

Session 8

Data Analysis I

Grand Averages

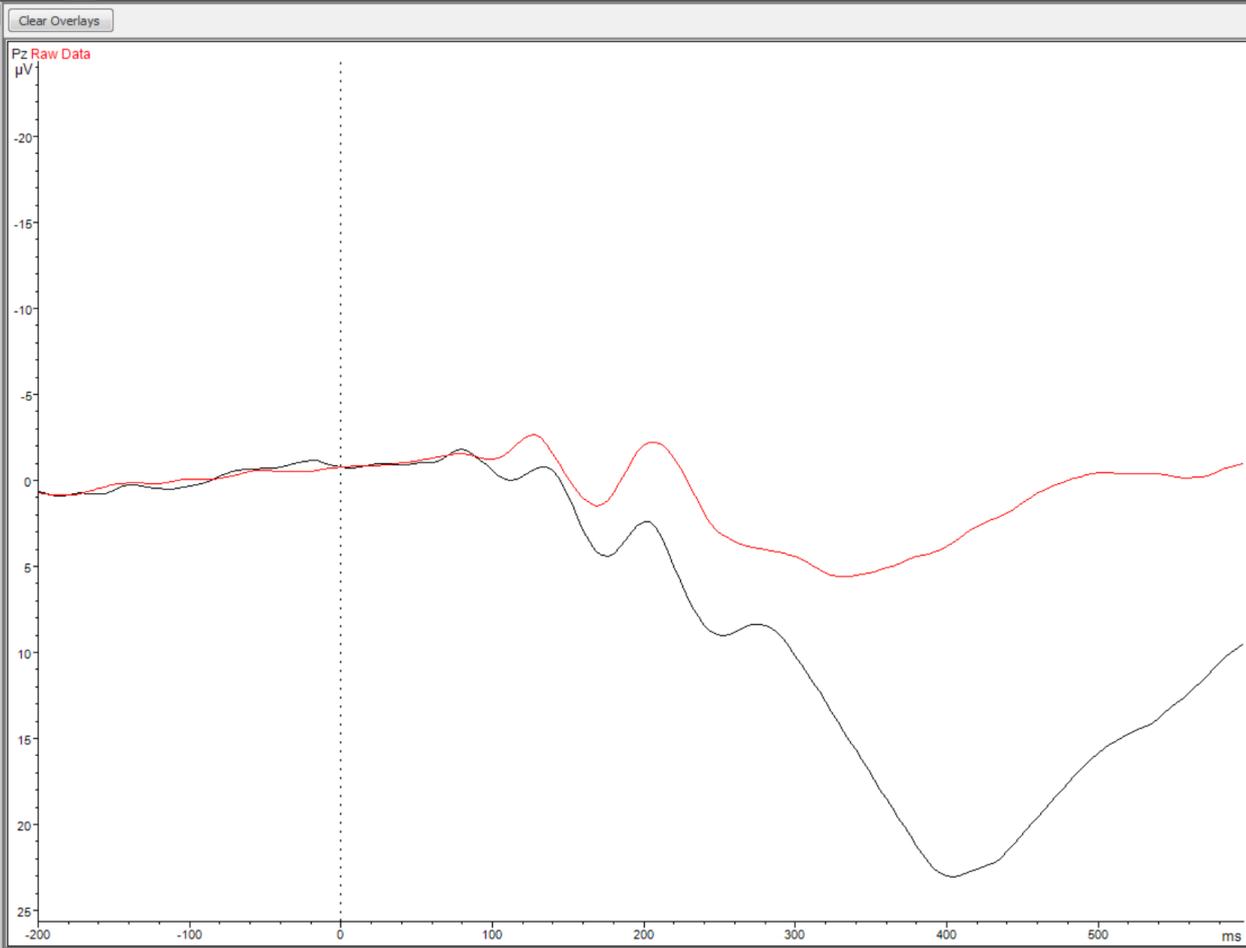
Grand Averages

The notion of a grand average waveform is very simple – average together all of the conditional waveforms for each participant to get a “grand average” for each condition.

Secondary

- DW
- Frequent
- Raw Data
- Infrequent
- Raw Data

Primary Secondary History



View Toolbox

- Channel Selection
- Delta Tool
- Magnifier
- Map Legend
- Mapping
- Scaling Bar
- Text Box
- Value Graphics

Navigation Bar

Standard Montage 0:00:00 Seg: 1/1 Chan: Pz Pos: 0.032 s 0.232 s Oddball

But don't forget...

“There is nothing special about the point in time a grand average waveform reaches a maxima or minima – this may have not reveal the true nature of the underlying components.”

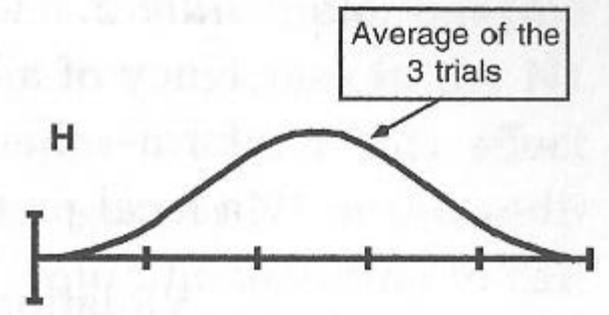
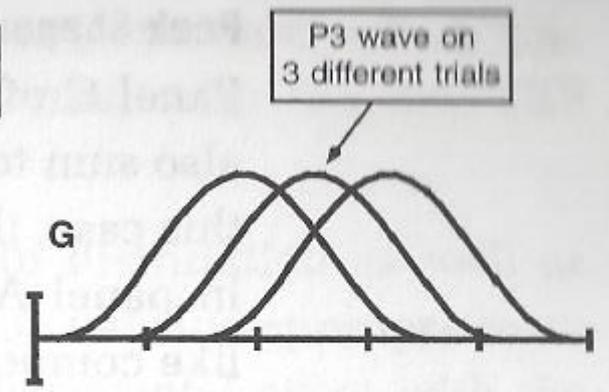
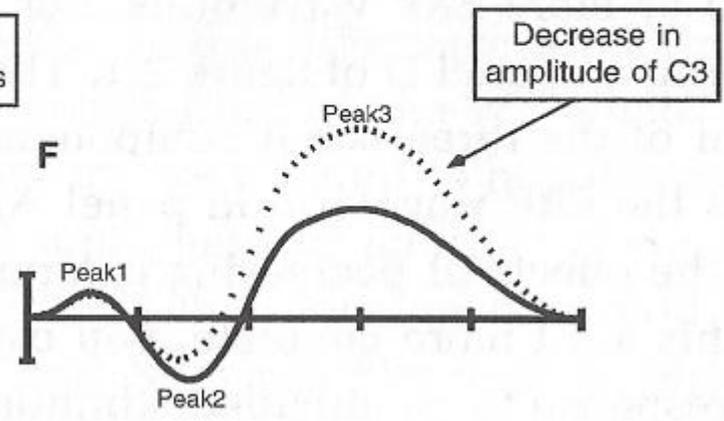
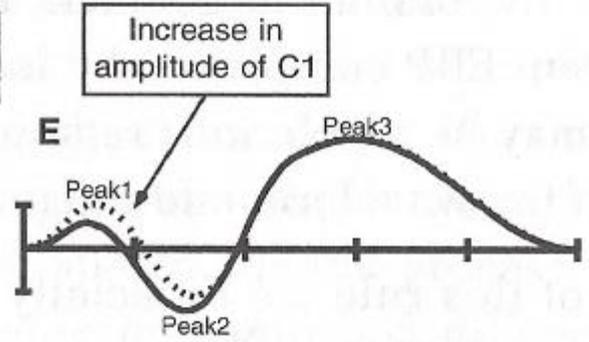
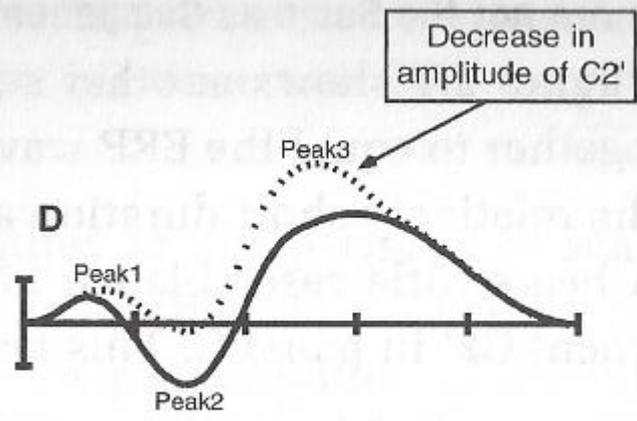
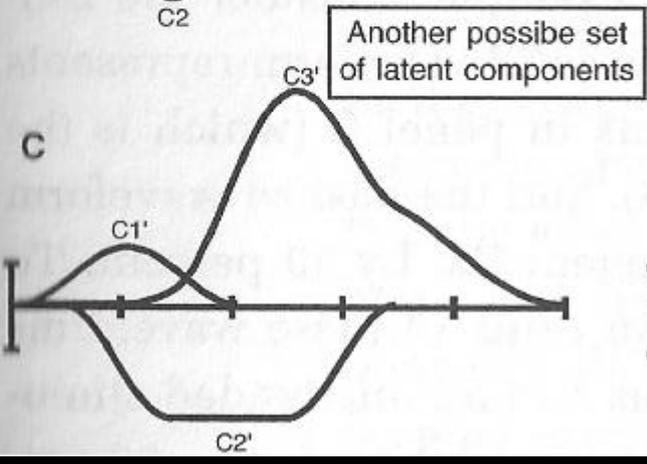
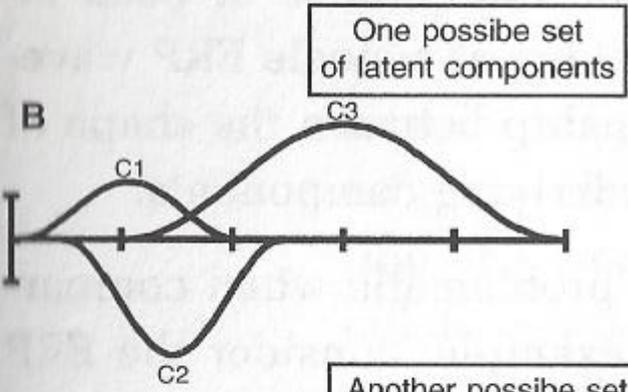
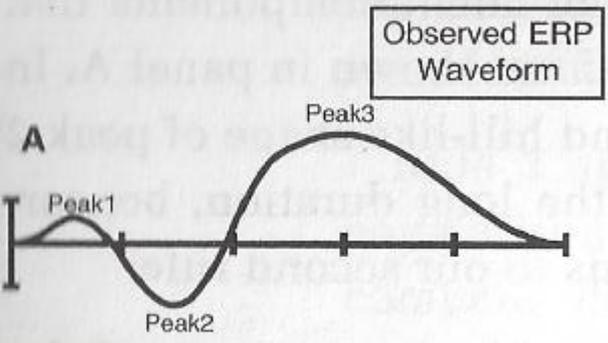
Things to check...

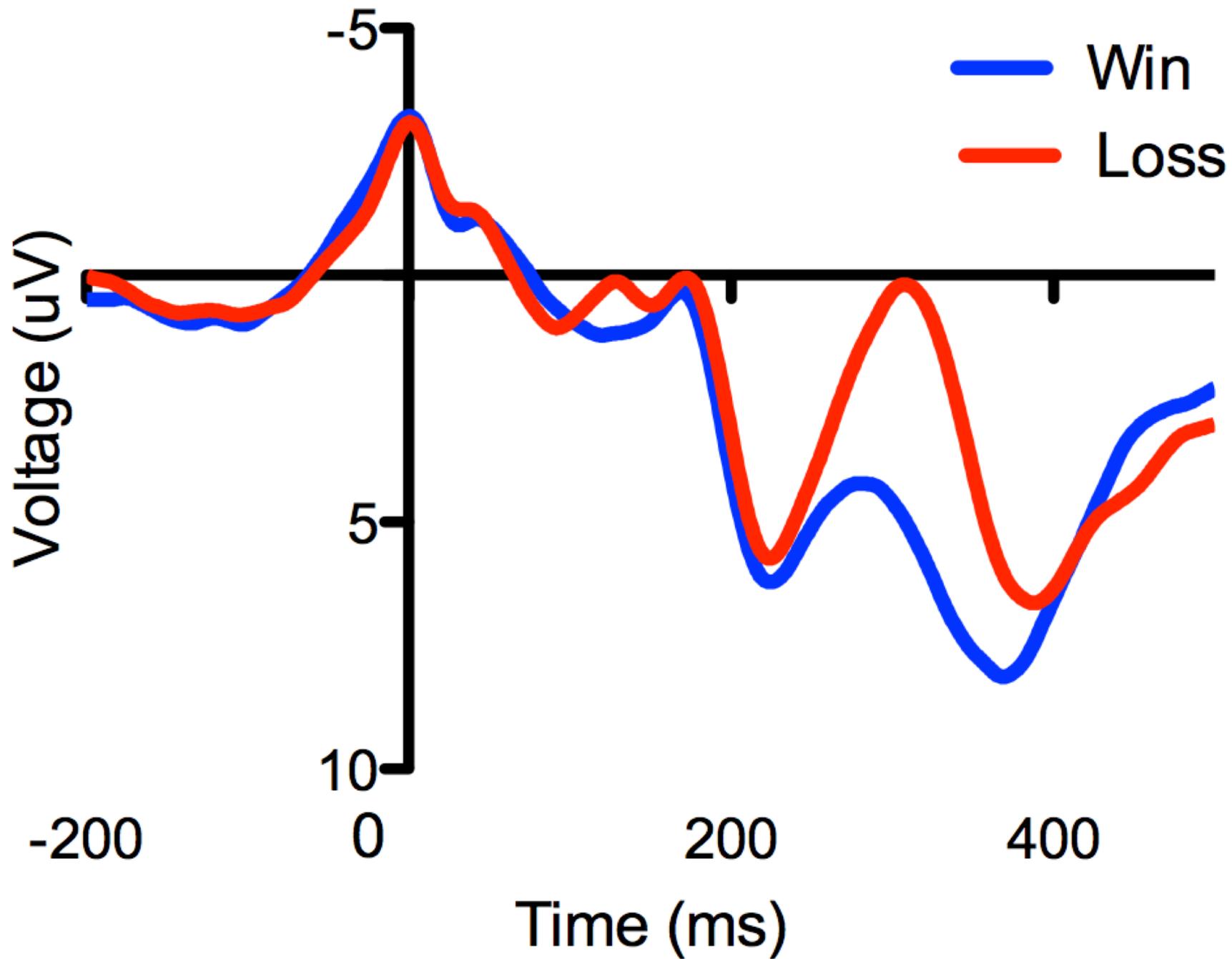
This is a good time to check:

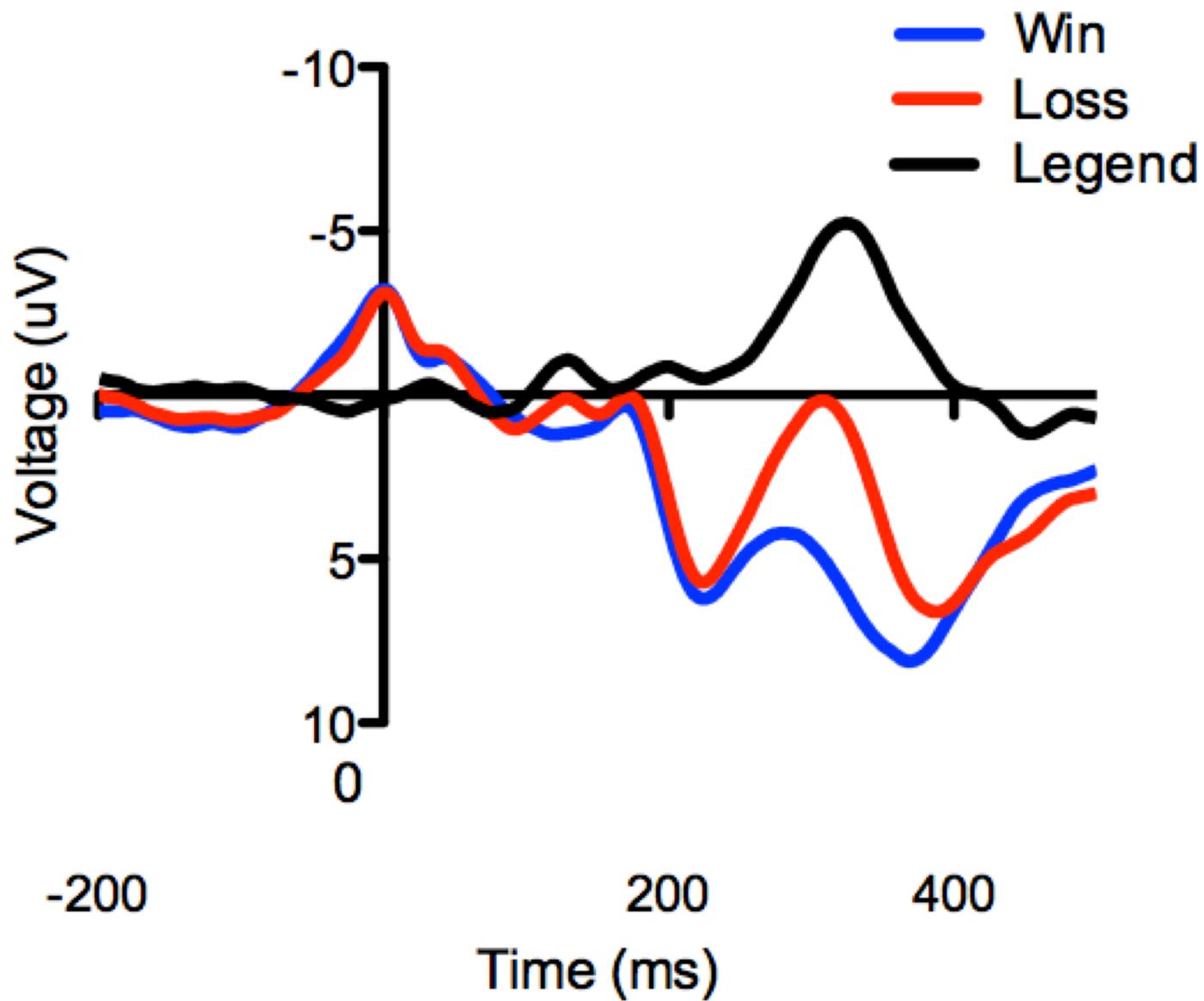
1. The number of blink trials for each participant for each condition (i.e., systematic blinking)
2. The number of artefact trials for each participant for each condition – again systematic effects.
3. To review individual participants waveforms to see the contribution of each or the similarity of each to the grand average.

Grand Average Demos

Difference Waveforms







Difference Waveforms

Whenever possible, you should construct difference waveforms for subsequent analysis.

You need to do this for each participant, although the grand average difference waveform will show the effects. You need the participant difference waveforms to get numbers for statistics.

