8674490	8.664525	8045	-73.61828569
32	experiment		MMN	P3	-715.3279254	8.664525	8045	-82.55824256
33	experiment		N170	N2pc	500.3828255	8.664525	8045	57.75075348
34	experiment		N170	N400	138.7067585	8.664525	8045	16.00858264

35	experiment	N170	P3	61.2462820	8.664525	8045	7.06862577
36	experiment	N2pc	N400	-361.6760670	8.664525	8045	-41.74217084
37	experiment	N2pc	P3	-439.1365434	8.664525	8045	-50.68212771
38	experiment	N400	P3	-77.4604764	8.664525	8045	-8.93995687
39		ref average	Cz	-32.6389000	12.371020	1139	-2.63833542
40		ref average	P9P10	-70.7331836	12.371020	1139	-5.71765176
41		ref Cz	P9P10	-38.0942836	12.371020	1139	-3.07931634
42	hpff	None	0.1	-64.5320245	12.371020	1139	-5.21638678
43	hpff	None	0.5	-215.3923013	12.371020	1139	-17.41103833
44	hpff	0.1	0.5	-150.8602768	12.371020	1139	-12.19465156
45	lpff	None	6	-1020.8947240	14.284823	1139	-71.46708794
46	lpff	None	20	-334.9777842	14.284823	1139	-23.44990742
47	lpff	None	45	-33.4495106	14.284823	1139	-2.34161178
48	lpff	6	20	685.9169398	14.284823	1139	48.01718052
49	lpff	6	45	987.4452134	14.284823	1139	69.12547616
50	lpff	20	45	301.5282736	14.284823	1139	21.10829563
51	emc	None	ica	149.5010064	10.100895	1139	14.80076766
52	mac	None	ica	108.2219086	10.100895	1139	10.71409057
53	base	200ms	400ms	-5.9116371	10.100895	1139	-0.58525872
54	det	offset	linear	-614.4679913	10.100895	1139	-60.83302171
55	ar	false	true	111.8686815	10.100895	1139	11.07512519
56	ref	average	Cz	-9.0415690	11.617184	1139	-0.77829267
57	ref	average	P9P10	-8.5571320	11.617184	1139	-0.73659263
58	ref	Cz	P9P10	0.4844370	11.617184	1139	0.04170003
59	hpff	None	0.1	-81.2668580	11.617184	1139	-6.99540090
60	hpff	None	0.5	-224.6536290	11.617184	1139	-19.33804551
61	hpff	0.1	0.5	-143.3867711	11.617184	1139	-12.34264462
62	lpff	None	6	-763.3825689	13.414368	1139	-56.90782801
63	lpff	None	20	-323.3431758	13.414368	1139	-24.10424155
64	lpff	None	45	-75.9113550	13.414368	1139	-5.65895857
65	lpff	6	20	440.0393930	13.414368	1139	32.80358645
66	lpff	6	45	687.4712139	13.414368	1139	51.24886943
67	lpff	20	45	247.4318208	13.414368	1139	18.44528298
68	emc	None	ica	68.3647801	9.485391	1139	7.20737618
69	mac	None	ica	111.6153447	9.485391	1139	11.76707913
70	base	200ms	400ms	-44.7452104	9.485391	1139	-4.71727640
71	det	offset	linear	-543.8507349	9.485391	1139	-57.33561679
72	ar	false	true	106.3484888	9.485391	1139	11.21181936
73	ref	average	Cz	-11.3174685	5.509329	1139	-2.05423707
74	ref	average	P9P10	27.6515940	5.509329	1139	5.01904904
75	ref	Cz	P9P10	38.9690626	5.509329	1139	7.07328611
76	hpff	None	0.1	-45.6161783	5.509329	1139	-8.27980606
77	hpff	None	0.5	-81.7695346	5.509329	1139	-14.84201249

78	hpf	0.1	0.5	-36.1533563	5.509329	1139	-6.56220643
79	lpf	None	6	-241.7083780	6.361626	1139	-37.99475099
80	lpf	None	20	-137.2745785	6.361626	1139	-21.57853803
81	lpf	None	45	-31.7022144	6.361626	1139	-4.98335122
82	lpf	6	20	104.4337996	6.361626	1139	16.41621297
83	lpf	6	45	210.0061637	6.361626	1139	33.01139977
84	lpf	20	45	105.5723641	6.361626	1139	16.59518681
85	emc	None	ica	3.2608122	4.498349	1139	0.72489095
86	mac	None	ica	25.2717467	4.498349	1139	5.61800544
87	base	200ms	400ms	30.9476150	4.498349	1139	6.87977256
88	det	offset	linear	-151.3262185	4.498349	1139	-33.64039417
89	ar	false	true	94.0976546	4.498349	1139	20.91826666
90	ref	average	Cz	-2.1277625	4.759202	1139	-0.44708390
91	ref	average	P9P10	-32.2588344	4.759202	1139	-6.77820259
92	ref	Cz	P9P10	-30.1310719	4.759202	1139	-6.33111870
93	hpf	None	0.1	-24.4613251	4.759202	1139	-5.13979567
94	hpf	None	0.5	-103.3973483	4.759202	1139	-21.72577488
95	hpf	0.1	0.5	-78.9360232	4.759202	1139	-16.58597921
96	lpf	None	6	-121.5753014	5.495453	1139	-22.12289002
97	lpf	None	20	-121.2861040	5.495453	1139	-22.07026518
98	lpf	None	45	-35.6662151	5.495453	1139	-6.49013201
99	lpf	6	20	0.2891973	5.495453	1139	0.05262484
100	lpf	6	45	85.9090862	5.495453	1139	15.63275802
101	lpf	20	45	85.6198889	5.495453	1139	15.58013318
102	emc	None	ica	19.8641442	3.885872	1139	5.11188838
103	mac	None	ica	13.1014317	3.885872	1139	3.37155508
104	base	200ms	400ms	-33.7359286	3.885872	1139	-8.68168796
105	det	offset	linear	-287.7221019	3.885872	1139	-74.04312293
106	ar	false	true	40.4927975	3.885872	1139	10.42051746
107	ref	average	Cz	-13.4612742	6.268295	1139	-2.14751749
108	ref	average	P9P10	-9.4125474	6.268295	1139	-1.50161195
109	ref	Cz	P9P10	4.0487268	6.268295	1139	0.64590554
110	hpf	None	0.1	-63.1874215	6.268295	1139	-10.08047907
111	hpf	None	0.5	-69.9132085	6.268295	1139	-11.15346407
112	hpf	0.1	0.5	-6.7257870	6.268295	1139	-1.07298499
113	lpf	None	6	-330.6928131	7.238004	1139	-45.68839765
114	lpf	None	20	-137.6536341	7.238004	1139	-19.01817555
115	lpf	None	45	-40.1946520	7.238004	1139	-5.55327837
116	lpf	6	20	193.0391790	7.238004	1139	26.67022210
117	lpf	6	45	290.4981611	7.238004	1139	40.13511929
118	lpf	20	45	97.4589821	7.238004	1139	13.46489719
119	emc	None	ica	132.3044030	5.118042	1139	25.85059037
120	mac	None	ica	36.5861136	5.118042	1139	7.14845927

