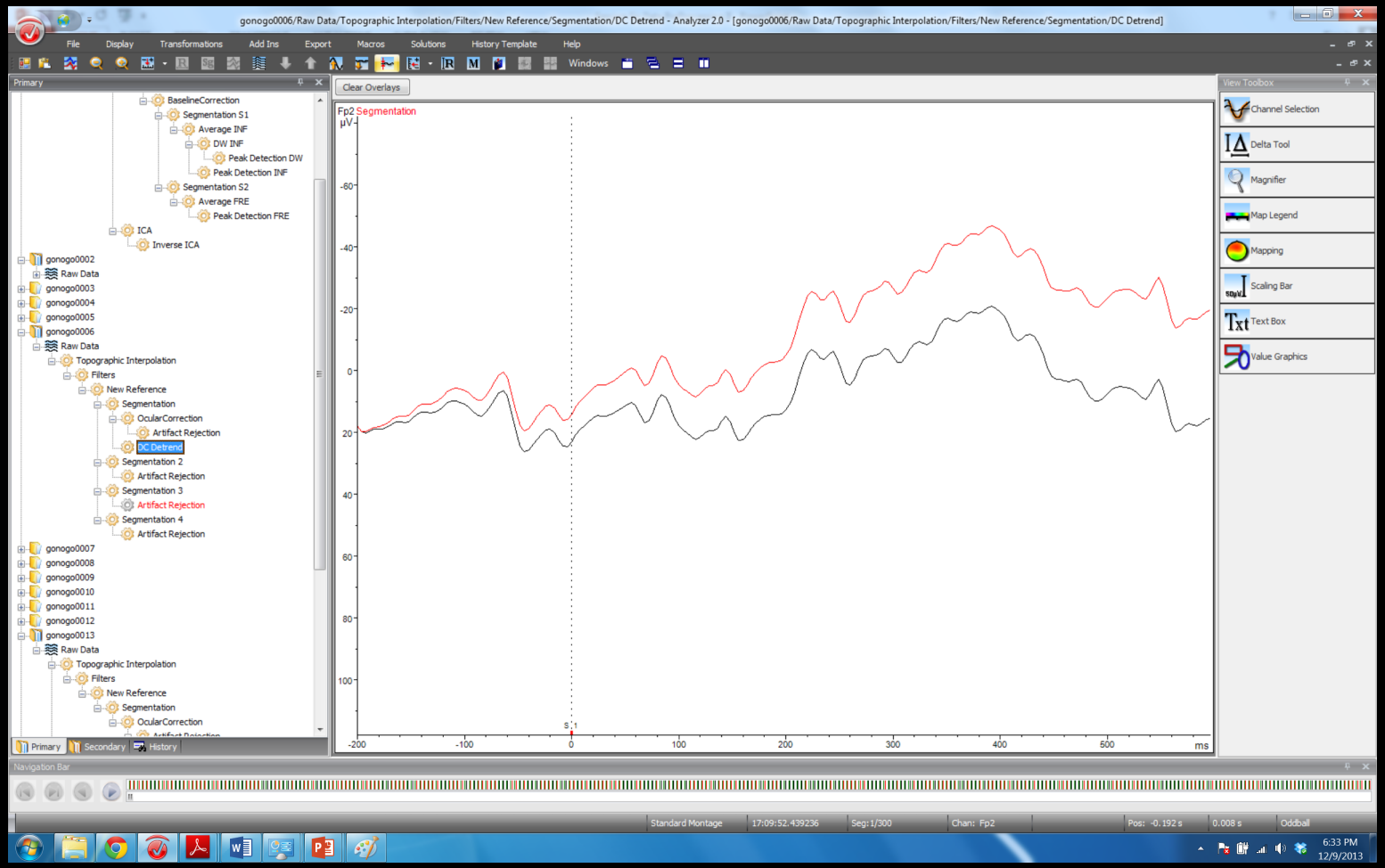
Some other things to consider…

DC Detrend (optional)

DC Detrend

Removes a continuous DC slope from each segment.

Note, this step, if used, should be done before ocular correction.


gonogo0006/Raw Data/Topographic Interpolation/Filters/New Reference/Segmentation/DC Detrend - Analyzer 2.0 - [gonogo0006/Raw Data/Topographic Interpolation/Filters/New Reference/Segmentation/DC Detrend]
File
Display
Transformations
Add Ins
Export
Macros
Solutions
History Template
Help
Windows
Primary
BaselineCorrection
Segmentation S1
Average INF
DW INF
Peak Detection DW
Peak Detection INF
Segmentation S2
Average FRE
Peak Detection FRE
ICA
Inverse ICA
gonogo0002
Raw Data
gonogo0003
gonogo0004
gonogo0005
gonogo0006
Raw Data
Topographic Interpolation
Filters
New Reference
Segmentation
OcularCorrection
Artifact Rejection
DC Detrend
Segmentation 2
Artifact Rejection
Segmentation 3
Artifact Rejection
Segmentation 4
Artifact Rejection
gonogo0007
gonogo0008
gonogo0009
gonogo0010
gonogo0011
gonogo0012
gonogo0013
Raw Data
Topographic Interpolation
Filters
New Reference
Segmentation
OcularCorrection
Primary
Secondary
History
Clear Overlays
Fp2 Segmentation
µV
-60
-40
-20
0
20
40
60
80
100
S 1
-200
-100
0
100
200
300
400
500
ms
View Toolbox
Channel Selection
Delta Tool
Magnifier
Map Legend
Mapping
Scaling Bar
Text Box
Value Graphics
Navigation Bar
Standard Montage
17:09:52.439236
Seg: 1/300
Chan: Fp2
Pos: -0.192 s
0.008 s
Oddball
6:33 PM
12/9/2013

DC Detrend Demo

Order of Operations

Most of these steps are linear – they can be interchanged.

For instance, if you are using gradient and max-min criteria for artifact rejection then it does not matter if it comes before or after baseline correction.

There are some exceptions…

Order of Operations

Rereference

Always reference on continuous data as soon as possible.

Order of Operations

Filtering

Always filter continuous data to avoid edge artifacts.

Order of Operations

DC Detrend

Must be done before ocular correction.

Order of Operations

Ocular Correction

Should be done as early as possible after segmentation and before artifact rejection.

Order of Operations

Channel Interpolation

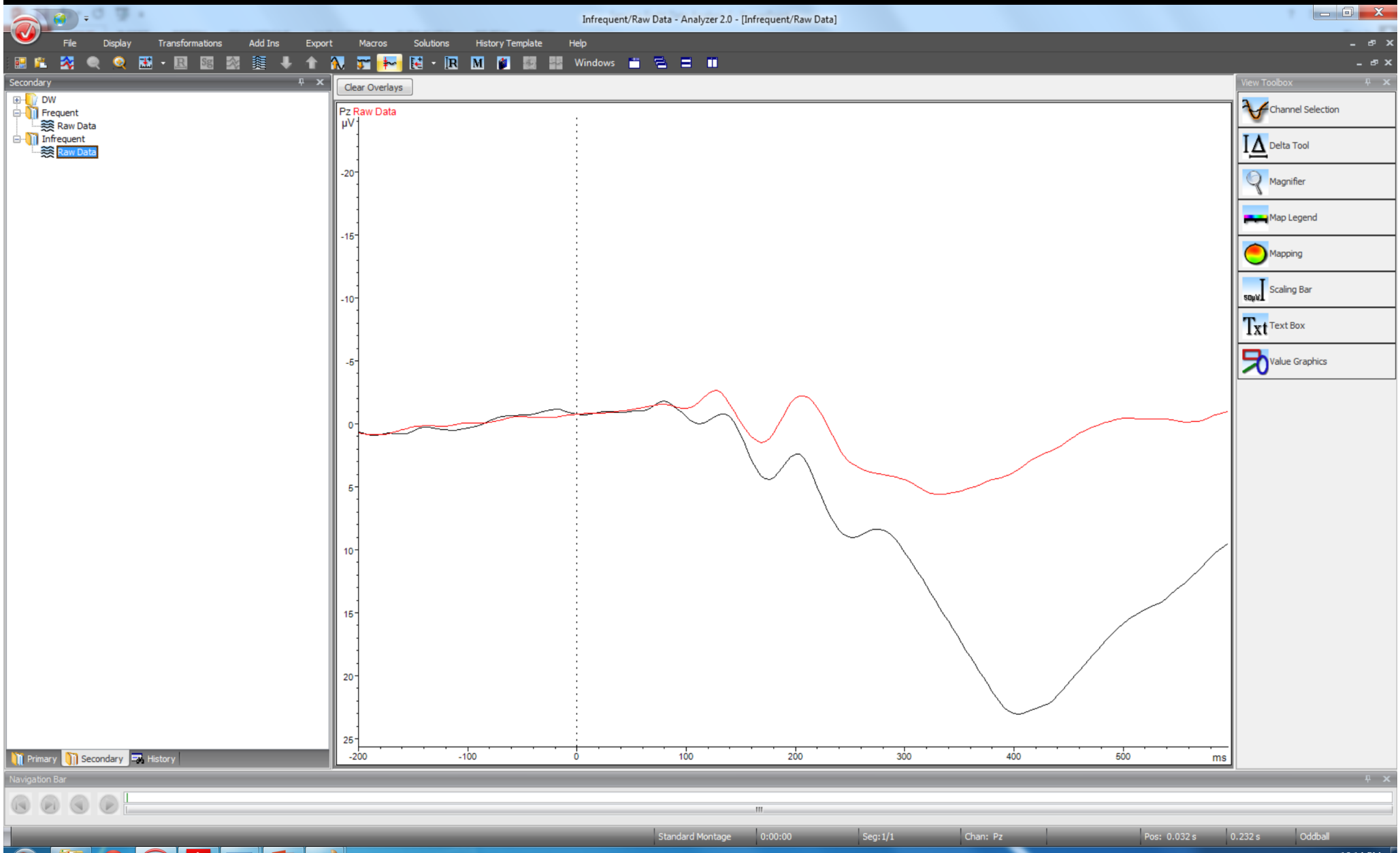
Always interpolate bad channels after ocular correction but before artifact rejection.

Session 4
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.


Infrequent/Raw Data - Analyzer 2.0 - [Infrequent/Raw Data]
File
Display
Transformations
Add Ins
Export
Macros
Solutions
History Template
Help
Windows
Secondary
DW
Frequent
Raw Data
Infrequent
Raw Data
Primary
Secondary
History
Clear Overlays
Pz Raw Data
µV
-20
-15
-10
-5
0
5
10
15
20
25
-200
-100
0
100
200
300
400
500
ms
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
10:14 PM
12/9/2013

But don’t forget…

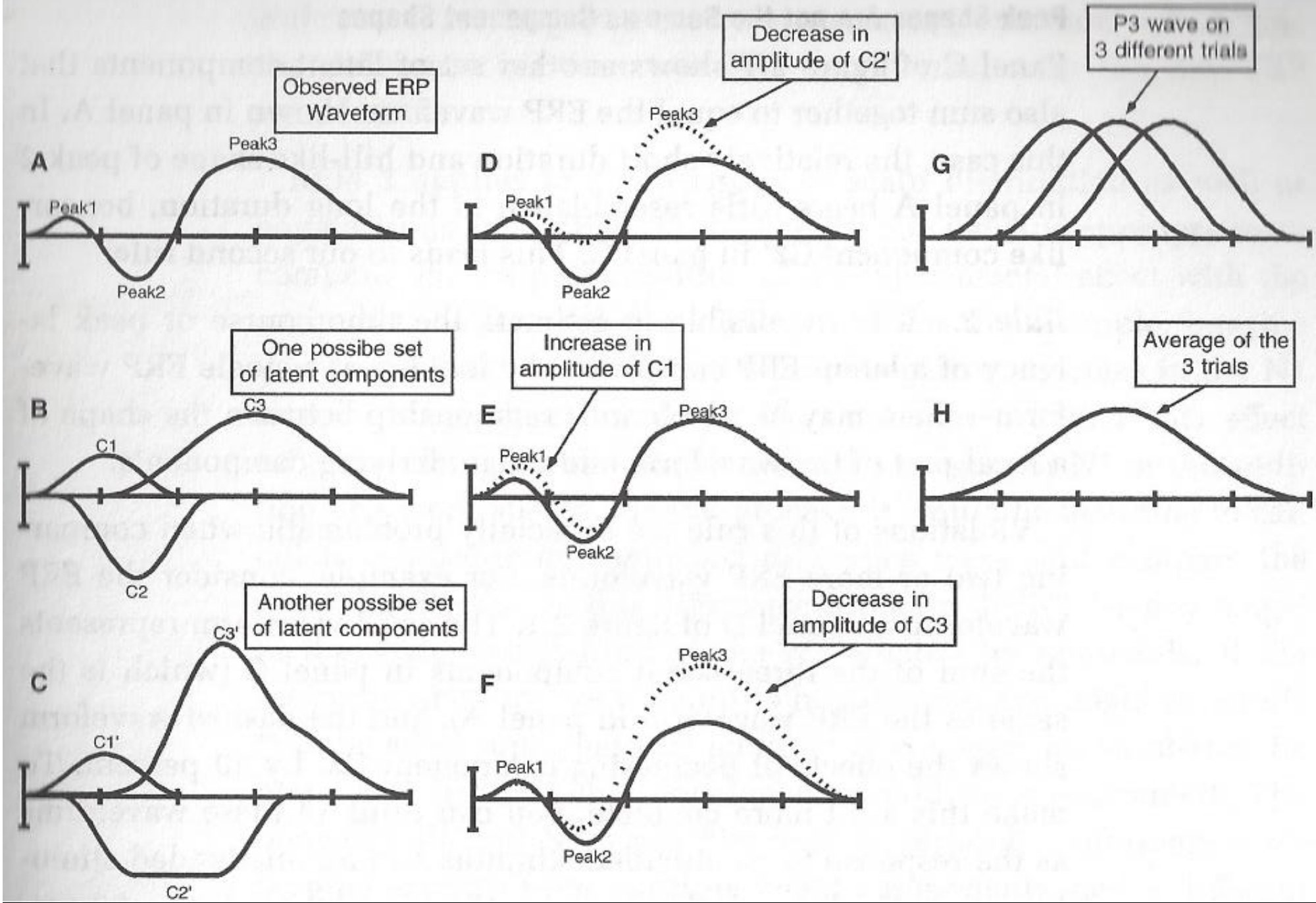
“There is nothing special about the point in time a grand average waveform reaches a maxima or minima – this may have not reveal the true nature of the underlying components.”

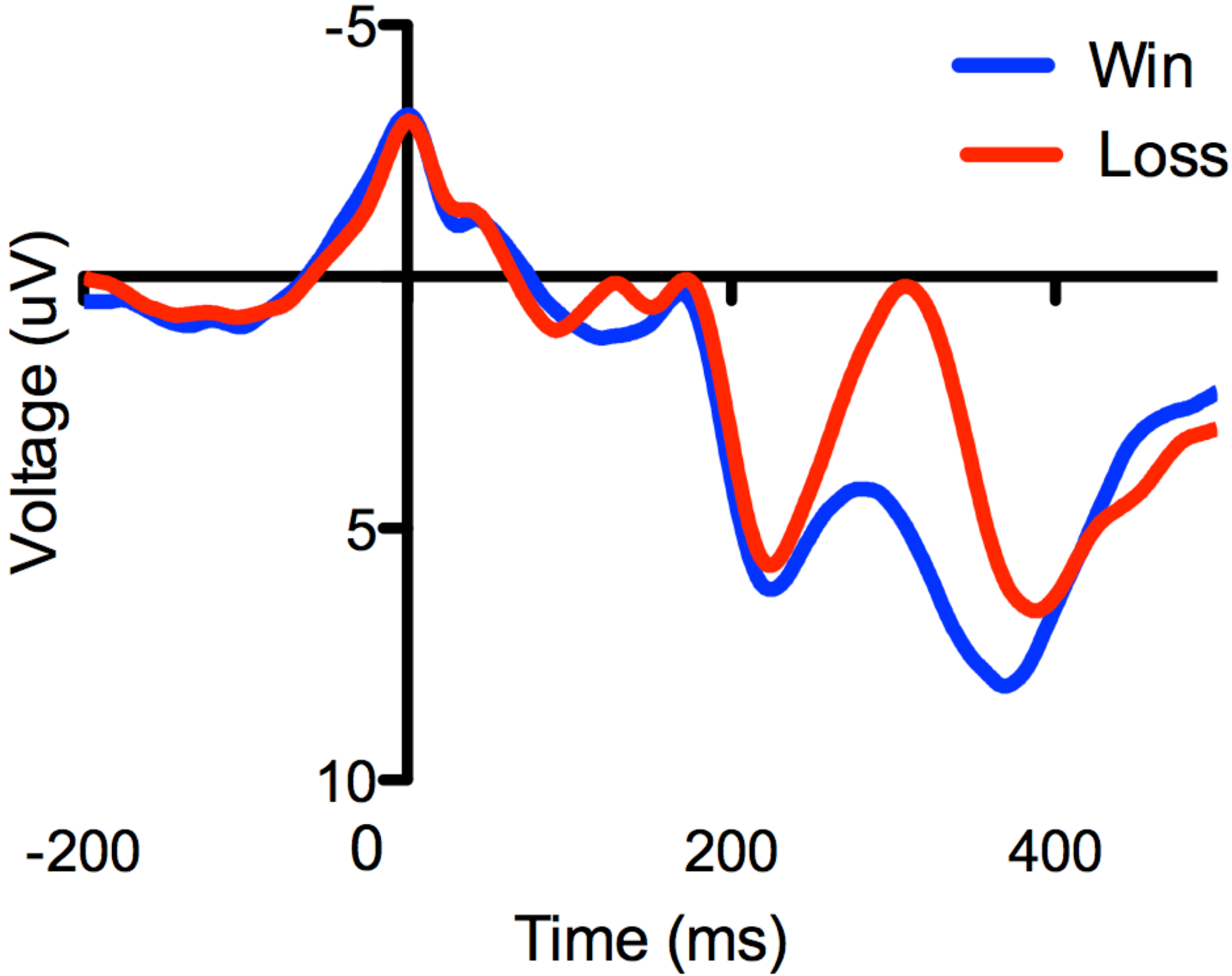
Things to check…

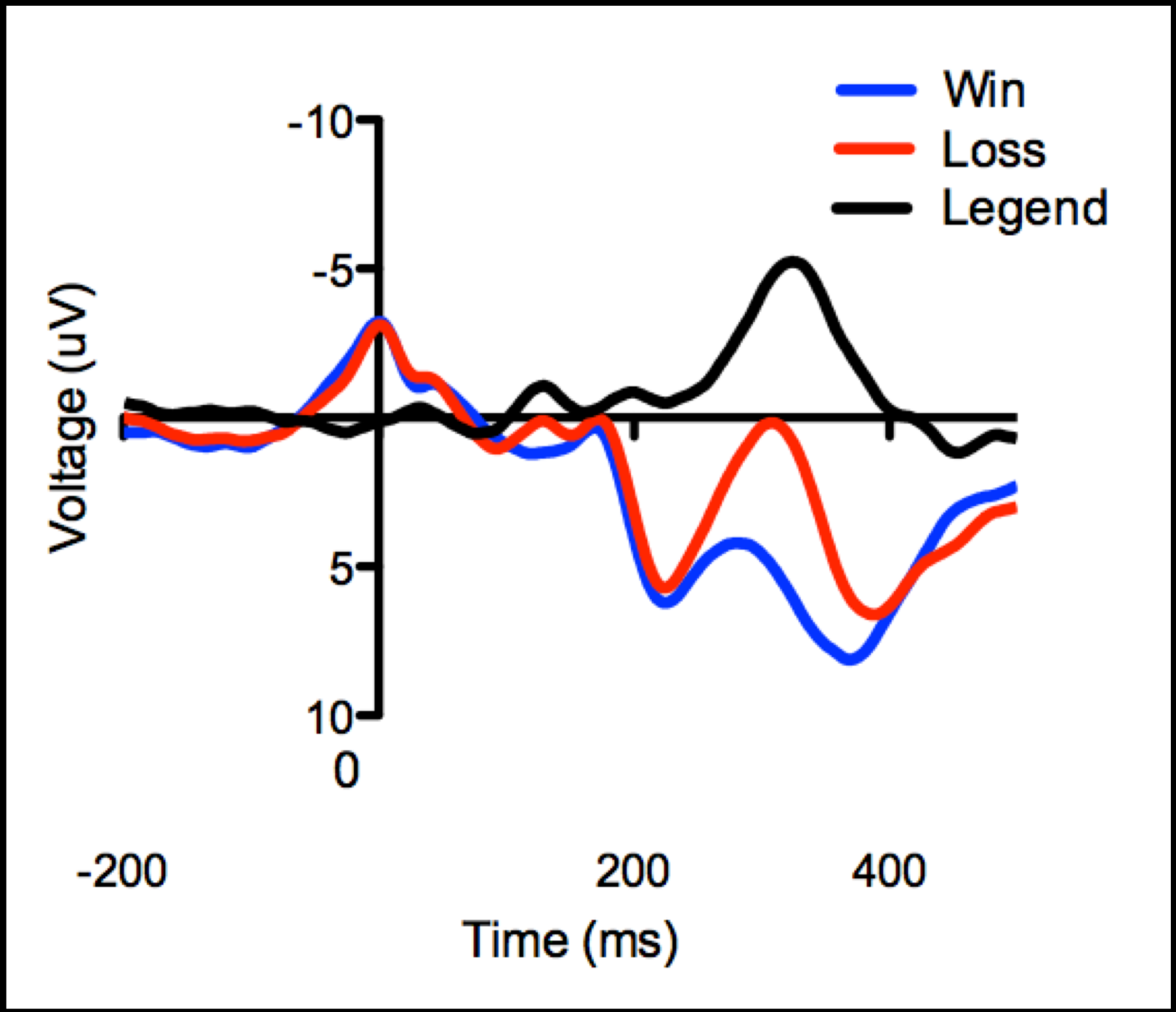
This is a good time to check:

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.

