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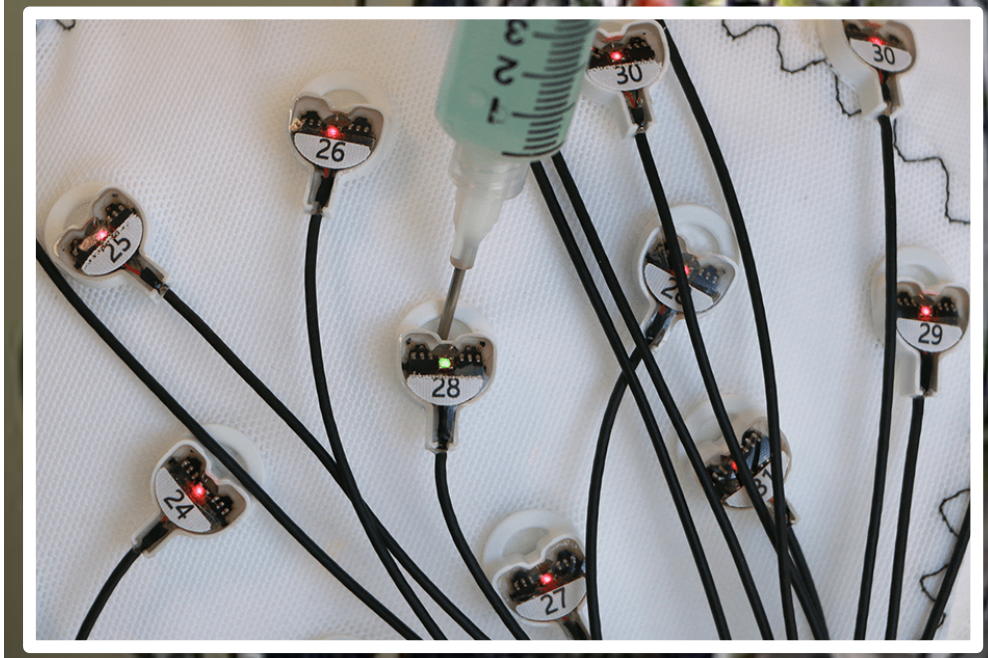
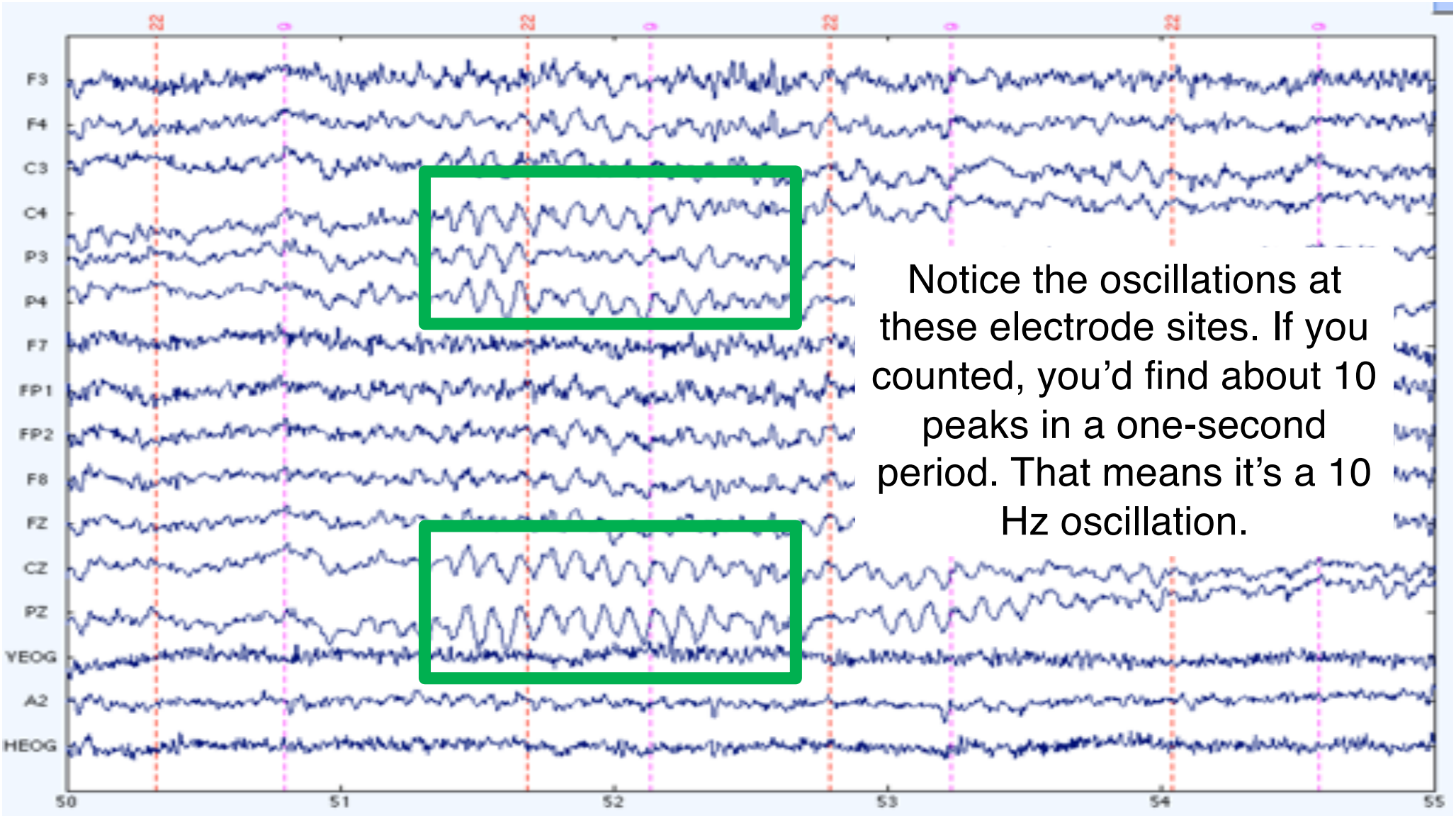
ERP Basics