121	base	200ms	400ms	-74.5385250	5.118042	1139	-14.56387568
122	det	offset	linear	-156.4459980	5.118042	1139	-30.56754967
123	ar	false	true	20.6531232	5.118042	1139	4.03535647
124	ref	average	Cz	-27.1486101	6.818477	1139	-3.98162391
125	ref	average	P9P10	-54.5294736	6.818477	1139	-7.99731016
126	ref	Cz	P9P10	-27.3808634	6.818477	1139	-4.01568625
127	hpf	None	0.1	-15.7050418	6.818477	1139	-2.30330649
128	hpf	None	0.5	-3.9729100	6.818477	1139	-0.58266825
129	hpf	0.1	0.5	11.7321318	6.818477	1139	1.72063823
130	lpf	None	6	-365.2491818	7.873299	1139	-46.39087008
131	lpf	None	20	-133.1659102	7.873299	1139	-16.91361062
132	lpf	None	45	-25.8663230	7.873299	1139	-3.28532216
133	lpf	6	20	232.0832715	7.873299	1139	29.47725946
134	lpf	6	45	339.3828588	7.873299	1139	43.10554792
135	lpf	20	45	107.2995872	7.873299	1139	13.62828846
136	emc	None	ica	95.1897593	5.567263	1139	17.09812519
137	mac	None	ica	27.2027452	5.567263	1139	4.88619729
138	base	200ms	400ms	-107.7339977	5.567263	1139	-19.35133982
139	det	offset	linear	10.4092503	5.567263	1139	1.86972491
140	ar	false	true	142.0408479	5.567263	1139	25.51358695
141	ref	average	Cz	-11.9073016	5.150997	1139	-2.31165002
142	ref	average	P9P10	-39.8574422	5.150997	1139	-7.73781163
143	ref	Cz	P9P10	-27.9501406	5.150997	1139	-5.42616161
144	hpf	None	0.1	11.9294606	5.150997	1139	2.31595189
145	hpf	None	0.5	-17.5233188	5.150997	1139	-3.40192778
146	hpf	0.1	0.5	-29.4527794	5.150997	1139	-5.71787967
147	lpf	None	6	-348.8463453	5.947859	1139	-58.65074549
148	lpf	None	20	-125.0782163	5.947859	1139	-21.02911706
149	lpf	None	45	-25.1086062	5.947859	1139	-4.22145305
150	lpf	6	20	223.7681290	5.947859	1139	37.62162843
151	lpf	6	45	323.7377392	5.947859	1139	54.42929244
152	lpf	20	45	99.9696102	5.947859	1139	16.80766401
153	emc	None	ica	67.9122530	4.205771	1139	16.14739598
154	mac	None	ica	33.9279271	4.205771	1139	8.06699307
155	base	200ms	400ms	-122.1971752	4.205771	1139	-29.05464166
156	det	offset	linear	-5.5100085	4.205771	1139	-1.31010658
157	ar	false	true	69.9756412	4.205771	1139	16.63800473
		p.value	significance	experiment			
1	1.844229e-02		*	ALL			
2	6.912558e-06		***	ALL			
3	1.083620e-01			ALL			
4	2.294143e-11		***	ALL			
5	1.948708e-11		***	ALL			

6	1.951228e-11	***	ALL
7	1.948708e-11	***	ALL
8	1.948708e-11	***	ALL
9	3.191409e-08	***	ALL
10	1.948708e-11	***	ALL
11	1.948708e-11	***	ALL
12	1.948708e-11	***	ALL
13	3.896971e-28	***	ALL
14	0.000000e+00	***	ALL
15	1.699154e-71	***	ALL
16	1.712789e-60	***	ALL
17	7.618365e-28	***	ALL
18	1.948708e-11	***	ALL
19	1.948708e-11	***	ALL
20	1.948708e-11	***	ALL
21	1.948708e-11	***	ALL
22	1.948708e-11	***	ALL
23	1.948708e-11	***	ALL
24	1.948708e-11	***	ALL
25	1.948708e-11	***	ALL
26	1.948708e-11	***	ALL
27	1.948708e-11	***	ALL
28	1.948708e-11	***	ALL
29	1.948708e-11	***	ALL
30	1.948708e-11	***	ALL
31	1.948708e-11	***	ALL
32	1.948708e-11	***	ALL
33	1.948708e-11	***	ALL
34	1.948708e-11	***	ALL
35	5.513789e-11	***	ALL
36	1.948708e-11	***	ALL
37	1.948708e-11	***	ALL
38	1.954081e-11	***	ALL
39	2.296002e-02	*	ERN
40	4.132648e-08	***	ERN
41	6.015407e-03	**	ERN
42	6.483731e-07	***	ERN
43	3.408385e-14	***	ERN
44	3.408385e-14	***	ERN
45	3.408385e-14	***	ERN
46	3.408385e-14	***	ERN
47	8.938729e-02	.	ERN
48	3.408385e-14	***	ERN

49	3.408385e-14	***	ERN
50	3.408385e-14	***	ERN
51	1.820623e-45	***	ERN
52	1.380181e-25	***	ERN
53	5.584897e-01		ERN
54	0.000000e+00	***	ERN
55	3.803253e-27	***	ERN
56	7.164554e-01		LRP
57	7.417713e-01		LRP
58	9.990418e-01		LRP
59	1.356260e-11	***	LRP
60	3.408385e-14	***	LRP
61	3.408385e-14	***	LRP
62	3.408385e-14	***	LRP
63	3.408385e-14	***	LRP
64	1.153192e-07	***	LRP
65	3.408385e-14	***	LRP
66	3.408385e-14	***	LRP
67	3.408385e-14	***	LRP
68	1.036199e-12	***	LRP
69	3.003834e-30	***	LRP
70	2.686382e-06	***	LRP
71	0.000000e+00	***	LRP
72	9.526435e-28	***	LRP
73	1.000286e-01		MMN
74	1.800729e-06	***	MMN
75	7.964407e-12	***	MMN
76	6.827872e-14	***	MMN
77	3.408385e-14	***	MMN
78	2.409839e-10	***	MMN
79	3.408385e-14	***	MMN
80	3.408385e-14	***	MMN
81	4.301947e-06	***	MMN
82	3.408385e-14	***	MMN
83	3.408385e-14	***	MMN
84	3.408385e-14	***	MMN
85	4.686678e-01		MMN
86	2.426878e-08	***	MMN
87	9.870675e-12	***	MMN
88	7.661183e-173	***	MMN
89	1.749366e-82	***	MMN
90	8.957045e-01		N170
91	5.850553e-11	***	N170