Difference Waveform Demos

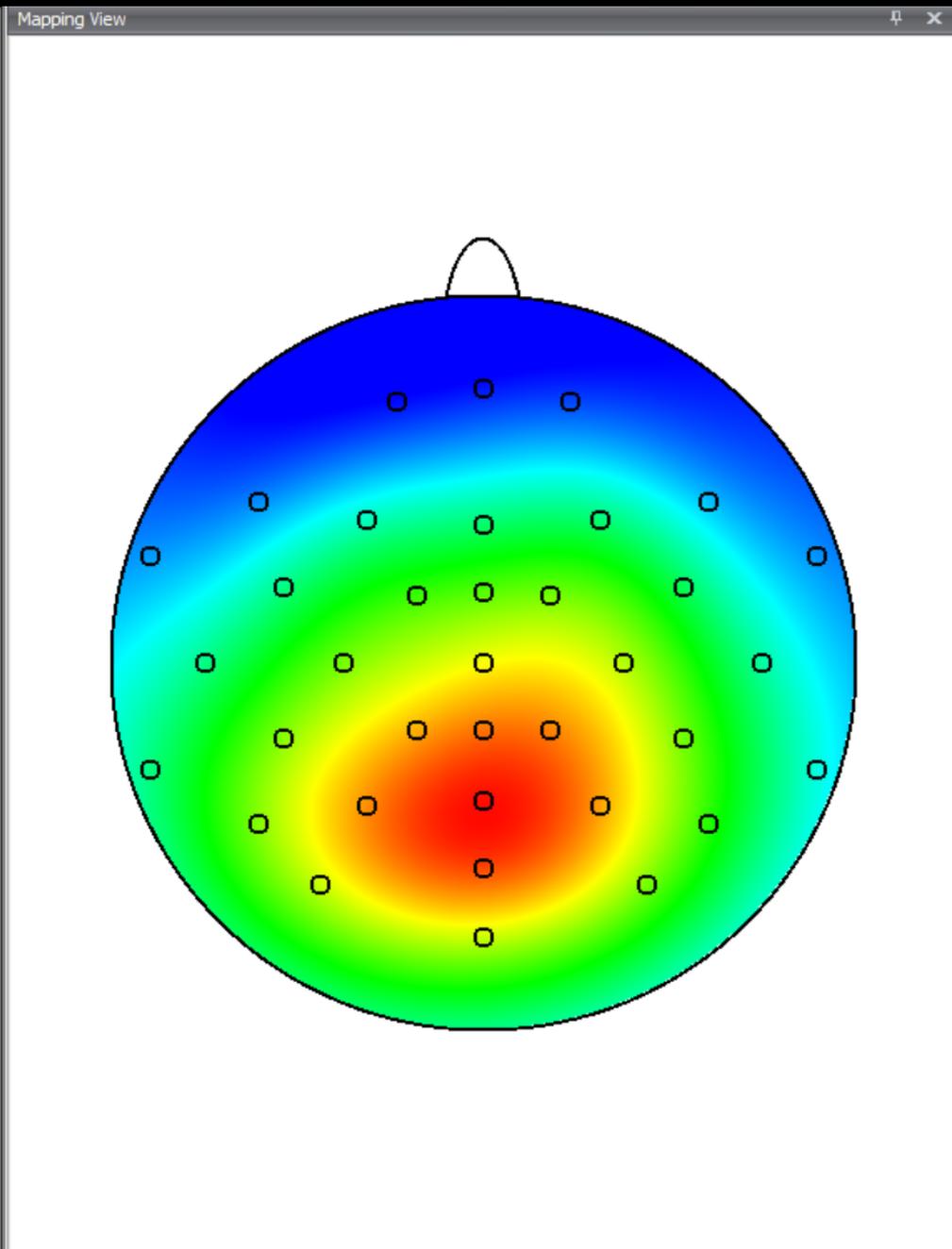
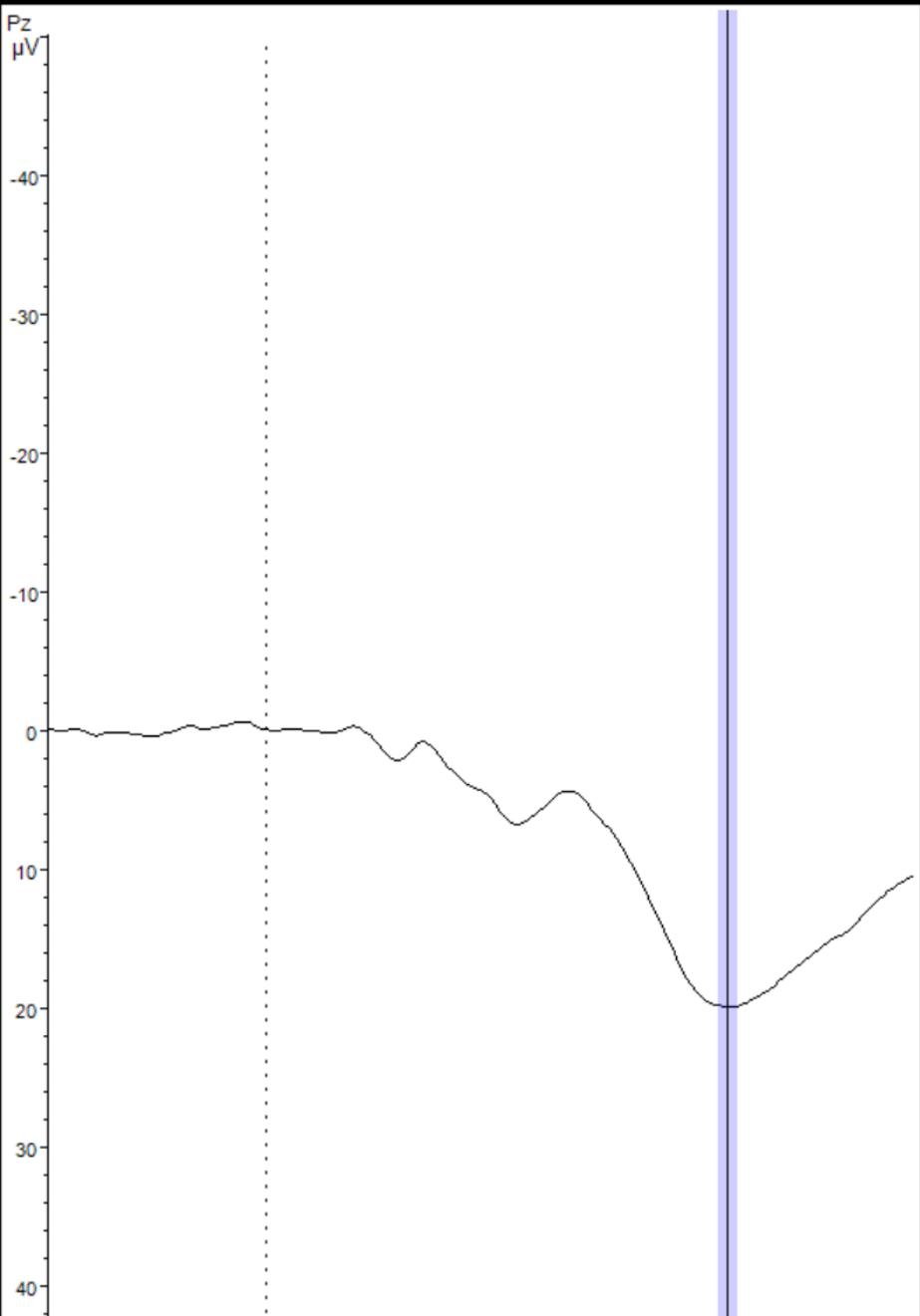
Scalp Topographies

Scalp Topographies

The topography of a component is important to verify that is indeed a “typical” component.

For instance, we expect the P300 to have a posterior topography with a positivity maximal at Pz for an Oddball Task.

But...



Scalp Topographies

Interpreting topographies can be tricky.

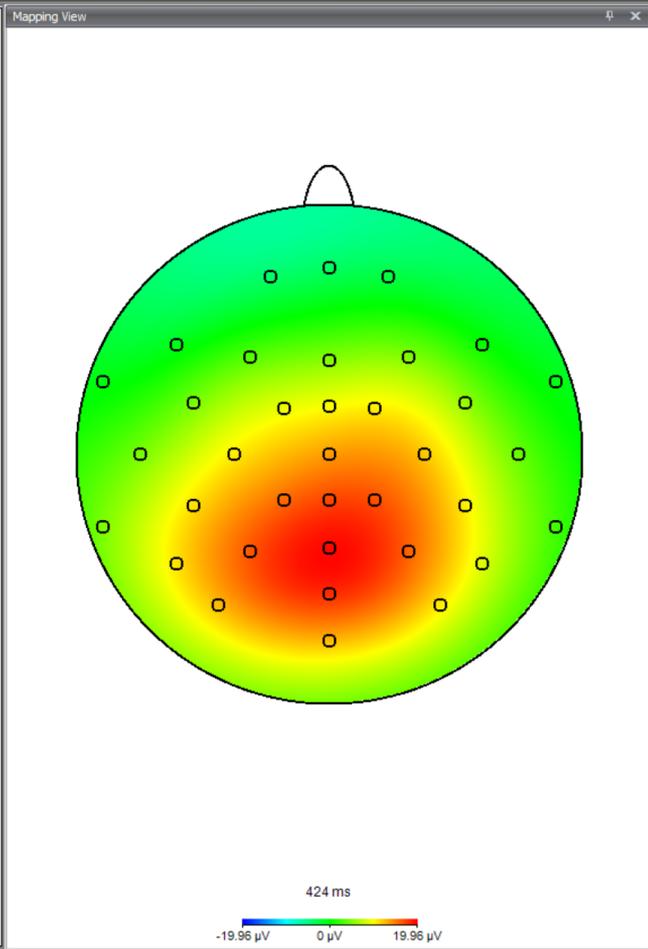
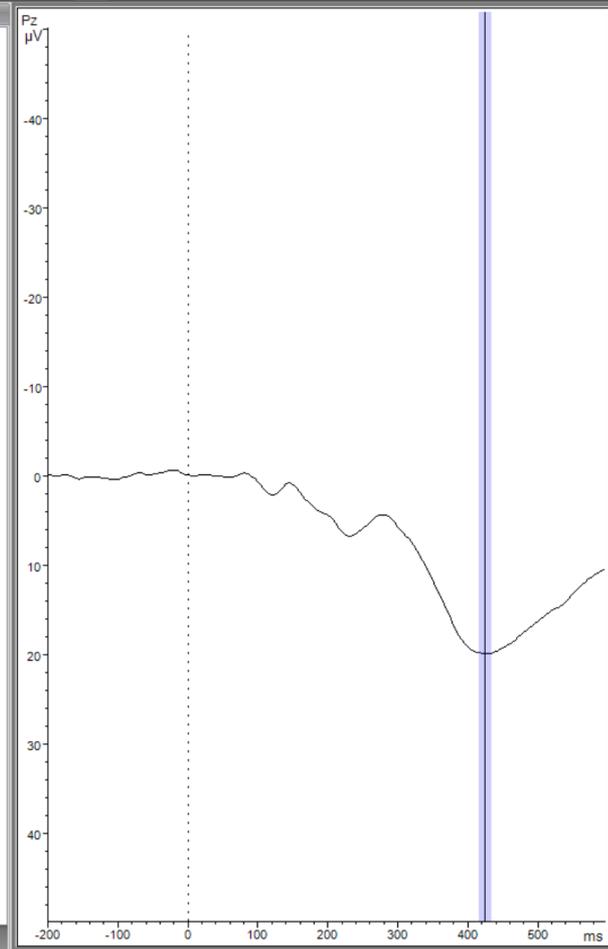
Some pitfalls...

1. Symmetric scaling may distort the topography.

Secondary

- DW
 - Raw Data
 - Frequent
 - Raw Data
 - Infrequent
 - Raw Data

Primary Secondary History



View Toolbox

- Channel Selection
- Delta Tool
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- Map Legend
- Mapping
- Scaling Bar
- Text Box
- Value Graphics

Scalp Topographies

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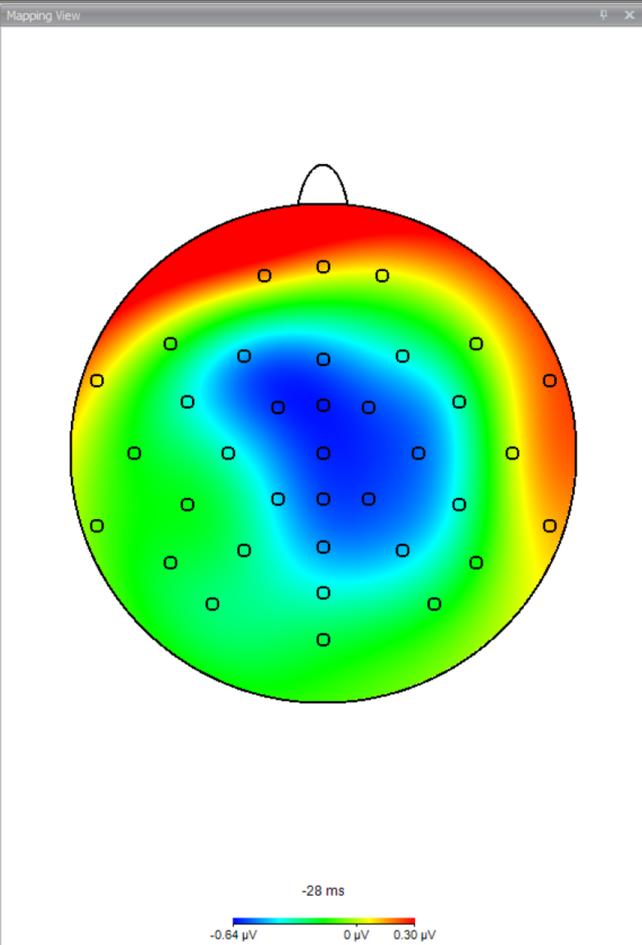
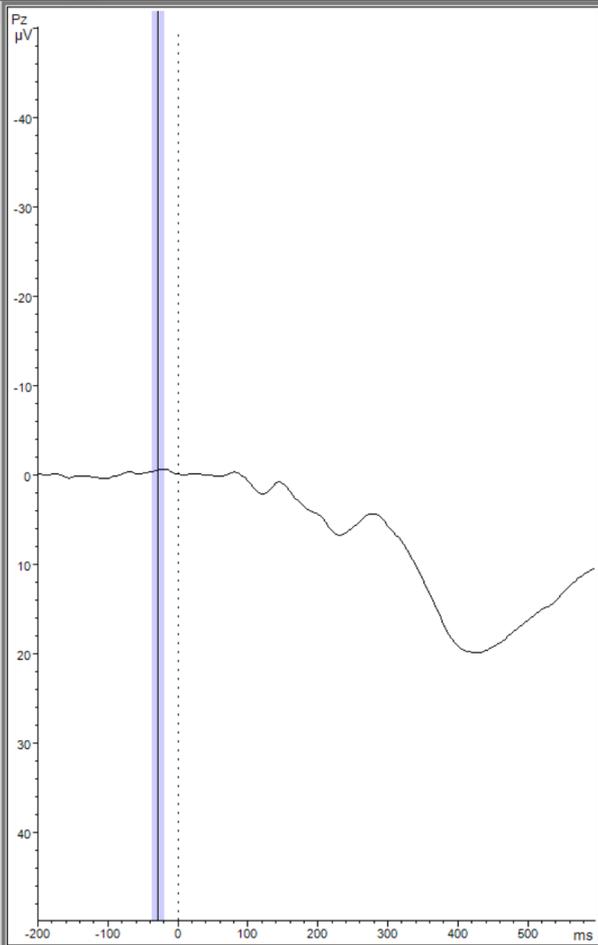
Some pitfalls...

2. Autoscaling may make it look like there is something when there is not.

Secondary

- DW
 - Raw Data
 - Frequent
 - Raw Data
 - Infrequent
 - Raw Data

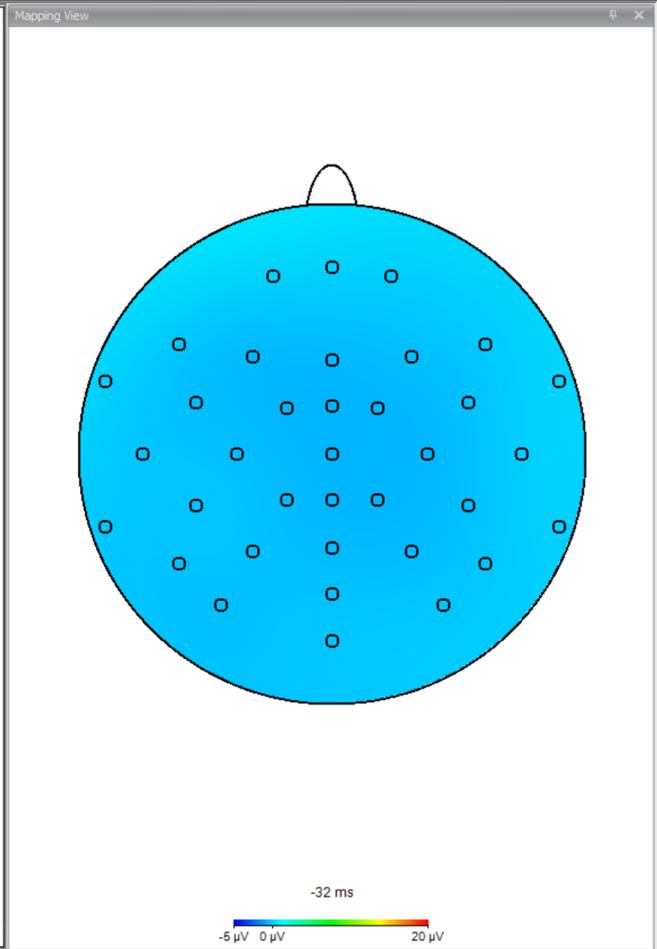
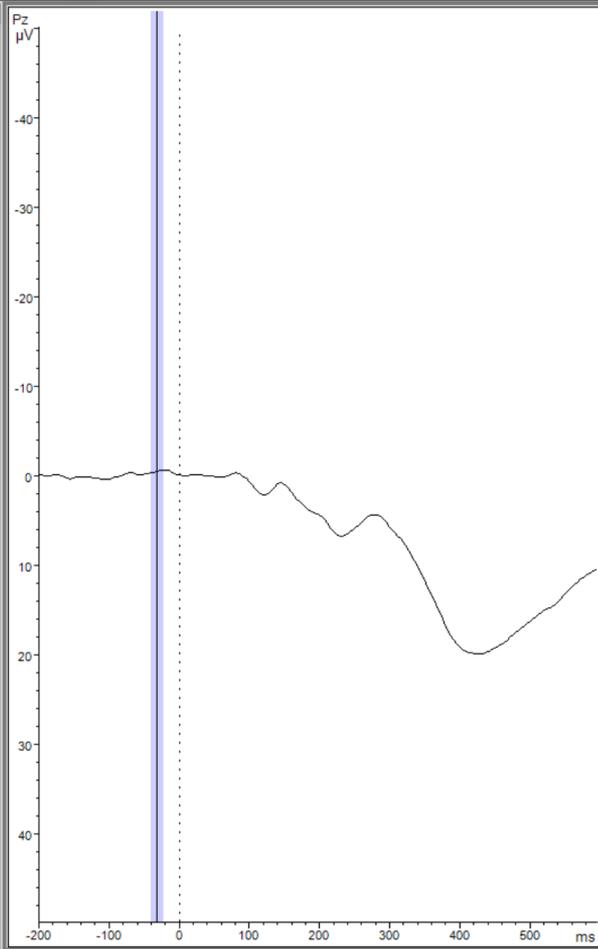
Primary Secondary History



Secondary

- DW
 - Raw Data
 - Frequent
 - Raw Data
 - Infrequent
 - Raw Data

Primary Secondary History



View Toolbox

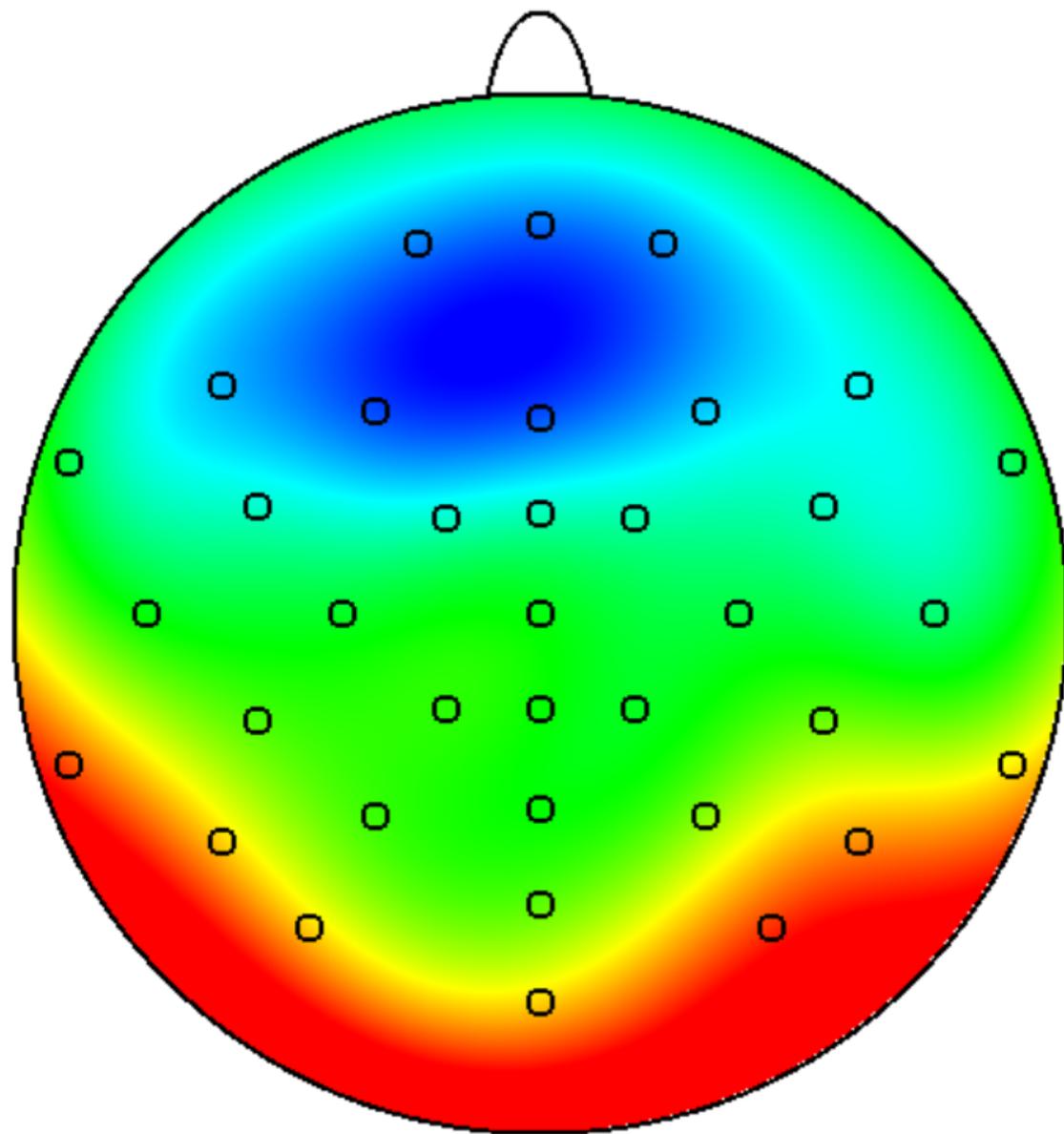
- Channel Selection
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- Text Box
- Value Graphics

Scalp Topographies

Interpreting topographies can be tricky.