Difference Waveforms


Observed ERP Waveform
A
Peak1
Peak2
Peak3
One possibe set of latent components
B
C1
C2
C3
Another possibe set of latent components
C
C1'
C2'
C3'
Decrease in amplitude of C2'
D
Peak1
Peak2
Peak3
Increase in amplitude of C1
E
Peak1
Peak2
Peak3
Decrease in amplitude of C3
F
Peak1
Peak2
Peak3
P3 wave on 3 different trials
G
Average of the 3 trials
H


Win
Loss
-5
5
10
Voltage (uV)
-200
0
200
400
Time (ms)


Win
Loss
Legend
-10
-5
5
10
0
Voltage (uV)
-200
200
400
Time (ms)

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.

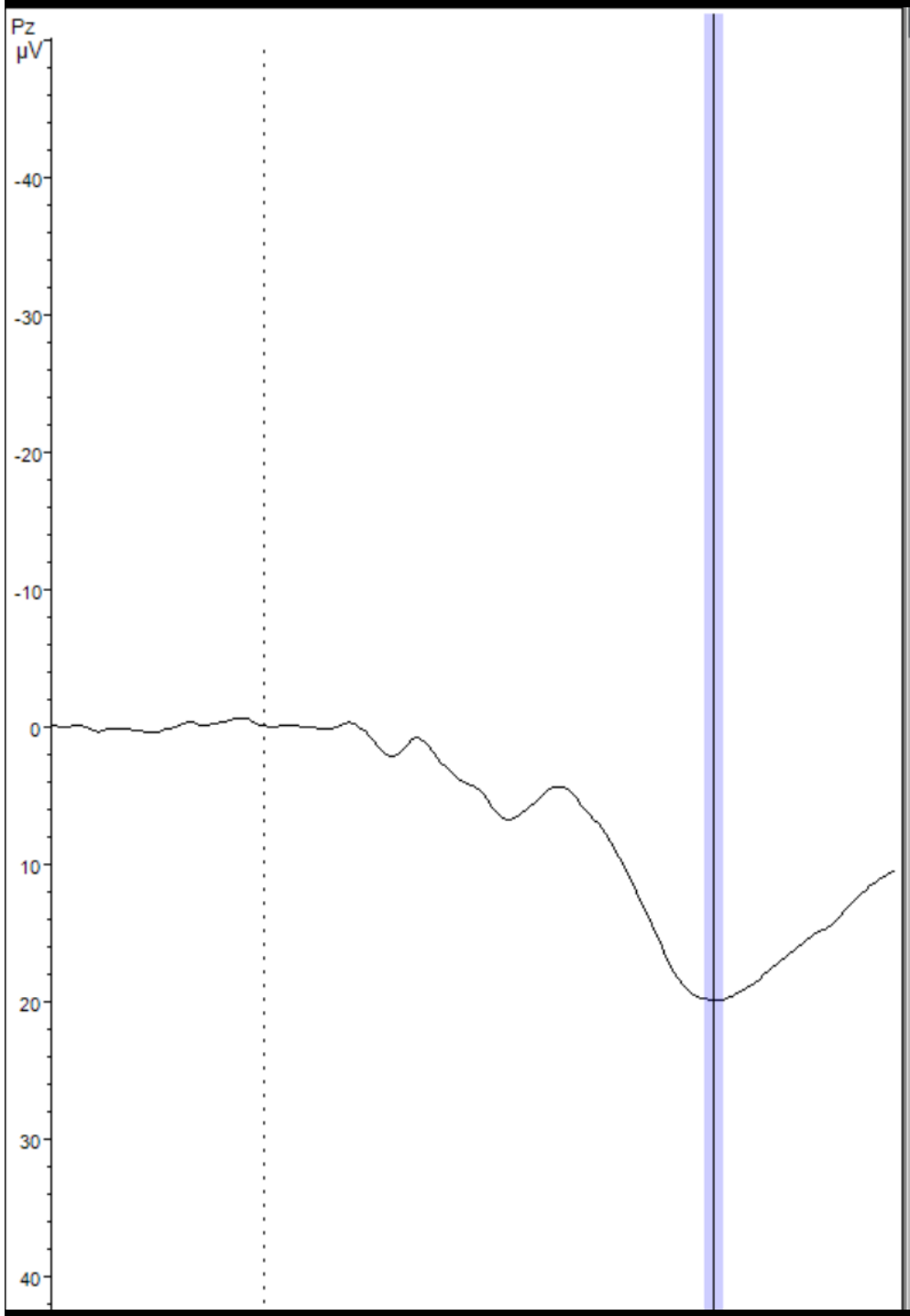
Scalp Topographies

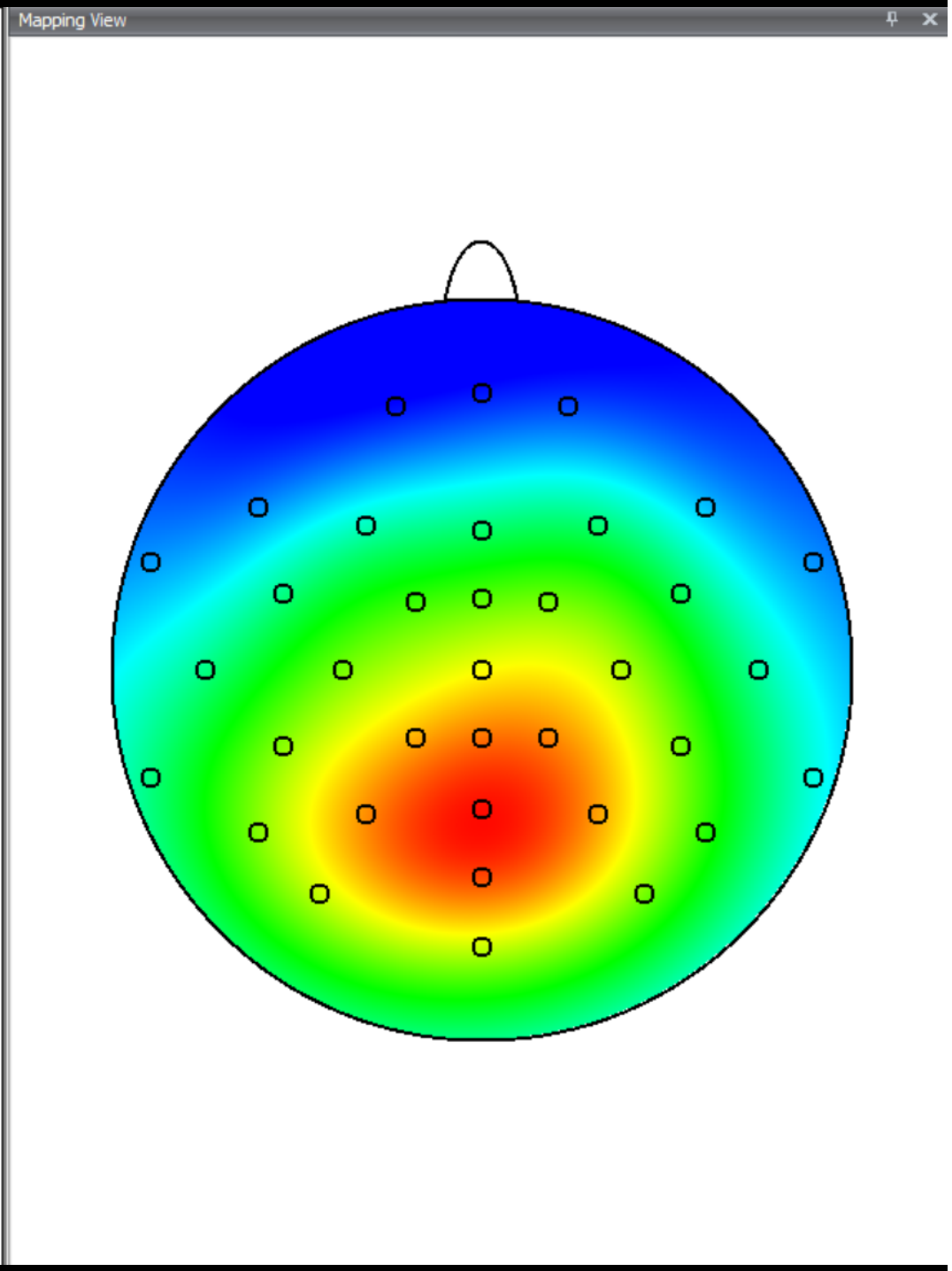
Scalp Topographies

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…


Pz
µV
-40
-30
-20
-10
0
10
20
30
40

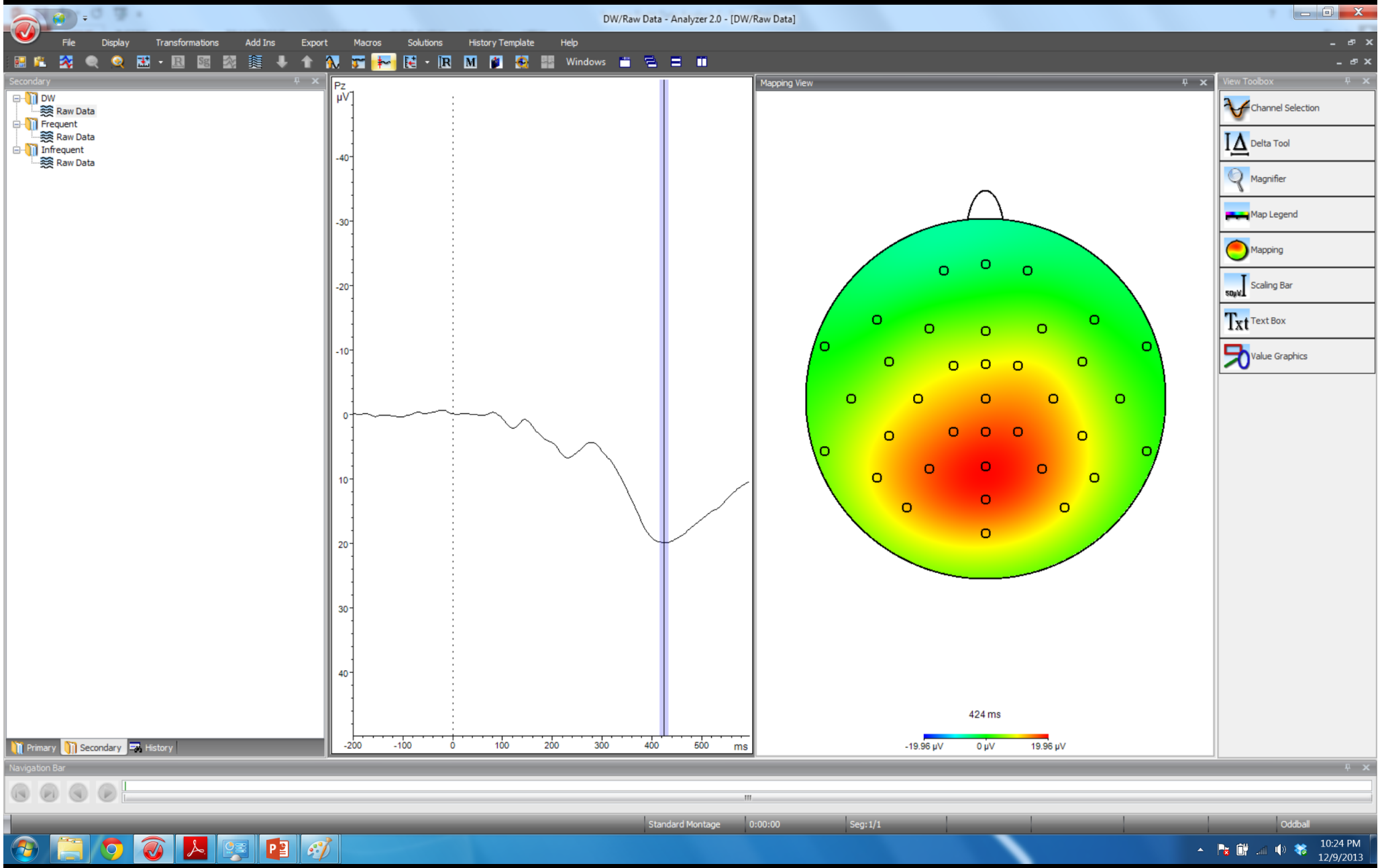

Mapping View

Scalp Topographies

Interpreting topographies can be tricky.

Some pitfalls…

1. Symmetric scaling may distort the topography.


DW/Raw Data - Analyzer 2.0 - [DW/Raw Data]
File
Display
Transformations
Add Ins
Export
Macros
Solutions
History Template
Help
Windows
Secondary
DW
Raw Data
Frequent
Raw Data
Infrequent
Raw Data
Primary
Secondary
History
Pz
µV
-40
-30
-20
-10
0
10
20
30
40
-200
-100
0
100
200
300
400
500
ms
Mapping View
424 ms
-19.96 µV
0 µV
19.96 µV
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
Oddball
10:24 PM
12/9/2013

Scalp Topographies

Interpreting topographies can be tricky.

Some pitfalls…

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

DW/Raw Data - Analyzer 2.0 - [DW/Raw Data]

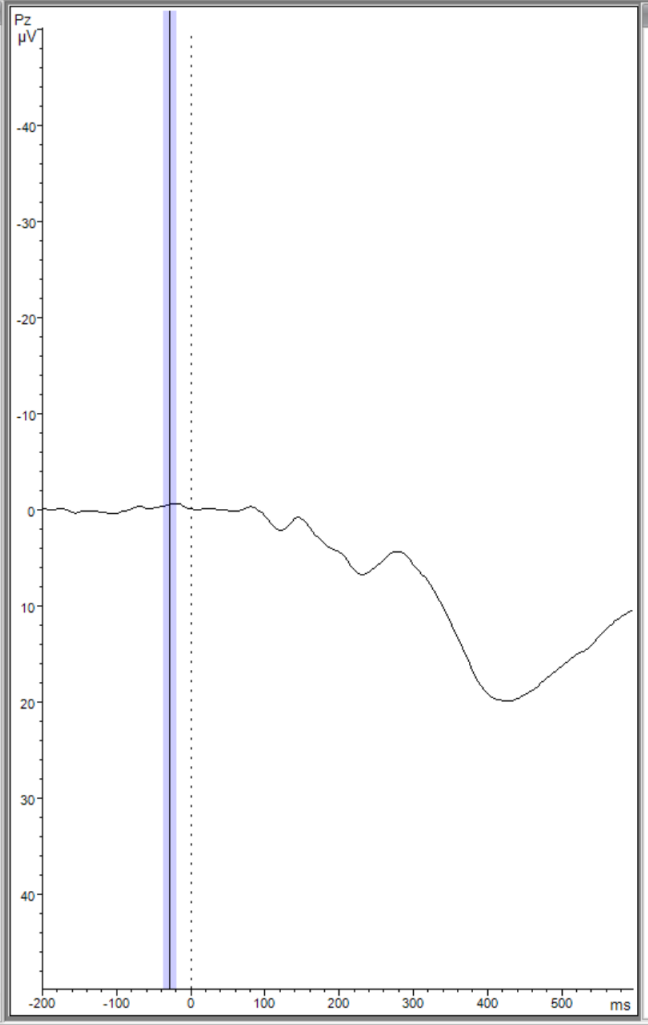
File Display Transformations Add Ins Export Macros Solutions History Template Help

Windows

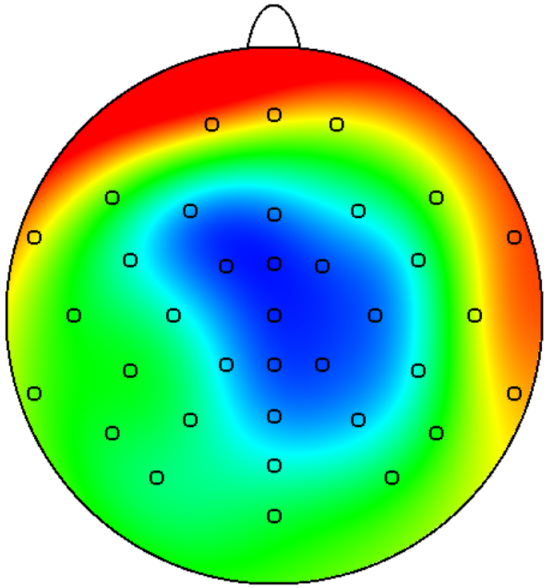
Secondary

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

Primary Secondary History



Mapping View



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 | Oddball

10:26 PM
12/9/2013

DW/Raw Data - Analyzer 2.0 - [DW/Raw Data]

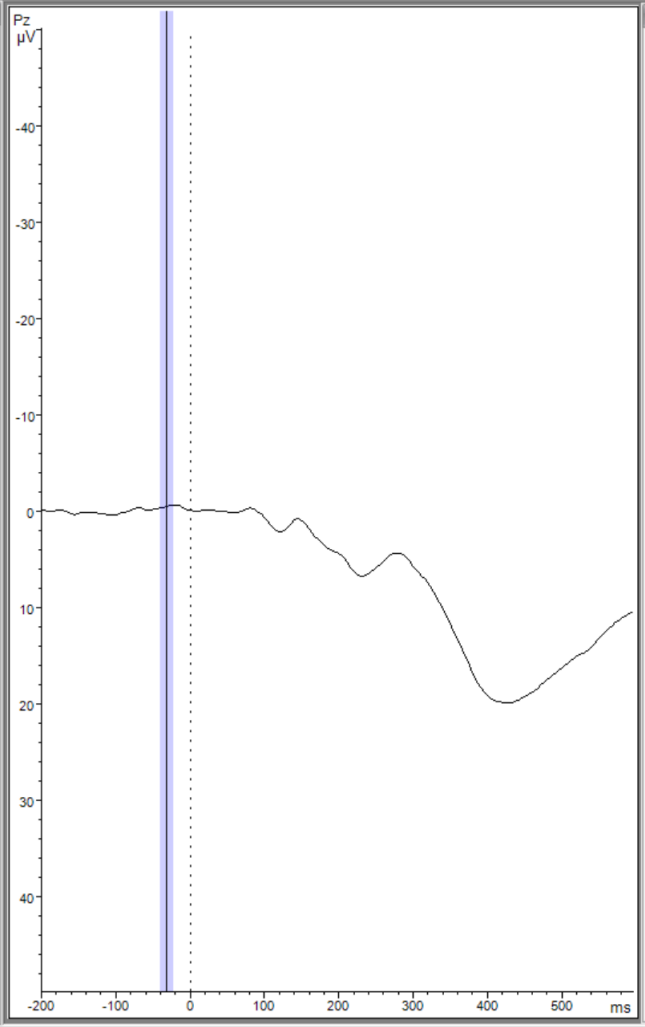
File Display Transformations Add Ins Export Macros Solutions History Template Help