92	1.048140e-09	***	N170
93	9.678987e-07	***	N170
94	3.408385e-14	***	N170
95	3.408385e-14	***	N170
96	3.408385e-14	***	N170
97	3.408385e-14	***	N170
98	7.659413e-10	***	N170
99	9.999477e-01		N170
100	3.408385e-14	***	N170
101	3.408385e-14	***	N170
102	3.738473e-07	***	N170
103	7.725395e-04	***	N170
104	1.329178e-17	***	N170
105	0.000000e+00	***	N170
106	2.386189e-24	***	N170
107	8.095855e-02	.	N2pc
108	2.905260e-01		N2pc
109	7.947222e-01		N2pc
110	6.294965e-14	***	N2pc
111	4.618528e-14	***	N2pc
112	5.310663e-01		N2pc
113	3.408385e-14	***	N2pc
114	3.408385e-14	***	N2pc
115	2.087472e-07	***	N2pc
116	3.408385e-14	***	N2pc
117	3.408385e-14	***	N2pc
118	3.408385e-14	***	N2pc
119	2.552342e-116	***	N2pc
120	1.564740e-12	***	N2pc
121	3.436988e-44	***	N2pc
122	2.445729e-150	***	N2pc
123	5.815802e-05	***	N2pc
124	2.147094e-04	***	N400
125	7.849277e-14	***	N400
126	1.864619e-04	***	N400
127	5.573635e-02	.	N400
128	8.294331e-01		N400
129	1.978717e-01		N400
130	3.408385e-14	***	N400
131	3.408385e-14	***	N400
132	5.780082e-03	**	N400
133	3.408385e-14	***	N400
134	3.408385e-14	***	N400

135	3.408385e-14	***	N400
136	1.624617e-58	***	N400
137	1.174962e-06	***	N400
138	2.345147e-72	***	N400
139	6.177842e-02	.	N400
140	6.178553e-114	***	N400
141	5.459462e-02	.	P3
142	1.257883e-13	***	P3
143	2.105888e-07	***	P3
144	5.401362e-02	.	P3
145	1.999569e-03	**	P3
146	4.127267e-08	***	P3
147	3.408385e-14	***	P3
148	3.408385e-14	***	P3
149	1.536726e-04	***	P3
150	3.408385e-14	***	P3
151	3.408385e-14	***	P3
152	3.408385e-14	***	P3
153	5.667893e-53	***	P3
154	1.813682e-15	***	P3
155	2.523676e-139	***	P3
156	1.904239e-01		P3
157	8.261426e-56	***	P3

### Omnibus F-Test per facet (Experiment-Model and Preprocessing Step)

```
tar_read(sliding_LM_emm_omni_comb)
```

	model	term	df1	df2	F.ratio	p.value	experiment	p.fdr
1		ref	2	8045	11.254	1.316550e-05	ALL	7.272831e-05
2		hpf	2	8045	165.279	4.526530e-71	ALL	5.834563e-70
3		lpf	3	8045	1995.113	0.000000e+00	ALL	0.000000e+00
4		base	1	8045	121.883	3.896971e-28	ALL	3.444398e-27
5		det	1	8045	2910.176	0.000000e+00	ALL	0.000000e+00
6		ar	1	8045	326.139	1.699154e-71	ALL	2.285384e-70
7		emc	1	8045	273.751	1.712789e-60	ALL	2.037909e-59
8		mac	1	8045	120.533	7.618365e-28	ALL	6.546565e-27
9	experiment		6	8045	13923.862	0.000000e+00	ALL	0.000000e+00
10		ref	2	1139	16.378	9.714195e-08	ERN	5.779066e-07
11		hpf	2	1139	159.688	7.353975e-62	ERN	9.099894e-61
12		lpf	3	1139	2198.745	0.000000e+00	ERN	0.000000e+00