Some pitfalls...

3. Keep an out for dipoles.



Scalp Topographies

Interpreting topographies can be tricky.

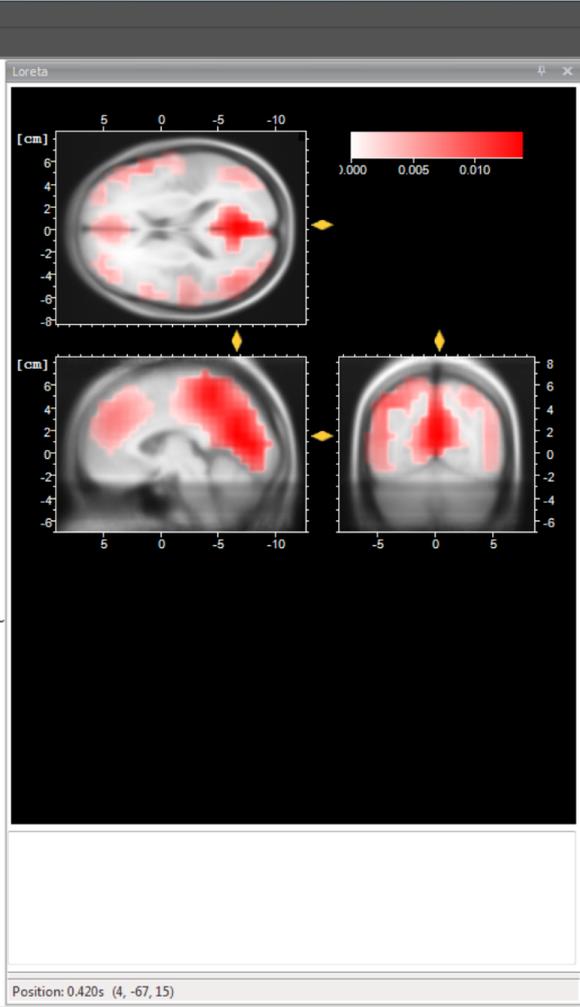
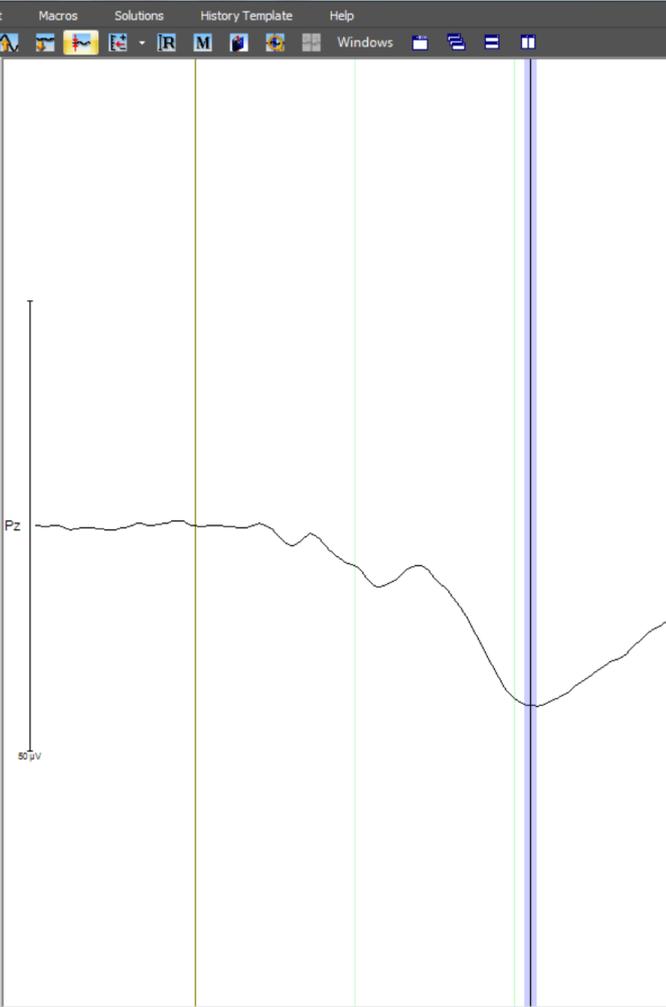
Some pitfalls...

4. Don't get caught up in Loreta...

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 - Infrequent
 - Raw Data

Primary Secondary History



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Navigation Bar

A Final Note

The topography of interest is actually not the topography of the grand average difference waveform – it is the topography of the peak detection process.

We will talk about this in a bit...

Quantifying Components: Peak Detection

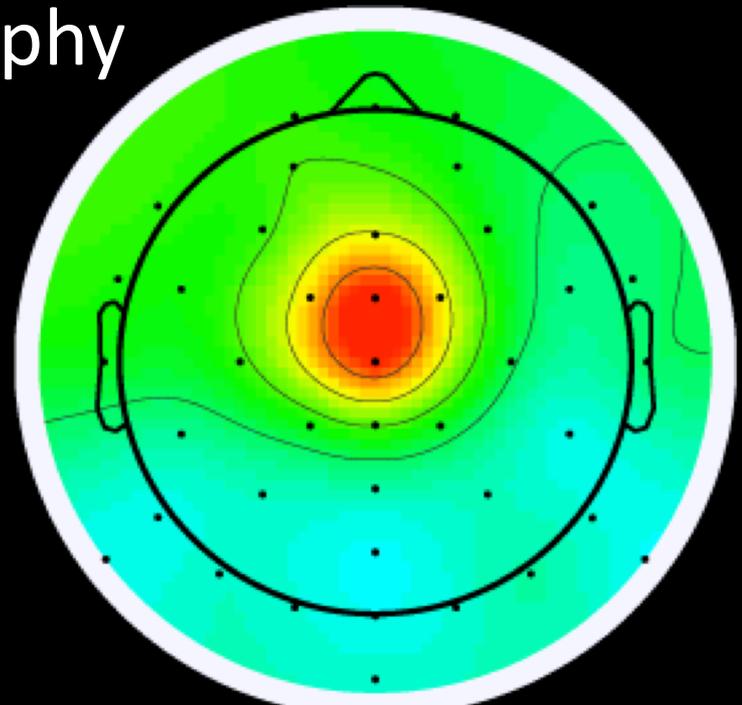
Component Definition

ERP Components have:

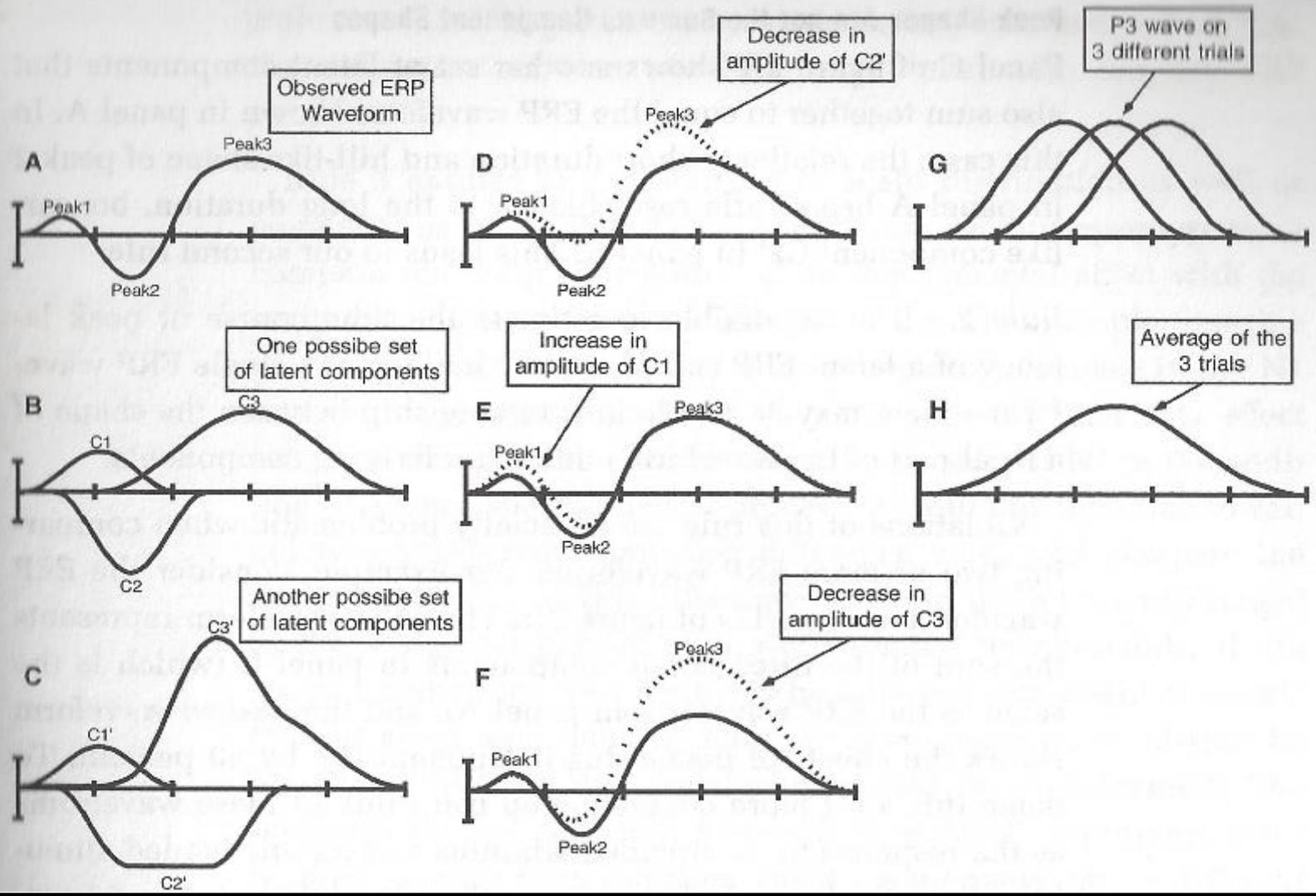
A Polarity (e.g., N200, P300)

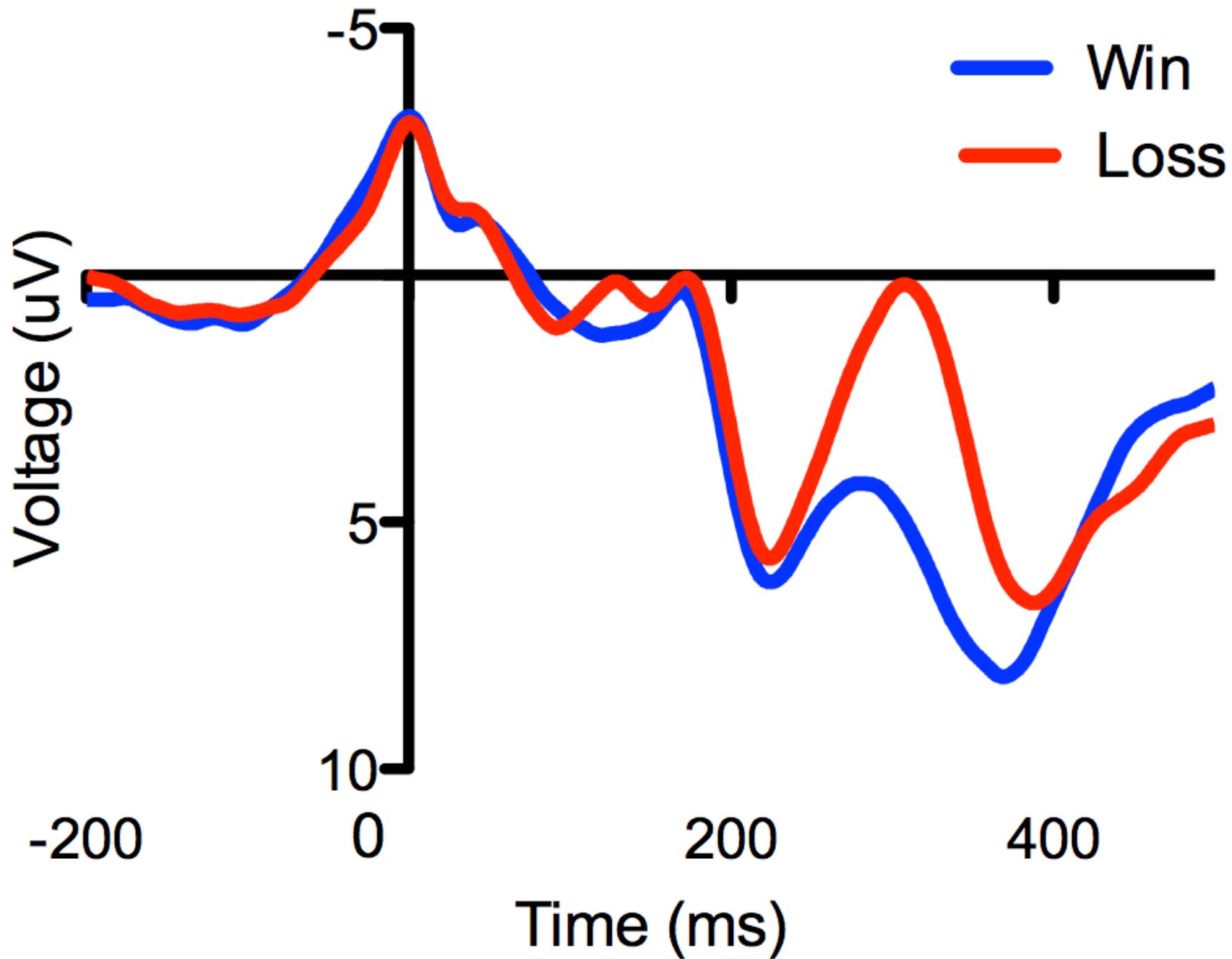
A Timing (e.g., 200 to 300 ms)

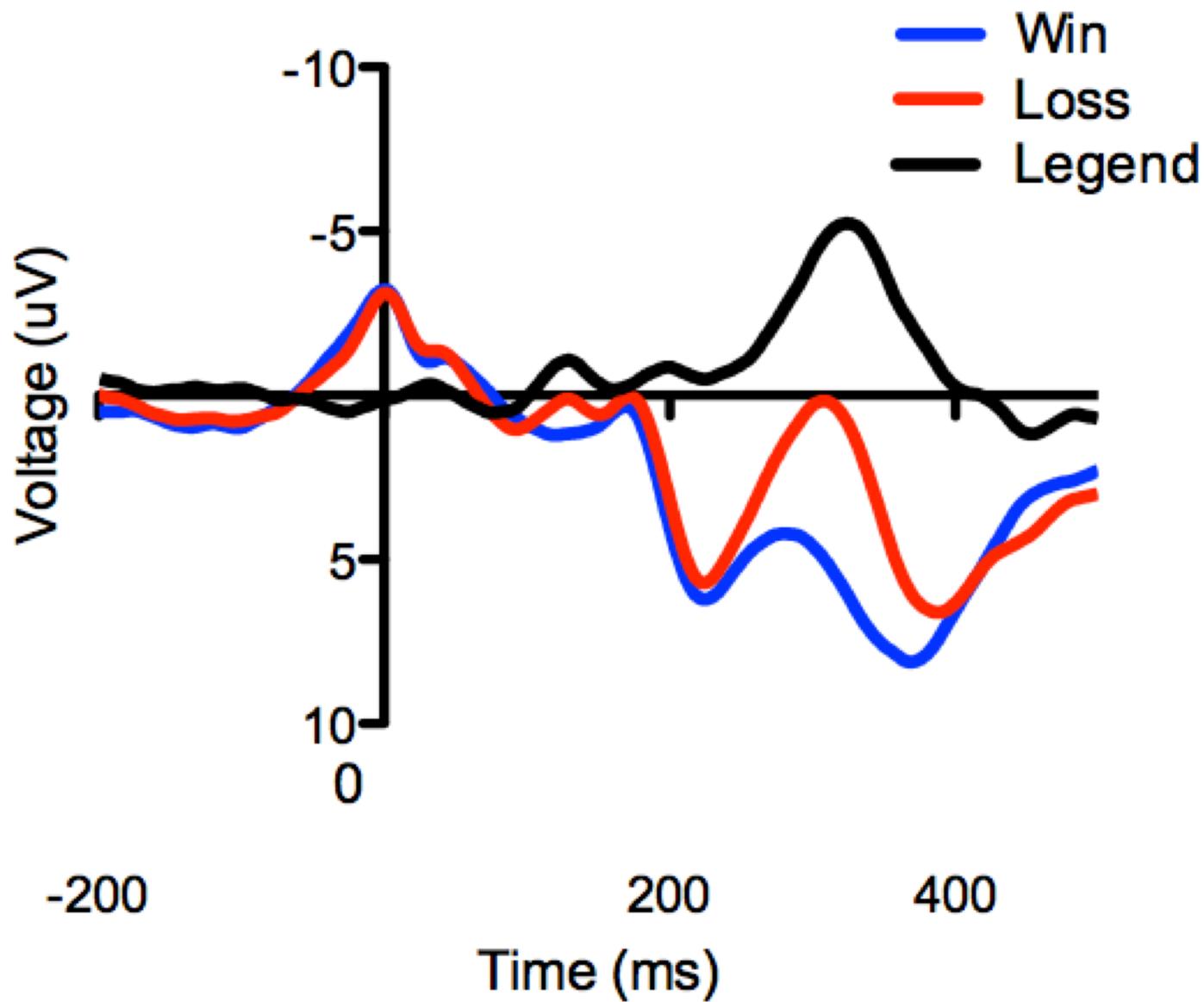
A Scalp Topography



Conditional Waveforms?