The EEG

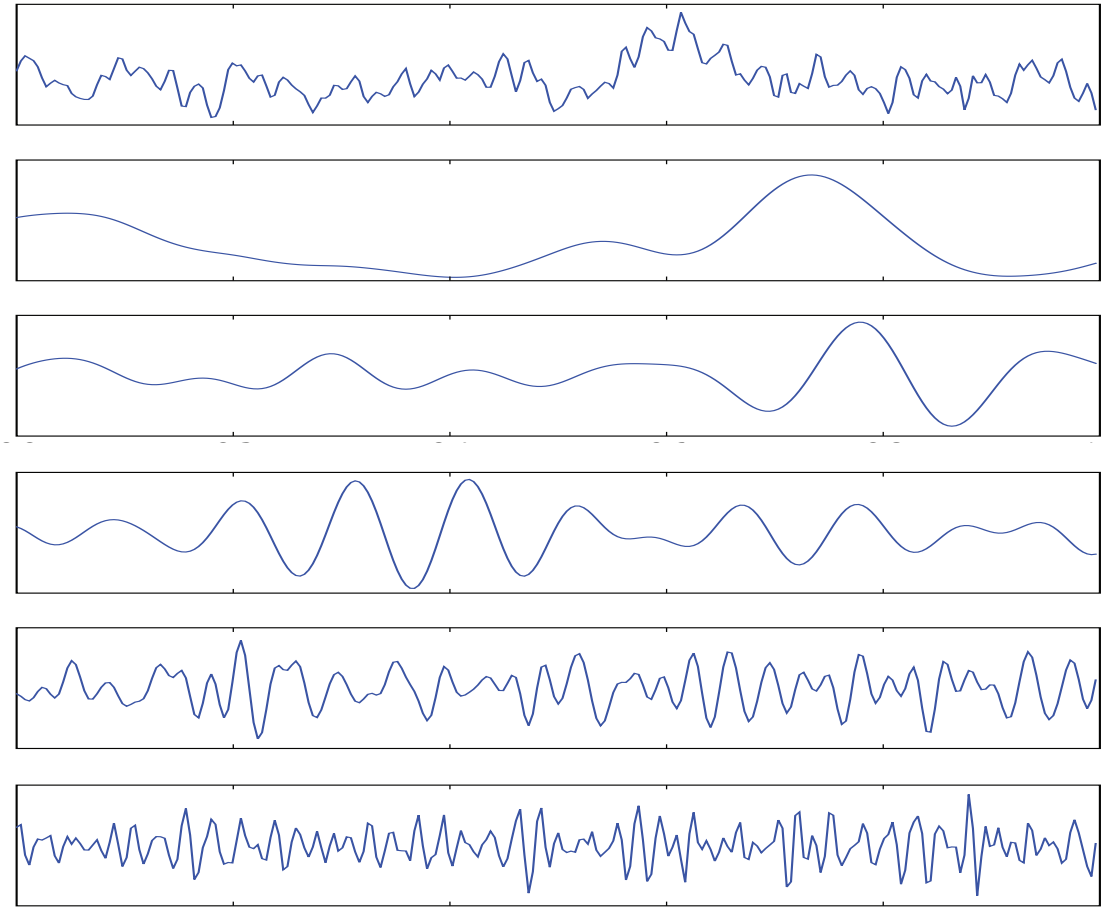
The Electroencephalogram (EEG)