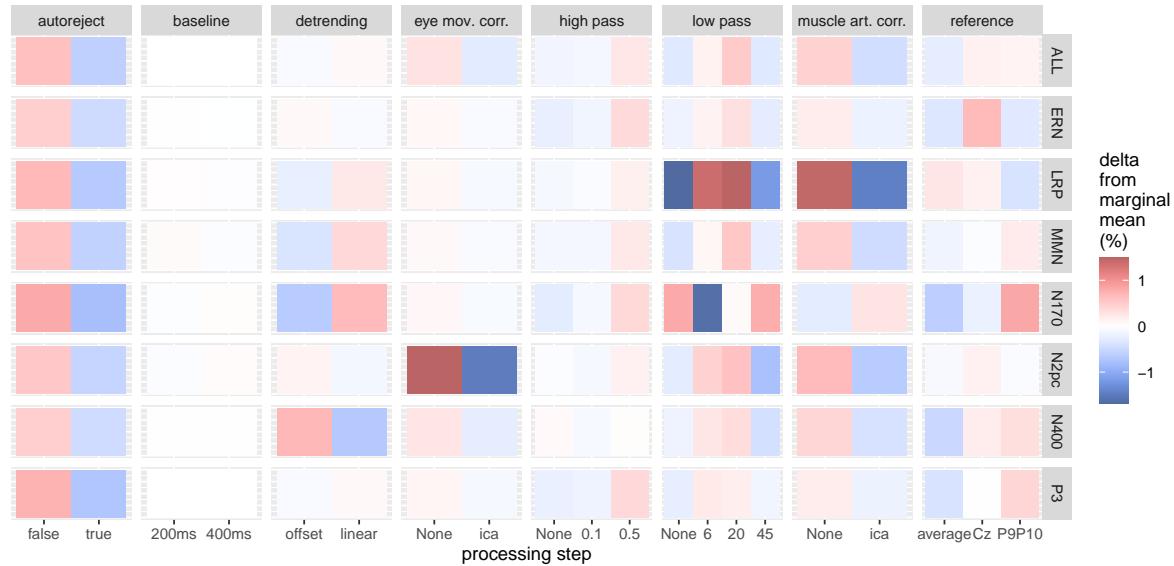
13	emc	1	1139	219.063	1.820623e-45	ERN	1.877383e-44
14	mac	1	1139	114.792	1.380181e-25	ERN	1.094777e-24
15	base	1	1139	0.343	5.584897e-01	ERN	1.000000e+00
16	det	1	1139	3700.657	0.000000e+00	ERN	0.000000e+00
17	ar	1	1139	122.658	3.803253e-27	ERN	3.096177e-26
18	ref	2	1139	0.383	6.816629e-01	LRP	1.000000e+00
19	hpf	2	1139	191.746	1.680112e-72	LRP	2.474989e-71
20	lpf	3	1139	1315.715	0.000000e+00	LRP	0.000000e+00
21	emc	1	1139	51.946	1.036199e-12	LRP	6.968505e-12
22	mac	1	1139	138.464	3.003834e-30	LRP	2.733073e-29
23	base	1	1139	22.253	2.686382e-06	LRP	1.510982e-05
24	det	1	1139	3287.373	0.000000e+00	LRP	0.000000e+00
25	ar	1	1139	125.705	9.526435e-28	LRP	7.964947e-27
26	ref	2	1139	26.481	5.740372e-12	MMN	3.699585e-11
27	hpf	2	1139	110.634	1.233071e-44	MMN	1.230497e-43
28	lpf	3	1139	594.785	1.563573e-232	MMN	4.030798e-231
29	emc	1	1139	0.525	4.686678e-01	MMN	1.000000e+00
30	mac	1	1139	31.562	2.426878e-08	MMN	1.501524e-07
31	base	1	1139	47.331	9.870675e-12	MMN	6.231678e-11
32	det	1	1139	1131.676	7.661183e-173	MMN	1.823084e-171
33	ar	1	1139	437.574	1.749366e-82	MMN	2.705857e-81
34	ref	2	1139	28.742	6.639710e-13	N170	4.564475e-12
35	hpf	2	1139	257.841	4.290208e-93	N170	6.985202e-92
36	lpf	3	1139	250.961	5.368798e-125	N170	1.038033e-123
37	emc	1	1139	26.131	3.738473e-07	N170	2.182090e-06
38	mac	1	1139	11.367	7.725395e-04	N170	4.120471e-03
39	base	1	1139	75.372	1.329178e-17	N170	1.002891e-16
40	det	1	1139	5482.384	0.000000e+00	N170	0.000000e+00
41	ar	1	1139	108.587	2.386189e-24	N170	1.845436e-23
42	ref	2	1139	2.428	8.867354e-02	N2pc	4.496954e-01
43	hpf	2	1139	75.722	1.330960e-31	N2pc	1.247686e-30
44	lpf	3	1139	830.565	4.216467e-286	N2pc	1.185797e-284
45	emc	1	1139	668.253	2.552342e-116	N2pc	4.644555e-115
46	mac	1	1139	51.100	1.564740e-12	N2pc	1.029908e-11
47	base	1	1139	212.106	3.436988e-44	N2pc	3.322632e-43
48	det	1	1139	934.375	2.445729e-150	N2pc	5.404238e-149
49	ar	1	1139	16.284	5.815802e-05	N2pc	3.156378e-04
50	ref	2	1139	31.979	3.074352e-14	N400	2.211767e-13
51	hpf	2	1139	2.868	5.719779e-02	N400	2.999034e-01
52	lpf	3	1139	893.617	1.170927e-298	N400	3.622296e-297
53	emc	1	1139	292.346	1.624617e-58	N400	1.861407e-57
54	mac	1	1139	23.875	1.174962e-06	N400	6.731075e-06
55	base	1	1139	374.474	2.345147e-72	N400	3.297628e-71

56	det	1	1139	3.496	6.177842e-02	N400	3.185222e-01
57	ar	1	1139	650.943	6.178553e-114	N400	1.061863e-112
58	ref	2	1139	31.554	4.598596e-14	P3	3.233157e-13
59	hpf	2	1139	16.544	8.271256e-08	P3	5.017131e-07
60	lpf	3	1139	1426.731	0.000000e+00	P3	0.000000e+00
61	emc	1	1139	260.738	5.667893e-53	P3	6.046135e-52
62	mac	1	1139	65.076	1.813682e-15	P3	1.335876e-14
63	base	1	1139	844.172	2.523676e-139	P3	5.204710e-138
64	det	1	1139	1.716	1.904239e-01	P3	9.501322e-01
65	ar	1	1139	276.823	8.261426e-56	P3	9.127487e-55
sign.unc sign.fdr							
1	***	***					
2	***	***					
3	***	***					
4	***	***					
5	***	***					
6	***	***					
7	***	***					
8	***	***					
9	***	***					
10	***	***					
11	***	***					
12	***	***					
13	***	***					
14	***	***					
15							
16	***	***					
17	***	***					
18							
19	***	***					
20	***	***					
21	***	***					
22	***	***					
23	***	***					
24	***	***					
25	***	***					
26	***	***					
27	***	***					
28	***	***					
29							
30	***	***					
31	***	***					
32	***	***					

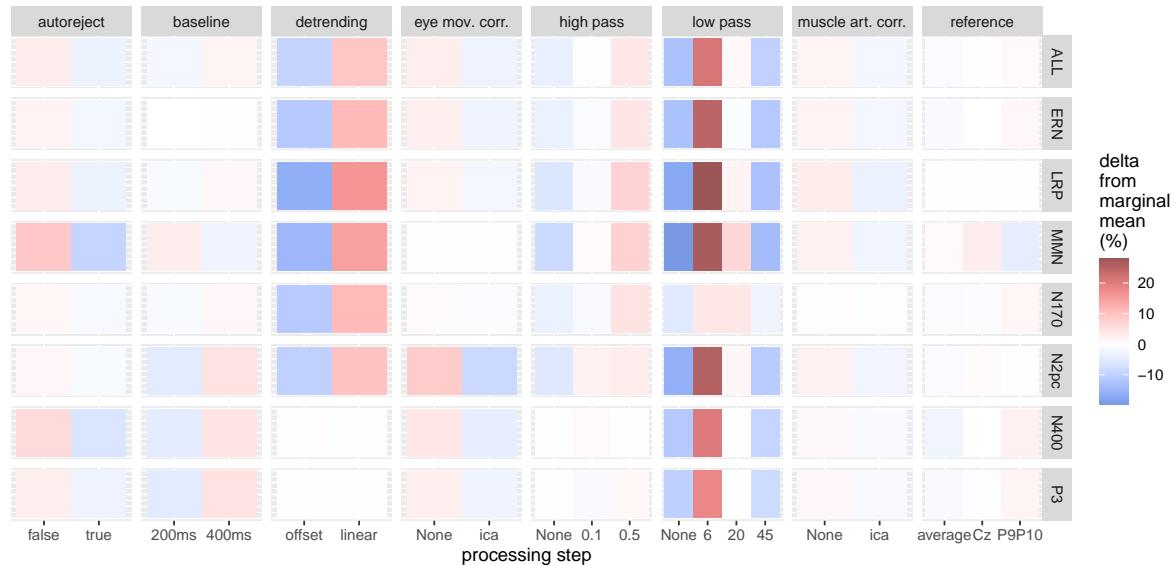
33        \*\*\*        \*\*\*  
34        \*\*\*        \*\*\*  
35        \*\*\*        \*\*\*  
36        \*\*\*        \*\*\*  
37        \*\*\*        \*\*\*  
38        \*\*\*        \*\*  
39        \*\*\*        \*\*\*  
40        \*\*\*        \*\*\*  
41        \*\*\*        \*\*\*  
42        .  
43        \*\*\*        \*\*\*  
44        \*\*\*        \*\*\*  
45        \*\*\*        \*\*\*  
46        \*\*\*        \*\*\*  
47        \*\*\*        \*\*\*  
48        \*\*\*        \*\*\*  
49        \*\*\*        \*\*\*  
50        \*\*\*        \*\*\*  
51        .  
52        \*\*\*        \*\*\*  
53        \*\*\*        \*\*\*  
54        \*\*\*        \*\*\*  
55        \*\*\*        \*\*\*  
56        .  
57        \*\*\*        \*\*\*  
58        \*\*\*        \*\*\*  
59        \*\*\*        \*\*\*  
60        \*\*\*        \*\*\*  
61        \*\*\*        \*\*\*  
62        \*\*\*        \*\*\*  
63        \*\*\*        \*\*\*  
64  
65        \*\*\*        \*\*\*