Windows

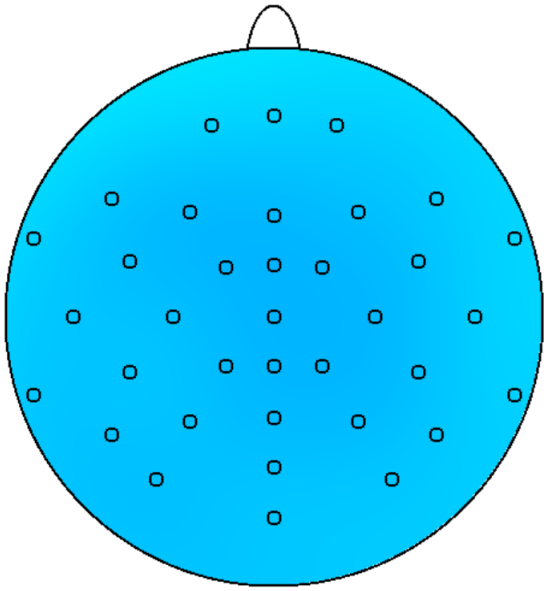
Secondary

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

Primary Secondary History



Mapping View



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 | Oddball

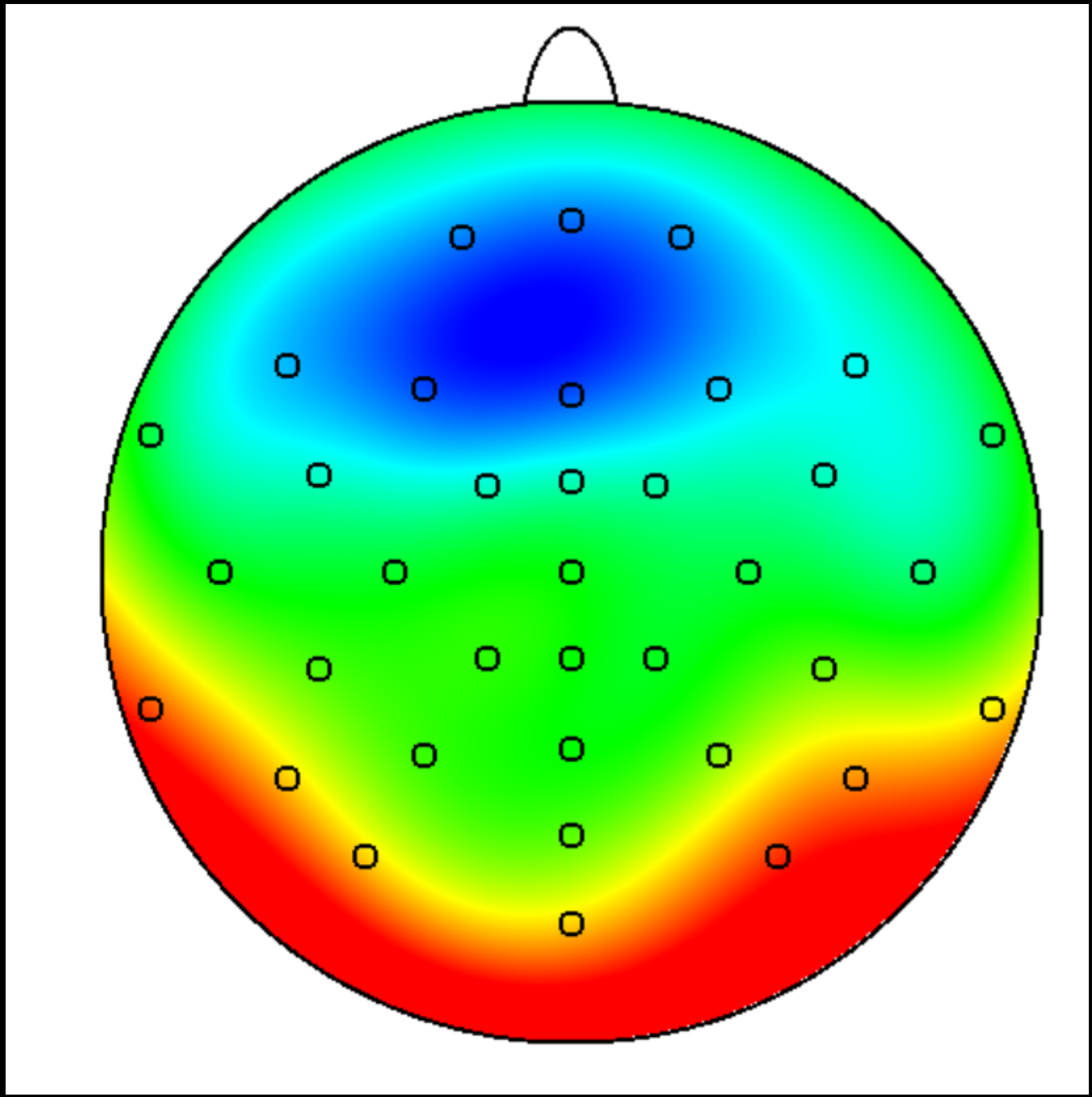
10:27 PM
12/9/2013

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…

DW/Raw Data - Analyzer 2.0 - [DW/Raw Data]

File Display Transformations Add Ins Export Macros Solutions History Template Help

Windows

Secondary

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

Primary Secondary History

Pz

50 µV

Loreta

[cm]

0.000 0.005 0.010

View Toolbox

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

Position: 0.420s (4, -67, 15)

Navigation Bar

Standard Montage | 0:00:00 | Seg: 1/1 | Pos: -0.184 s | 0.016 s | Oddball

10:32 PM
12/9/2013

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 till talk about this in a bit…

Quantifying Components: Peak Detection

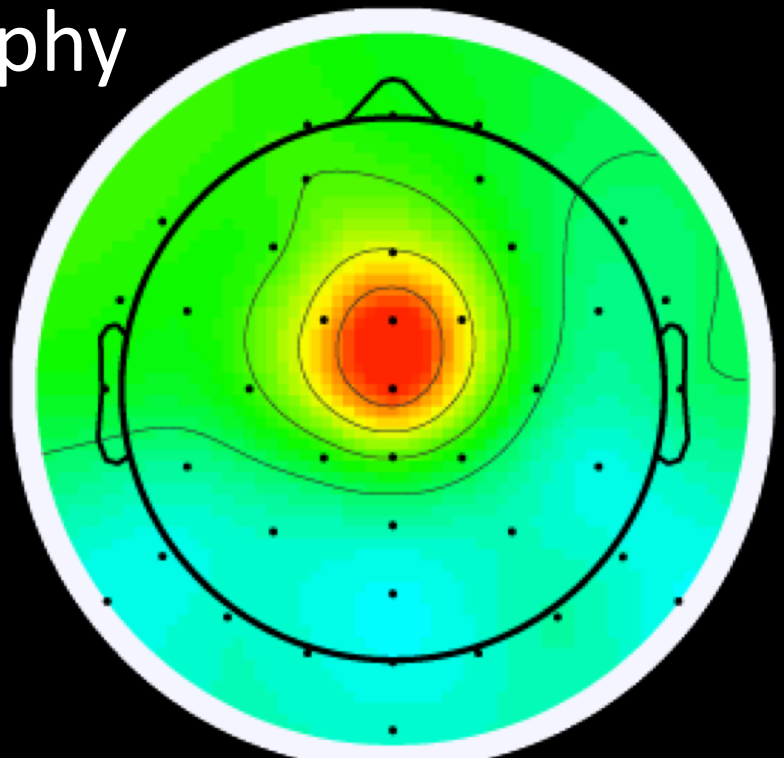
Component Definition

ERP Components have:

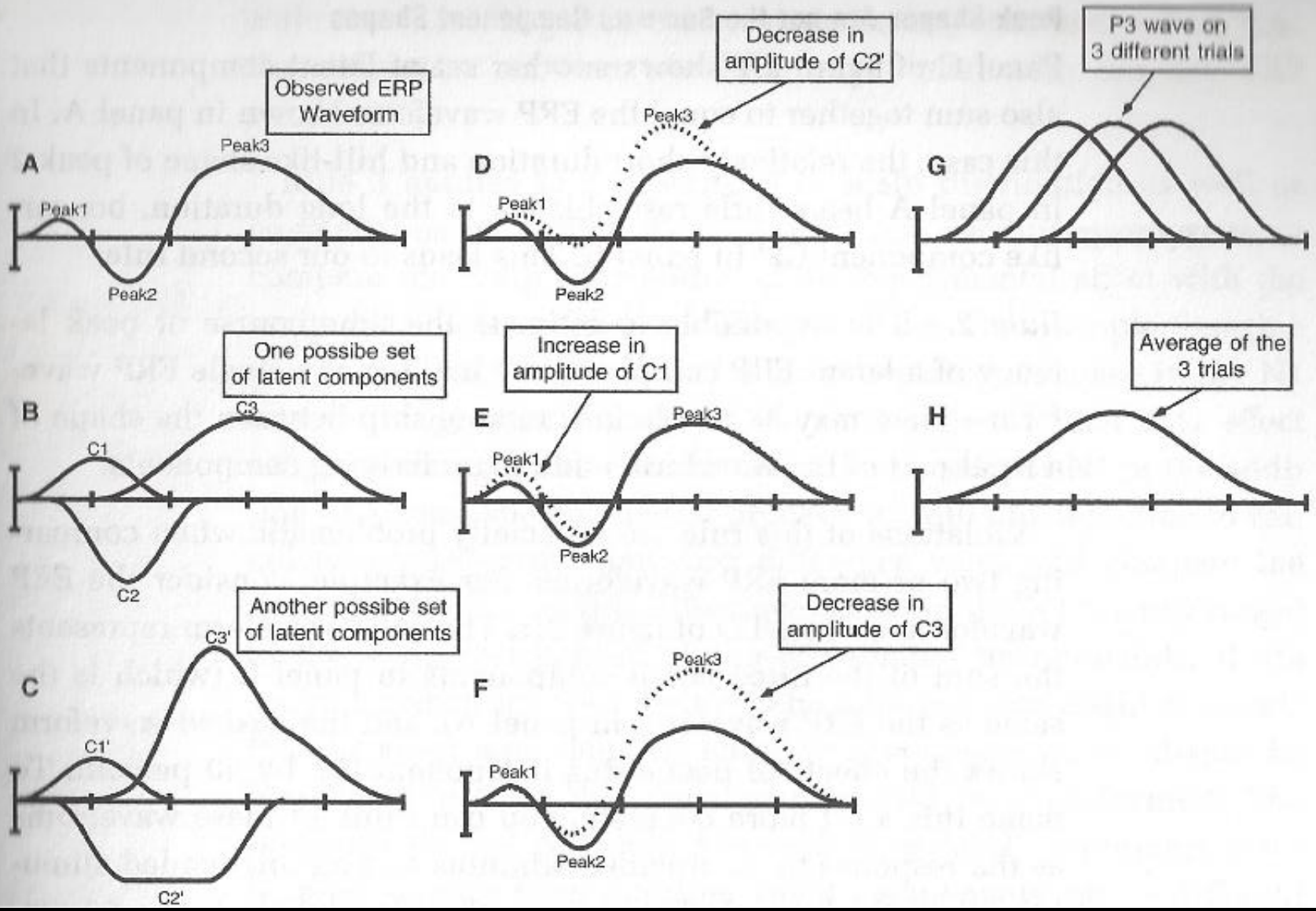
A Polarity (e.g., N200, P300)

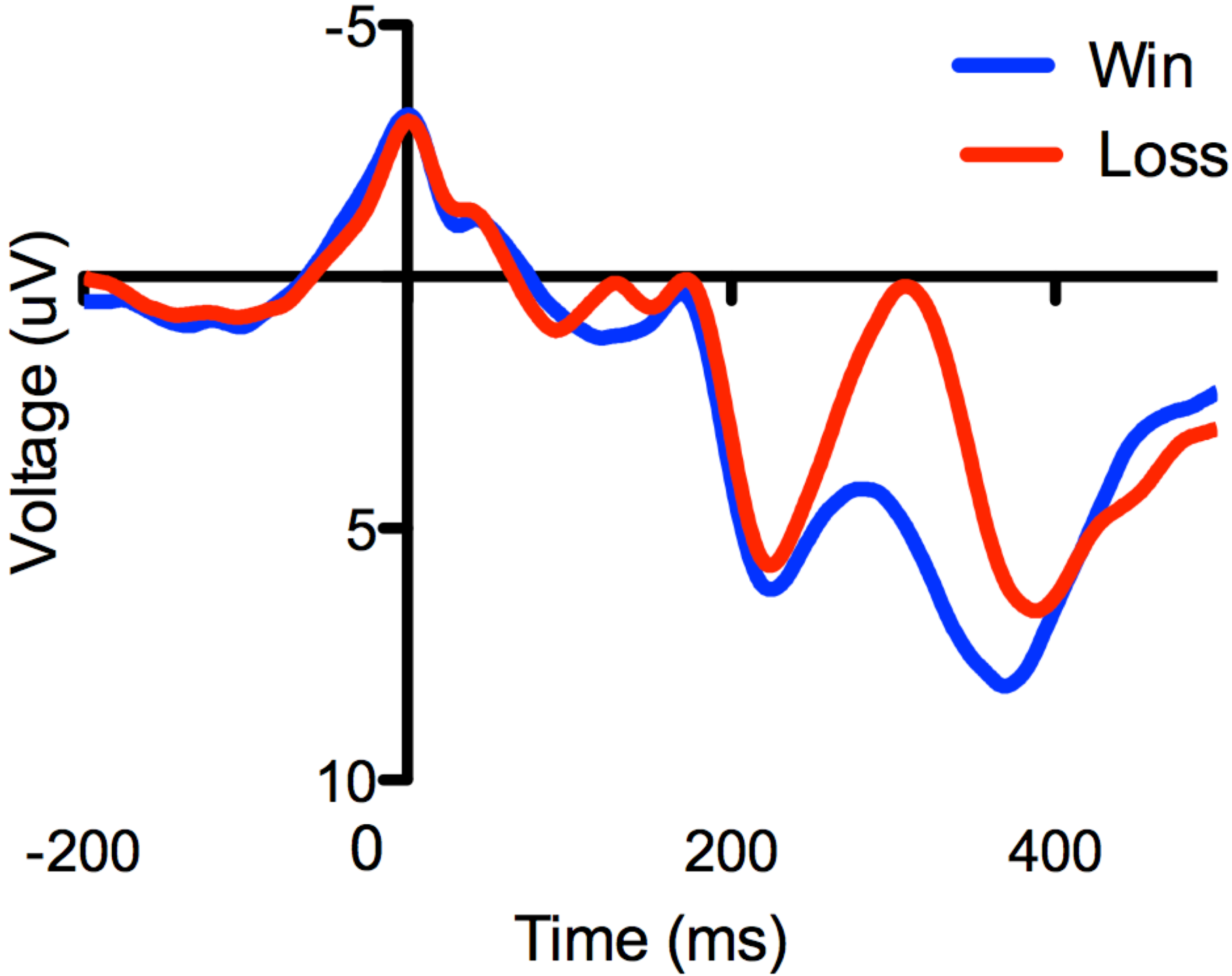
A Timing (e.g., 200 to 300 ms)