The electrodes don't directly contact the skin. Instead, we squirt in a conductive gel that makes contact between the skin and the metal electrode pellet.


F3
F4
C3
C4
P3
P4
F7
FP1
FP2
F8
FZ
CZ
PZ
YEOG
A2
HEOG
50
51
52
53
54
55
Notice the oscillations at these electrode sites. If you counted, you'd find about 10 peaks in a one-second period. That means it's a 10 Hz oscillation.

Major EEG Bands



Slow-wave sleep

Not the same as hippocampal theta

Internal rather than external focus

Mentally active

Local communication

https://en.wikipedia.org/wiki/Eeg

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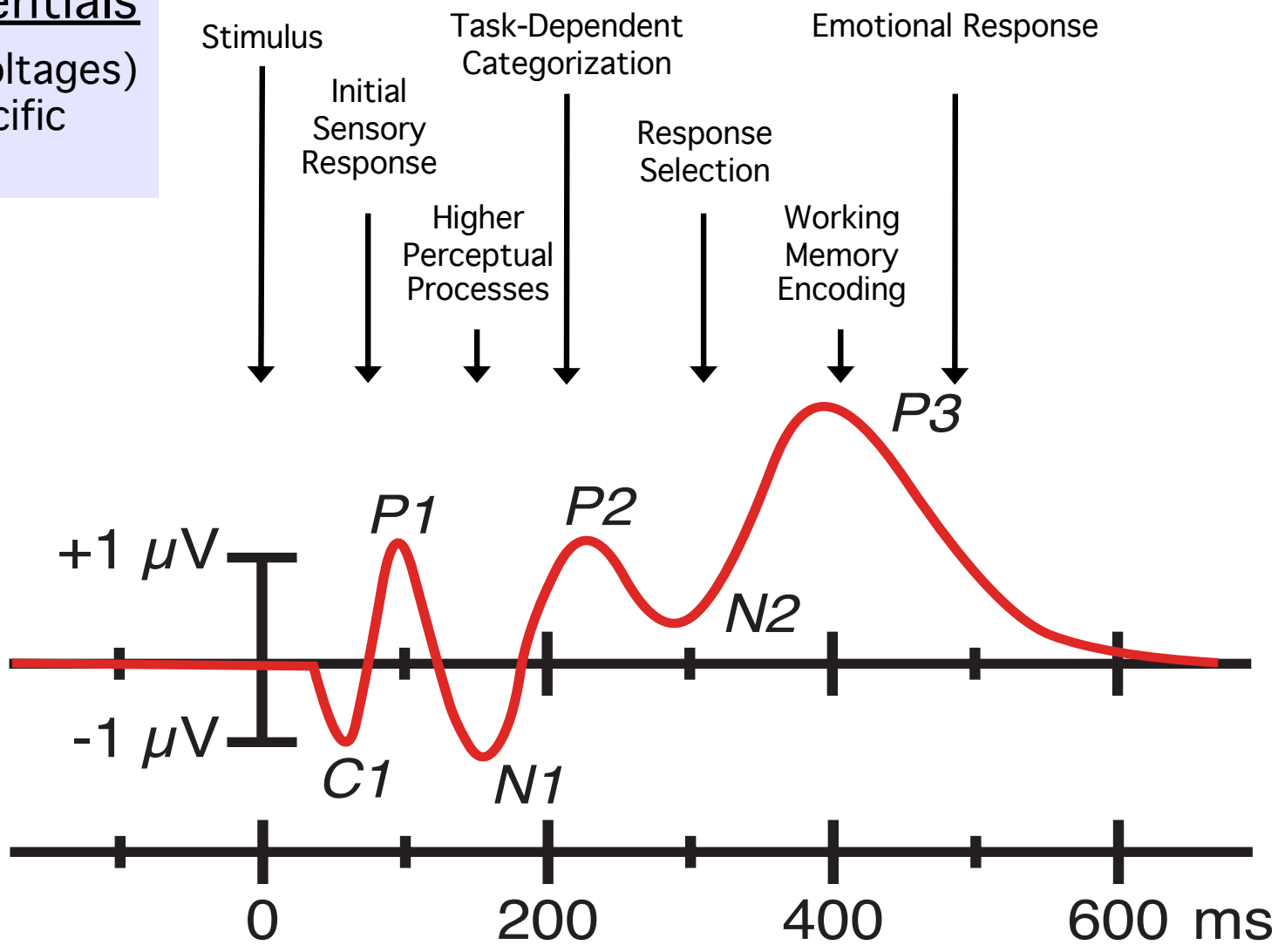
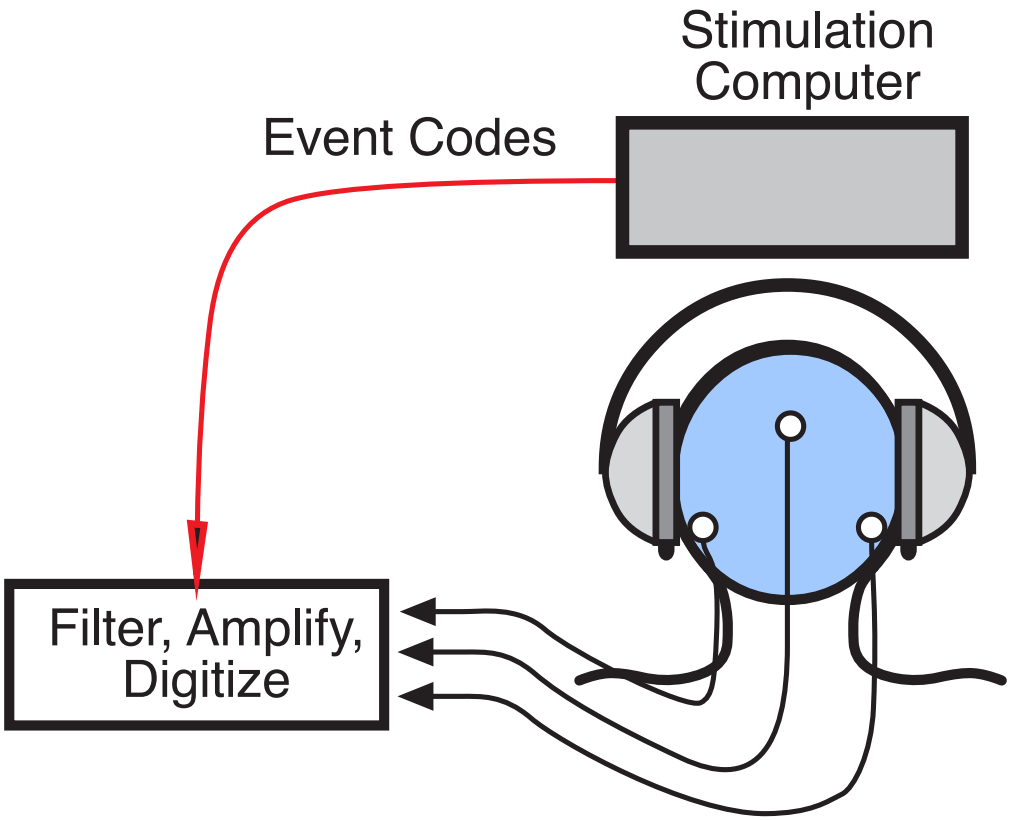
ERP Basics