## Relative performance differences

**A EEGNet**



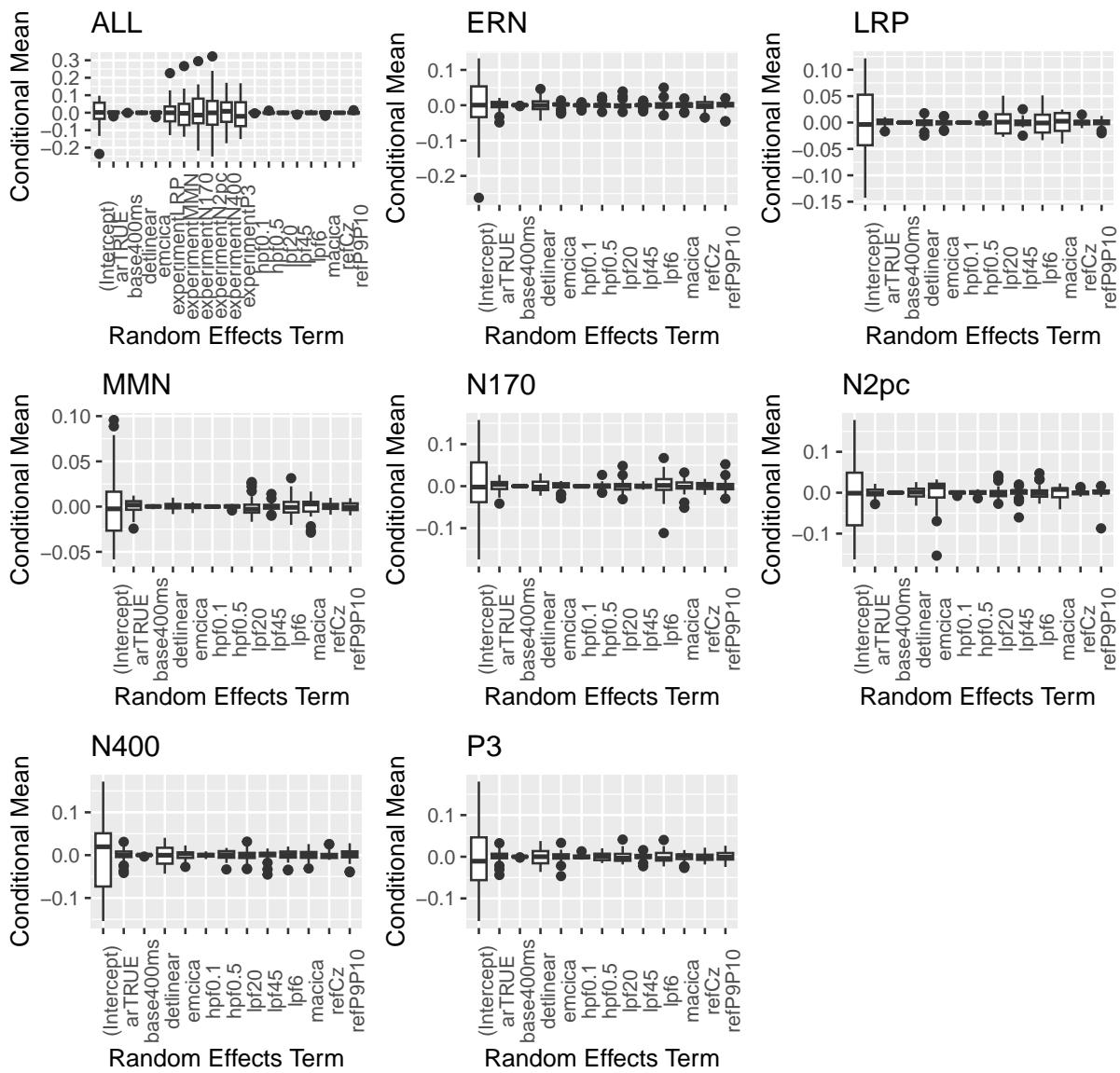
**B Time-resolved**



## Random Effects

Inspection of RFX parameter estimates (Intercept corresponds to Random Intercept (Subject), and the remaining terms are random slopes by subject).

