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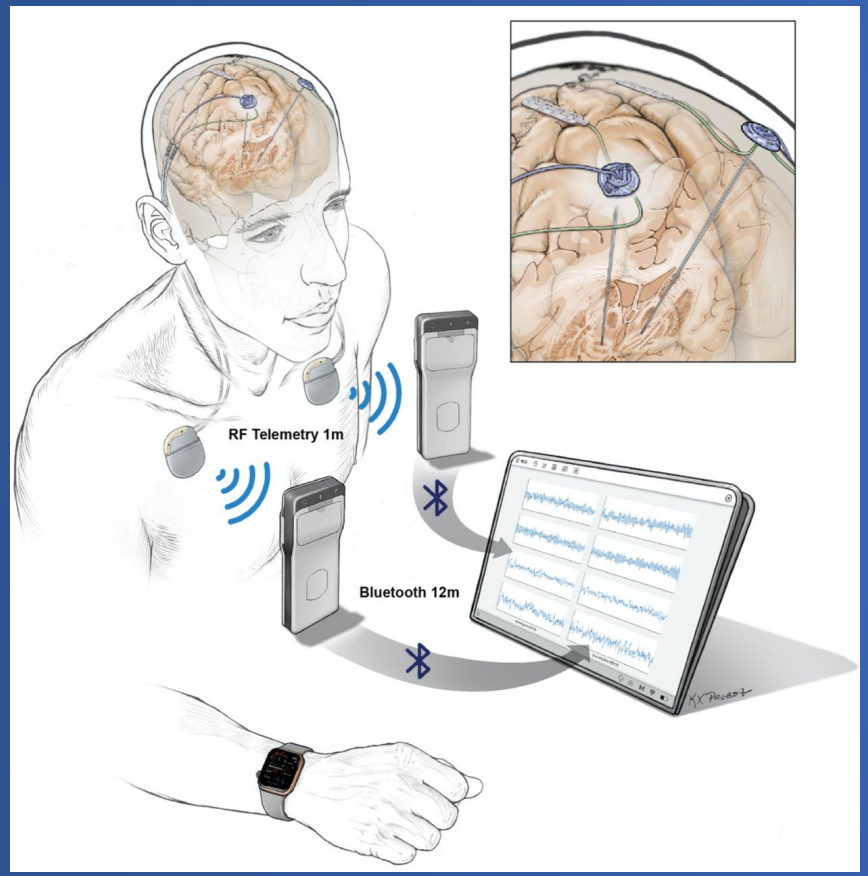
How do packet losses affect measures of averaged neural signals?