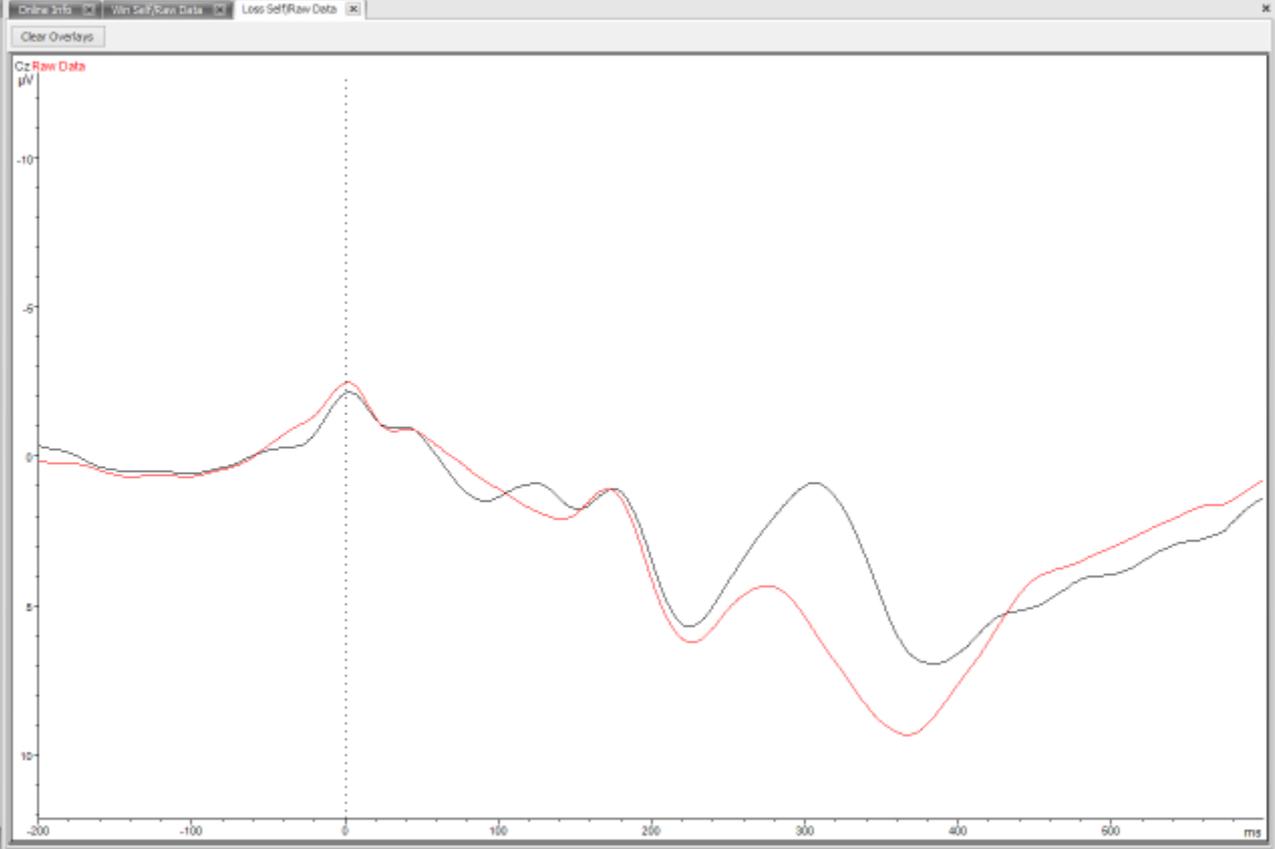




Subject or Grand Averages

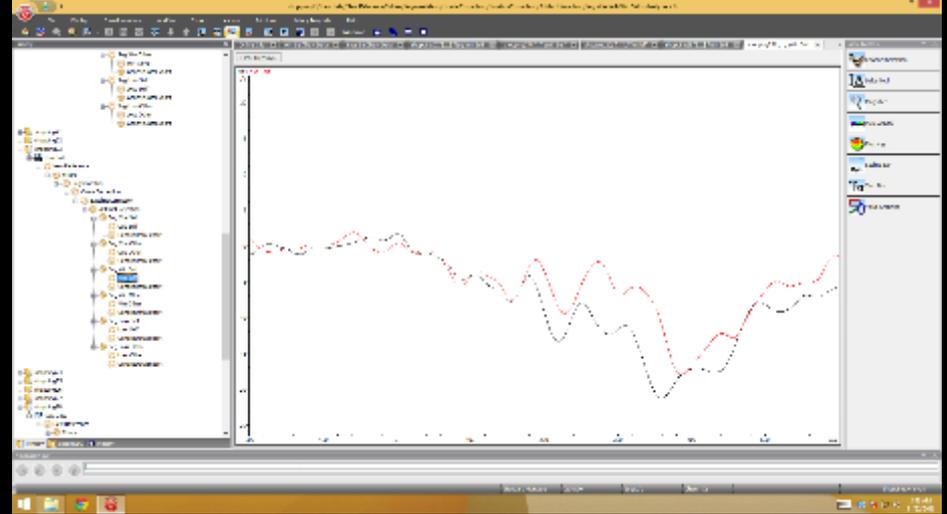
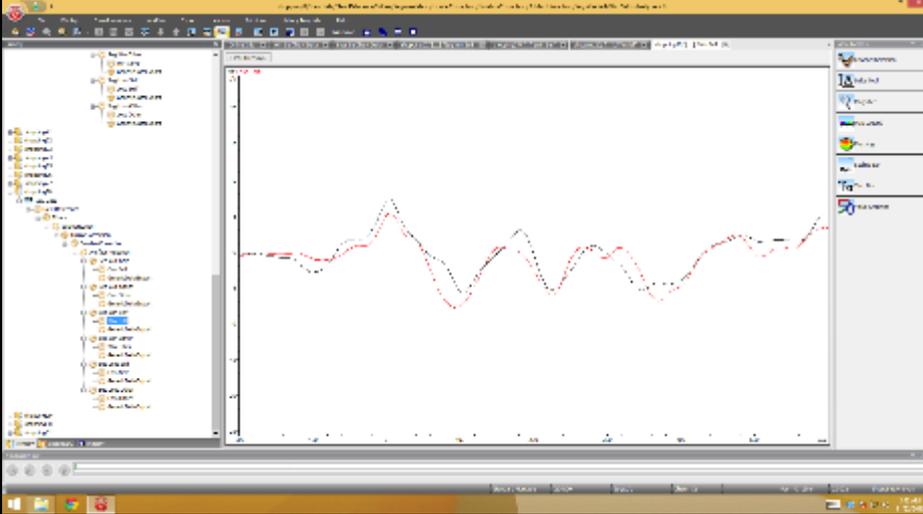
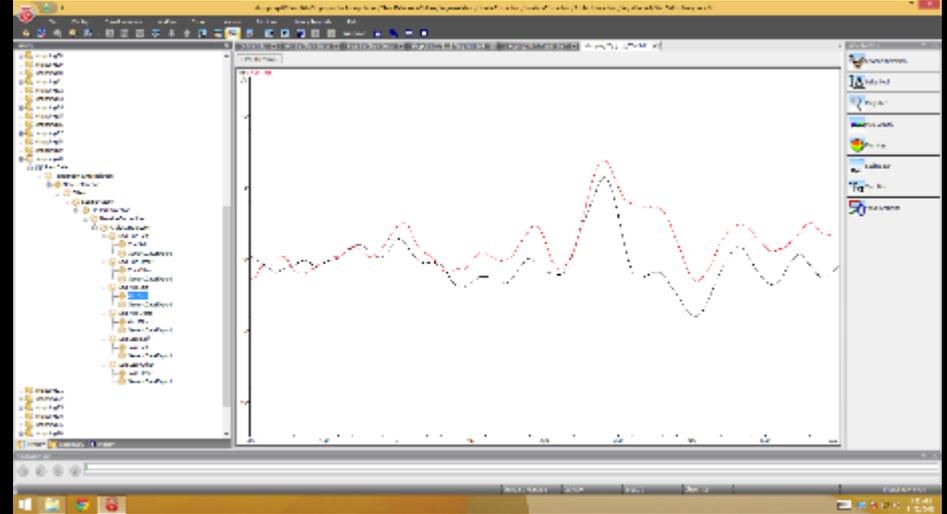
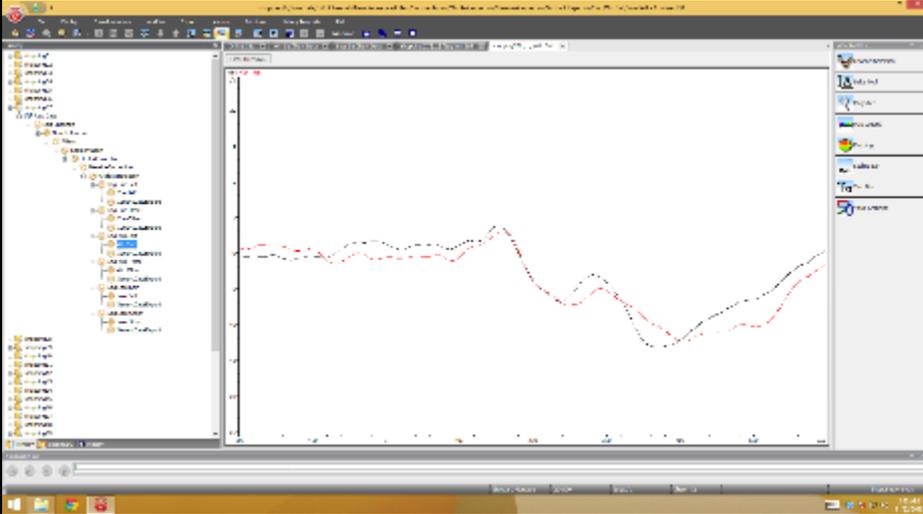
Secondary

- OO
- OS
- Out Other
- Out Self
- LO
- Loss Other
- Loss Self
- Raw Data
- LS
- Win Other
- Win Self
- Raw Data
- Standard Deviation
- WO
- WS



View Toolbox

- Channel Selection
- Delta Tool
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- Value Graphics

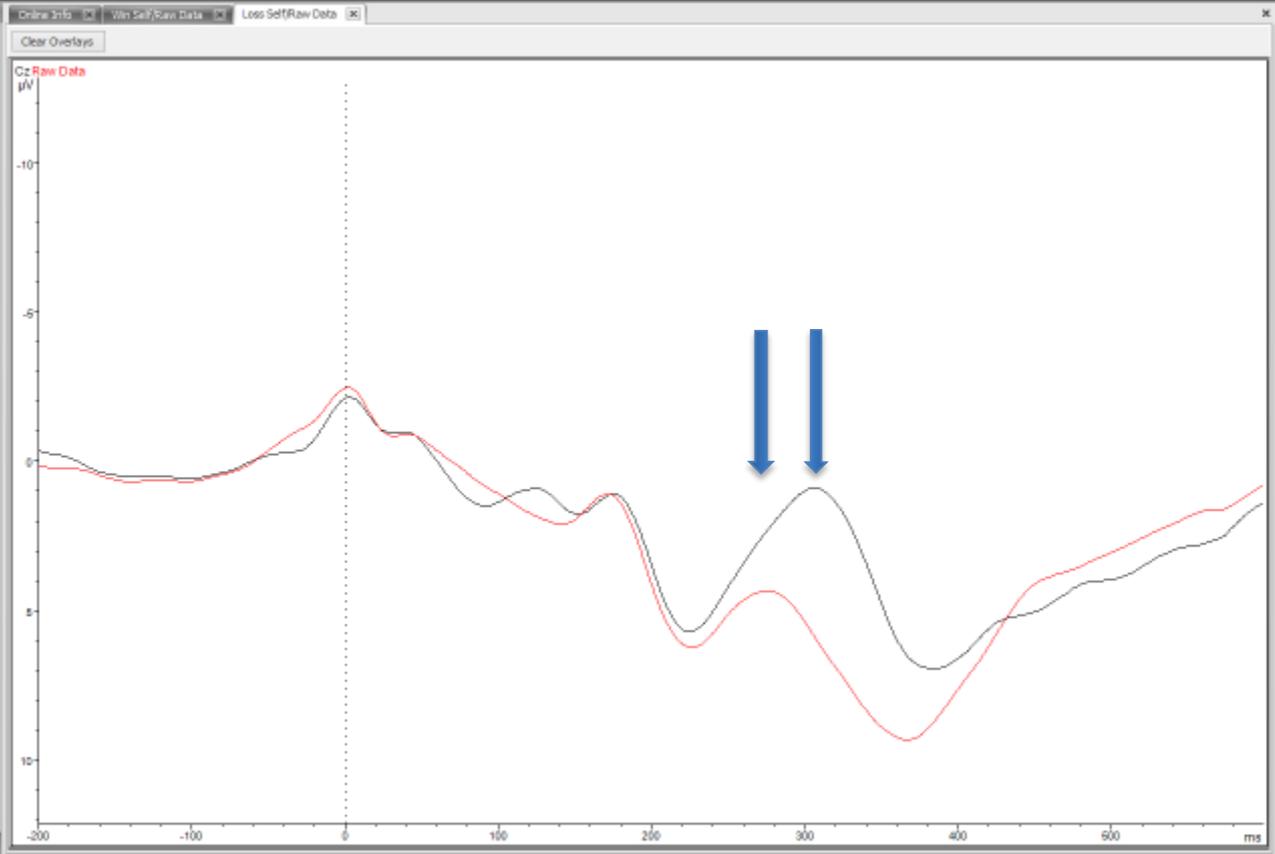


So, we base the “timing” of the component on
either the GRAND AVERAGE WAVEFORM or
APRIORI KNOWLEDGE

e.g., The P300 “lives” between 300 and 600 ms
post stimulus onset based on the literature...
BUT... what is the problem with this...

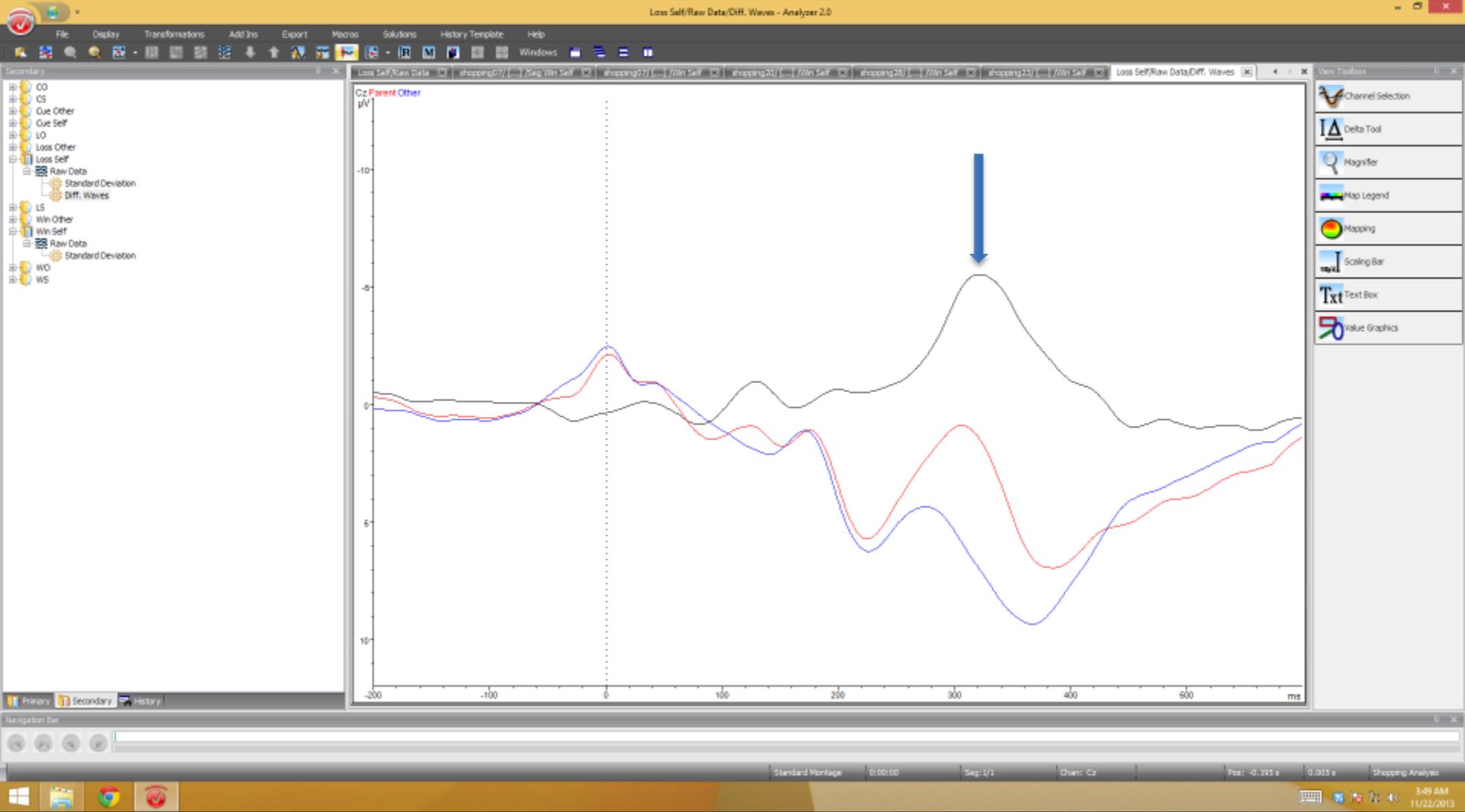
Secondary

- OO
- OS
- Out Other
- Out Self
- LO
- Loss Other
- Loss Self
- Raw Data
- LS
- Win Other
- Win Self
- Raw Data
- Standard Deviation
- WO
- WS



View Toolbox

- Channel Selection
- Delta Tool
- Magnifier
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- Mapping
- Scaling Bar
- Text Text Box
- Value Graphics



BUT WHAT IS THE PROBLEM HERE?

