ERPs

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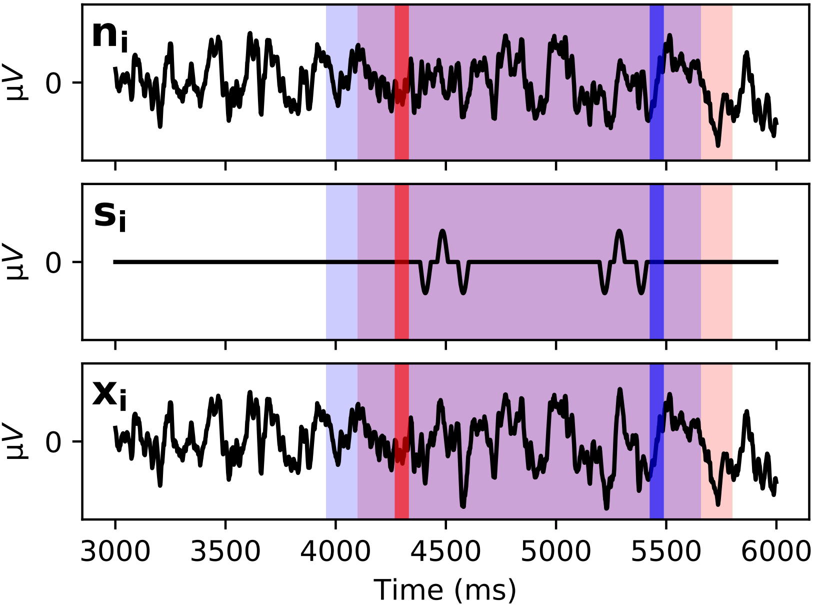
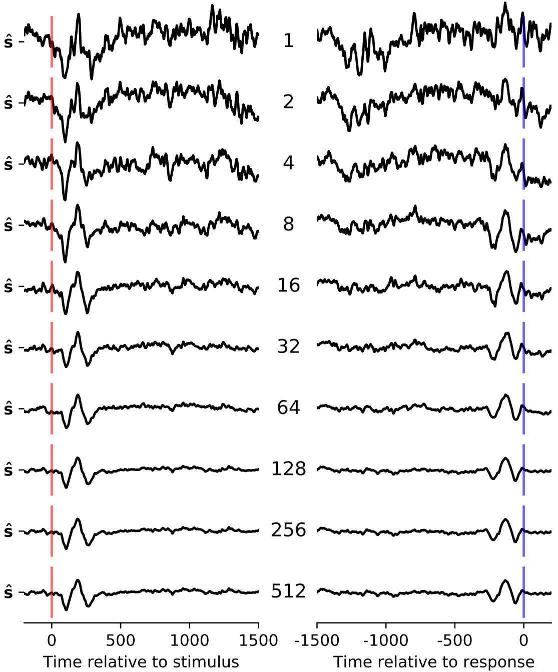
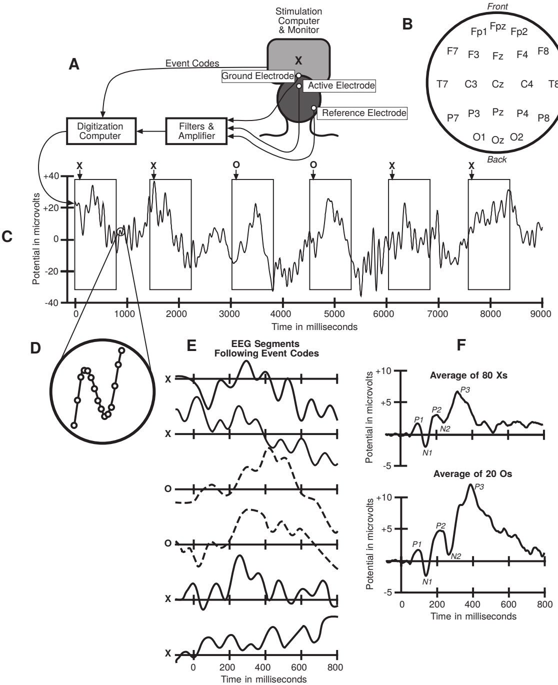
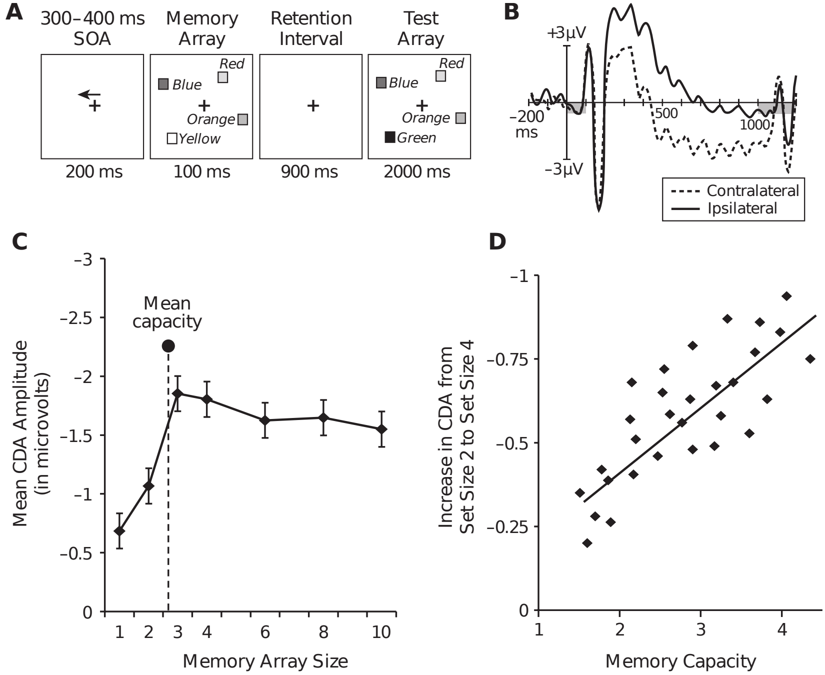