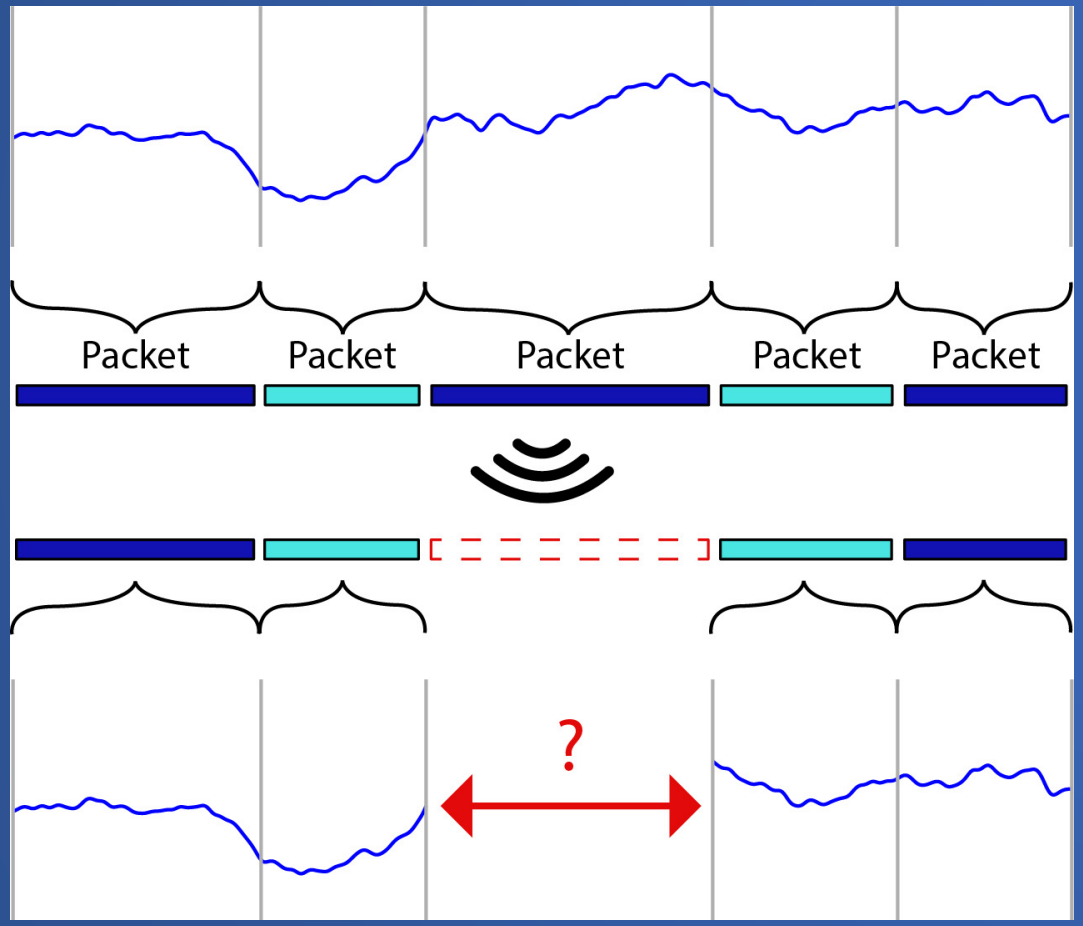
Background



Gilron et al. 2021

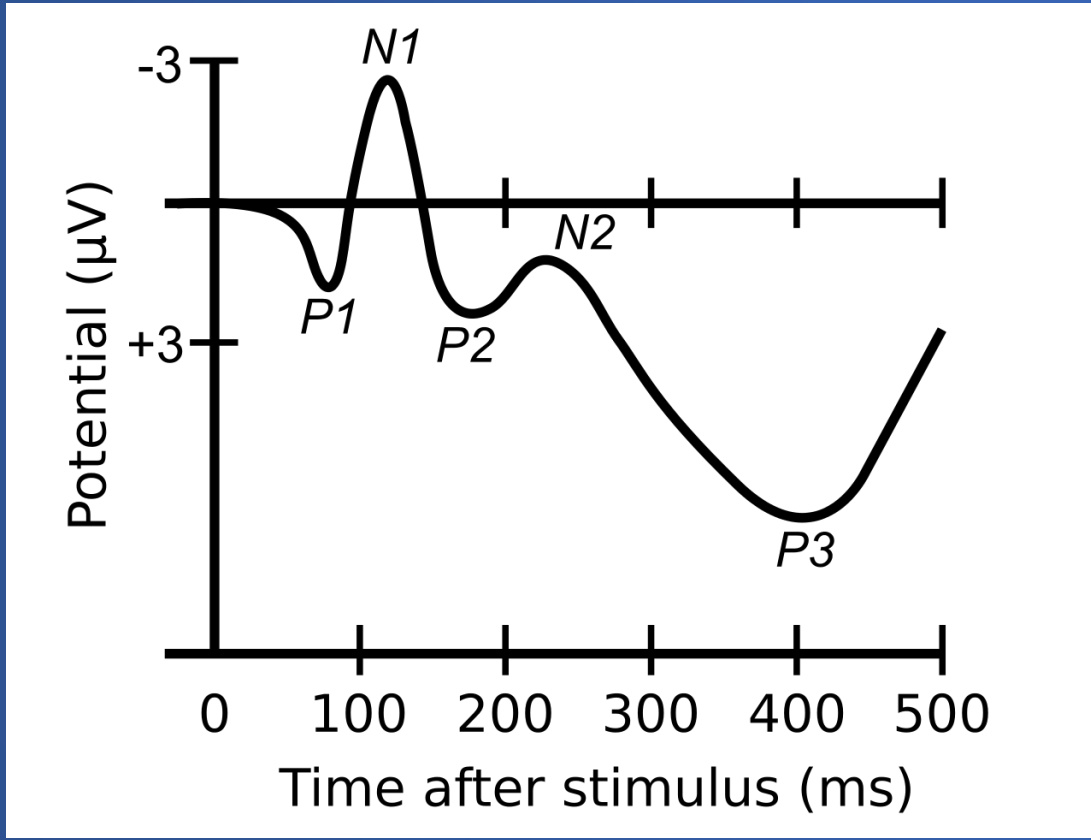
- There is currently an effort in the neuromodulation community to develop closed-loop therapies
- For this purpose, manufacturers have designed ‘bidirectional’ implants
- Recent devices are rechargeable and capable of wireless data transmission
- These advances allow access to long timescale recordings in natural environments