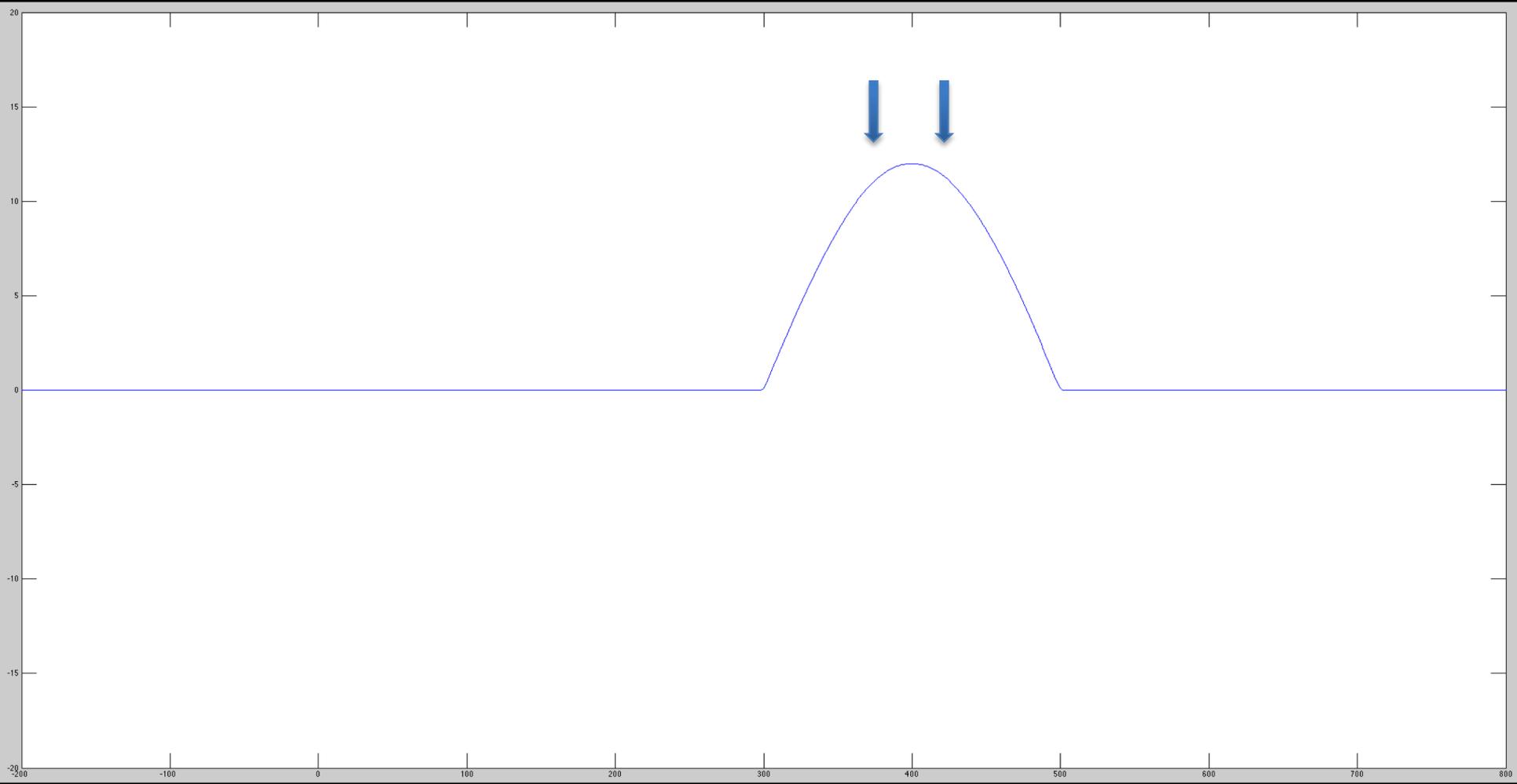
Mean Peak Measures

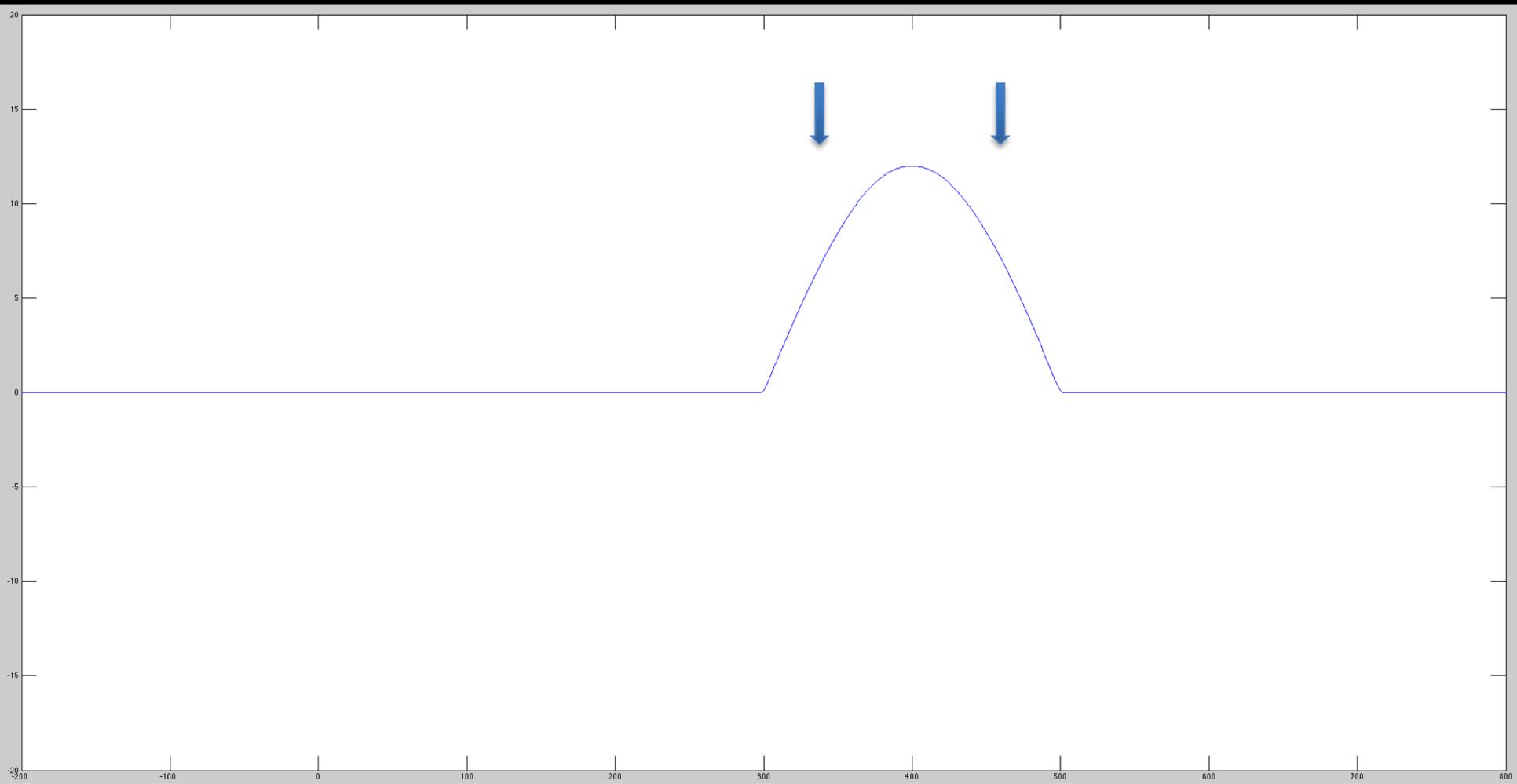
It is worth noting that some researchers base the timing of their component on absolute time points – i.e., “I will use the mean from 200 to 300 ms” ... to be fair, I have done this myself. But, WHY???

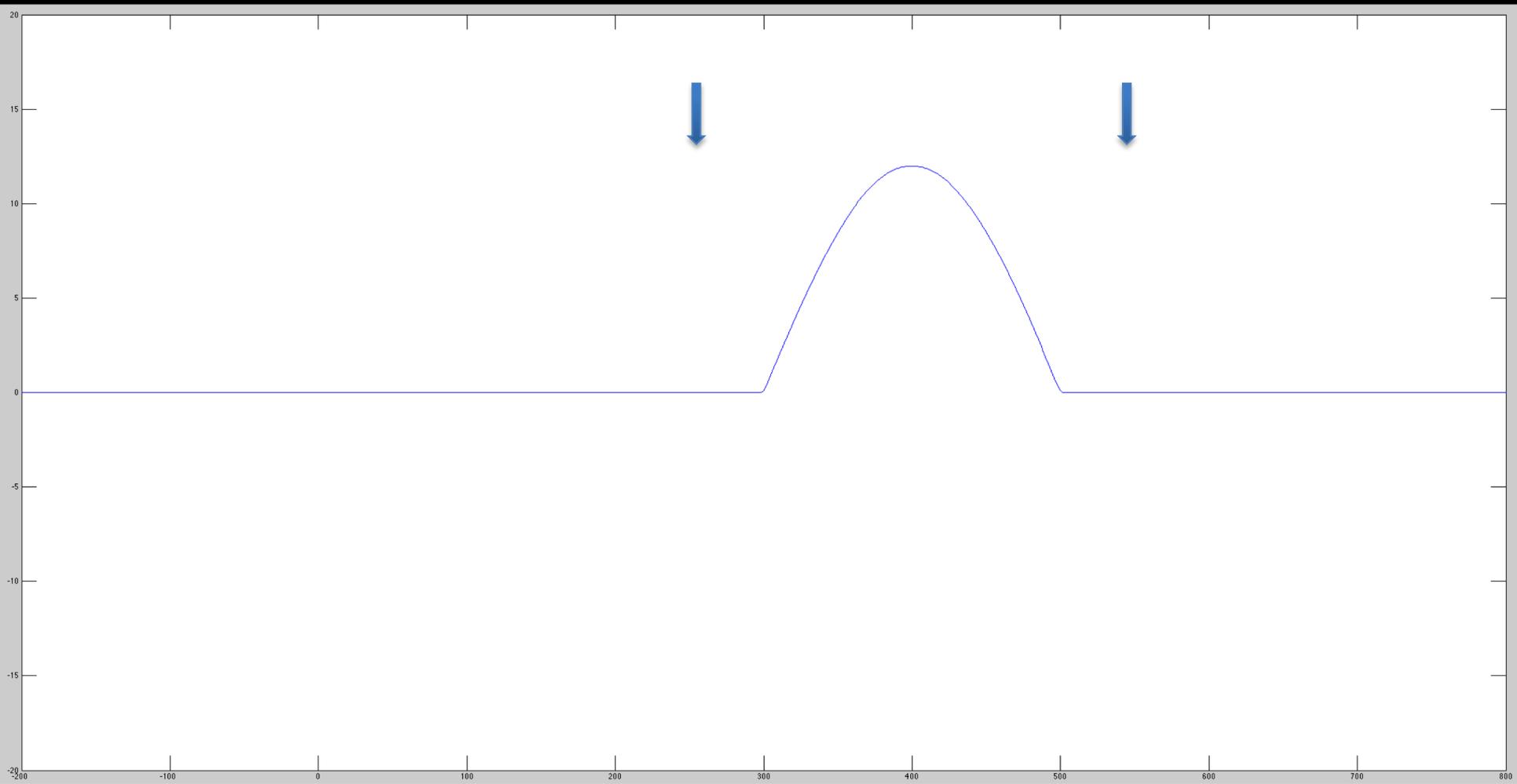
Do the underlying components really care about discrete time bins?

But the idea is simple, a mean peak is simply the mean voltage over a time window.

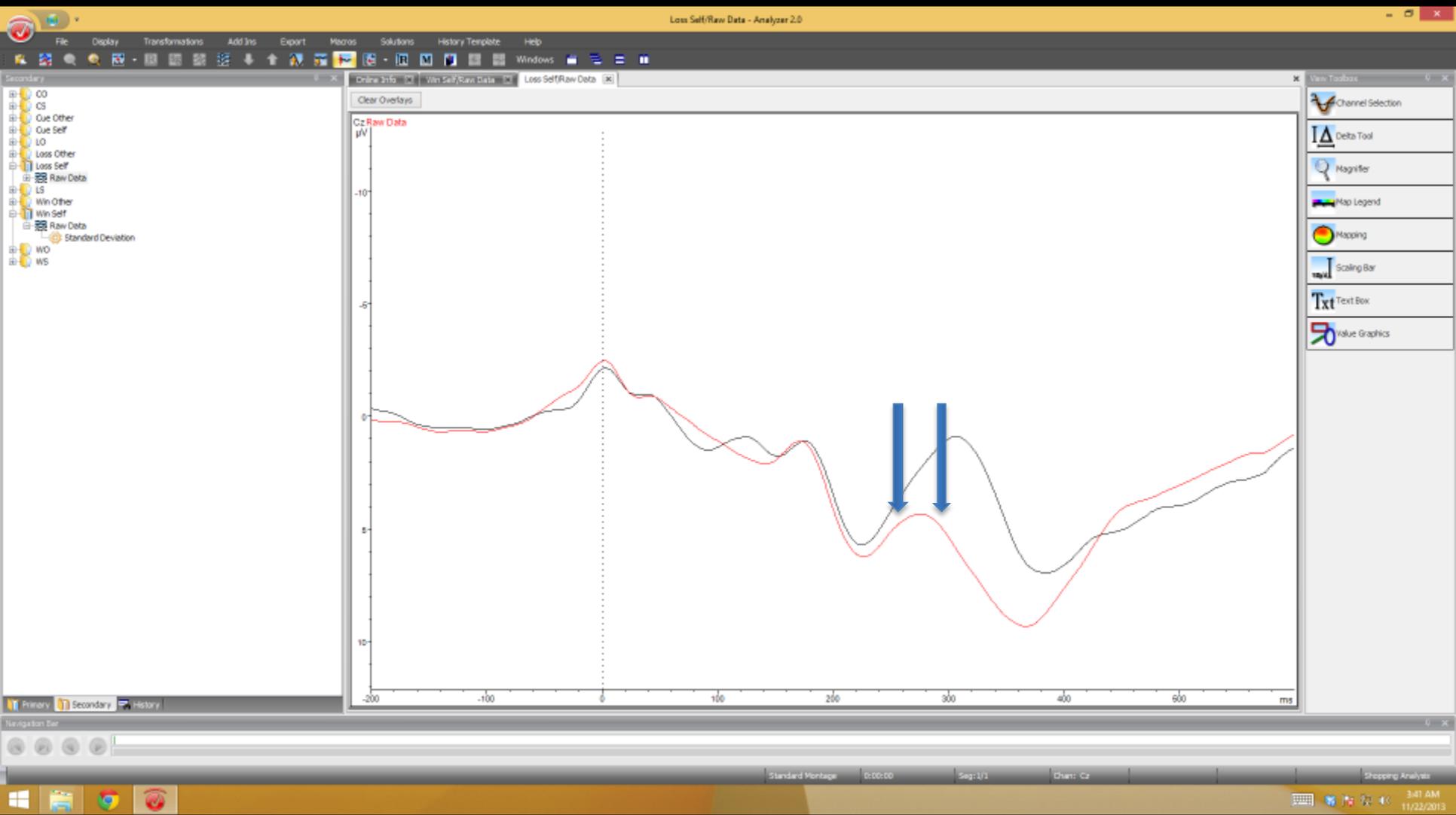
Mean Window Width



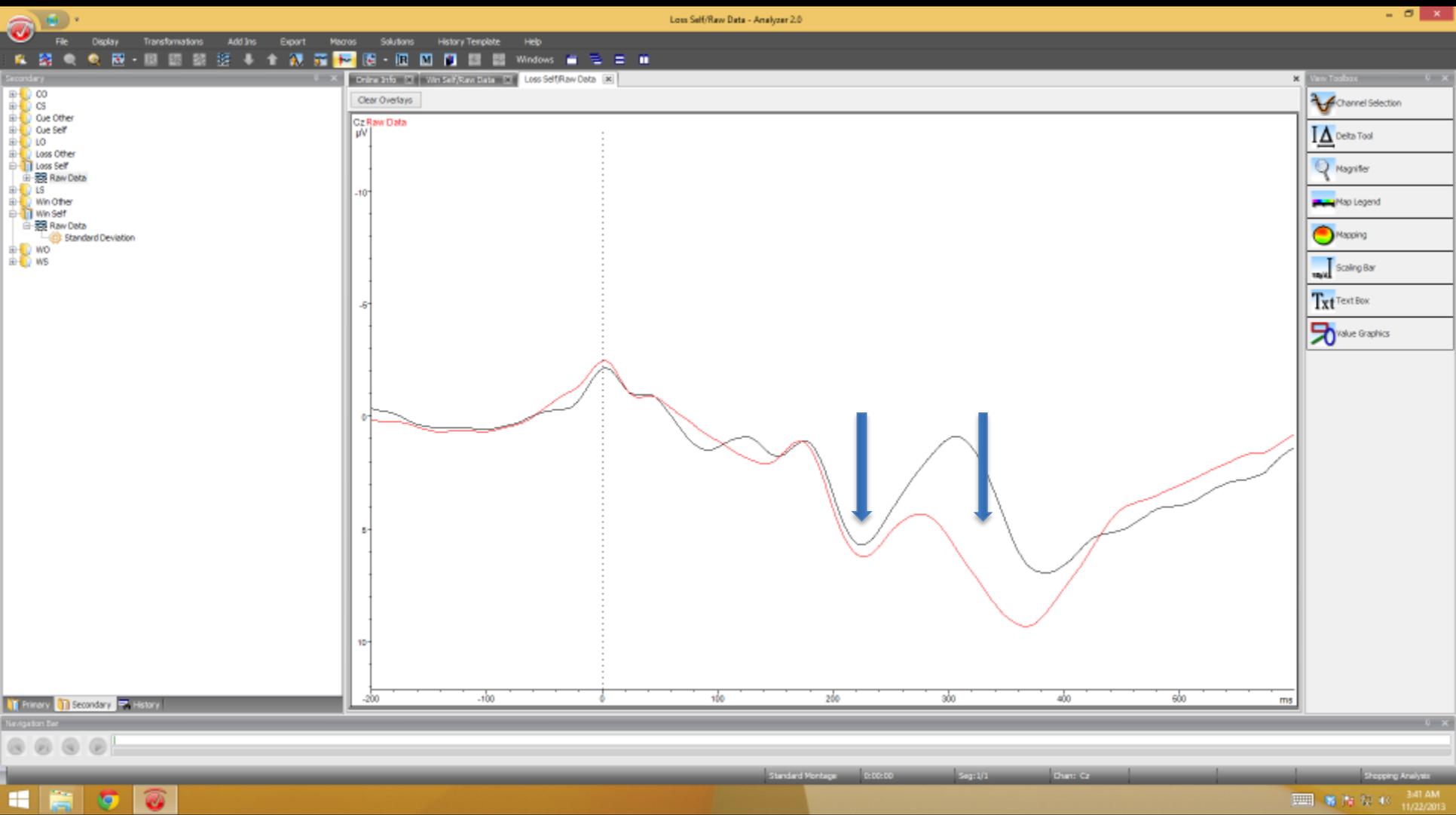




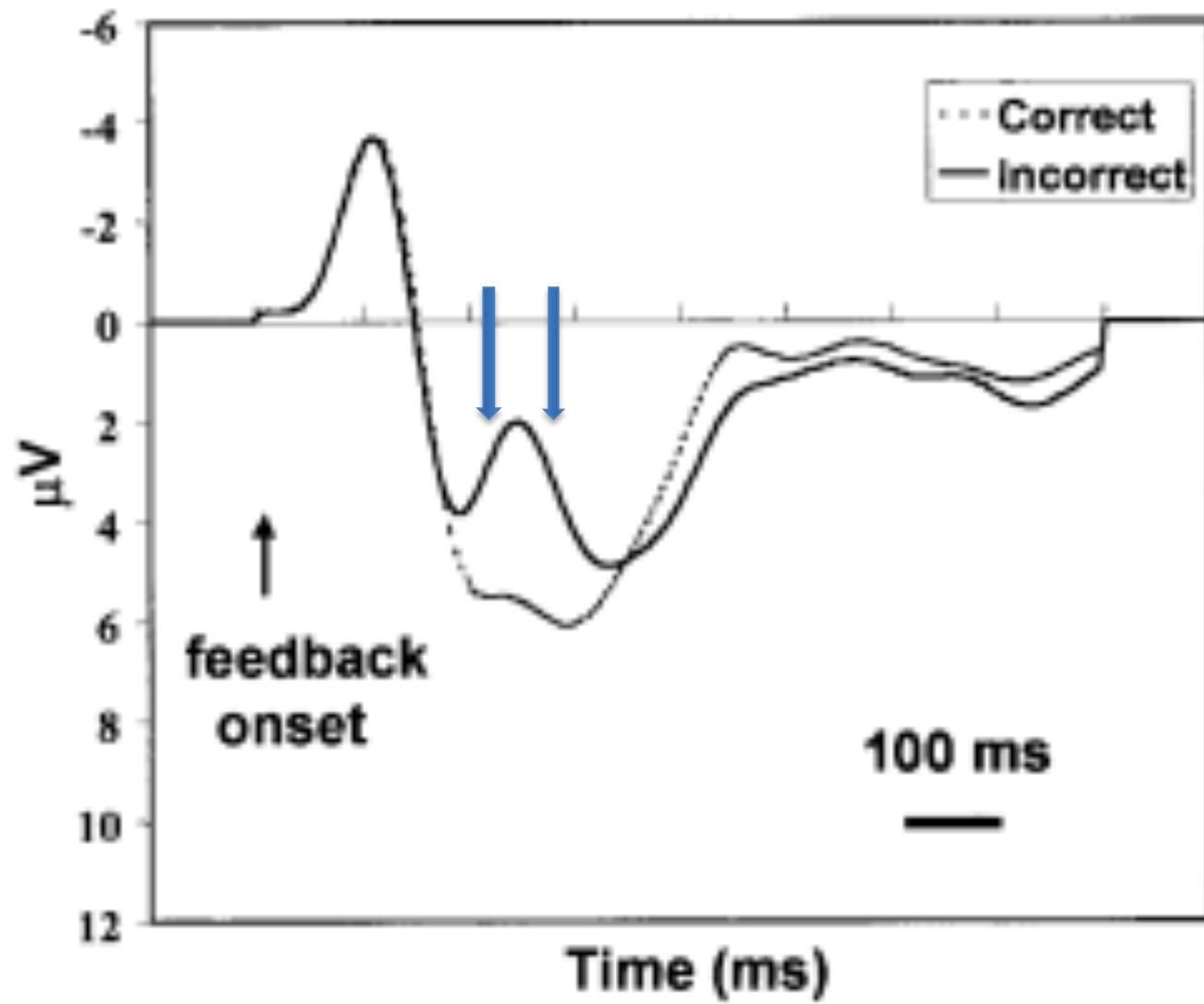
What is the trend in the components amplitude?