## Random Effects – EEGNet



## EDA of sociodemographics (EEGNet)

```
tar_read(rfx_demographics)
```



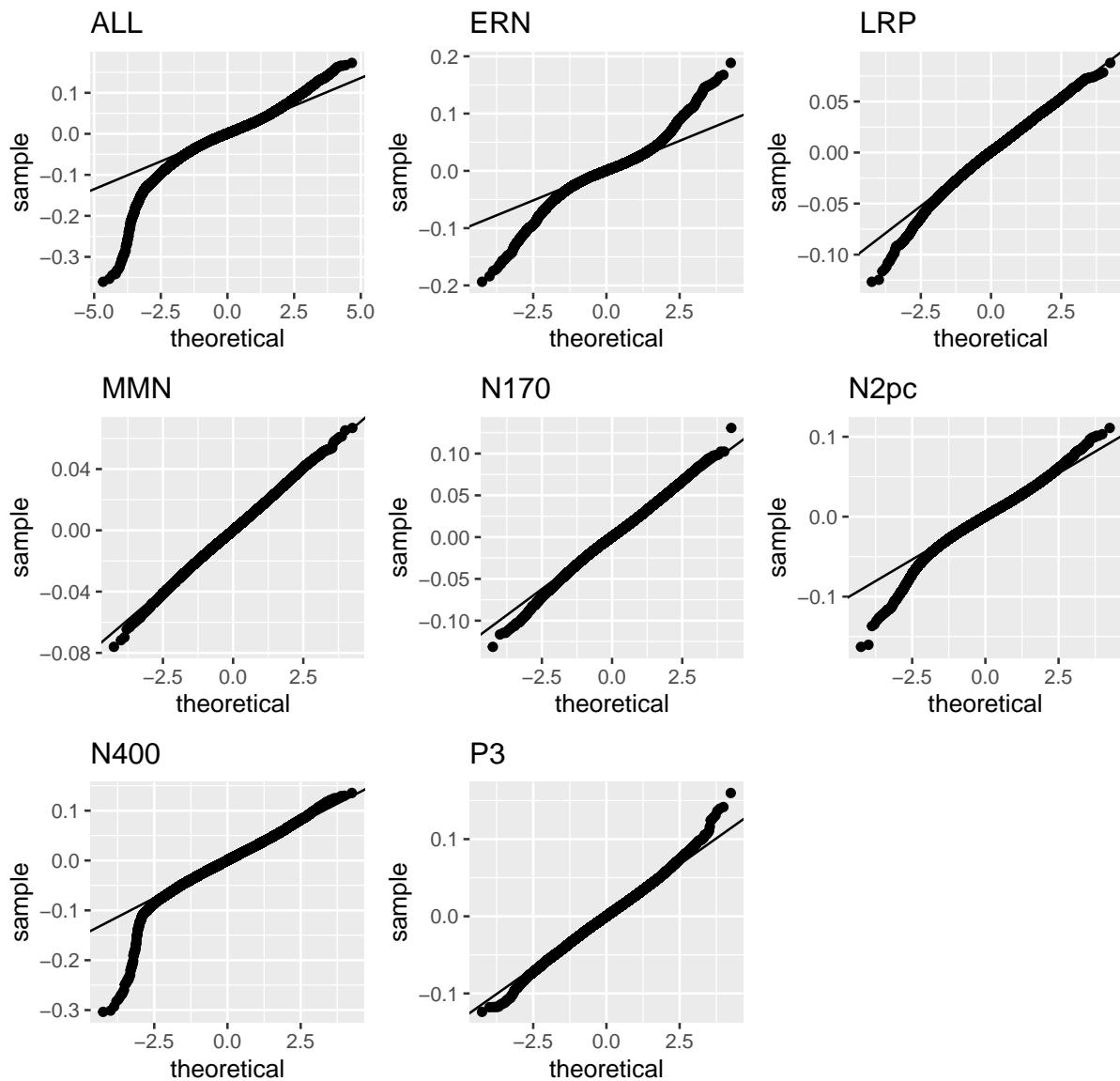
## Model diagnostics

- Mixed-effects models are somewhat robust to mild deviations from normality, especially with more random effects.
- Visual inspection of diagnostic plots is often more informative than relying solely on p-values from these tests.
- Tests often focus on residuals at the observation level, whereas mixed-effects models also have random effects variability to consider.

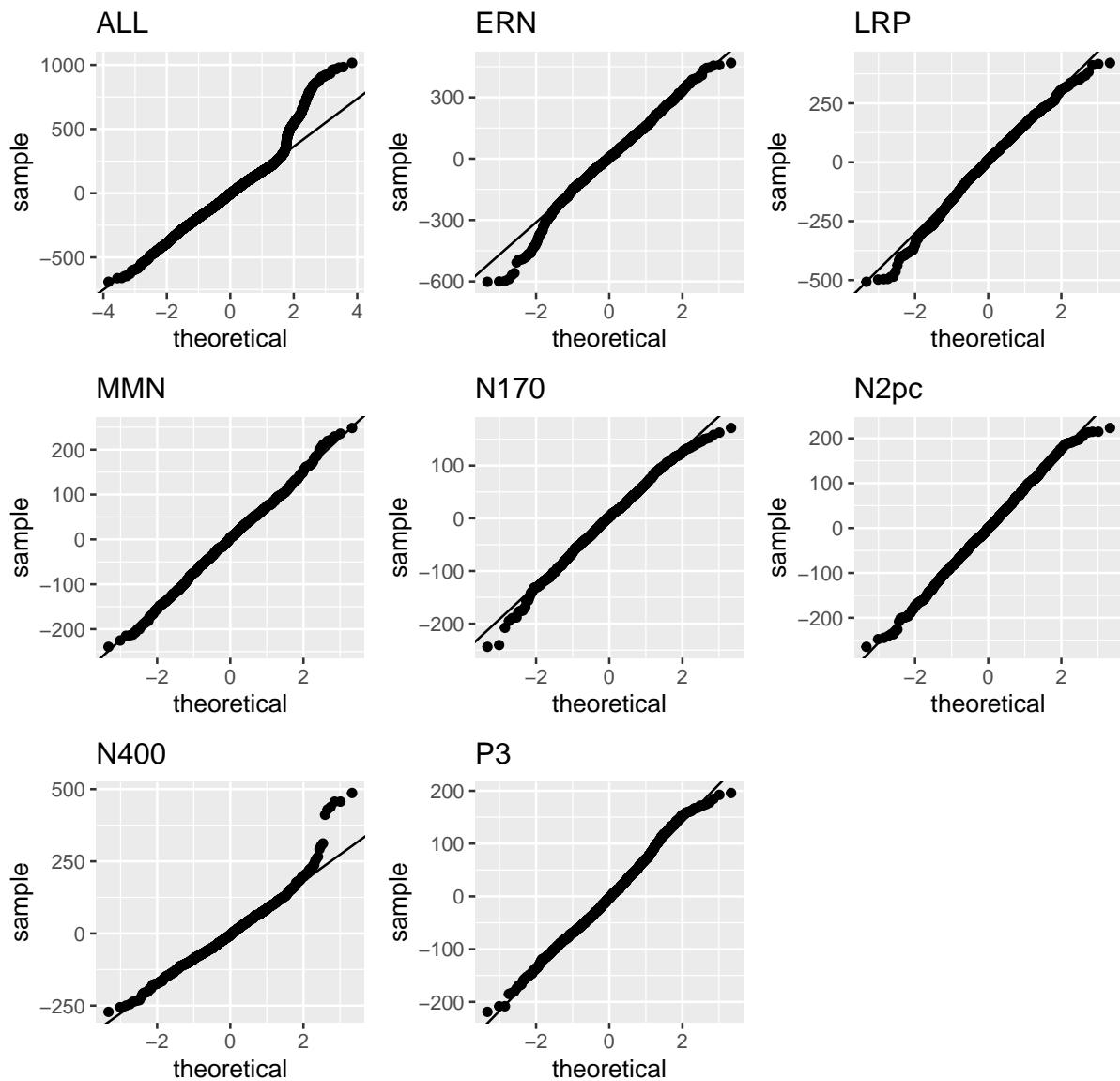
## QQ-Plots

- **What to look for:**
  - Ideally, the majority of the residuals should fall close to the straight diagonal line. This indicates that the residuals are approximately normally distributed.
- **What you shouldn't see:**
  - Substantial deviations from the diagonal line, especially in the tails of the distribution. This suggests the normality assumption of the model might be violated.