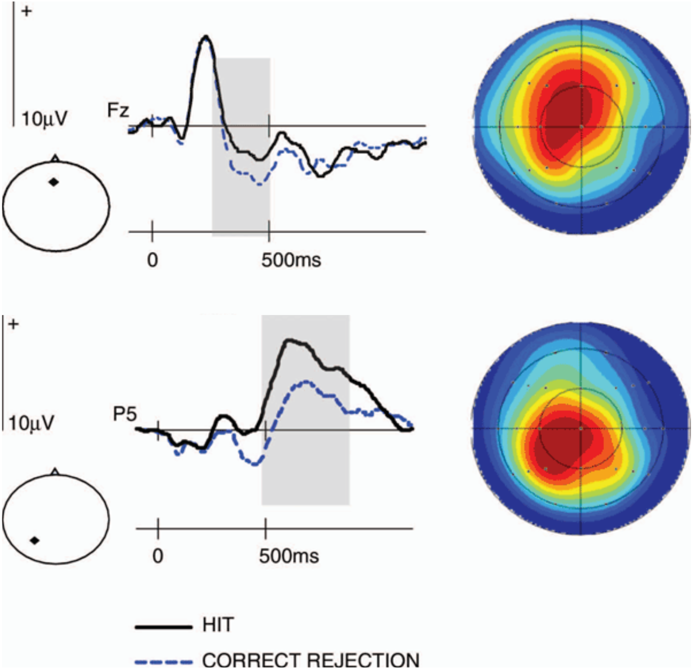
$\mathbf{n_i}$
$\mathbf{s_i}$
$\mathbf{x_i}$
μV
0
3000
3500
4000
4500
5000
5500
6000
Time (ms)

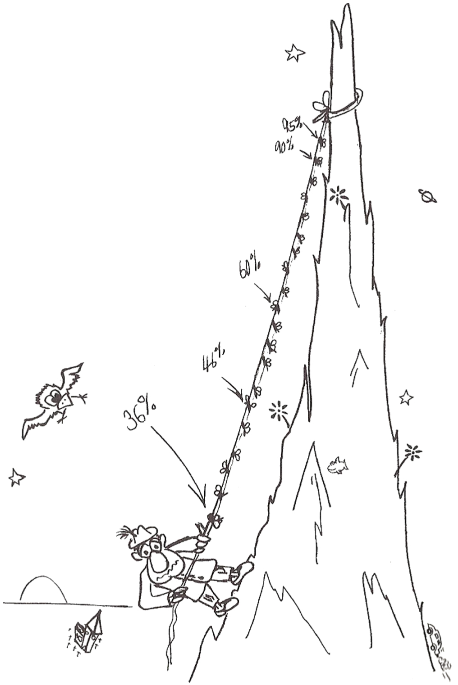

ŝ
1
2
4
8
16
32
64
128
256
512
0
500
1000
1500
-1500
-1000
-500
0
Time relative to stimulus
Time relative to response



A
Stimulation Computer & Monitor
X
Event Codes
Ground Electrode
Active Electrode
Reference Electrode
Digitization Computer
Filters & Amplifier
B
Front
Fpz
Fp1
Fp2
F7
F3
Fz
F4
F8
T7
C3
Cz
C4
T8
P7
P3
Pz
P4
P8
O1
Oz
O2
Back
C
Potential in microvolts
Time in milliseconds
D
E
EEG Segments Following Event Codes
Time in milliseconds
F
Average of 80 Xs
Average of 20 Os
P1
P2
P3
N1
N2
Potential in microvolts
Time in milliseconds


A
300–400 ms SOA
Memory Array
Retention Interval
Test Array
Blue
Red
Orange
Yellow
Green
200 ms
100 ms
900 ms
2000 ms
B
+3μV
−3μV
−200 ms
500
1000
Contralateral
Ipsilateral
C
Mean capacity
Mean CDA Amplitude (in microvolts)
Memory Array Size
−3
−2.5
-2
-1.5
-1
-0.5
0
1
2
3
4
6
8
10
D
Increase in CDA from Set Size 2 to Set Size 4
Memory Capacity
-1
−0.75
-0.5
−0.25
0
1
2
3
4


+
10µV
Fz
0
500ms
+
10µV
P5
0
500ms
HIT
CORRECT REJECTION


95%
90%
60%
46%
36%

		Decision	
		H_0	$\neg H_0$
Truth	H_o	✓	Type I error (α)
	$\neg H_0$	Type II error (β)	✓

FWER: Probability of making at least one Type I error in the family of tests.