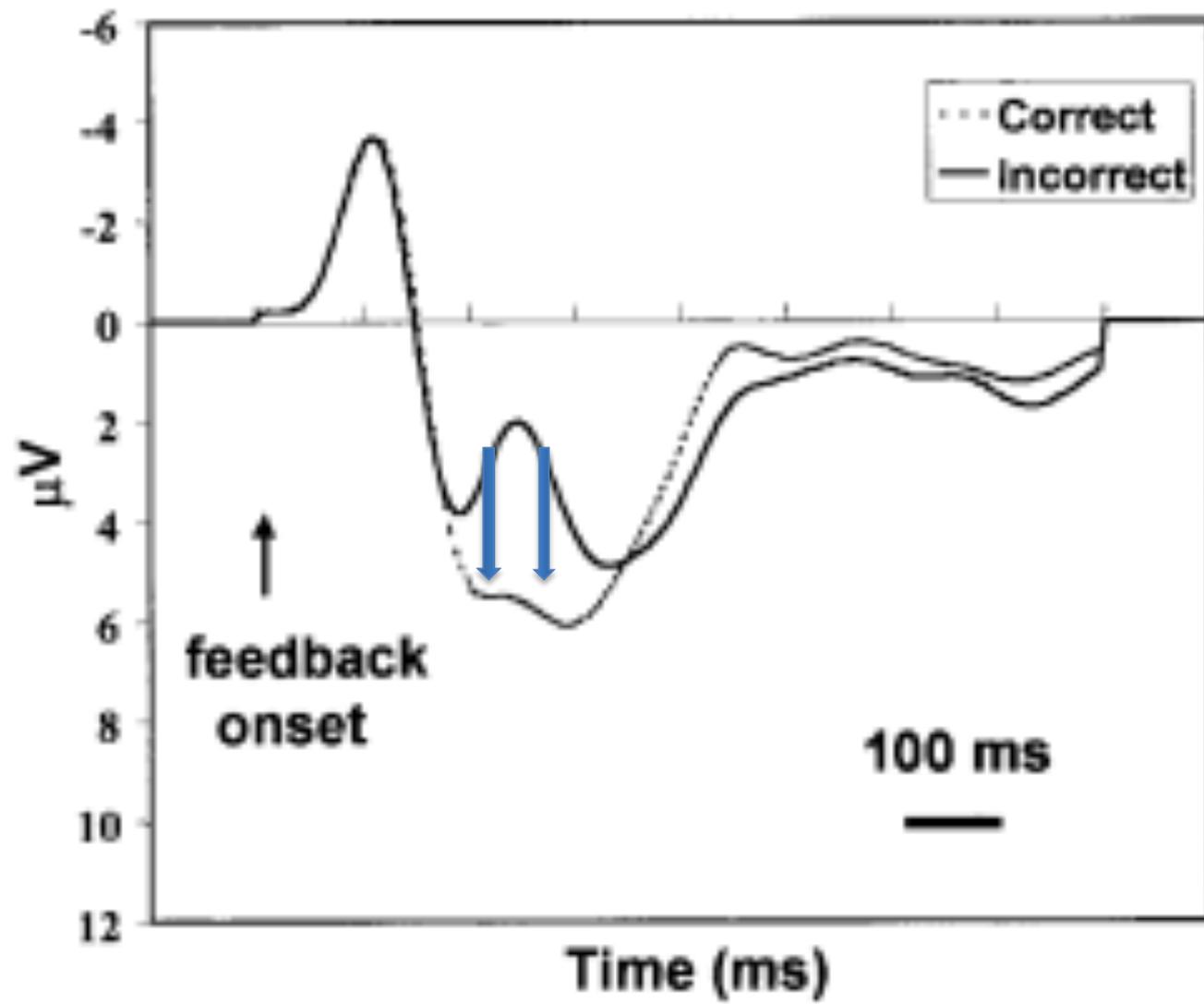


And what would happen here?



And what would happen here?



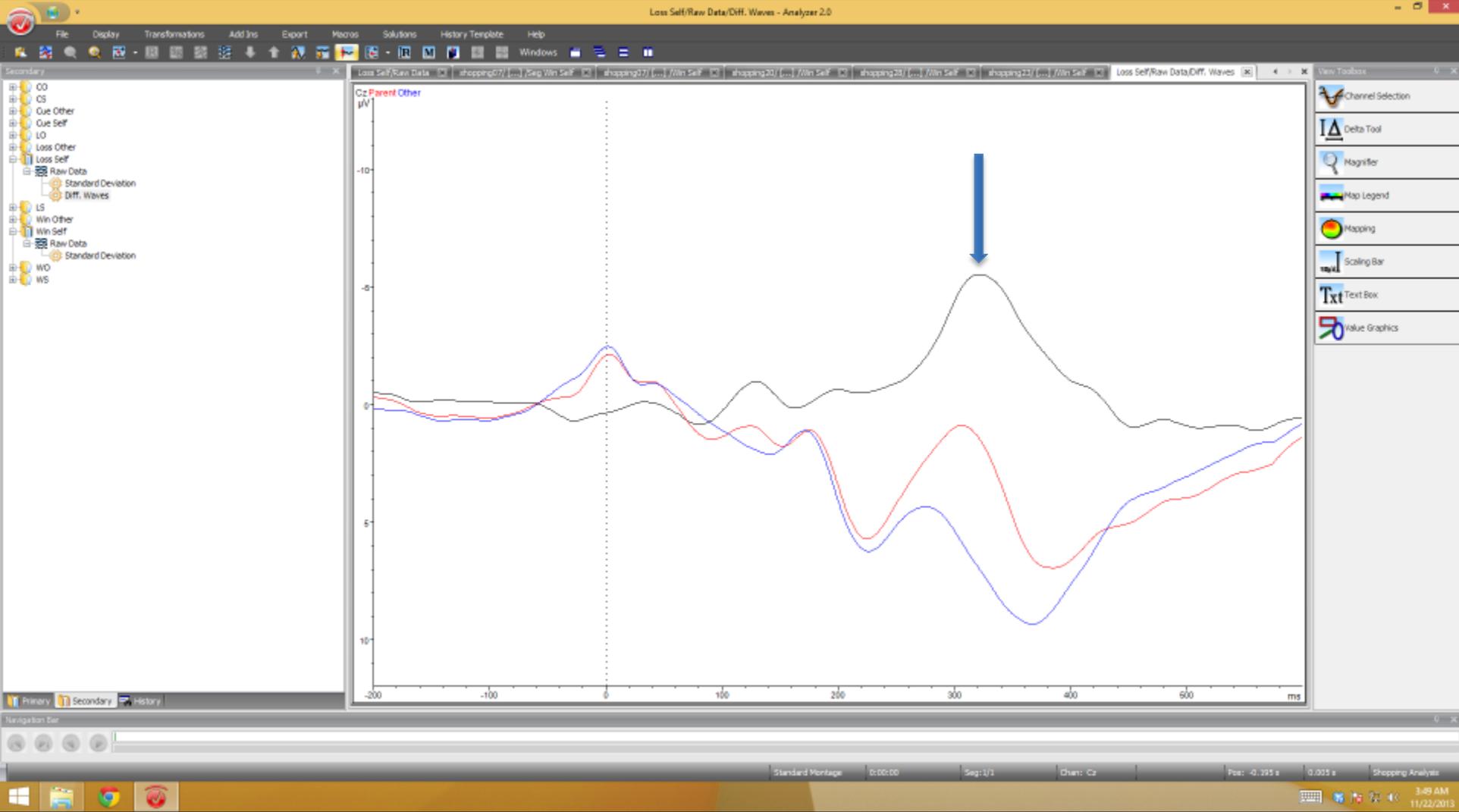


So, we use a WINDOW based on the grand average that we “hope” captures a mean voltage for each participant that measures the component of interest.

WINDOW WIDTH? Hard to have an absolute value. We can use prior research to guide us.

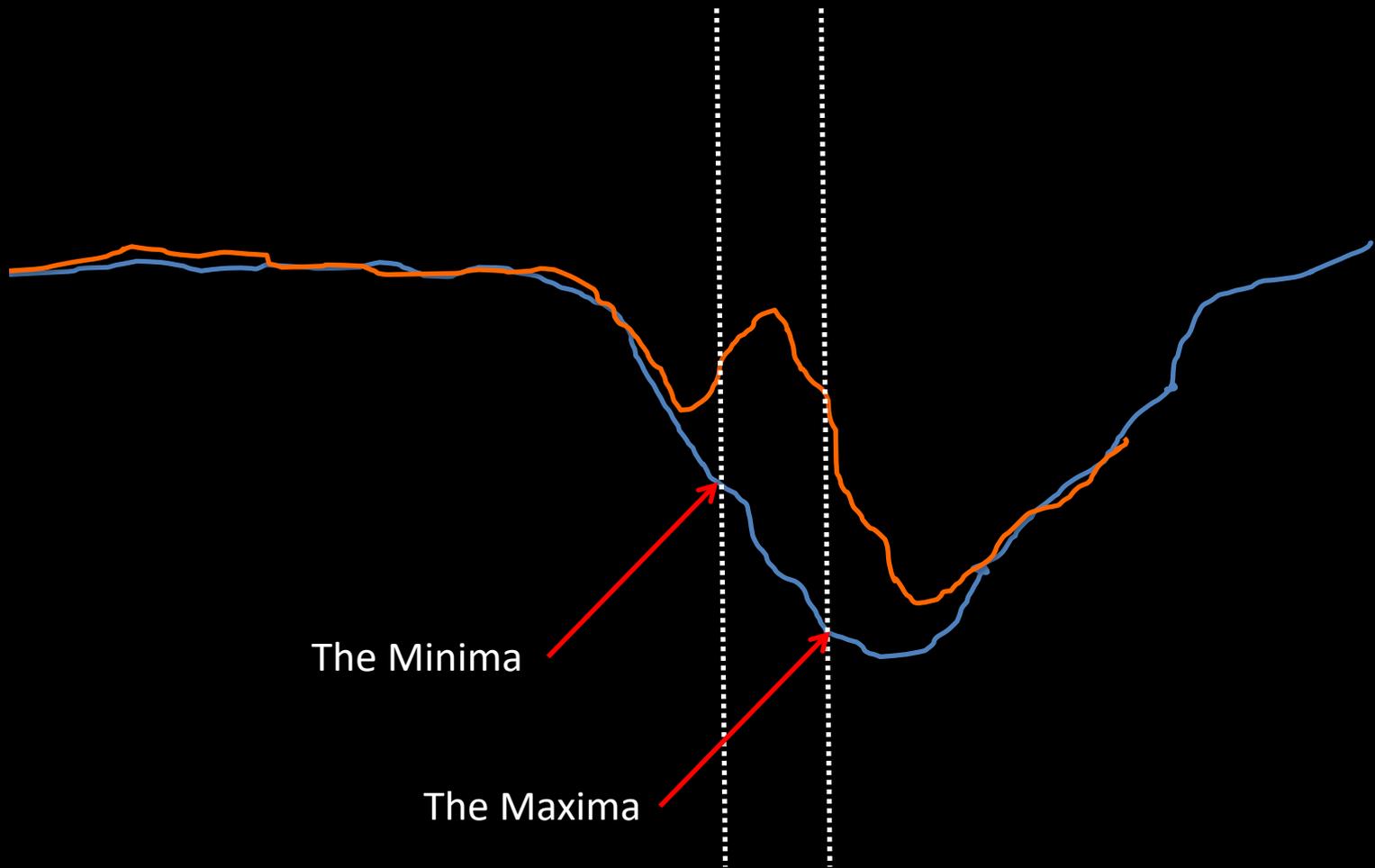
Mean Peak Export Demos

Peak Measures



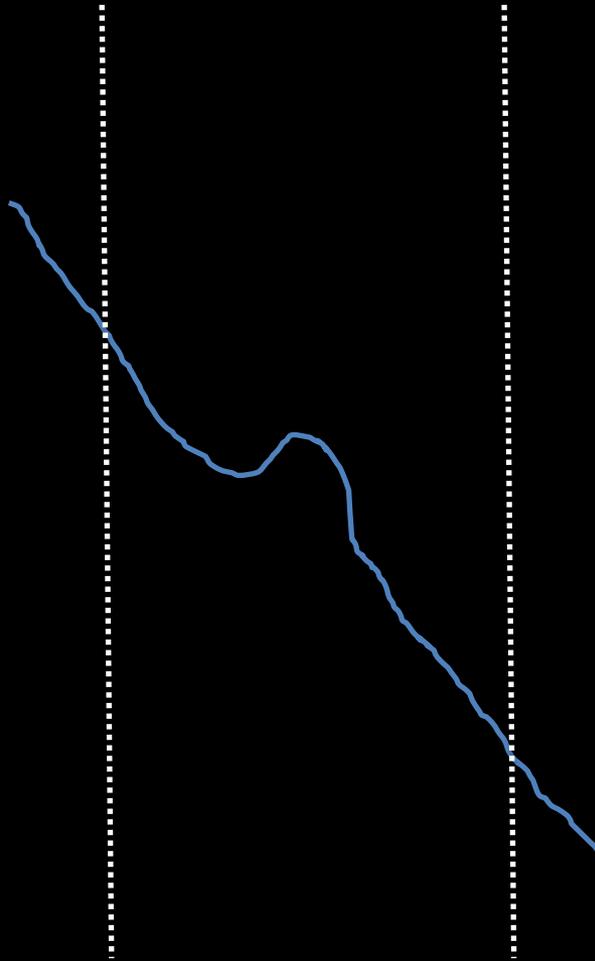
Simply put, we search for a maxima or a minima depending on the component.

But there are many problems...

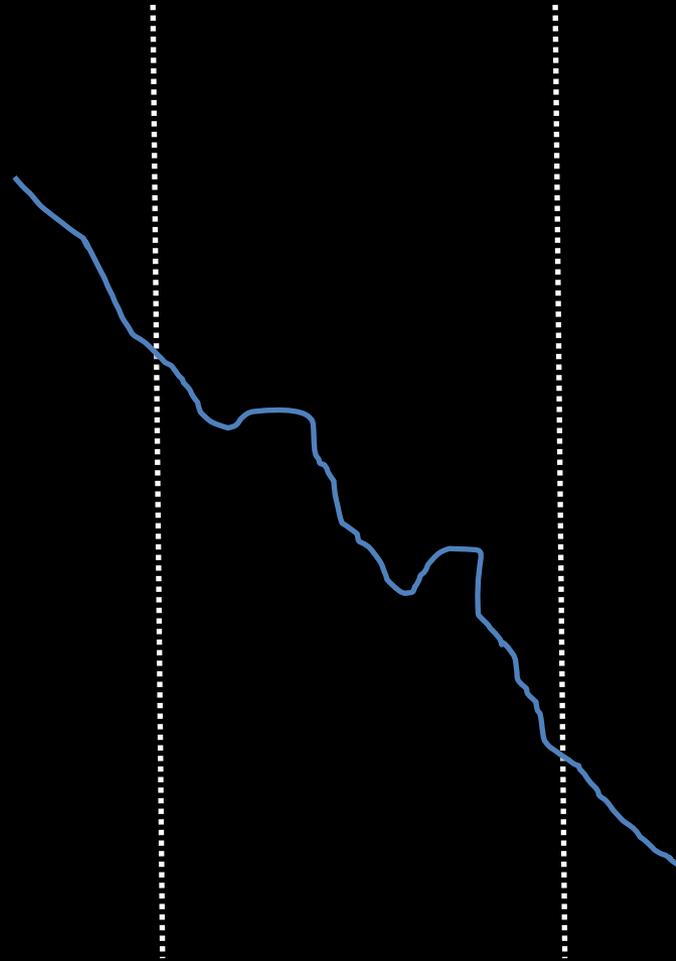


The Minima

The Maxima



This would be a problem for a GLOBAL search, but not a LOCAL search. A LOCAL search defines a start and end time then looks for the first reversal and then a subsequent one to find this peak.



But this still would be a problem.

Indicators of a FAILED PEAK search

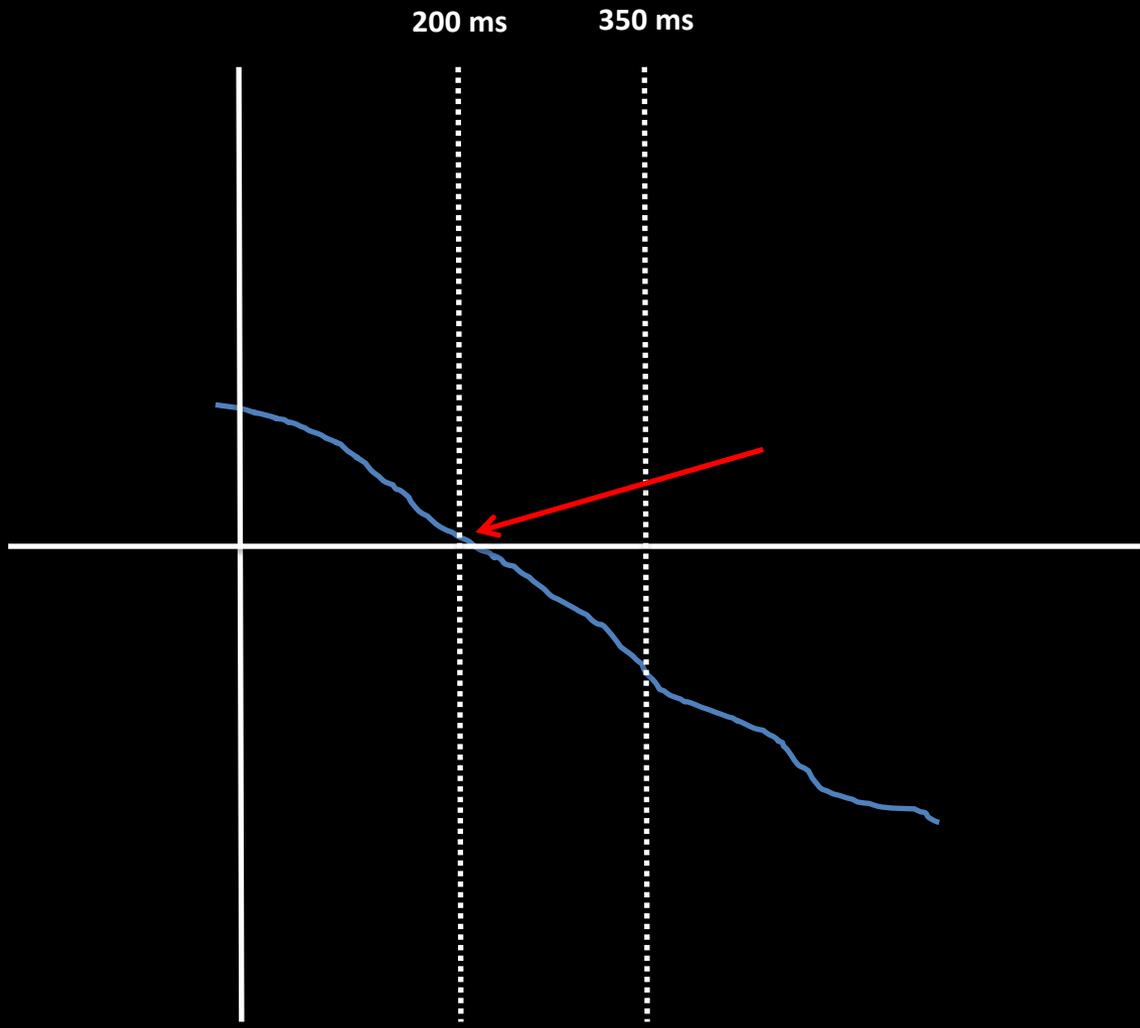
Peak detection search, 200 to 350 ms, looking for a minima

Subject	Peak	Latency
1	-4.56	214
2	-1.23	256
3	-0.12	200
4	2.43	278
5	-5.67	244
6	-11.23	321
7	-4.11	350