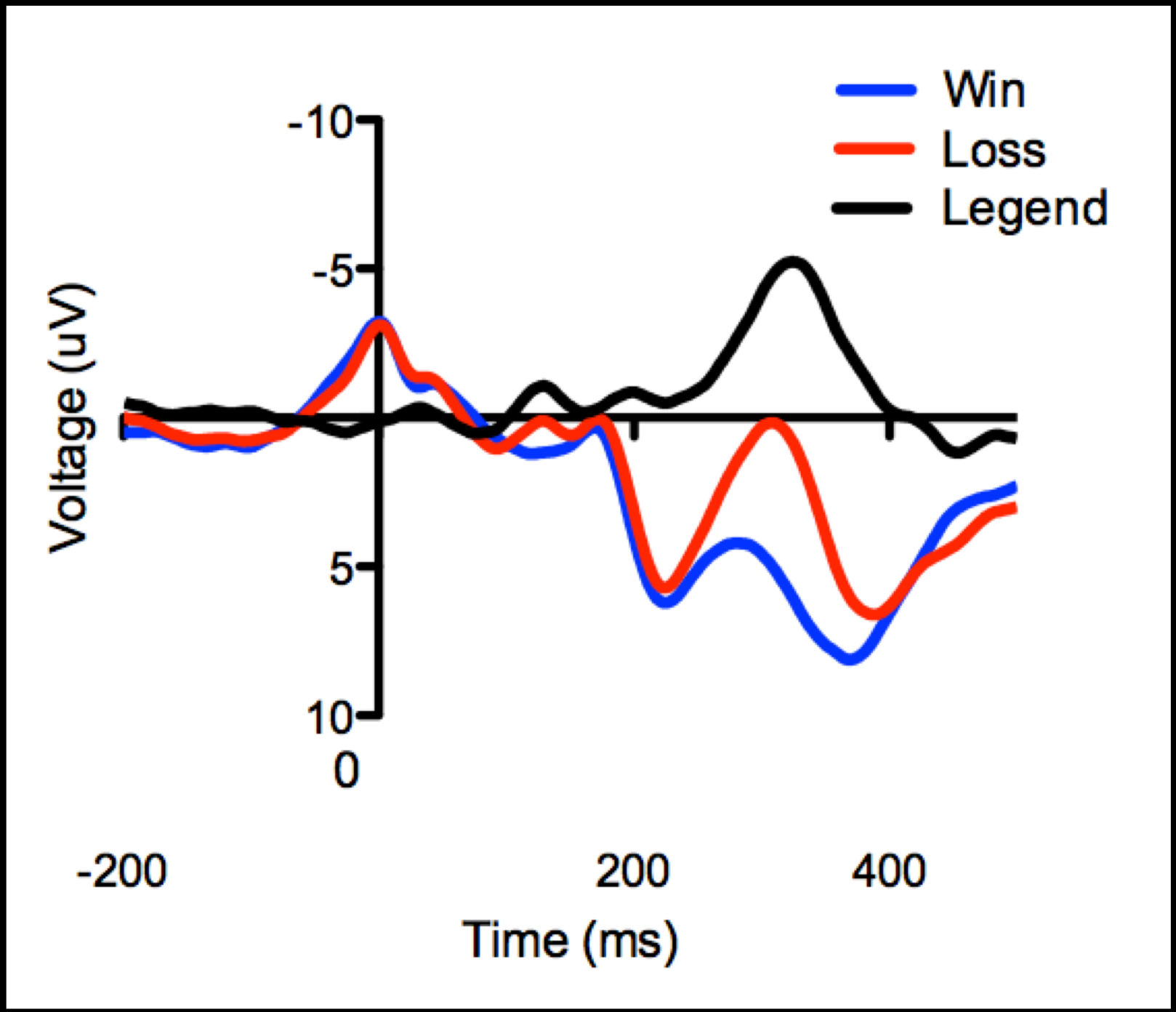
A Scalp Topography



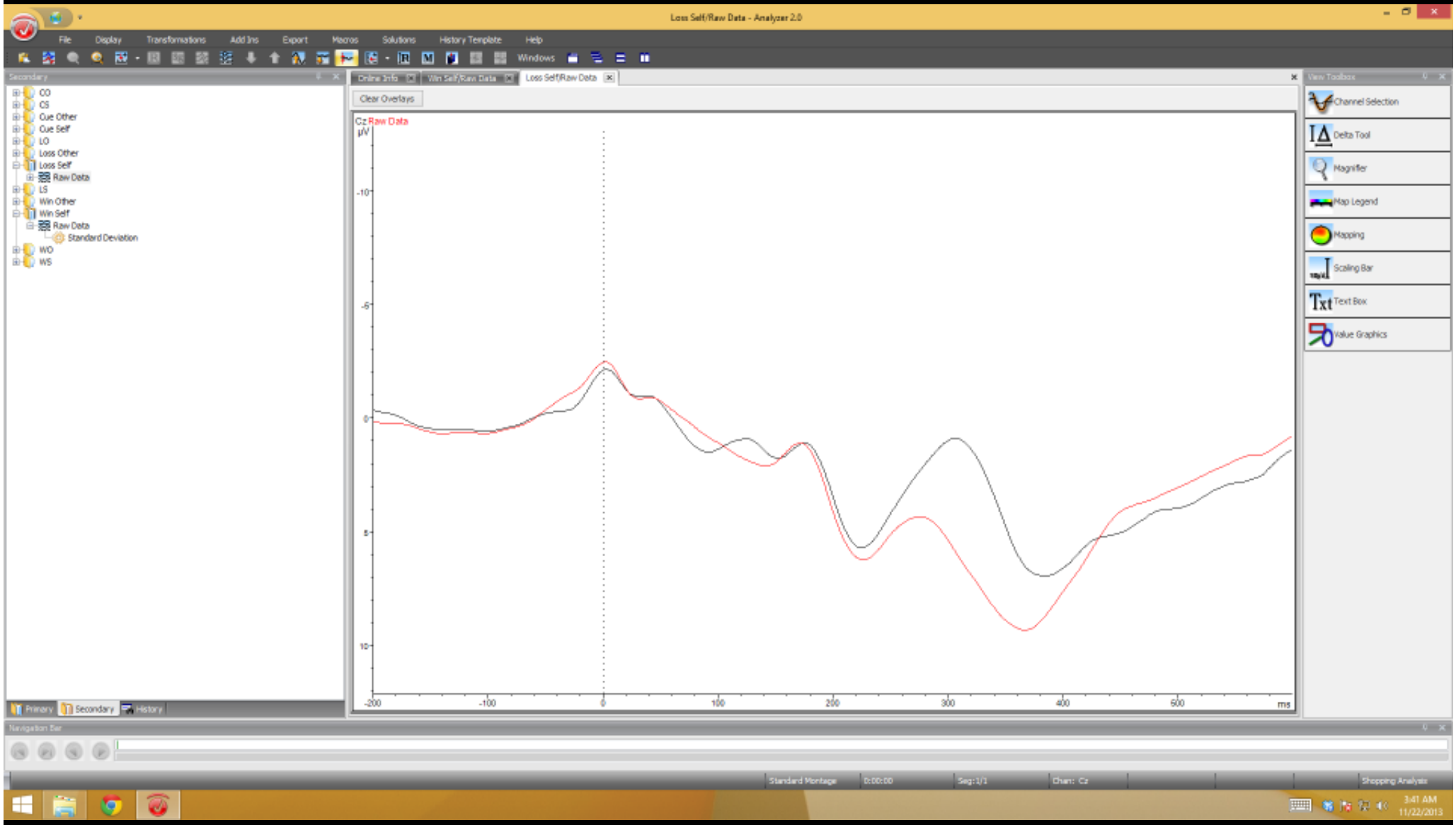
Conditional Waveforms?


Observed ERP Waveform
A
Peak1
Peak2
Peak3
One possibe set of latent components
B
C1
C2
C3
Another possibe set of latent components
C
C1'
C2'
C3'
Decrease in amplitude of C2'
D
Peak1
Peak2
Peak3
Increase in amplitude of C1
E
Peak1
Peak2
Peak3
Decrease in amplitude of C3
F
Peak1
Peak2
Peak3
P3 wave on 3 different trials
G
Average of the 3 trials
H


Win
Loss
-5
5
10
Voltage (uV)
-200
0
200
400
Time (ms)


Win
Loss
Legend
-10
-5
5
10
0
Voltage (uV)
-200
200
400
Time (ms)

Subject or Grand Averages


Loss Self/Raw Data - Analyzer 2.0
File
Display
Transformations
Add Ins
Export
Macros
Solutions
History Template
Help
Windows
Secondary
CO
CS
Cue Other
Cue Self
LO
Loss Other
Loss Self
Raw Data
LS
Win Other
Win Self
Raw Data
Standard Deviation
WO
WS
Primary
Secondary
History
Online Info
Win Self/Raw Data
Loss Self/Raw Data
Clear Overlays
Cz Raw Data
µV
-10
-5
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5
10
-200
-100
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100
200
300
400
500
ms
View Toolbox
Channel Selection
Delta Tool
Magnifier
Map Legend
Mapping
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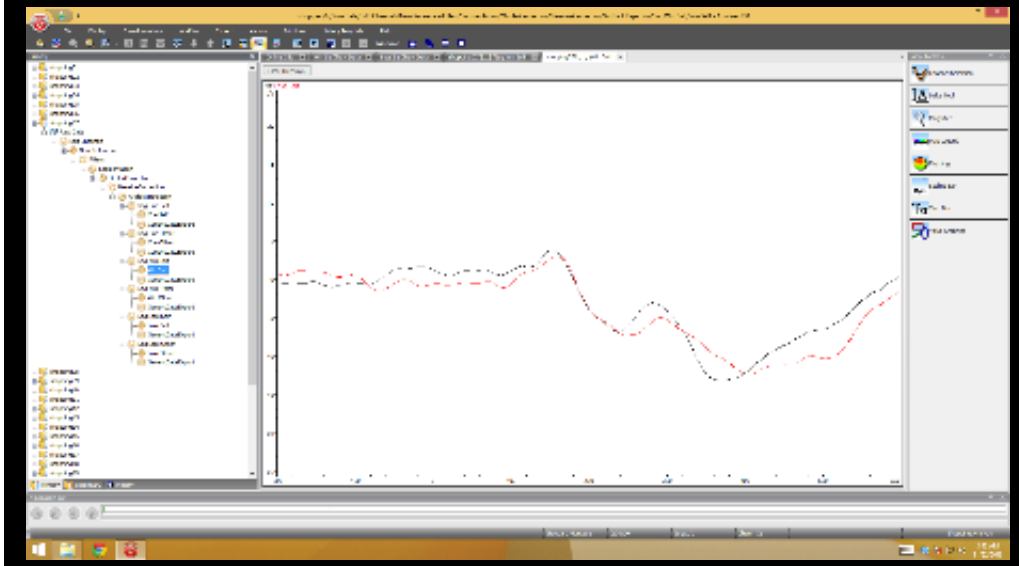
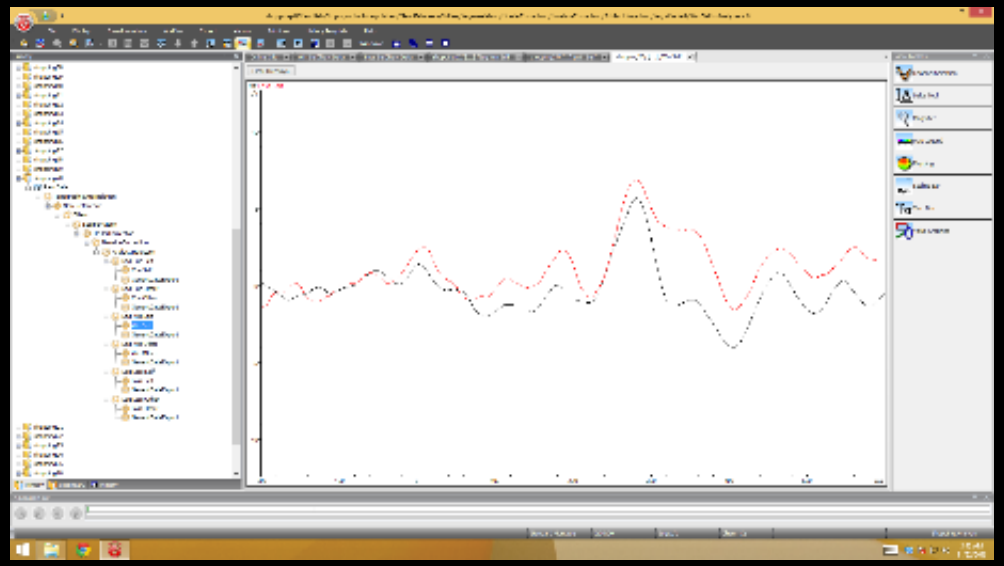
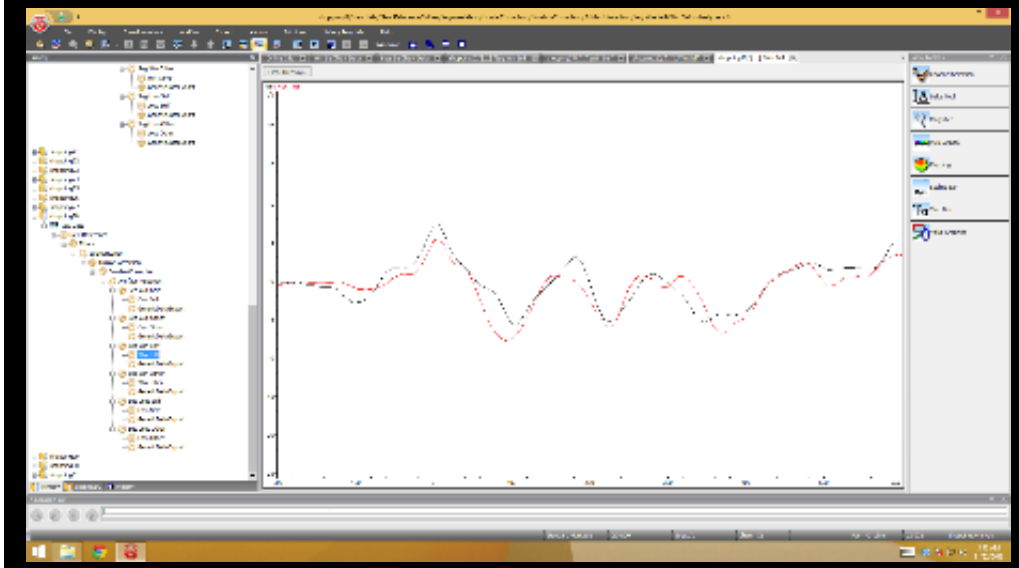
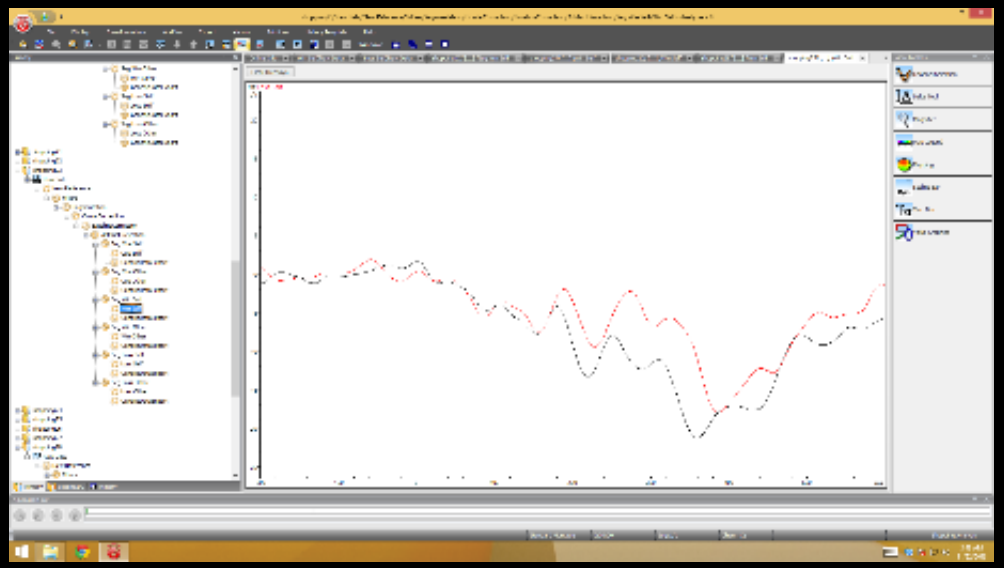
Text Box
Value Graphics
Navigation Bar
Standard Montage
0:00:00
Seg: 1/1
Chan: Cz
Shopping Analysis
3:41 AM
11/22/2013



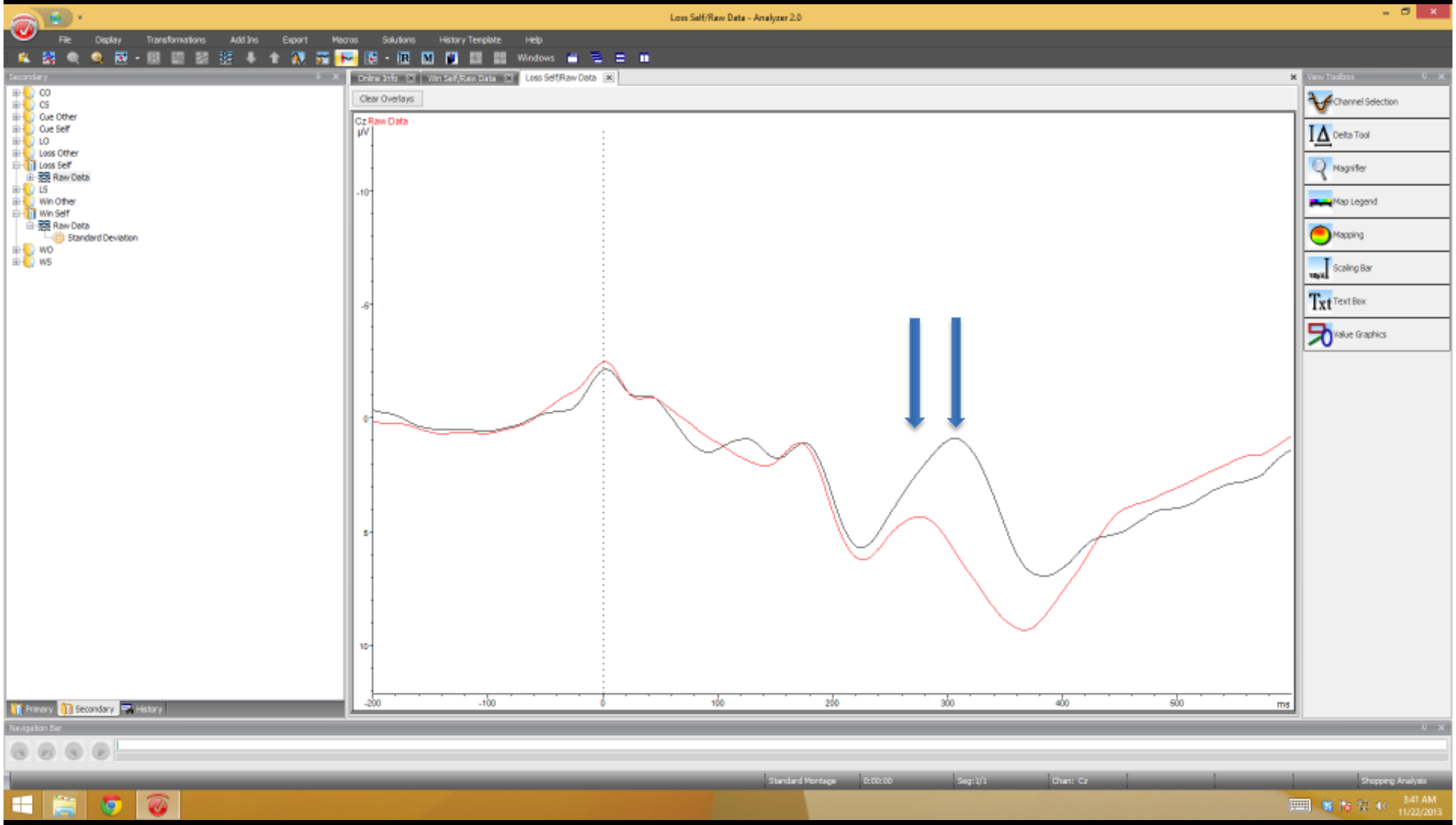


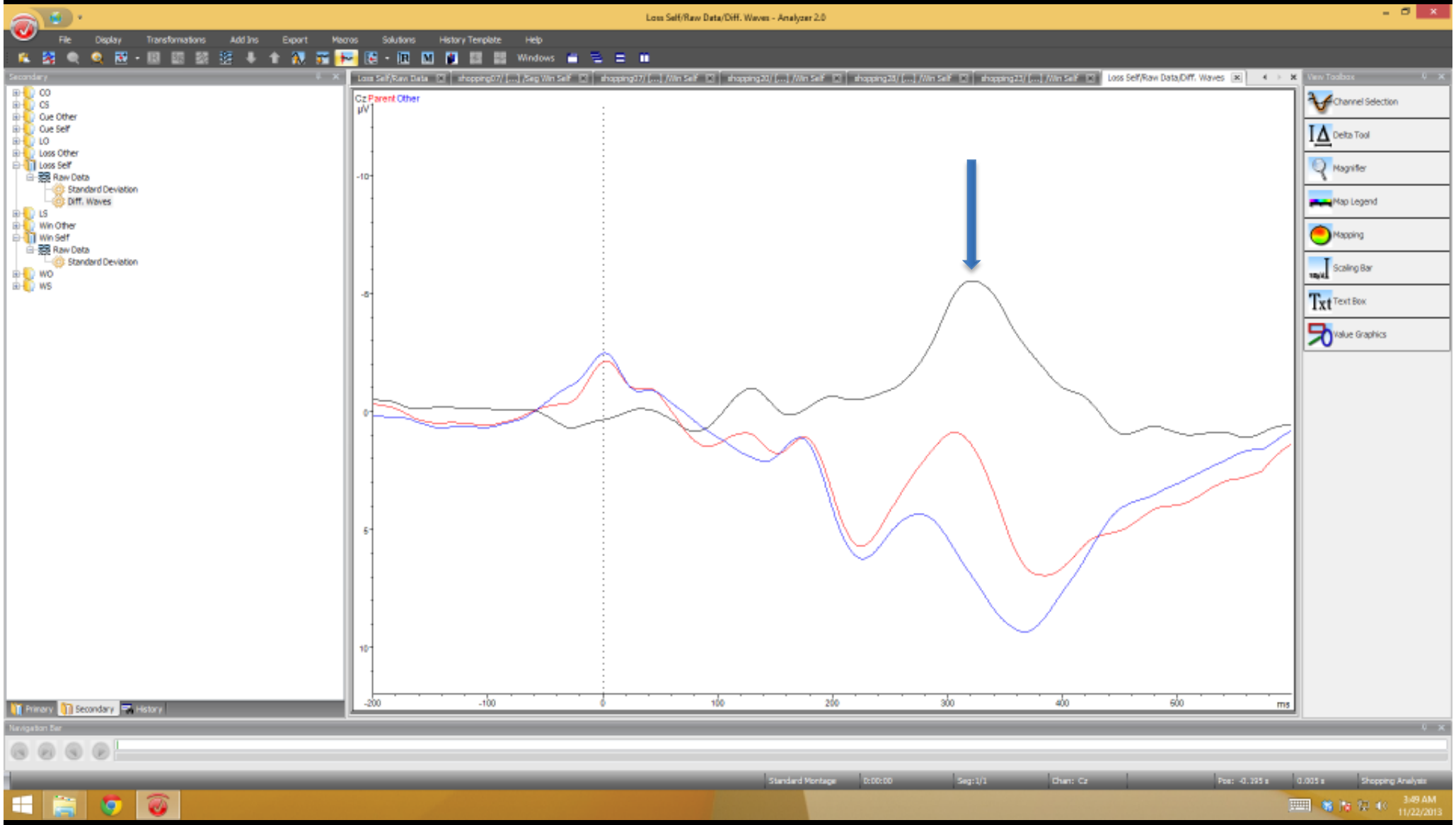




So, we base the “timing” of the component on either the GRAND AVERAGE WAVEFORM or APRIORI KNOWLEDGE