## Quantile–Quantile Plots – EEGNet



## Quantile–Quantile Plots – Time–Resolved



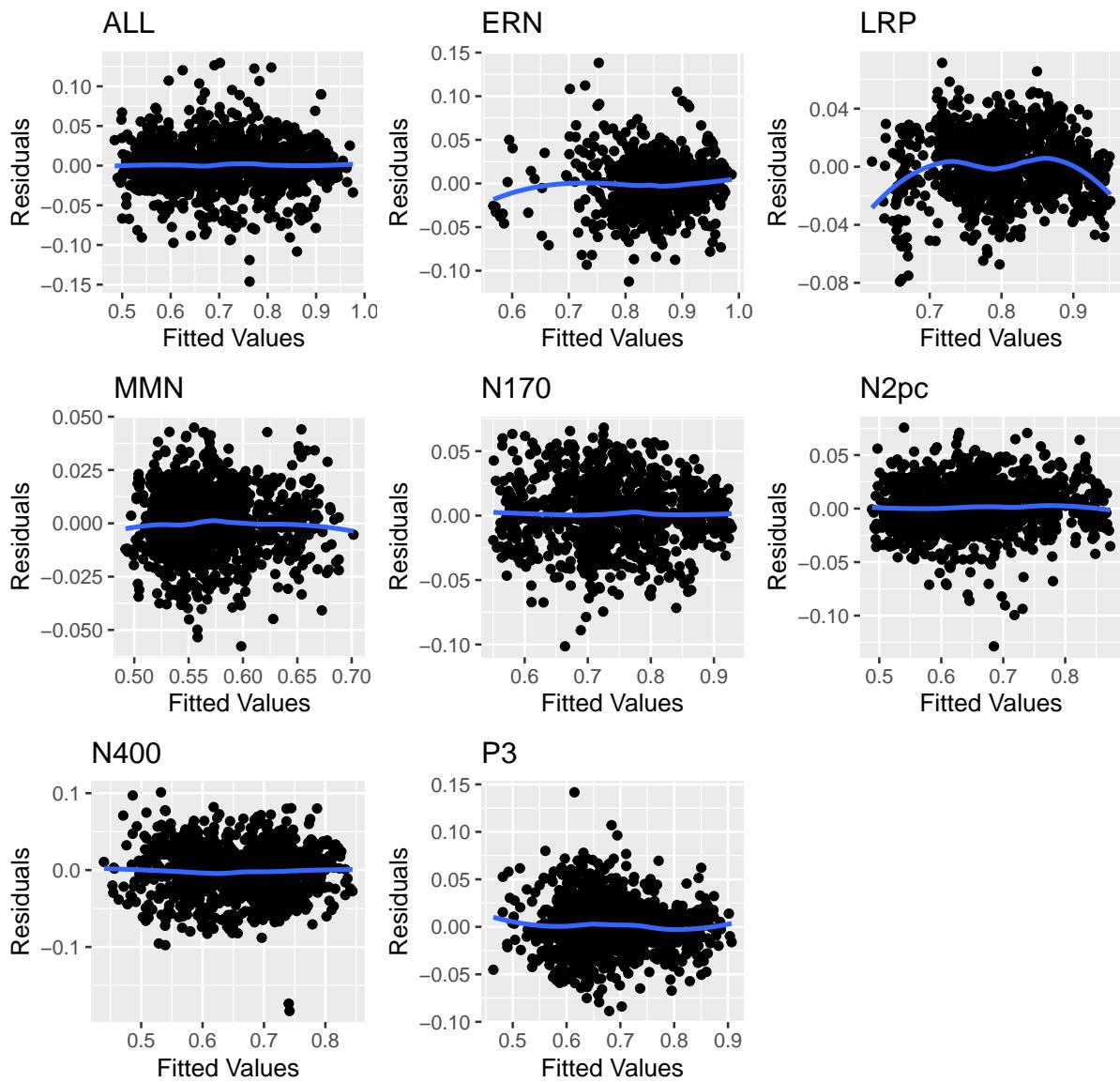
### Residuals vs Fitted - Plots

- What to look for:

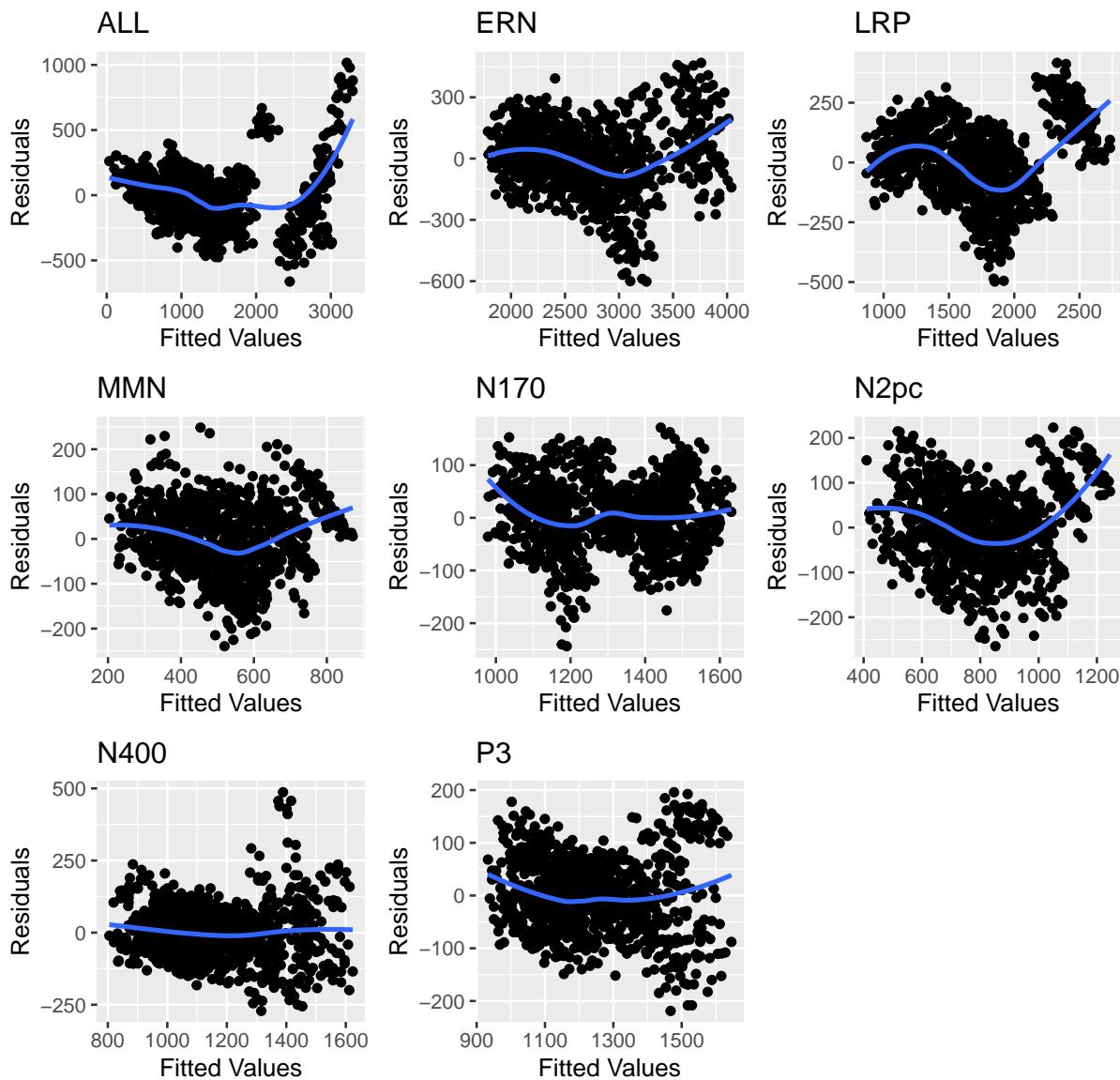
- **Linearity:** Ideally, there should be no clear pattern in the residuals (they should be randomly scattered around zero). A curved pattern might indicate a nonlinear relationship you haven't modeled.