Indicators of a FAILED PEAK search

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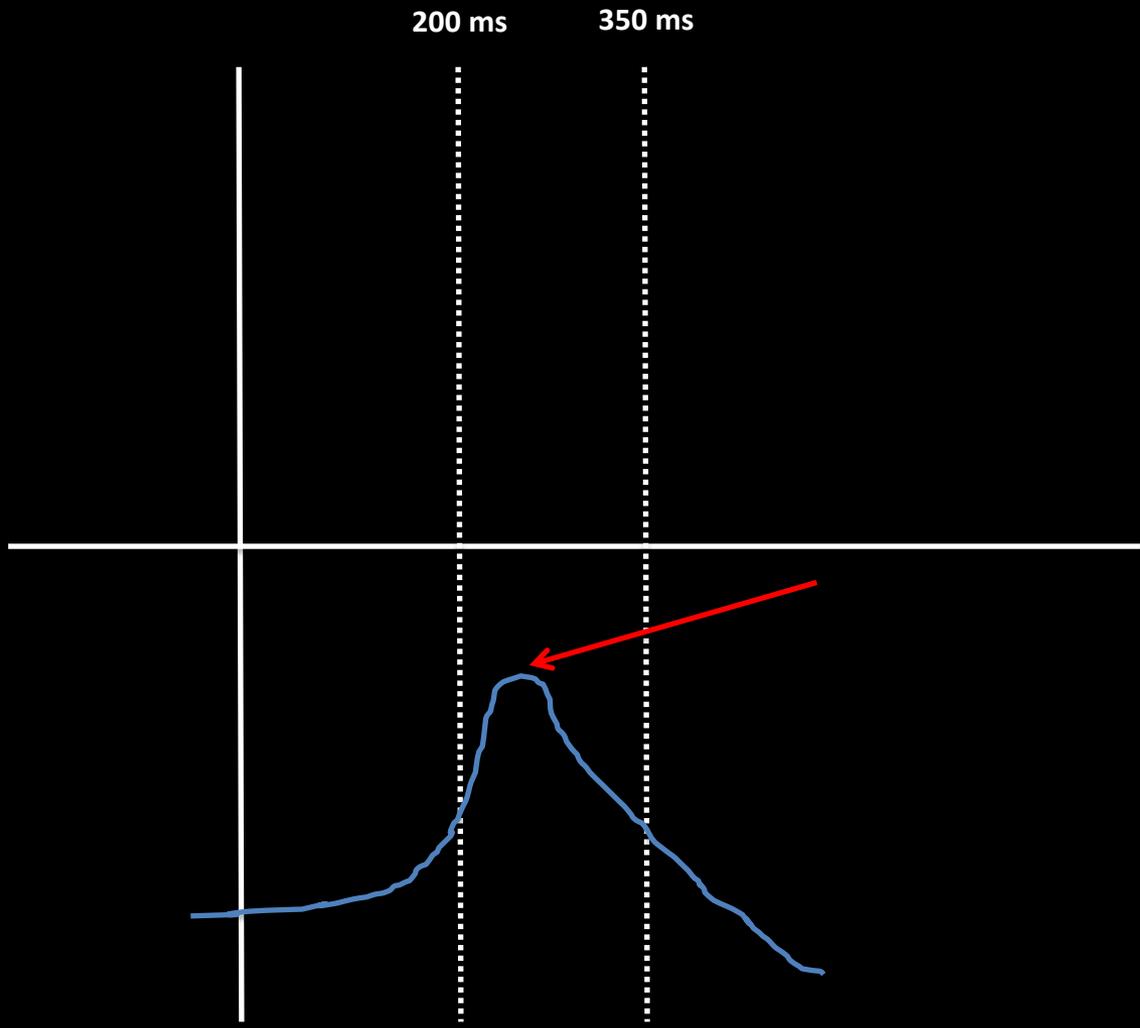
200 ms

350 ms

Indicators of a FAILED PEAK search

Peak detection search, 200 to 350 ms, looking for a minima

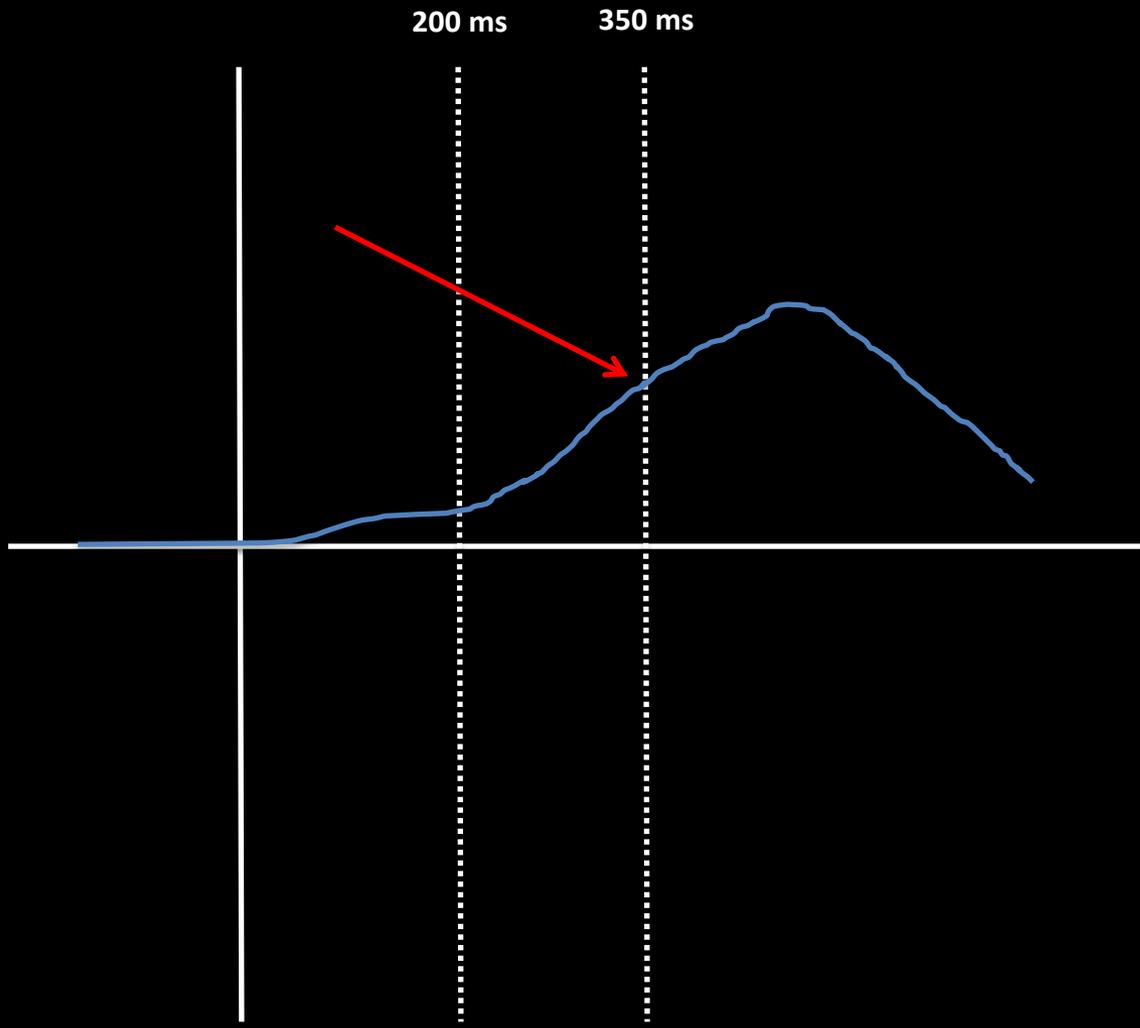
Subject	Peak	Latency
1	-4.56	214
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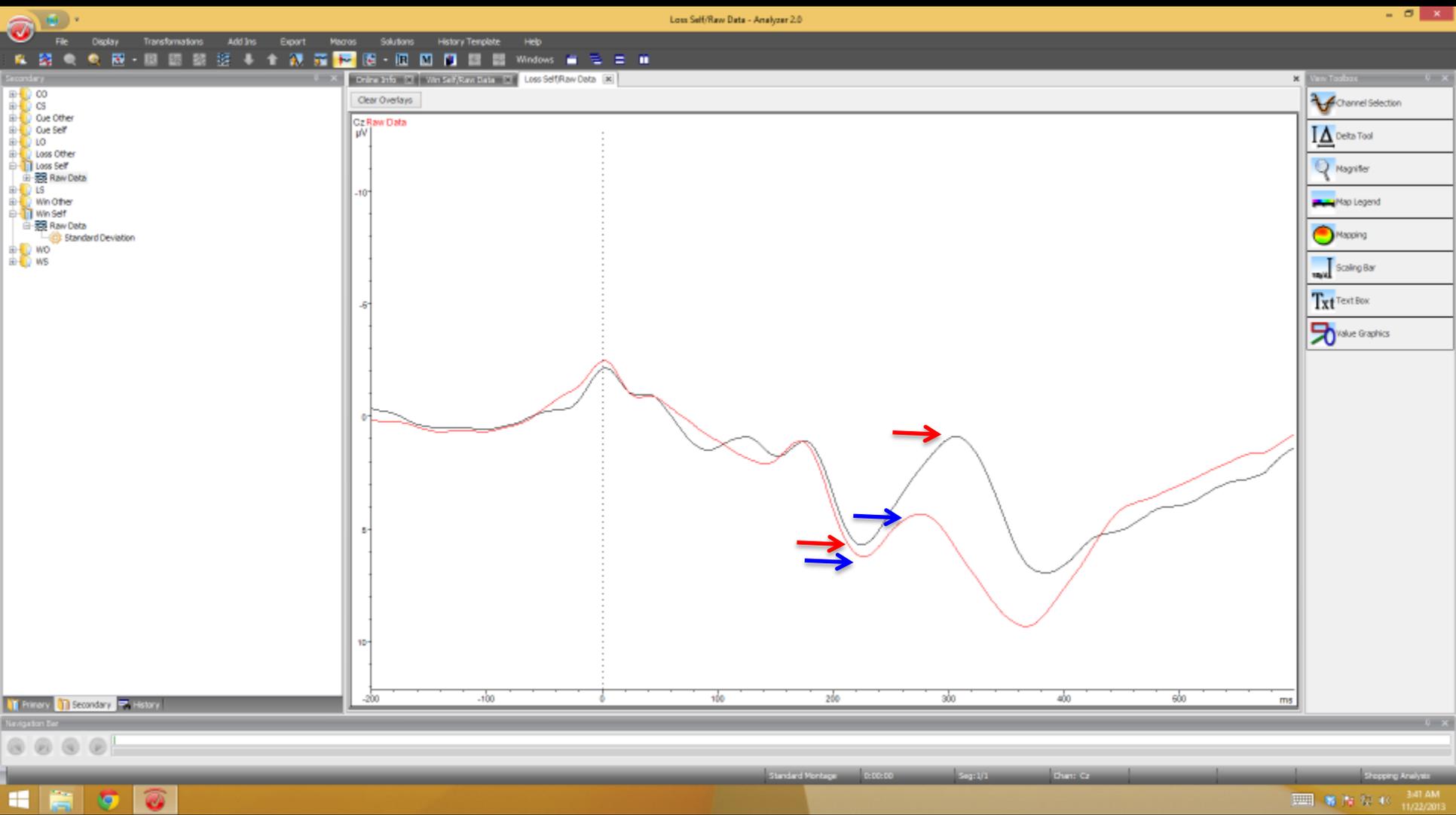
Peak Differences

It should be worth noting there is nothing special about the peak amplitude difference.

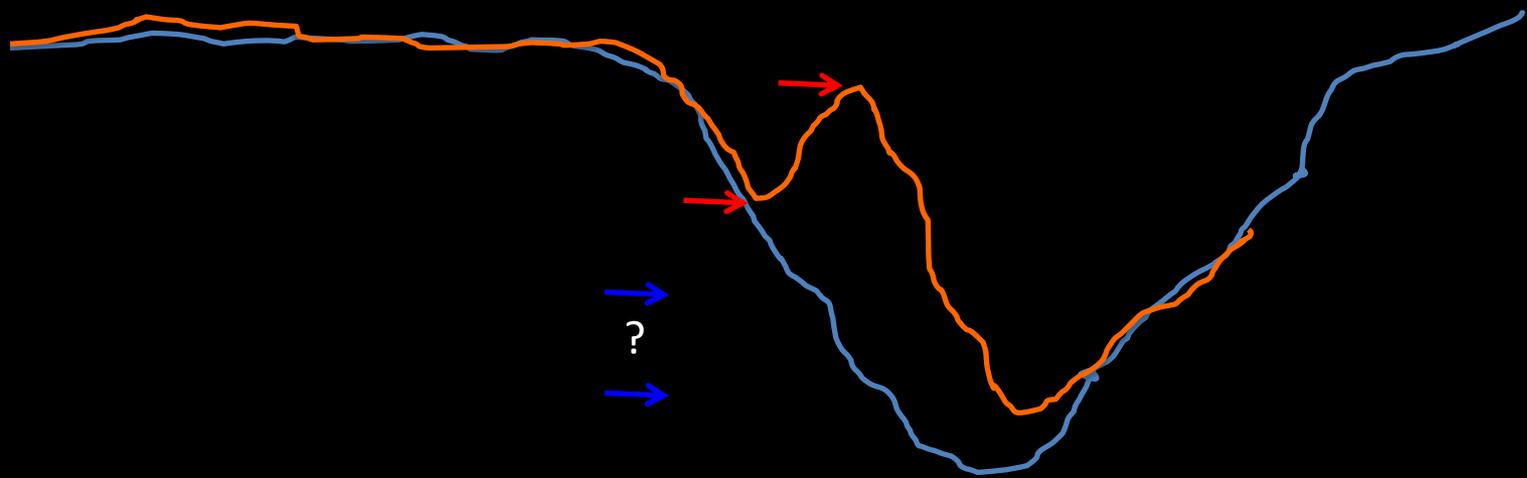
Recall, we are interested in underlying components. Just because we use difference waveforms does not mean that the underlying component is isolated – thus – the “peak difference” may not reflect what we think it does.

Max/Min Peak Detetion Demos

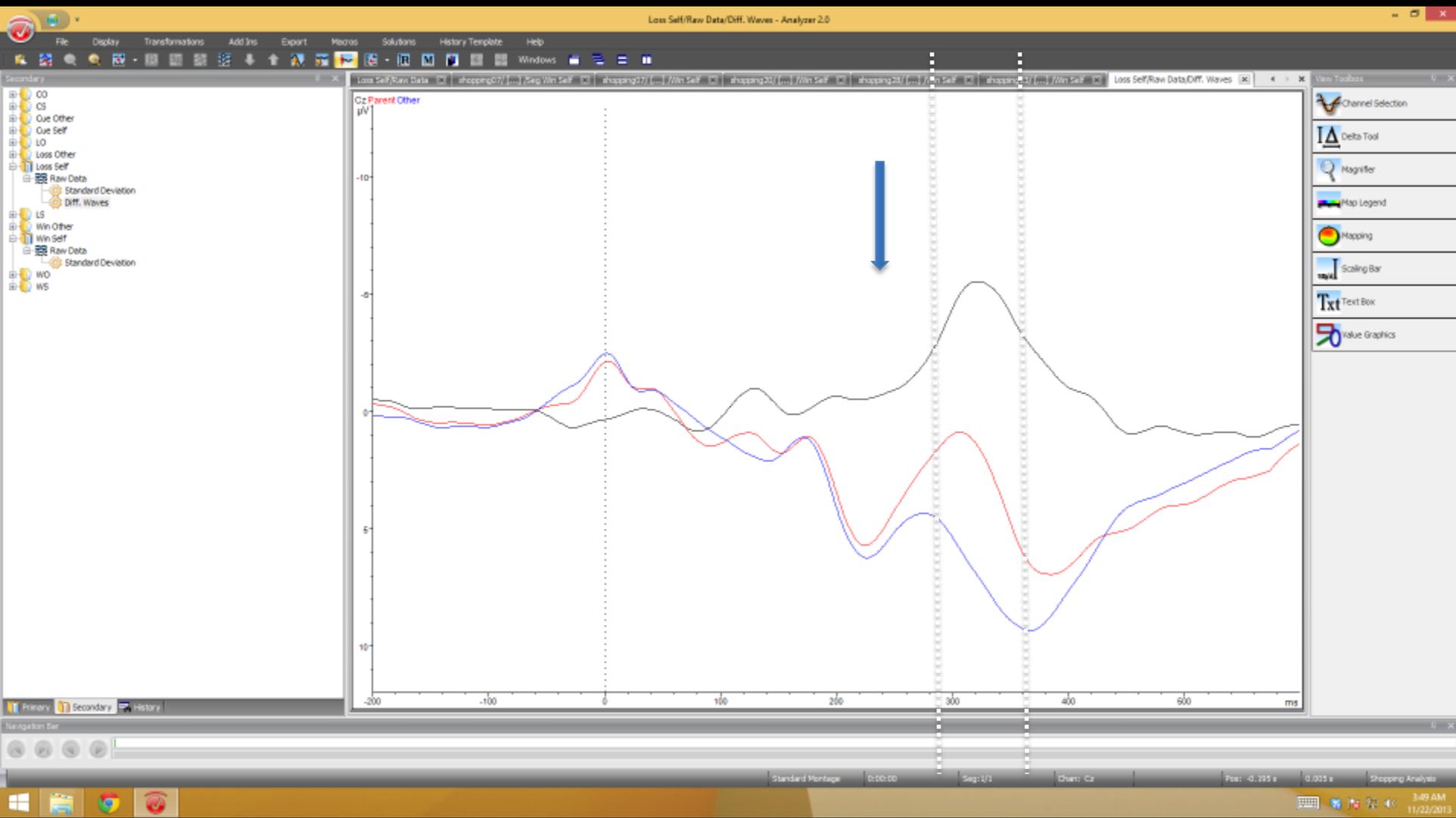
Base to Peak Measures



So, what are the problems?



Other Thoughts...



What happens if a subject's peak lies outside this region?
 NOTE: This is a problem for mean measures too.

So in sum...

1. Create a difference waveform for each subject
2. Create a grand average difference waveform
3. Get the peak latency of the component from the grand average difference waveform
4. Use a mean centered around this window
5. Generate a topography from the peak detection (hard to do in BV) to verify the component

Topography Quantification

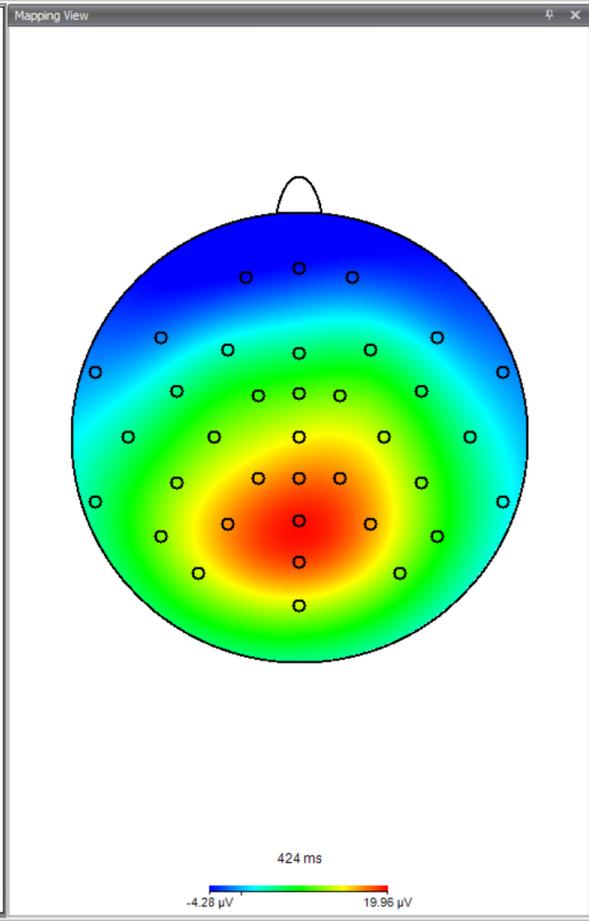
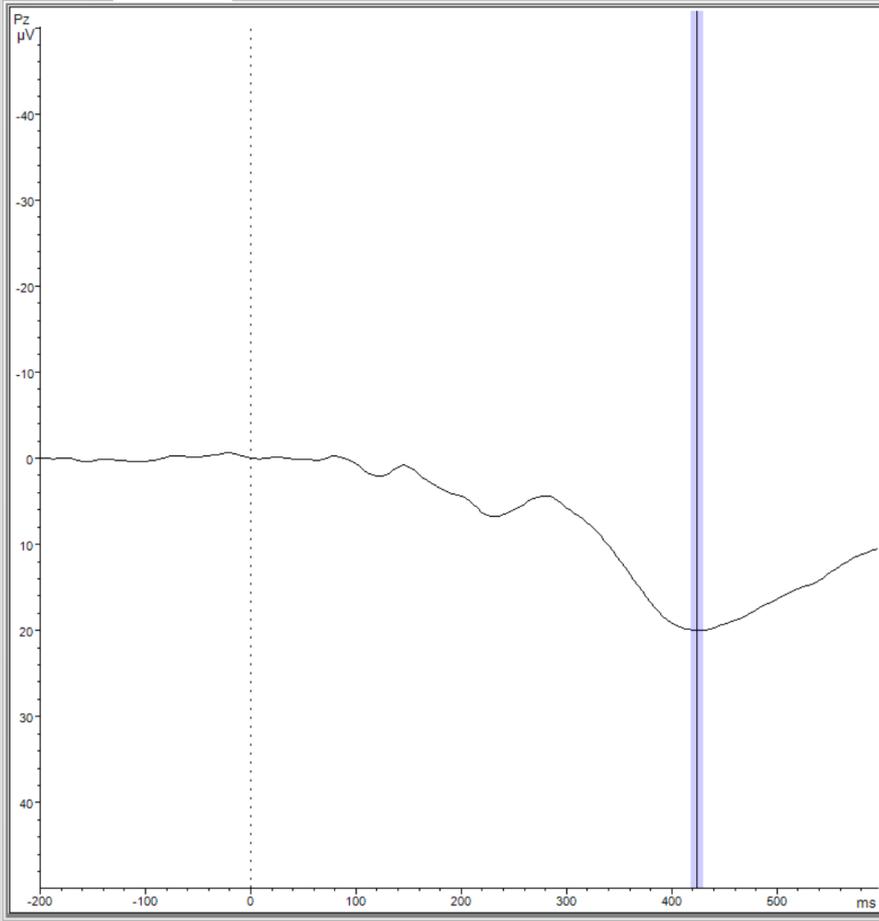
Grand Average Topographies

Simply put, this is the topography of the grand average peak difference (or conditional maxima or minima).