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


Loss Self/Raw Data - Analyzer 2.0
File
Display
Transformations
Add Ins
Export
Macros
Solutions
History Template
Help
Windows
Secondary
CO
CS
Cue Other
Cue Self
LO
Loss Other
Loss Self
Raw Data
LS
Win Other
Win Self
Raw Data
Standard Deviation
WO
WS
Online Info
Win Self/Raw Data
Loss Self/Raw Data
Clear Overlays
Cz Raw Data
µV
-10
-5
0
5
10
-200
-100
0
100
200
300
400
500
ms
View Toolbox
Channel Selection
Delta Tool
Magnifier
Map Legend
Mapping
Scaling Bar
Text Box
Value Graphics
Primary
Secondary
History
Navigation Bar
Standard Montage
0:00:00
Seg: 1/1
Chan: Cz
Shopping Analysis
3:41 AM
11/22/2013



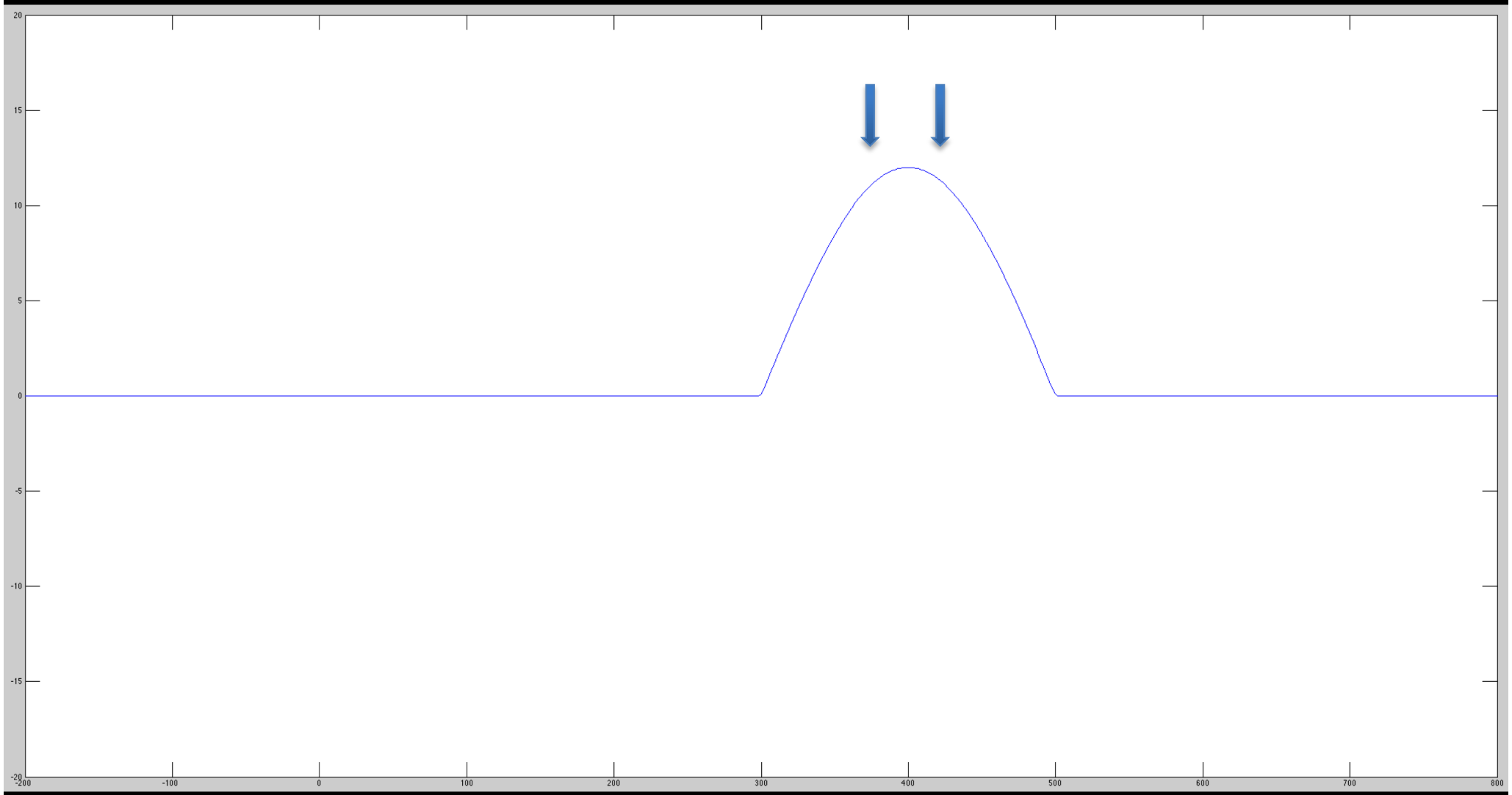
BUT WHAT IS THE PROBLEM HERE?

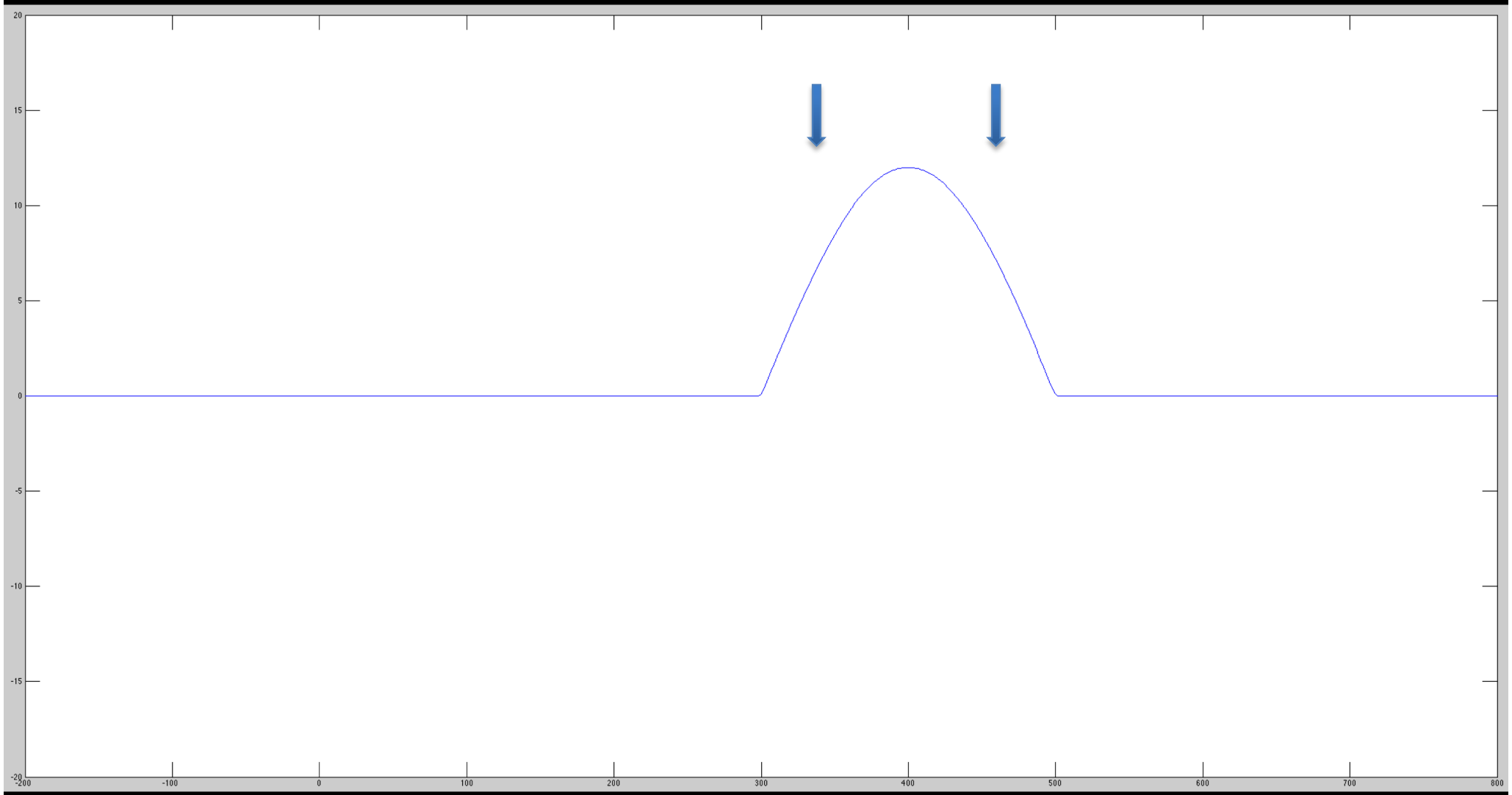
Mean Peak Measures

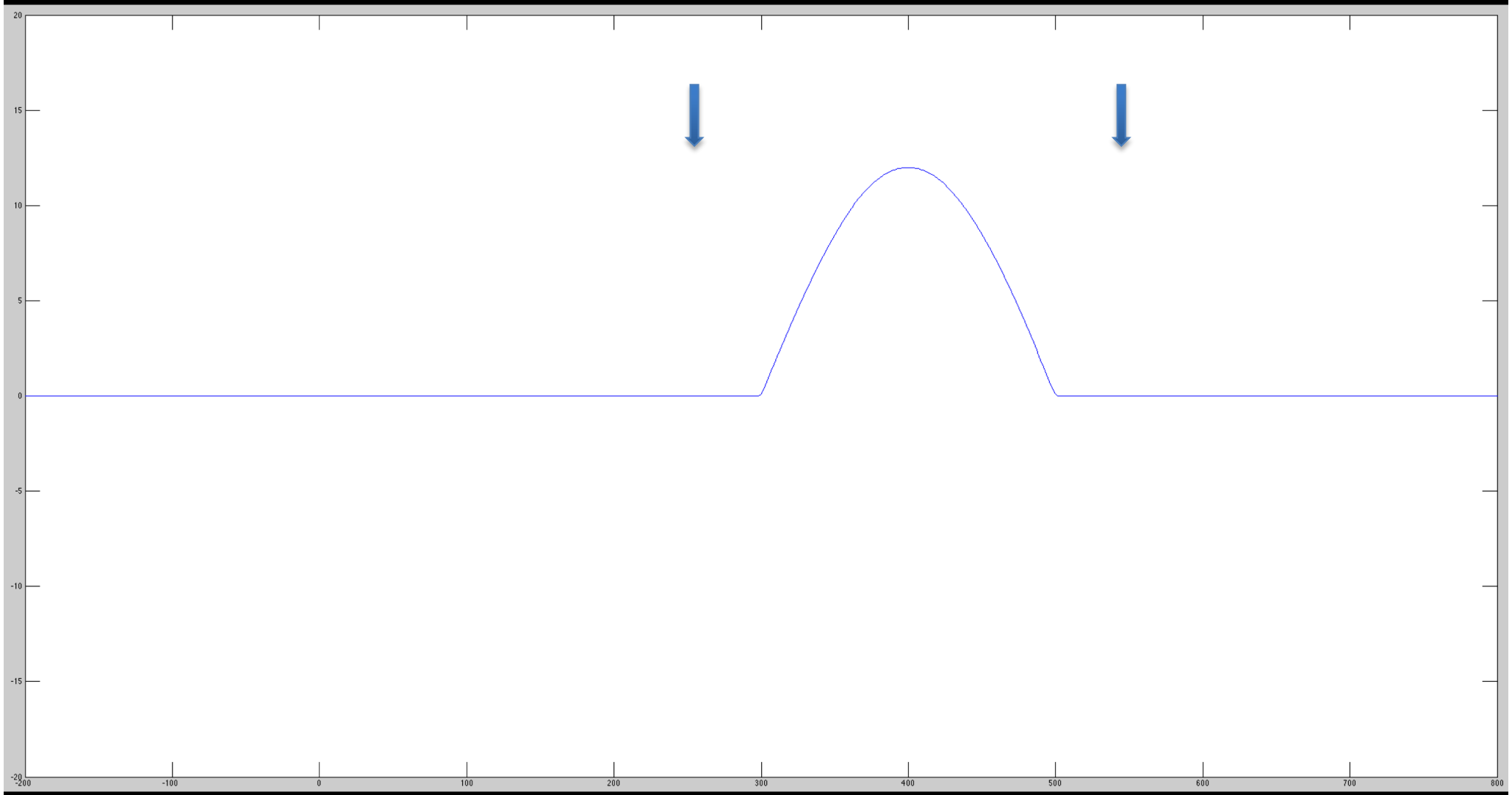
It is worth noting that some researchers base the timing of their component on absolute time points – i.e., “I will use the mean from 200 to 300 ms”… to be fair, I have done this myself. But, WHY??? Do the underlying components really care about discrete time bins?