FDR: Expected proportion of Type I errors among all rejections of the null hypothesis (i.e., "significant results")

Controlling FWER

Bonferroni: α/m

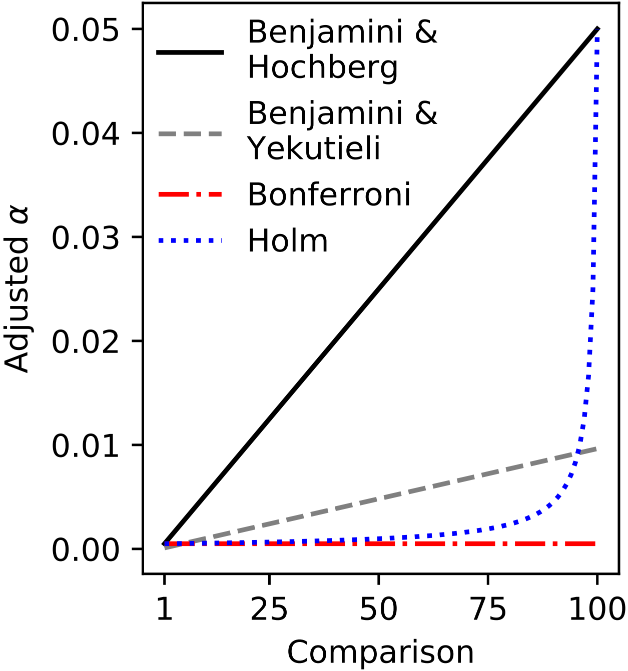
Holm: Sort all p-values from smallest to largest and find the smallest index, i, in the resulting list of p-values for which $p_i > \alpha/(m - i + 1)$, where m is the number of statistical tests. Reject all null hypotheses corresponding to indices $i - 1$ or below.

Controlling FDR

- Sort p-values from smallest to largest.
- Find the largest index i in the corresponding list of sorted p-values for which $p_i \leq (i/m) \times \alpha$. (Benjamini & Hochberg, 1995)
- Alternatively find the largest index i in the corresponding list of sorted p-values for which $p_i \leq (i/(m \times (\sum_{j=1}^{m} 1/j))) \times \alpha$. (Benjamini & Yekutieli, 2001).
- Reject the null hypothesis at this and lower indices.

Controlling for FWER and FDR

FWER		FDR	
Bonferroni	Holm	BH95	BY01
α/m	α/m	α/m	$\alpha/(m\sum_{j=1}^{m} 1/j)$
α/m	$\alpha/(m-1)$	$2\alpha/m$	$2\alpha/(m\sum_{j=1}^{m} 1/j)$
$\vdots$	$\vdots$	$\vdots$	$\vdots$
α/m	α	α	$\alpha/(\sum_{j=1}^{m} 1/j)$



Benjamini & Hochberg
Benjamini & Yekutieli
Bonferroni
Holm
Adjusted α
0.05
0.04
0.03
0.02
0.01
0.00
1
25
50
75
100
Comparison

$$\hat{\mathbf{s}} = \frac{1}{N}\sum_{i=1}^{N}\mathbf{x}_i = \mathbf{s} + \frac{1}{N}\sum_{i=1}^{N}\mathbf{n}_i \ .$$

$$E\left[\hat{\mathbf{s}}\right] = E\left[\frac{1}{N}\sum_{i=1}^{N}\mathbf{x}_i\right] = \mathbf{s} + \frac{1}{N}\sum_{i=1}^{N}E\left[\mathbf{n}_i\right] = \mathbf{s}$$

$$\begin{aligned}
\Sigma_{\hat{\mathbf{s}}} &= E\left[(\hat{\mathbf{s}}-\mathbf{s})(\hat{\mathbf{s}}-\mathbf{s})^T\right] \\
&= E\left[\sum_{i=1}^{N}\frac{\mathbf{n}_i}{N}\frac{\mathbf{n}_i^T}{N}\right] \\
&= \frac{1}{N^2}\sum_{i=1}^{N}E\left[\mathbf{n}_i\mathbf{n}_i^T\right] \\
&= \frac{1}{N^2}\times N\times\Sigma_n
\end{aligned}$$

$$\sigma_{\hat{\mathbf{s}}} = \frac{\sigma_n}{\sqrt{N}}$$