- **Homoscedasticity:** The spread of the residuals should be relatively constant across fitted values. If the spread increases or decreases, it suggests non-constant variance (heteroscedasticity).
  - **Outliers:** Look for points that lie far away from the majority of the residuals. These could be influential observations.
- **What you shouldn't see:**
    - Clear patterns (e.g., U-shapes, funnel shapes).
    - Significant changes in the spread of residuals across fitted values.
    - Extreme outliers.

## Residual vs. Fitted Plots – EEGNet



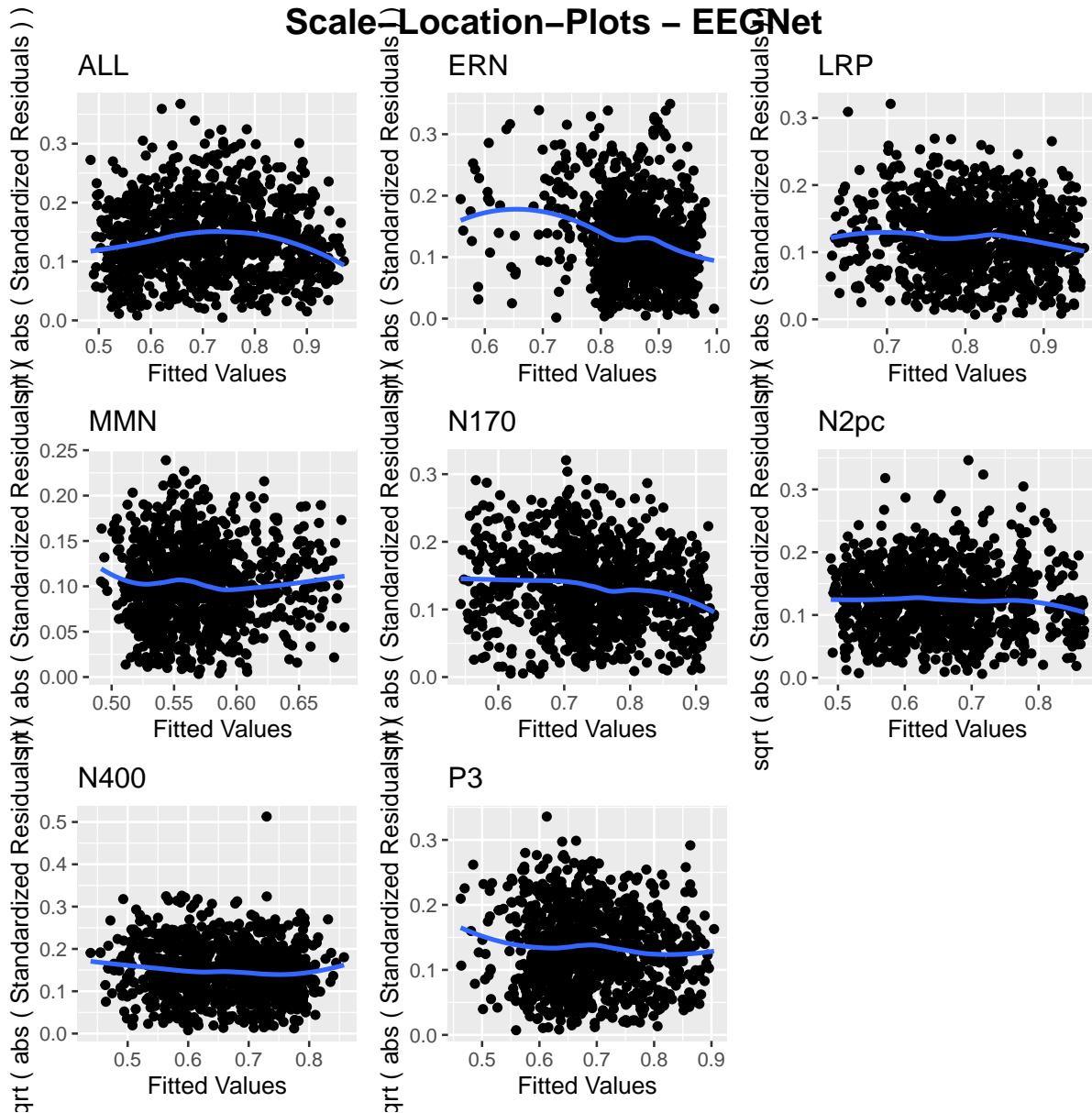
## Residual vs. Fitted Plots – Time-Resolved



### Scale-Location-Plots

- **What to look for:**
  - Ideally, the line should be relatively horizontal, indicating constant variance (homoscedasticity).
- **What you shouldn't see:**

- Strong trends or patterns in the line suggesting changing variance across fitted values (heteroscedasticity).



## Scale–Location–Plots – Time–Resolved