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

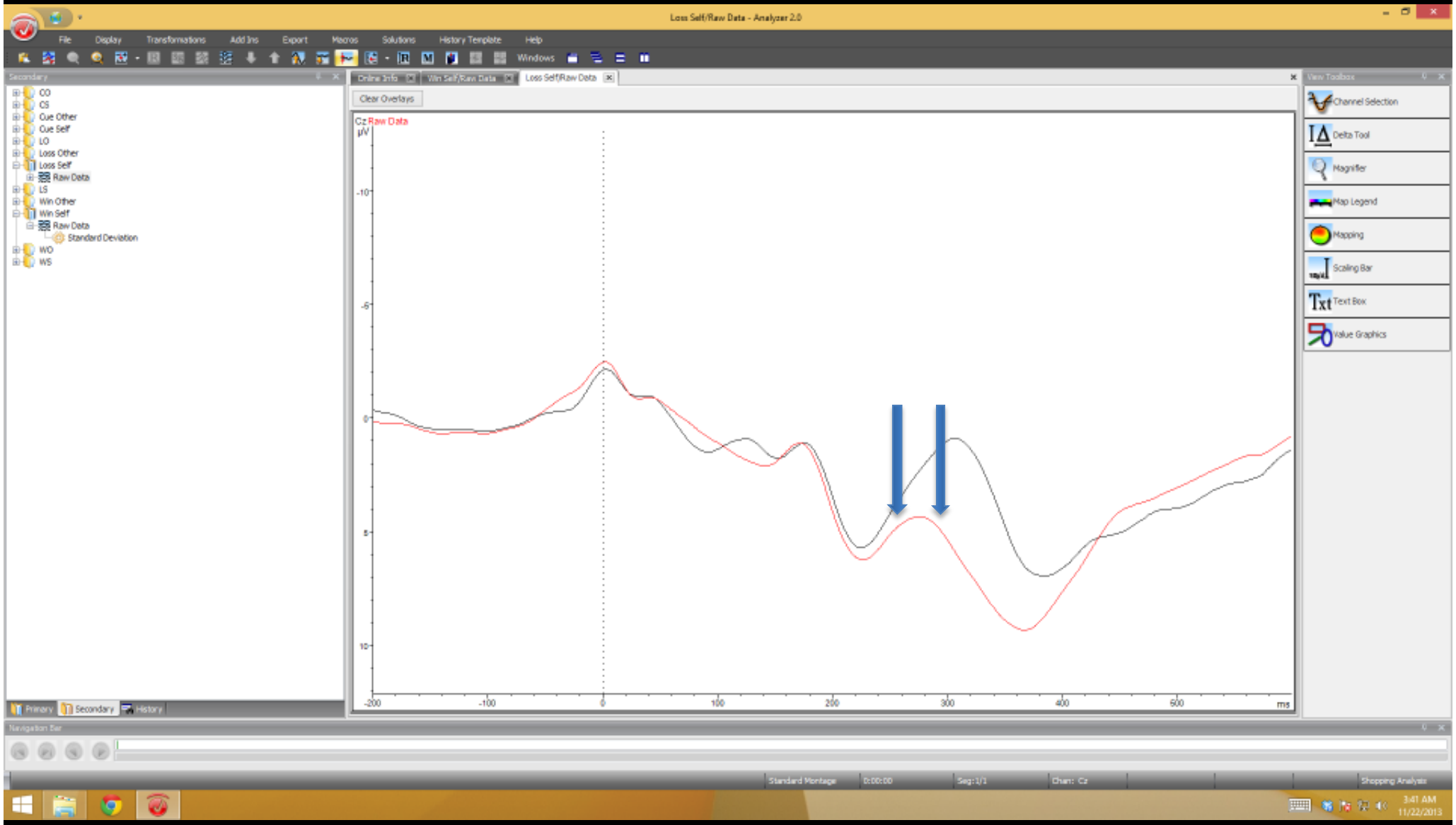
Mean Window Width


20
15
10
5
0
-5
-10
-15
-20
-200
-100
0
100
200
300
400
500
600
700
800

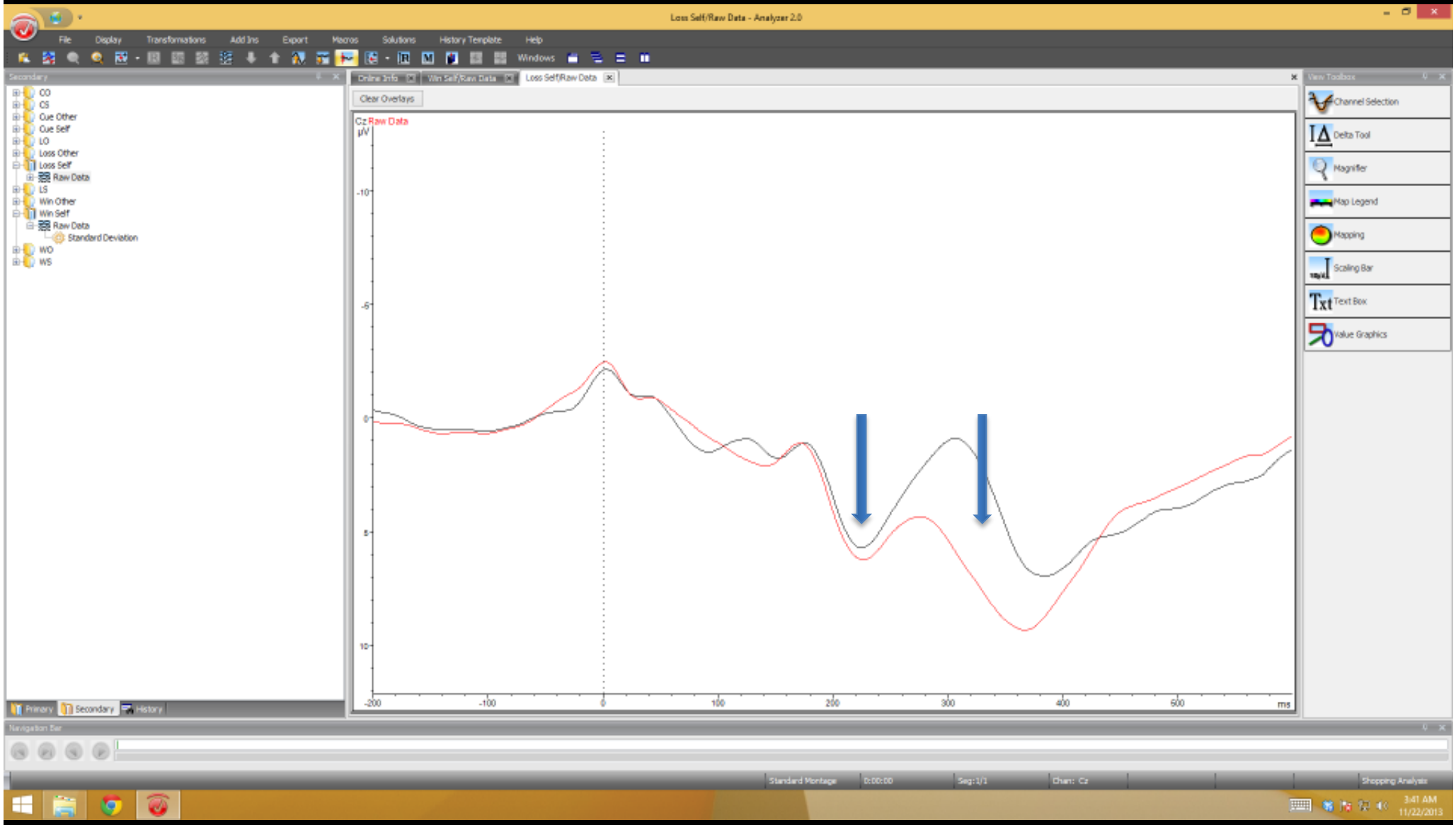

20
15
10
5
0
-5
-10
-15
-20
-200
-100
0
100
200
300
400
500
600
700
800



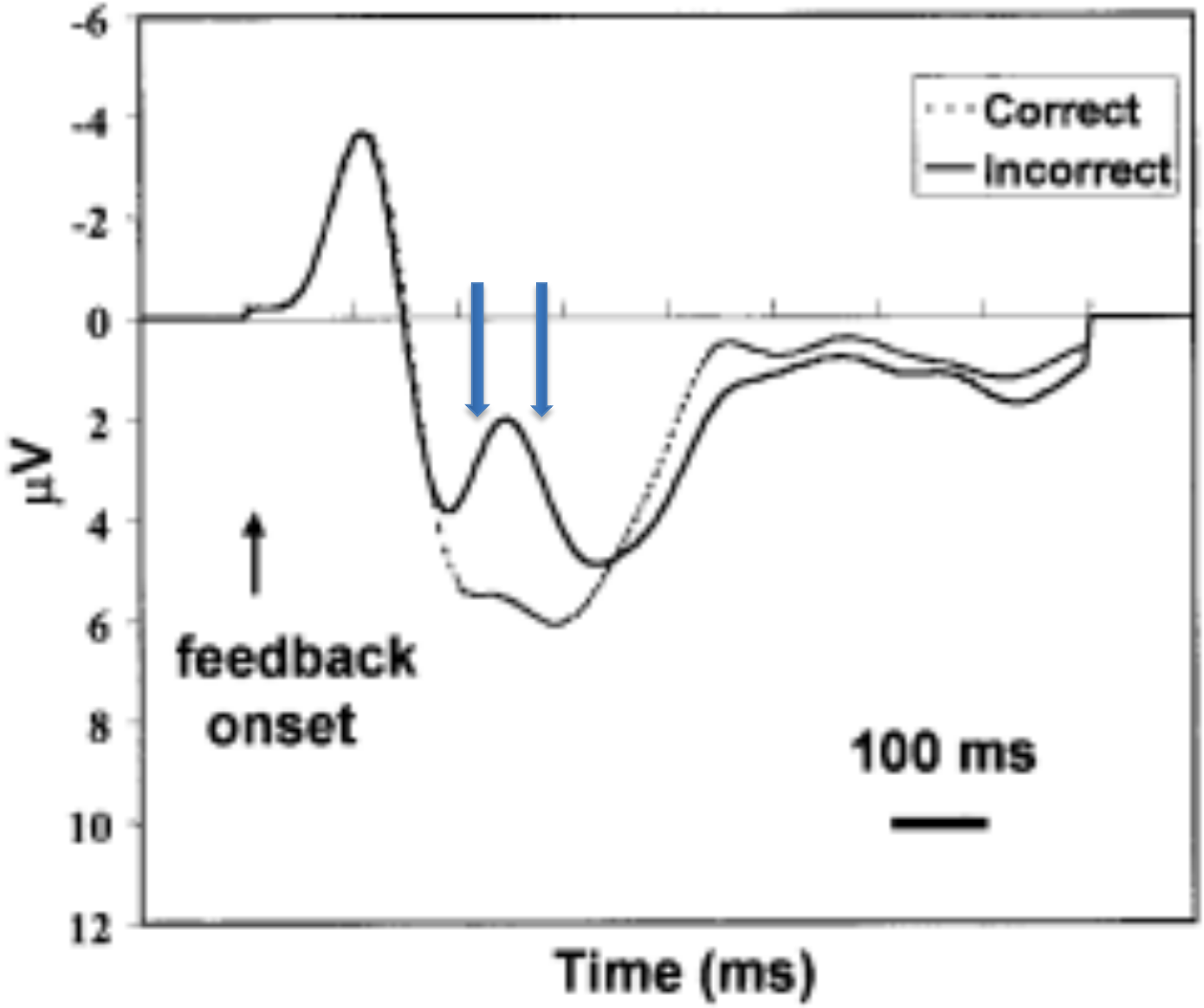
What is the trend in the components amplitude?

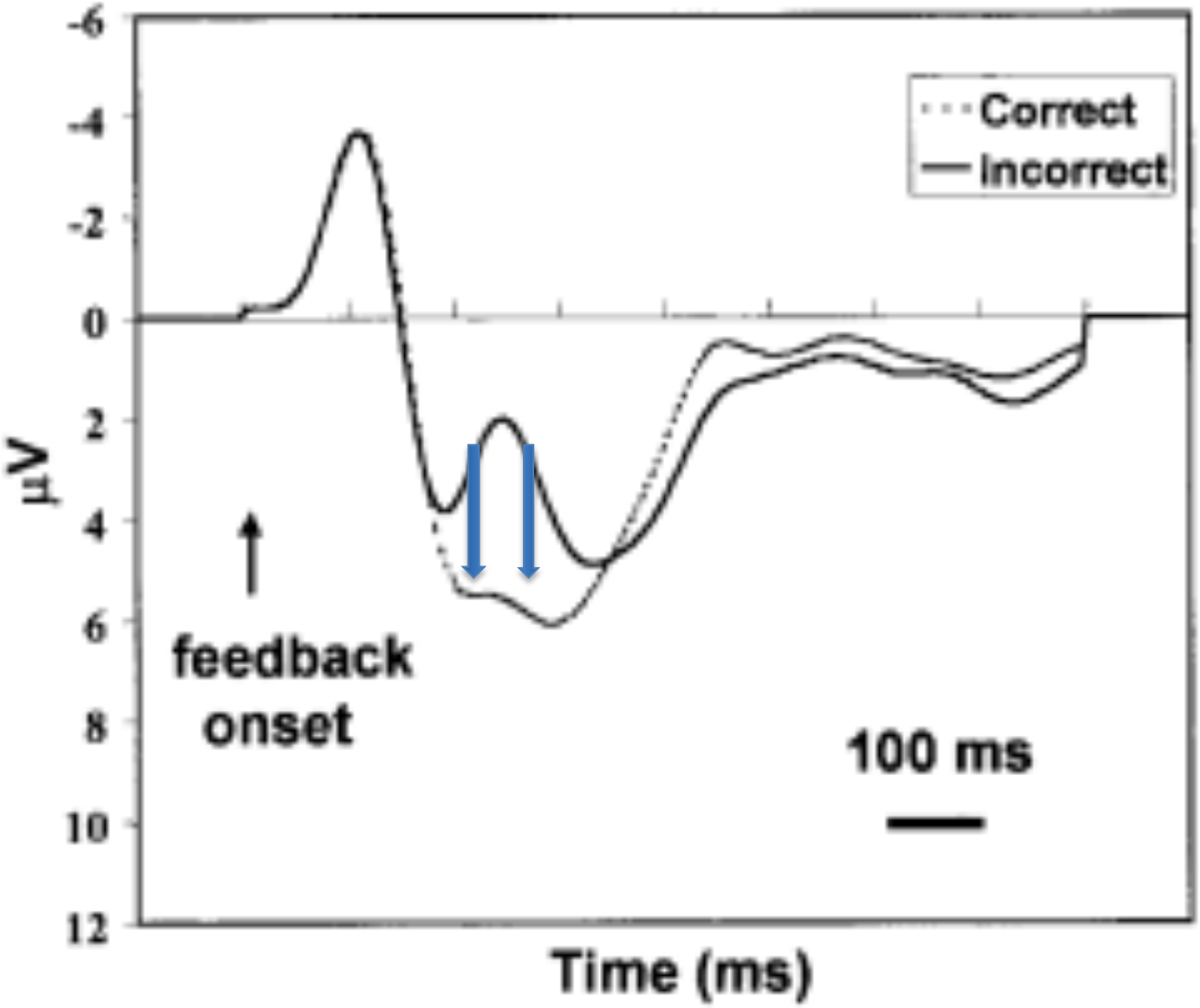


And what would happen here?



And what would happen here?

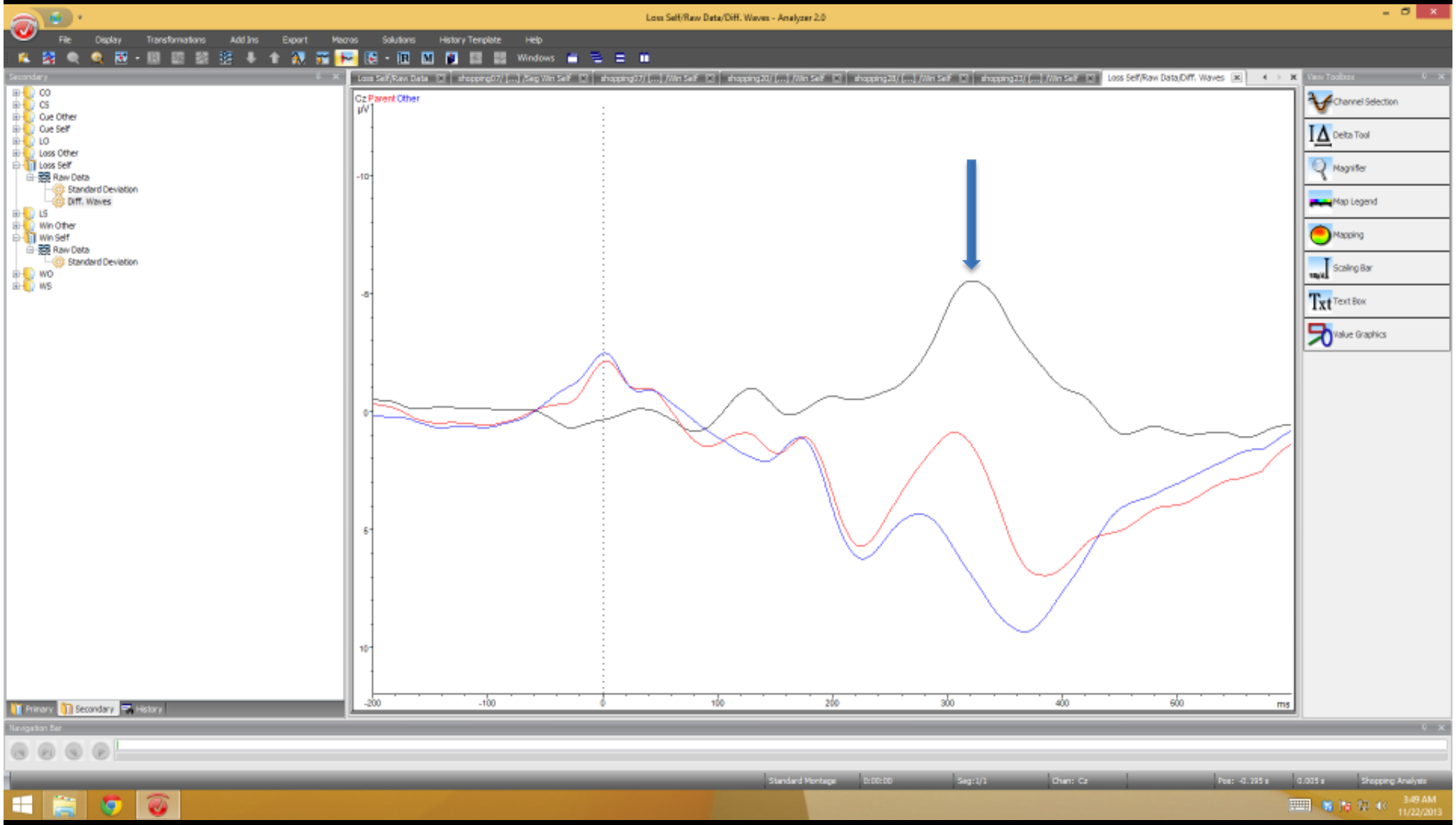

-6
-4
-2
0
2
4
6
8
10
12
μV
Correct
Incorrect
feedback
onset
100 ms
Time (ms)


-6
-4
-2
0
2
4
6
8
10
12
μV
Correct
Incorrect
feedback
onset
100 ms
Time (ms)

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.

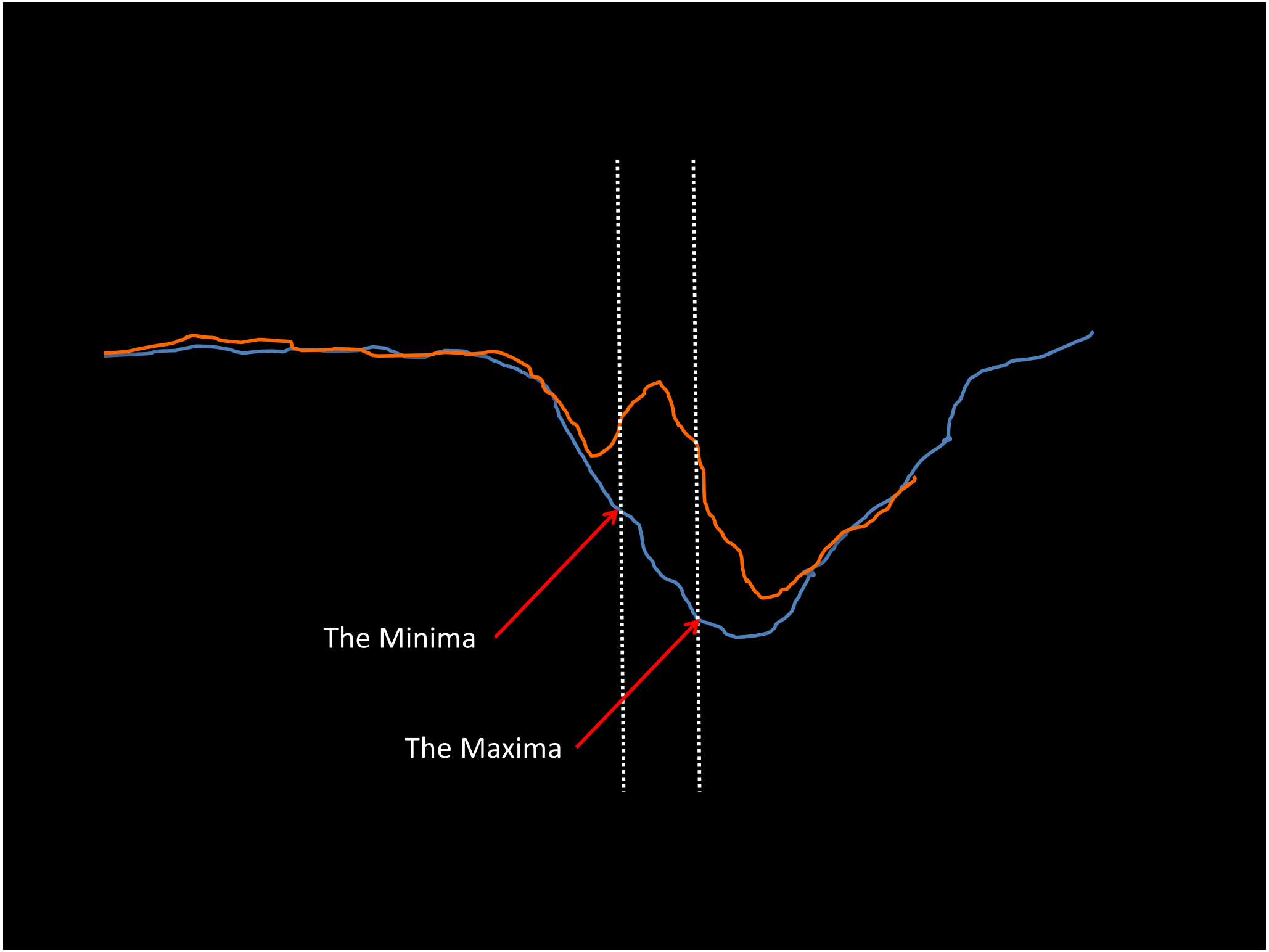
WINDOW WIDTH? Hard to have an absolute value. We can use prior research to guide us.

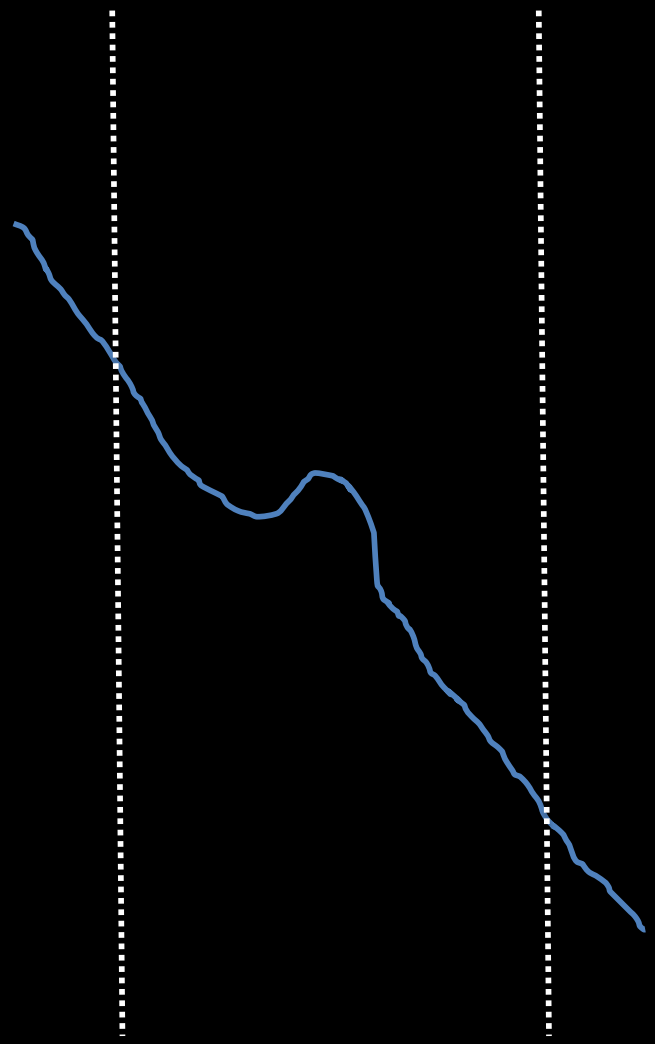
Peak Measures



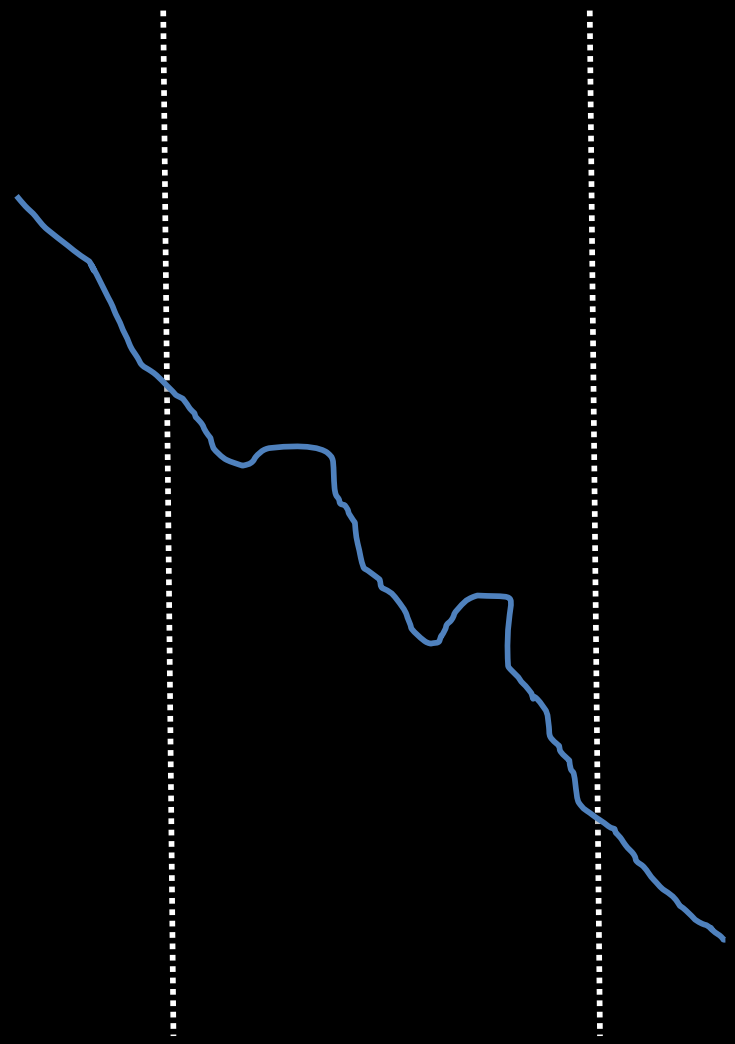
Simply put, we search for a maxima or a minima depending on the component.