Secondary

- DW
 - Raw Data
 - Generic Data Export
 - Generic Data Export 2
 - Frequent
 - Raw Data
 - Infrequent
 - Raw Data

Primary Secondary History



Grand Average Topographies

What is this useful for?

Determining where to run your peak detection (but not peak verification)

How do you get values?

Data Export (next section)

Peak Topographies

If you are going to use mean peak detection, then the individual peak topography matches the grand average topography.

Peak Topographies

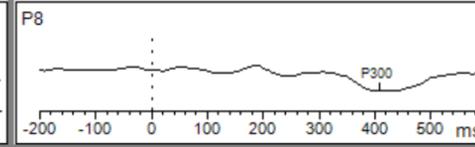
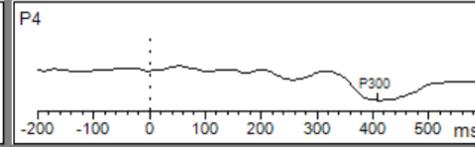
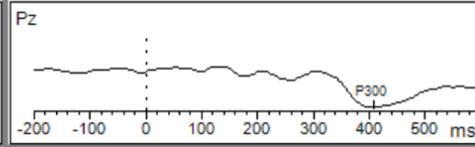
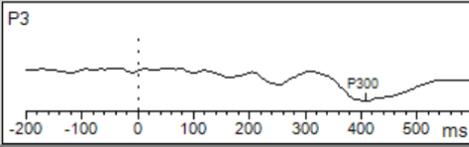
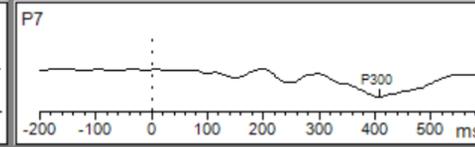
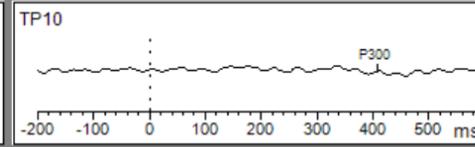
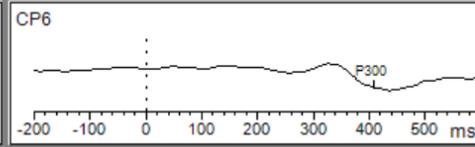
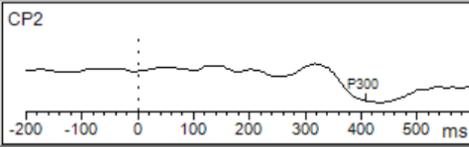
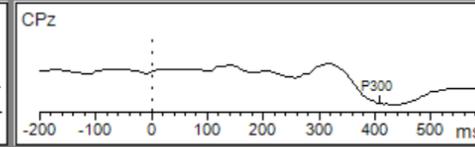
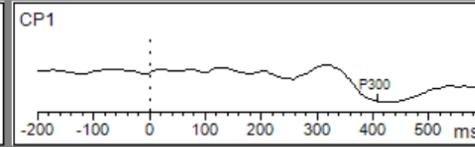
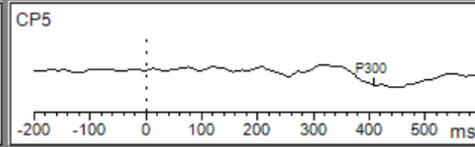
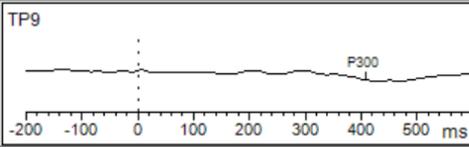
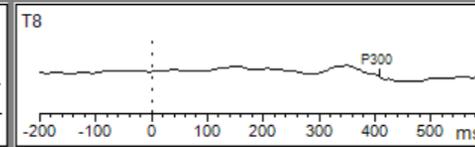
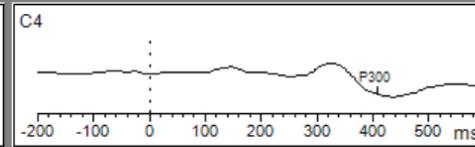
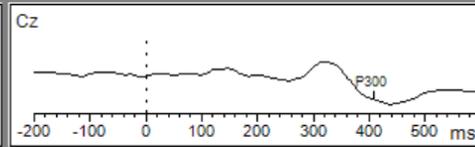
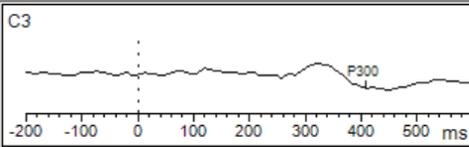
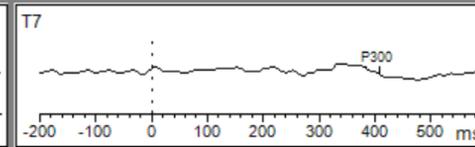
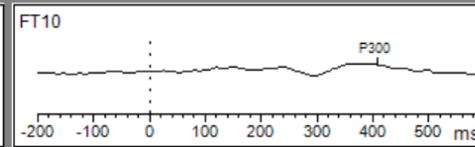
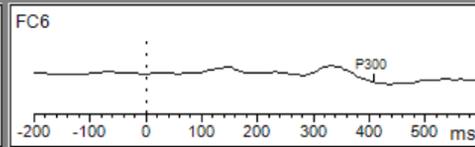
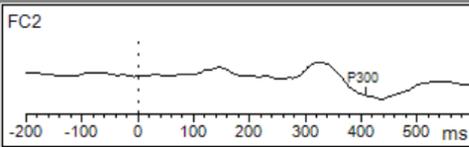
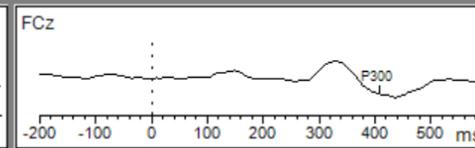
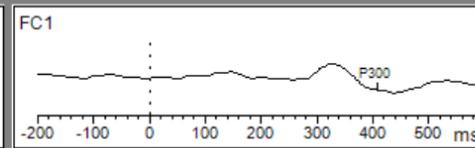
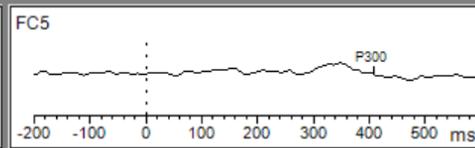
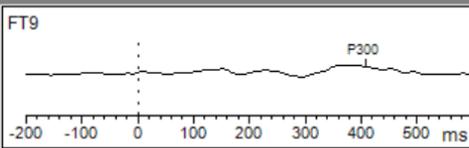
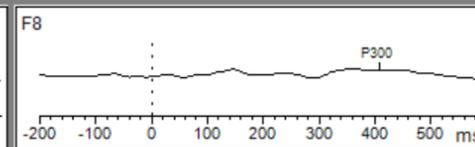
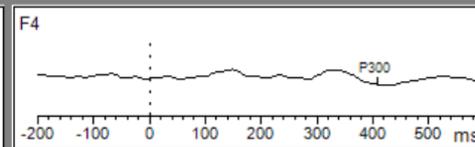
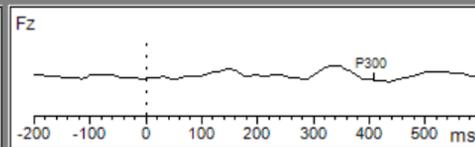
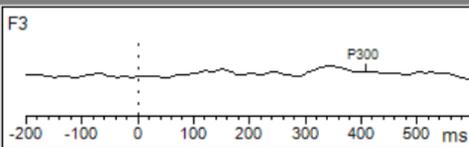
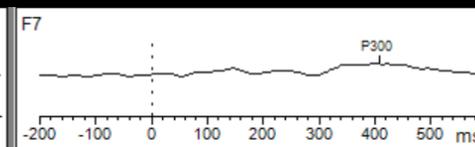
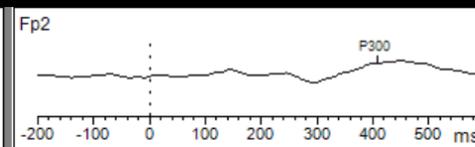
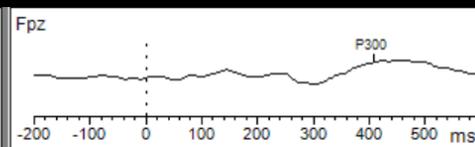
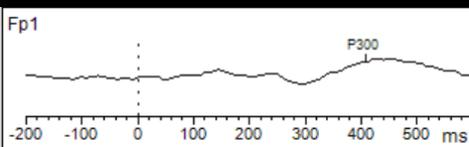
If you are going to use maximum or minimum values in your search, it is important to search on a specific channel based on the topography of the grand average waveform and/or previous literature.

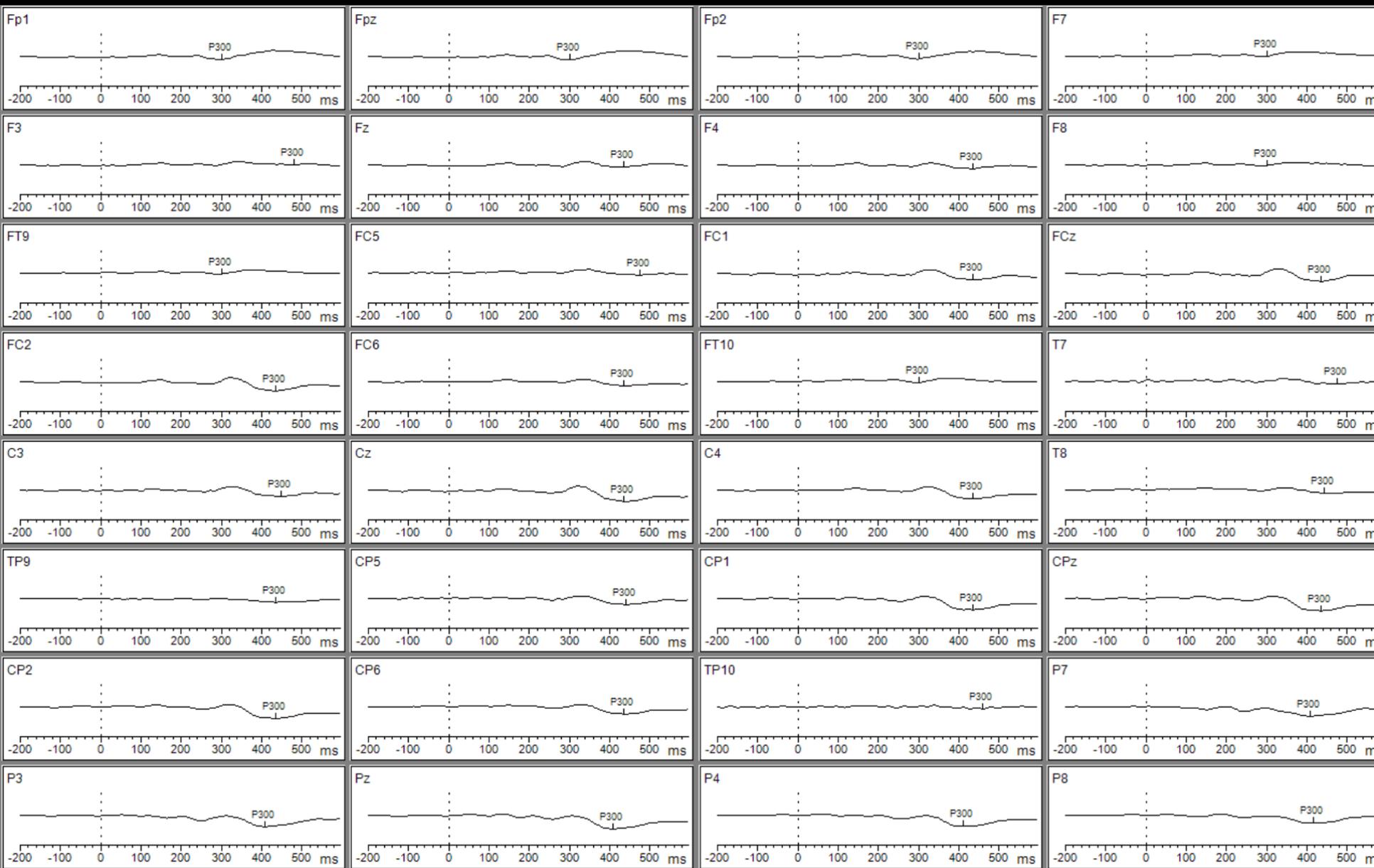
Example:

I want to find the maxima (or minima) on channel Pz

At that point in time, get the voltages for all other channels

Generate a “peak topography” that is the mean of the individual peak topographies (MATLAB or EXCEL)





Again, you always want to get the voltages with respect to a peak reference channel. IE, in a maxima and minima search you define the reference channel and get all the peaks at this point in time.

Exporting Data

Why? Because if you are correct in your hypothesis then the maxima (or minima) will be at the channel you pick. If not, then it will not be and your hypothesis is potentially wrong.

Note, the same logic applies for means but you do not need to select a reference channel.

Exporting Data

Exporting Data

Brain Vision handles things a bit differently...

If you want to use maxima/minima, then you need to create a Peak Detection node and identify specific peaks that you can then export via the export command.

If you want to use means, then you can just go straight to the export command.

You can also easily export data for plotting

Another Option

You can also do a “Generic Data Export” and export files for each participant for each condition.

If you read these into MATLAB, and create a 4D matrix, CHANNELS x TIME x CONDITIONS x SUBJECTS, life gets a lot easier and you have a lot more flexibility.

MATLAB DEMO

```
clear all;  
close all;  
clc;
```

```
load('gonogoERP.mat');
```

```
theChannel = 30;
```

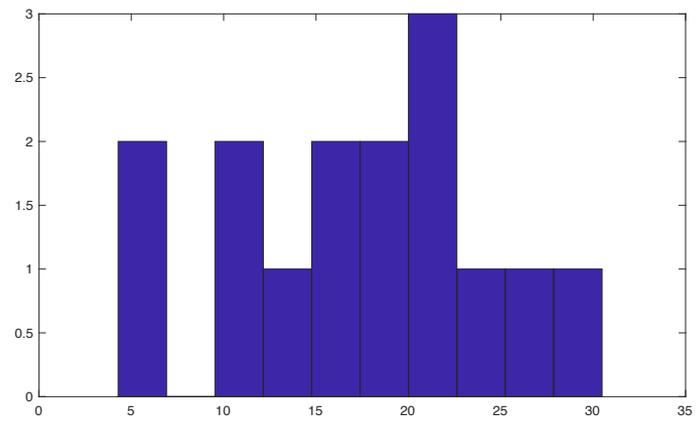
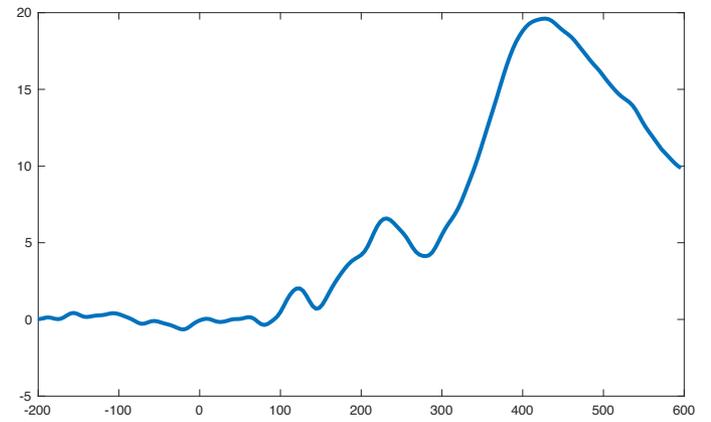
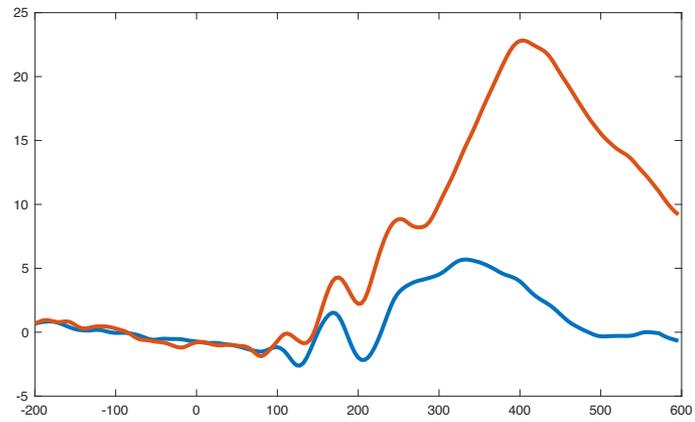
```
data = ERP.data;  
dwData = data(:,2,:) - data(:,1,:);  
meanData = mean(data,4);  
meandwData = mean(dwData,4);
```

```
erpPeaks = squeeze(mean(dwData(theChannel,160:180,:)));
```

```
subplot(2,2,1);  
plot(ERP.time,meanData(theChannel,:,1),'linewidth',3);  
hold on;  
plot(ERP.time,meanData(theChannel,:,2),'linewidth',3);
```

```
subplot(2,2,2);  
plot(ERP.time,meandwData(theChannel,:,1),'linewidth',3);
```

```
subplot(2,2,3);  
hist(erpPeaks);
```



Statistics

Peak Statistics

If you are using conditional waveforms:

Paired Samples T-Tests

ANOVA

If you are using difference waveforms:

Single Sample T-Tests

Paired Samples T-Tests

ANOVA

Topography Statistics

1. Don't do them. Simply report a maximum (or minimum literature), show a picture, and hopefully cite a similarity with the literature.

Topography Statistics

2. T-Test

Lets say you hypothesize that the N200 is maximal at FCz, but the P300 is maximal at Pz.

Get the peak values at FCz and Pz for the N200 at the same time and t-test them.

Hypothesis, $FCz > Pz$

Repeat for the P300.

Hypothesis, $Pz > FCz$

Topography Statistics

3. Create a 3 x 3 grid of electrodes.

F3	Fz	F4
C3	Cz	C4
P3	Pz	P4

RM ANOVA: 3 (laterality) x 3 (azimuth) design

More complex

RM ANOVA: 3 (laterality) x 3 (azimuth) x 2 condition design

I'm always amazed when this actually works...

Topography Statistics

4. Trend Analysis

Two separate ANOVAs

T7 C3 Cz C4 T8

Fpz Fz FCz Cz CPz Pz POz Oz

Look for linear or quadratic trends

Estimated Marginal Means of MEASURE_1