Packet Loss



- During wireless transmission, neural data are grouped into formatted units called packets
- It is possible for packets to fail to reach the receiver during transmission leading to missing samples known as packet losses
- Failure to receive packets leads to uncertainties in timing of the remaining data

Event Related Potentials (ERPs)



Wikipedia

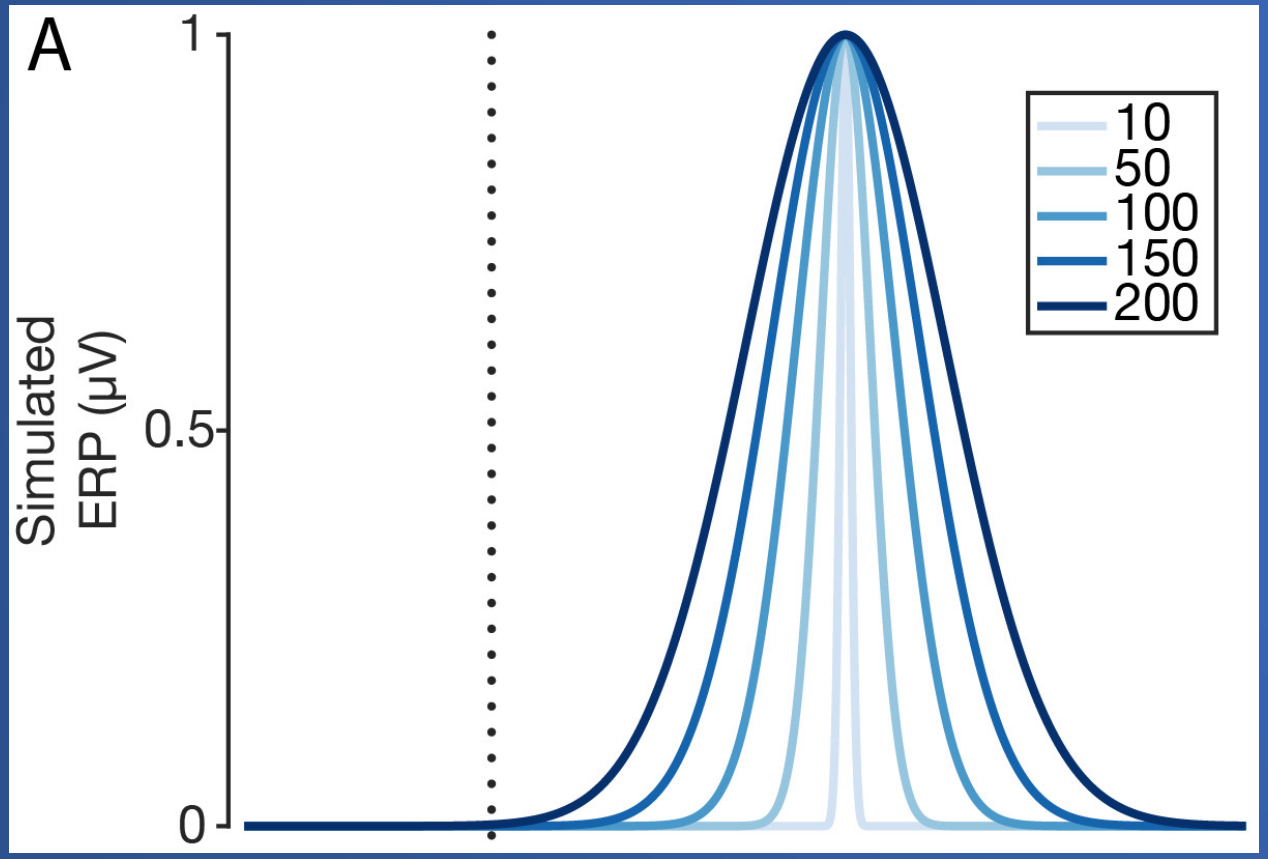
- ERPs are measured brain responses that are the direct result of a specific event
- To observe ERPs, it is typically necessary to average many trials due to noise and random brain activity that is also present