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

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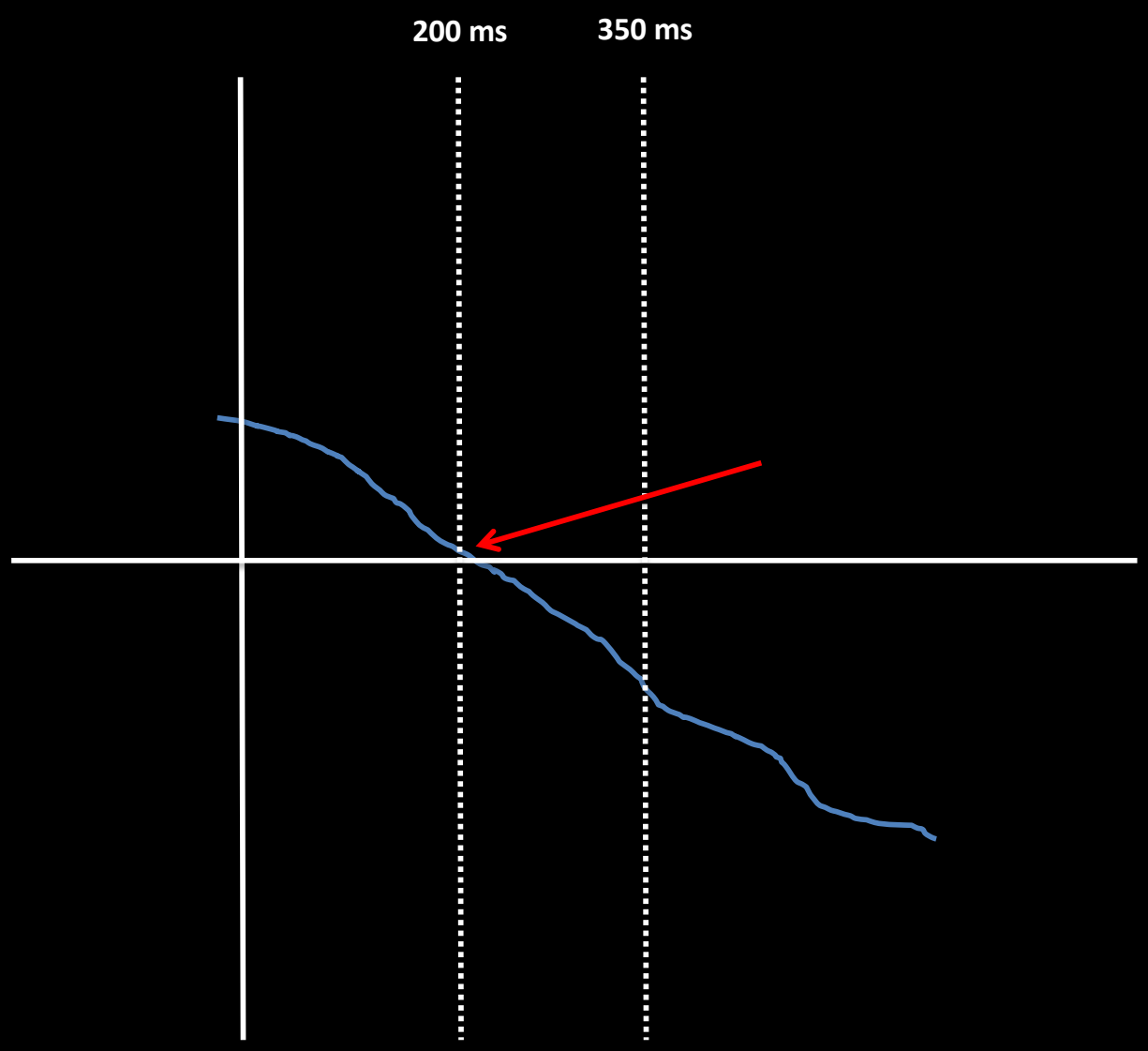
200 ms
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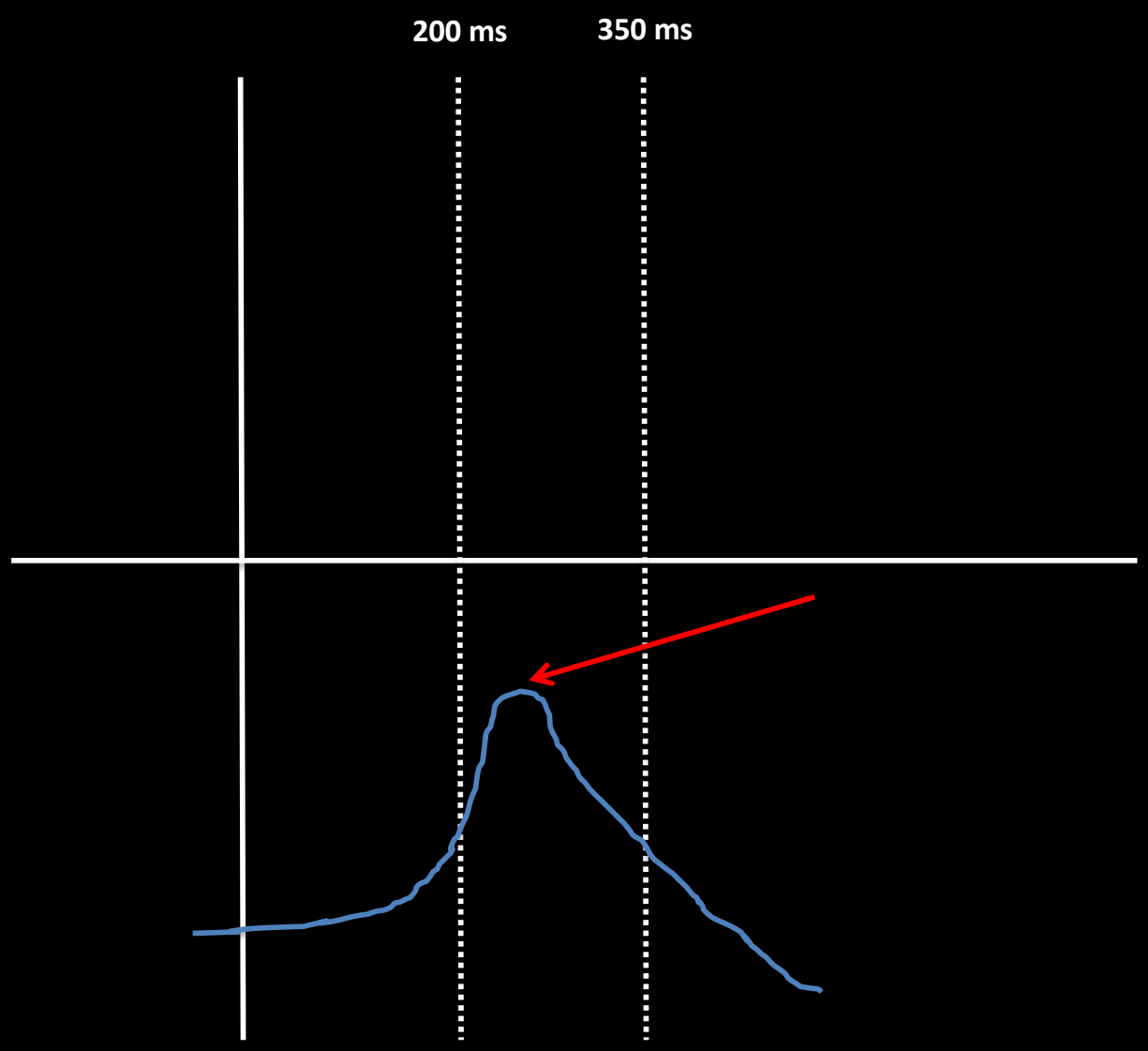
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350 ms

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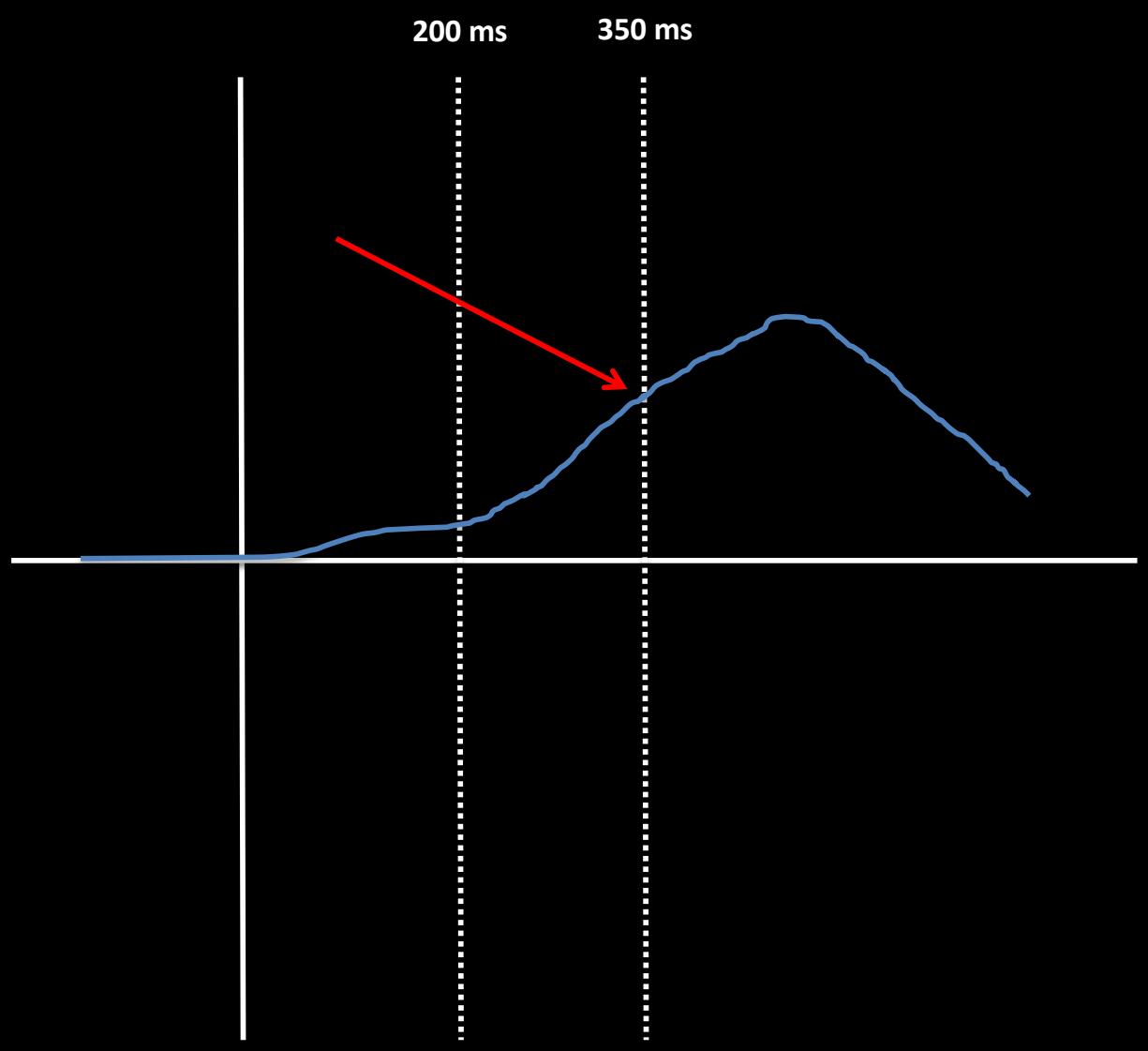
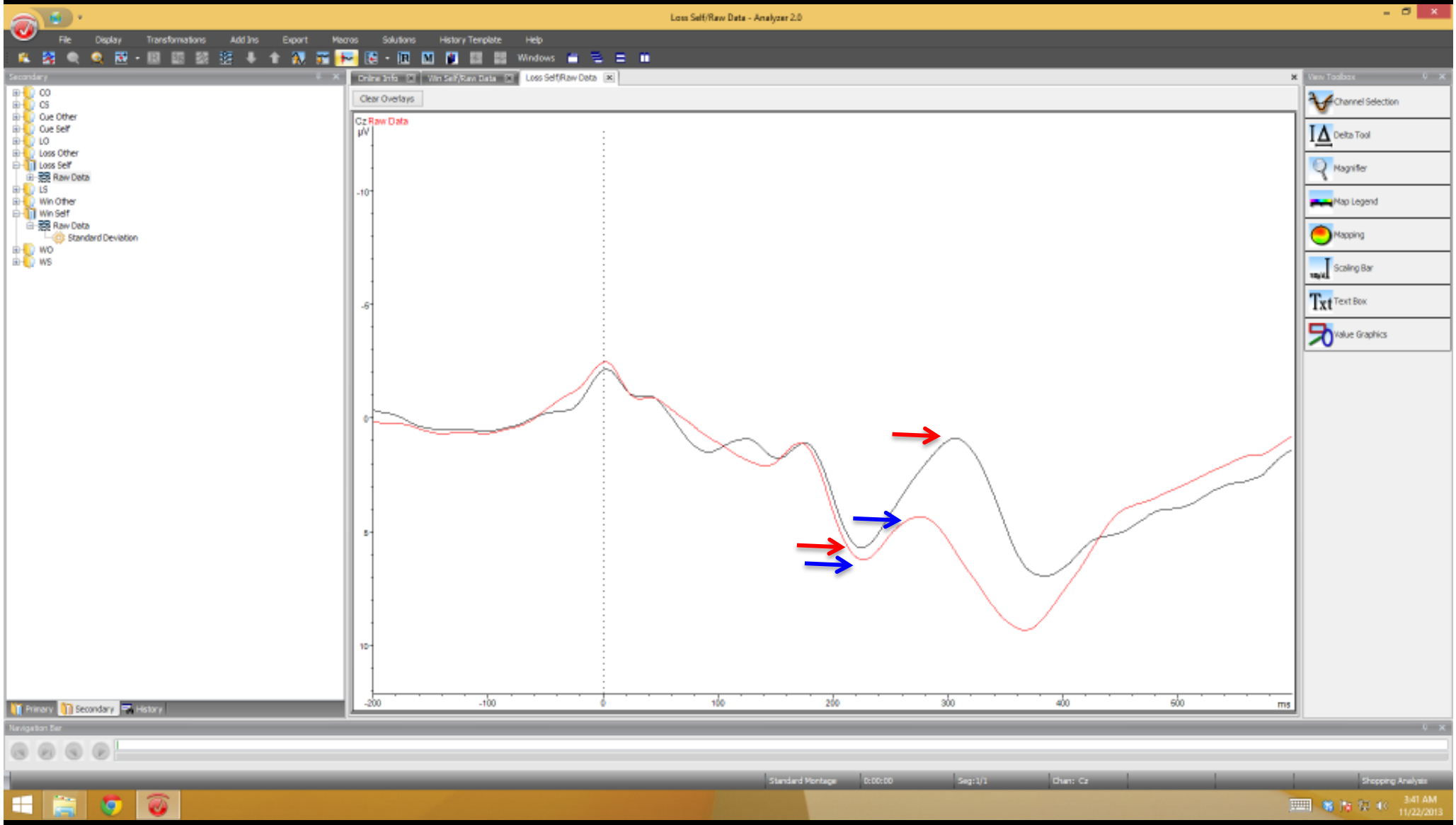

200 ms
350 ms

Peak Differences

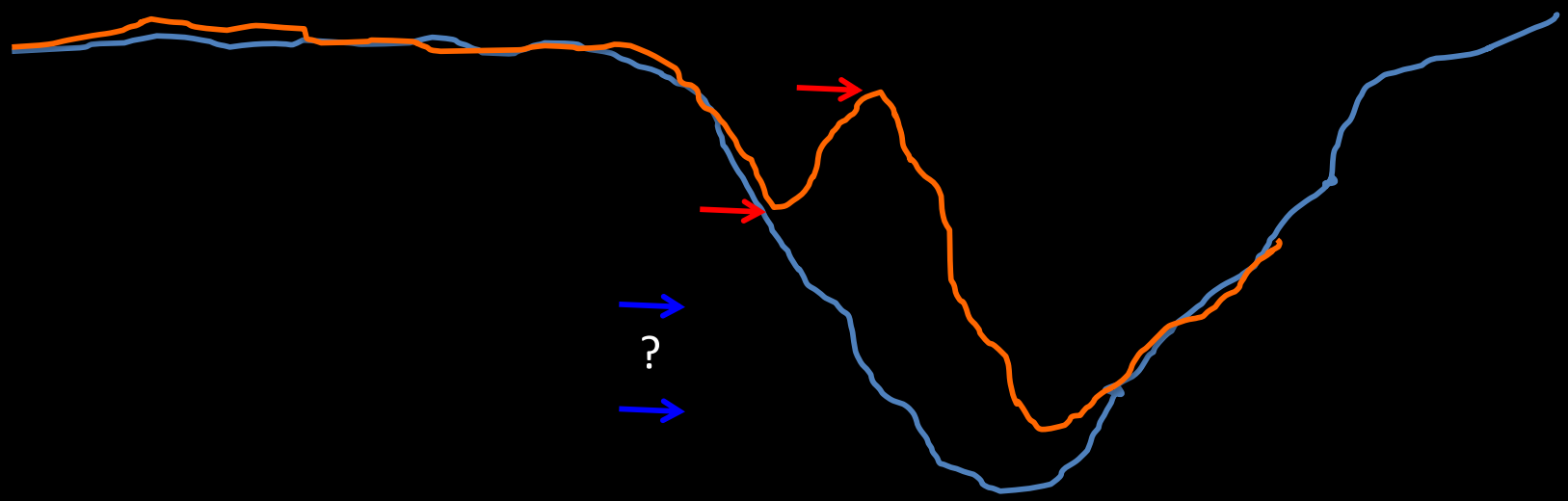
It should be worth noting there is nothing special about the peak amplitude difference.

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.