Objective

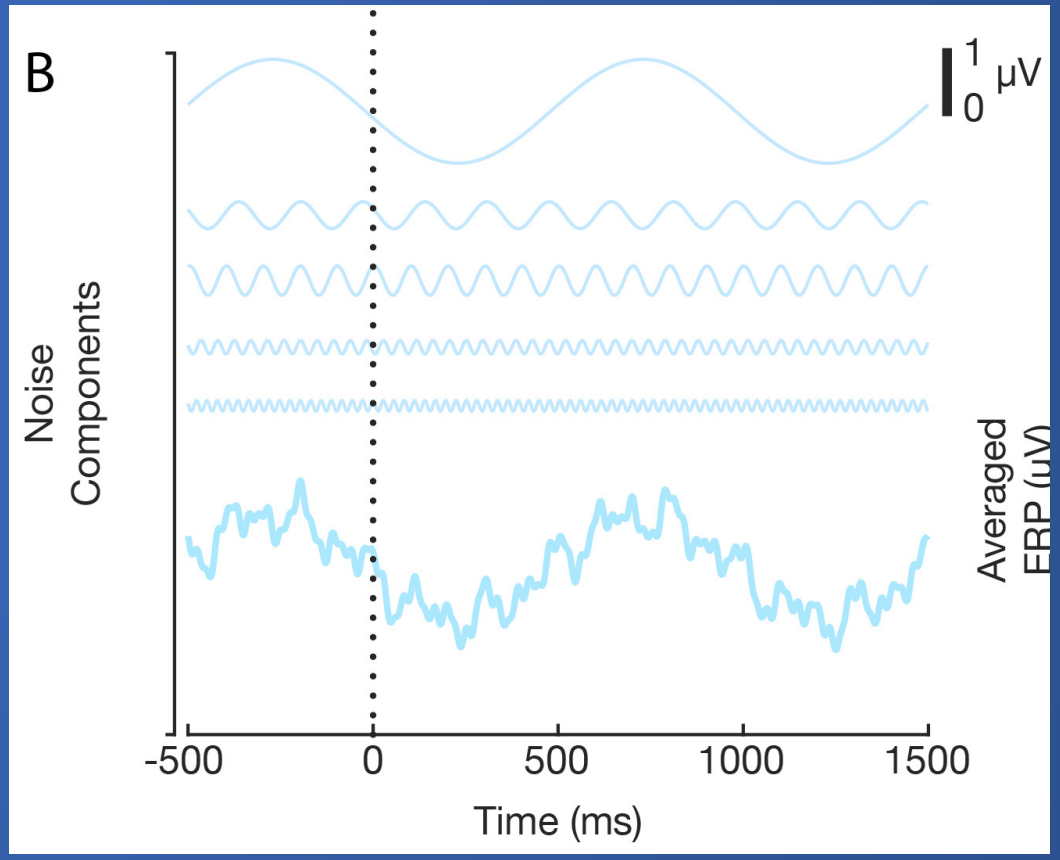
- Uncertainty in packet timing may affect recovery of biological signals as samples will be offset from the true time at which they were recorded
- We hypothesize that these effects will be compounded for averaged signals such as ERPs
- To investigate these effects, we simulated ERPs, noise, and packet losses to determine the impact of losses on timing, localization, amplitude, and resolution of small differences in signal

Simulation

ERP

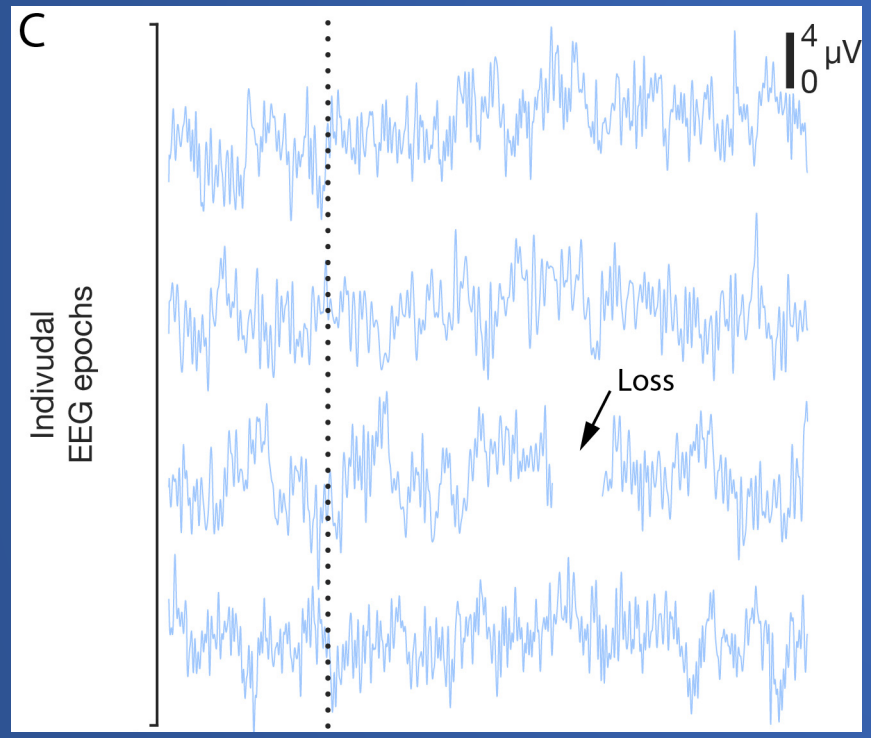


Sinusoidal Noise

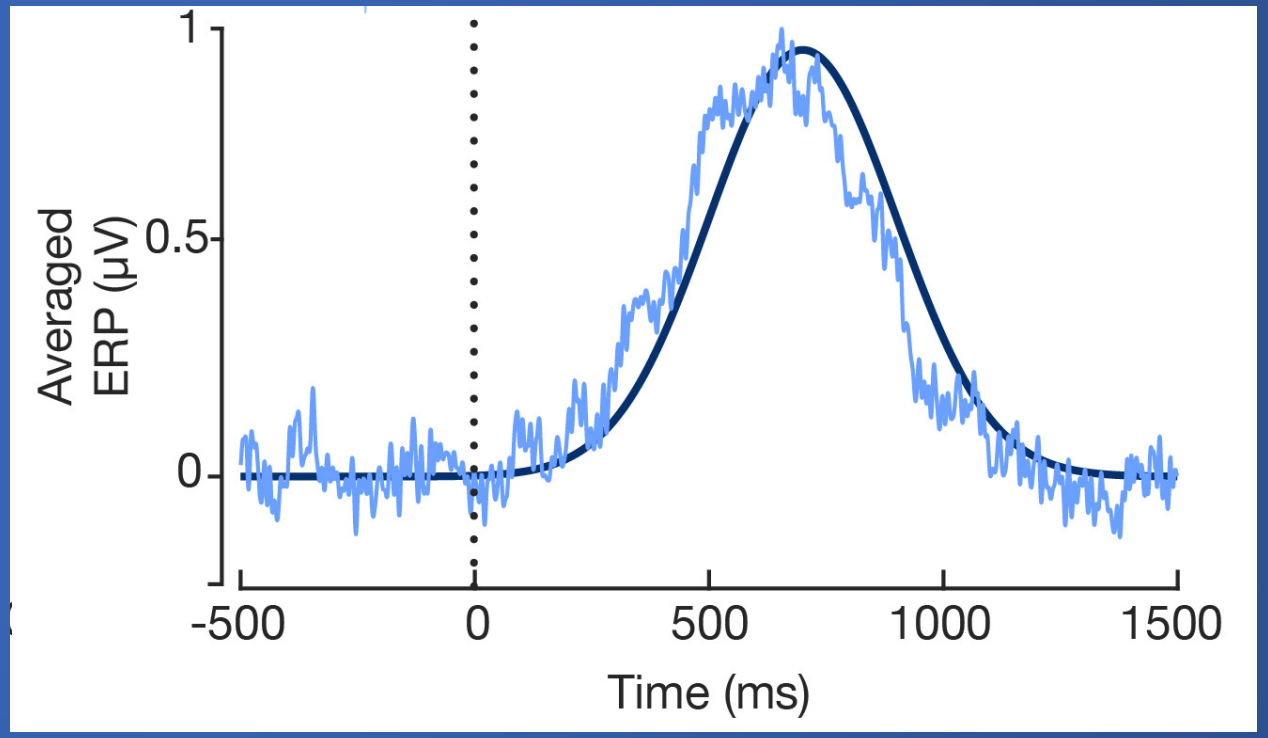


Simulation

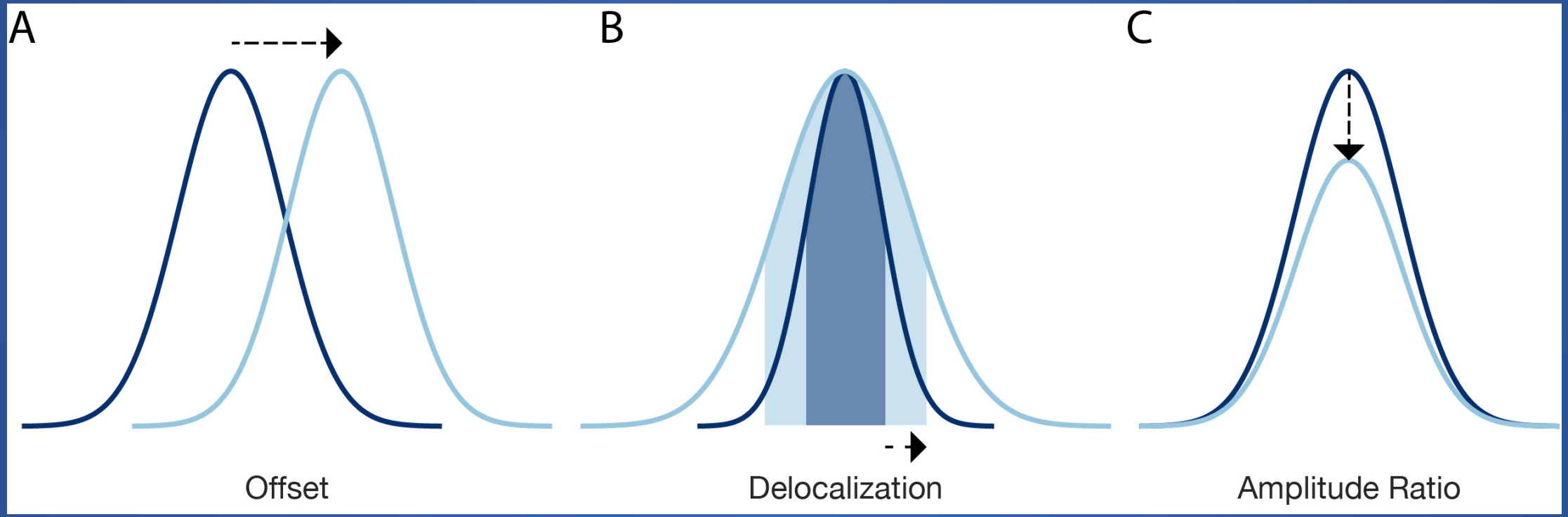
Trials



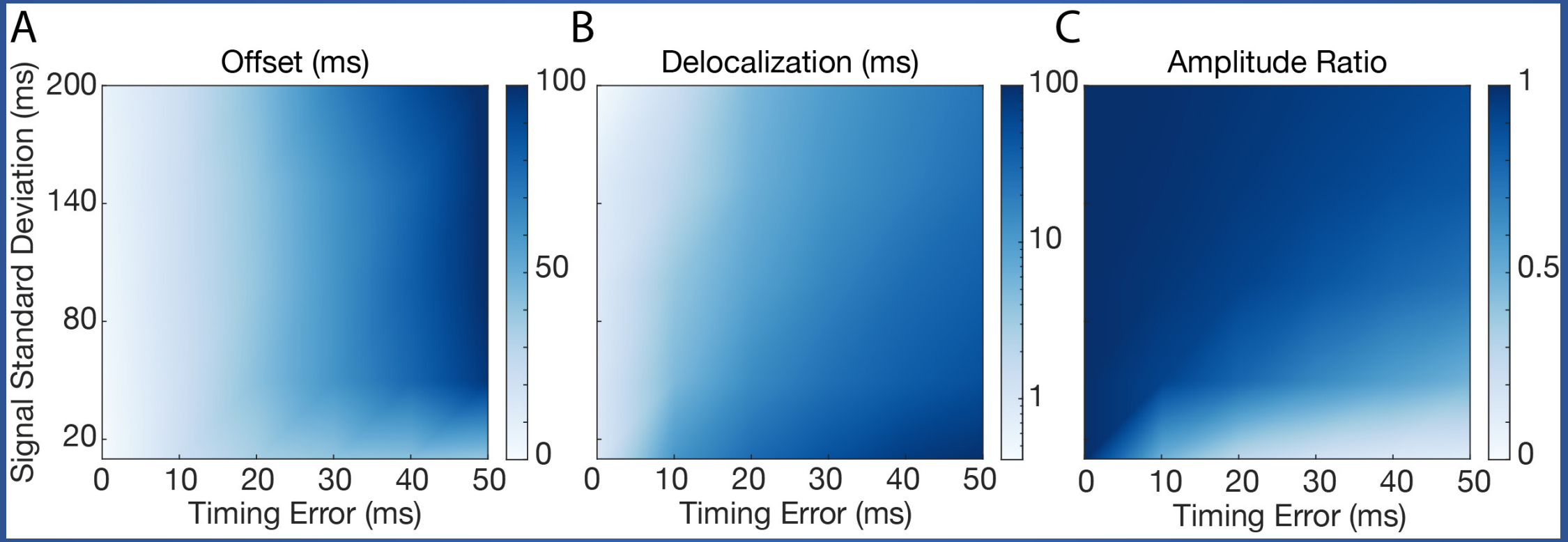
Averaged ERP



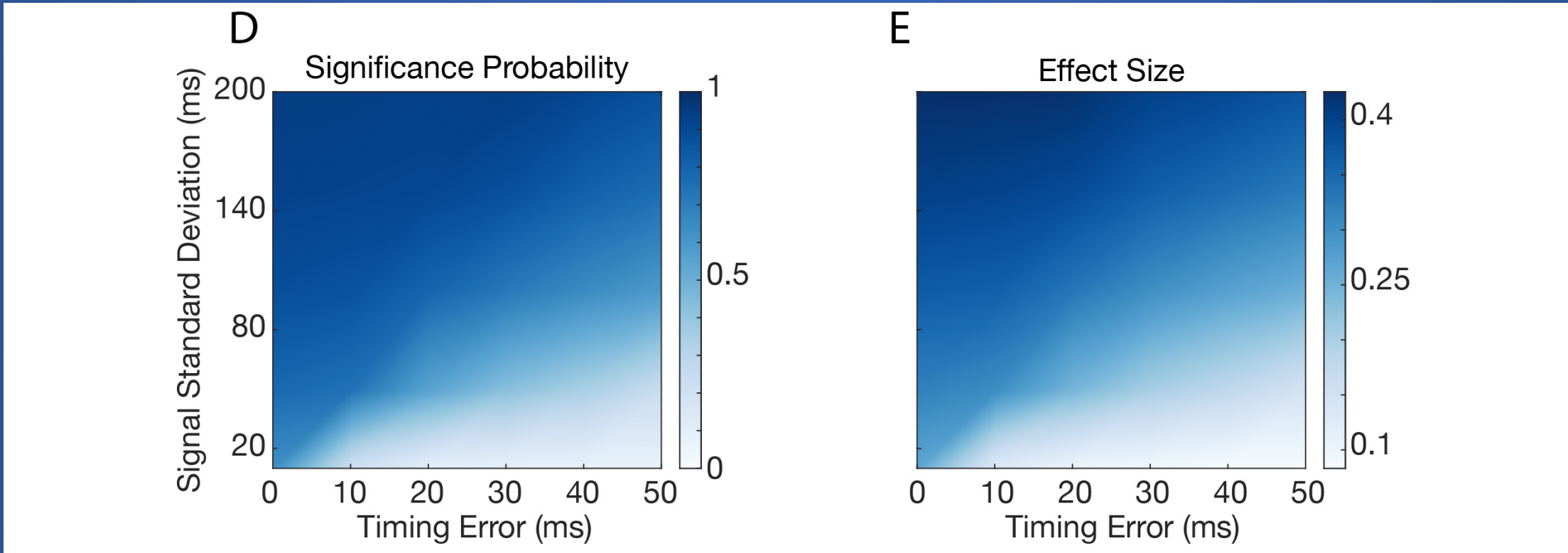
Comparison Metrics



Results


A
Offset (ms)
Signal Standard Deviation (ms)
200
140
80
20
0
10
20
30
40
50
Timing Error (ms)
100
50
0
B
Delocalization (ms)
0
10
20
30
40
50
Timing Error (ms)
100
10
1
C
Amplitude Ratio
0
10
20
30
40
50
Timing Error (ms)
1
0.5
0

Results


D
Significance Probability
Signal Standard Deviation (ms)
200
140
80
20
0
10
20
30
40
50
Timing Error (ms)
1
0.5
0
E
Effect Size
0
10
20
30
40
50
Timing Error (ms)
0.4
0.25
0.1

Conclusions

- Signals with standard deviations greater than 100 ms are robust o the effects of packet losses on averaged timeseries data

- Signal timing may be offset on the order of twice the timing uncertainty

- Shorter signals less than 80 ms in duration are noticeably obscured by packet losses

Thank you!

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