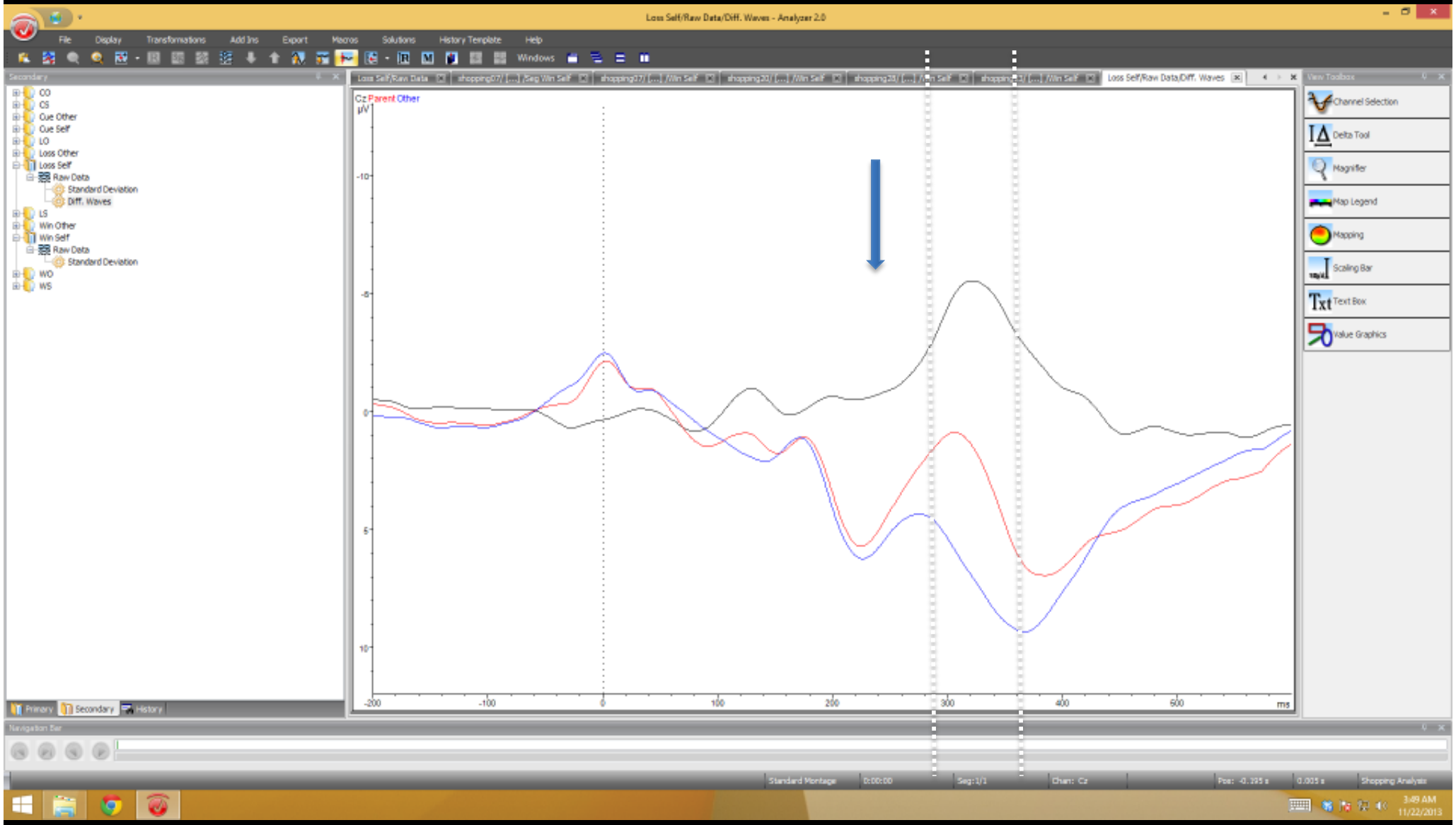
Base to Peak Measures



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).

DW/Raw Data - Analyzer 2.0

File Display Transformations Add Ins Export Macros Solutions History Template Help

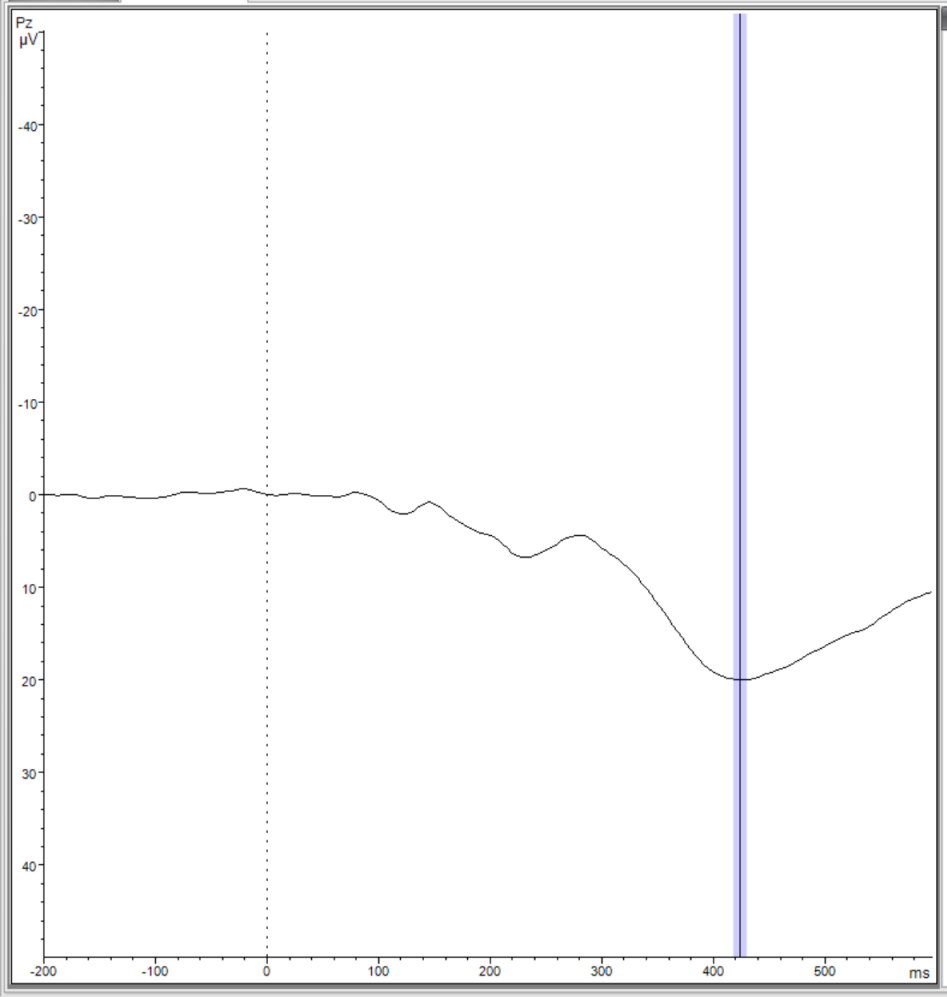
Windows

Secondary

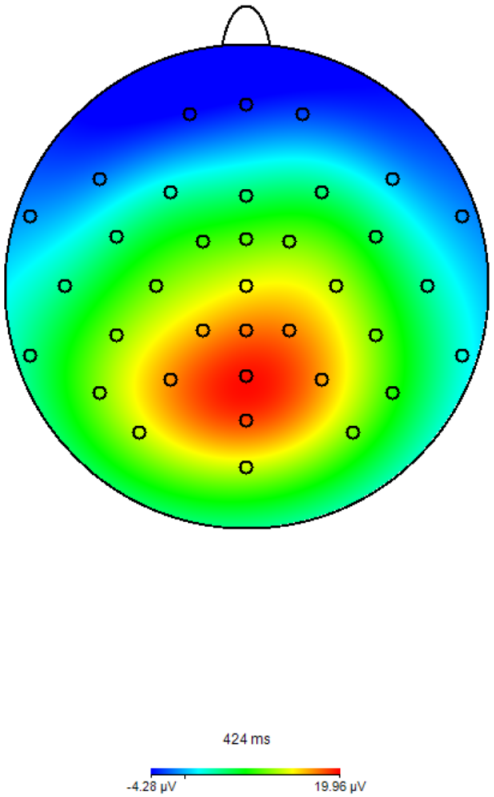
- DW
  - Raw Data
    - Generic Data Export
    - Generic Data Export 2
- Frequent
  - Raw Data
- Infrequent
  - Raw Data

Primary Secondary History

Online Info | DW/Raw Data



Mapping View



Navigation Bar

Standard Montage | 0:00:00 | Seg: 1/1 | Chan: Pz | Pos: -0.184 s | 0.016 s | Oddball

5:34 PM
12/10/2013

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

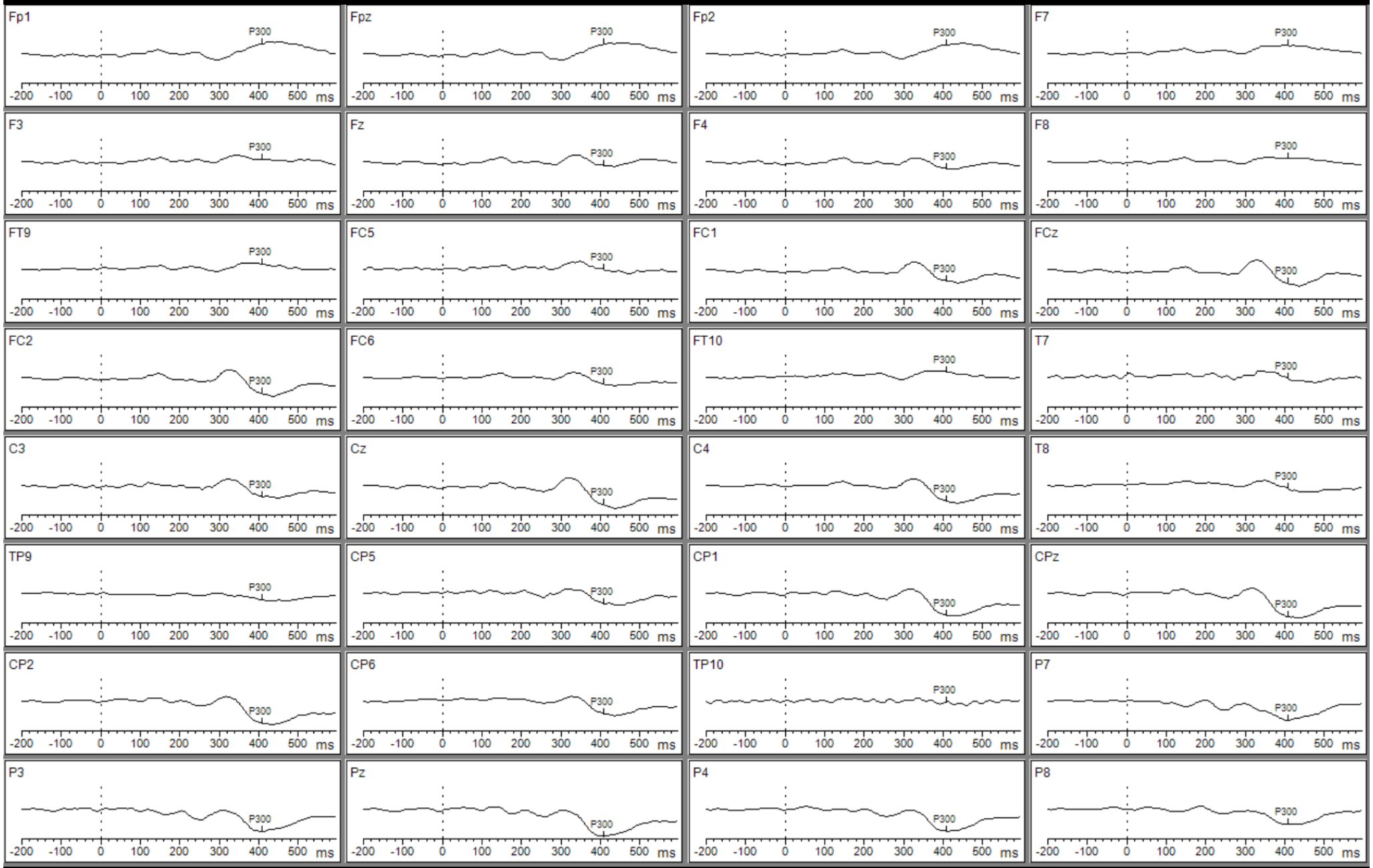
If you are going to use maximum or minimum values in your search, it is important to search on a specific channel based on the topography of the grand average waveform and/or previous literature.

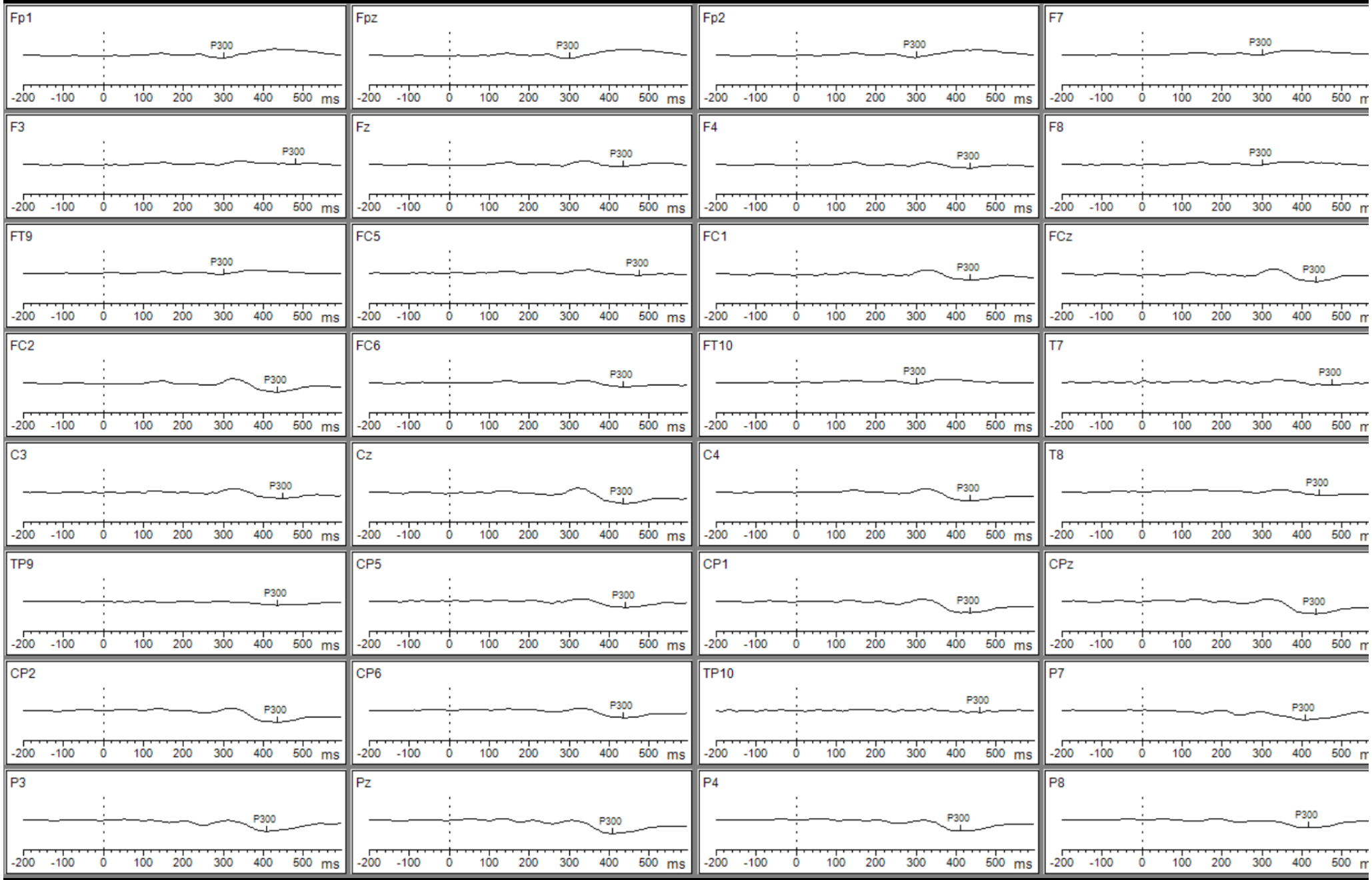
Example:

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)


Fp1
Fpz
Fp2
F7
F3
Fz
F4
F8
FT9
FC5
FC1
FCz
FC2
FC6
FT10
T7
C3
Cz
C4
T8
TP9
CP5
CP1
CPz
CP2
CP6
TP10
P7
P3
Pz
P4
P8
P300
-200 -100 0 100 200 300 400 500 ms


Fp1
Fpz
Fp2
F7
F3
Fz
F4
F8
FT9
FC5
FC1
FCz
FC2
FC6
FT10
T7
C3
Cz
C4
T8
TP9
CP5
CP1
CPz
CP2
CP6
TP10
P7
P3
Pz
P4
P8
P300
-200 -100 0 100 200 300 400 500 ms

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.

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

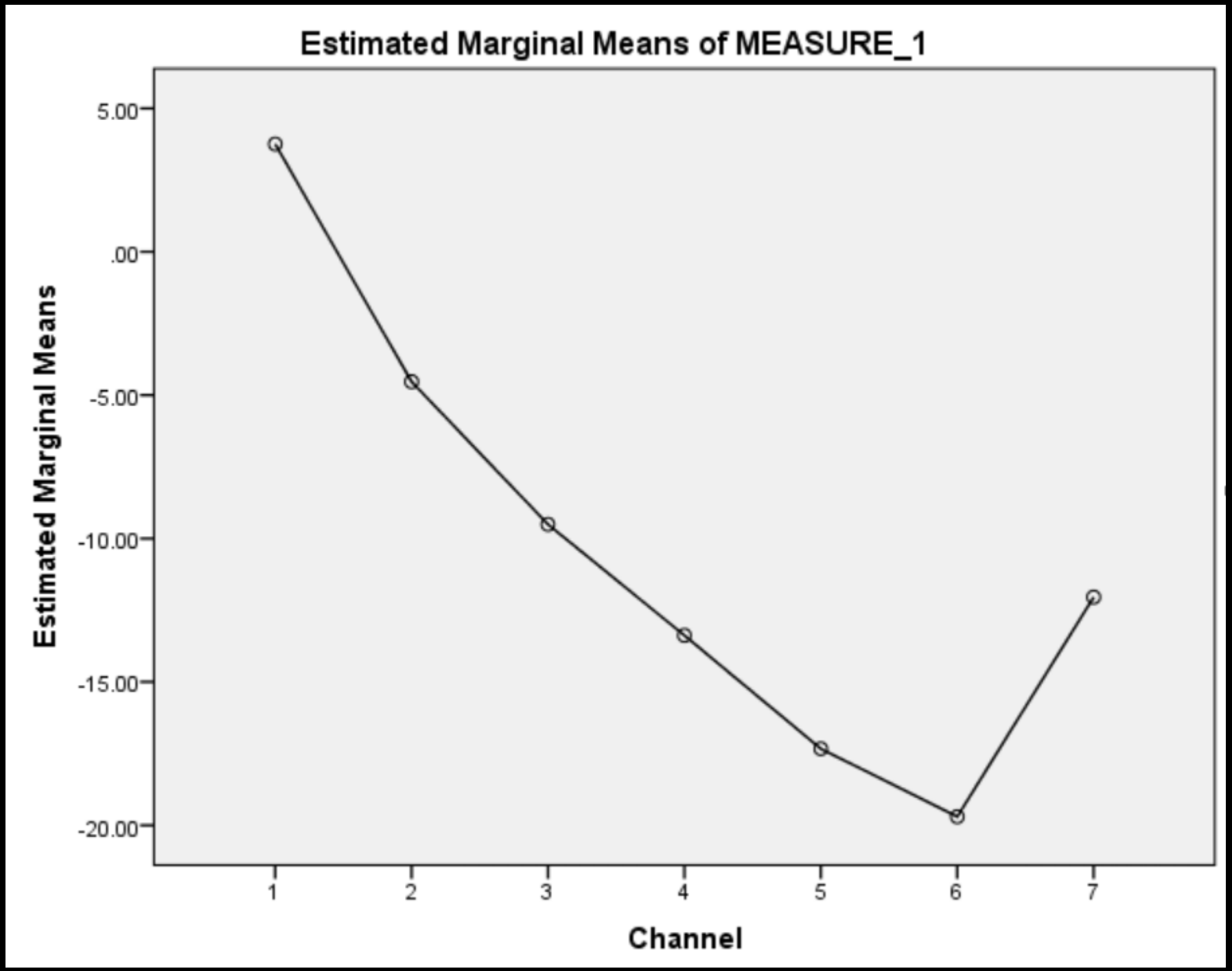
4. Trend Analysis

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
Estimated Marginal Means
5.00
.00
-5.00
-10.00
-15.00
-20.00
1
2
3
4
5
6
7
Channel