Averaged ERPs

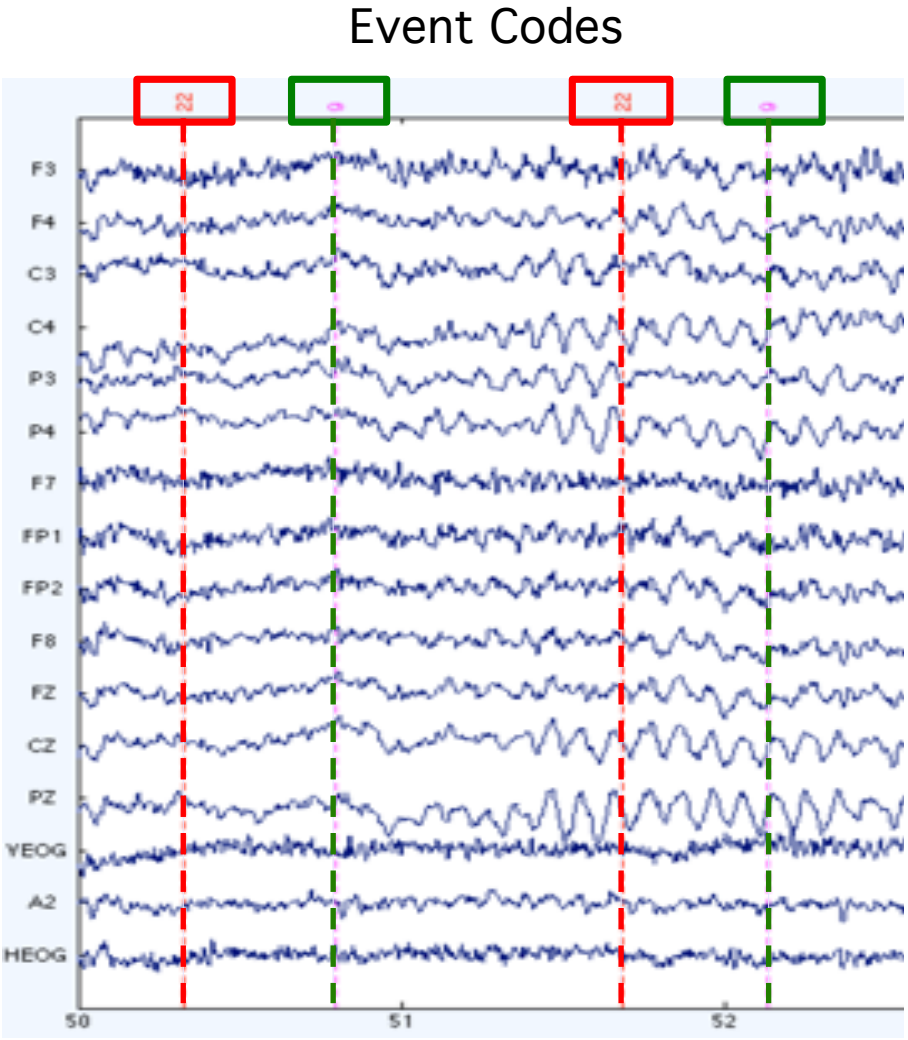
Event-Related Potentials

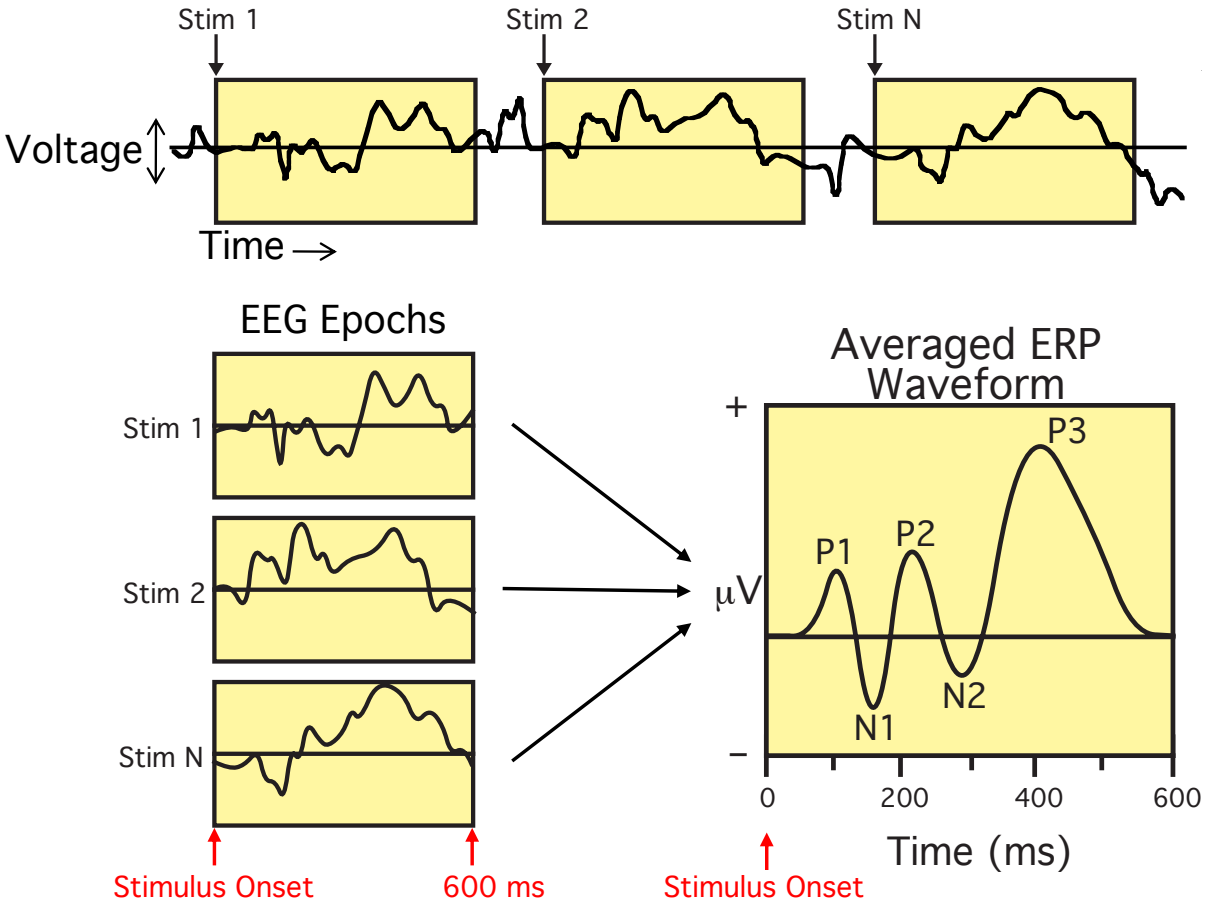
Electrical potentials (voltages) that are related to specific events





Most labs use two computers, one that presents the stimuli and records the responses, and another that records the EEG and event codes



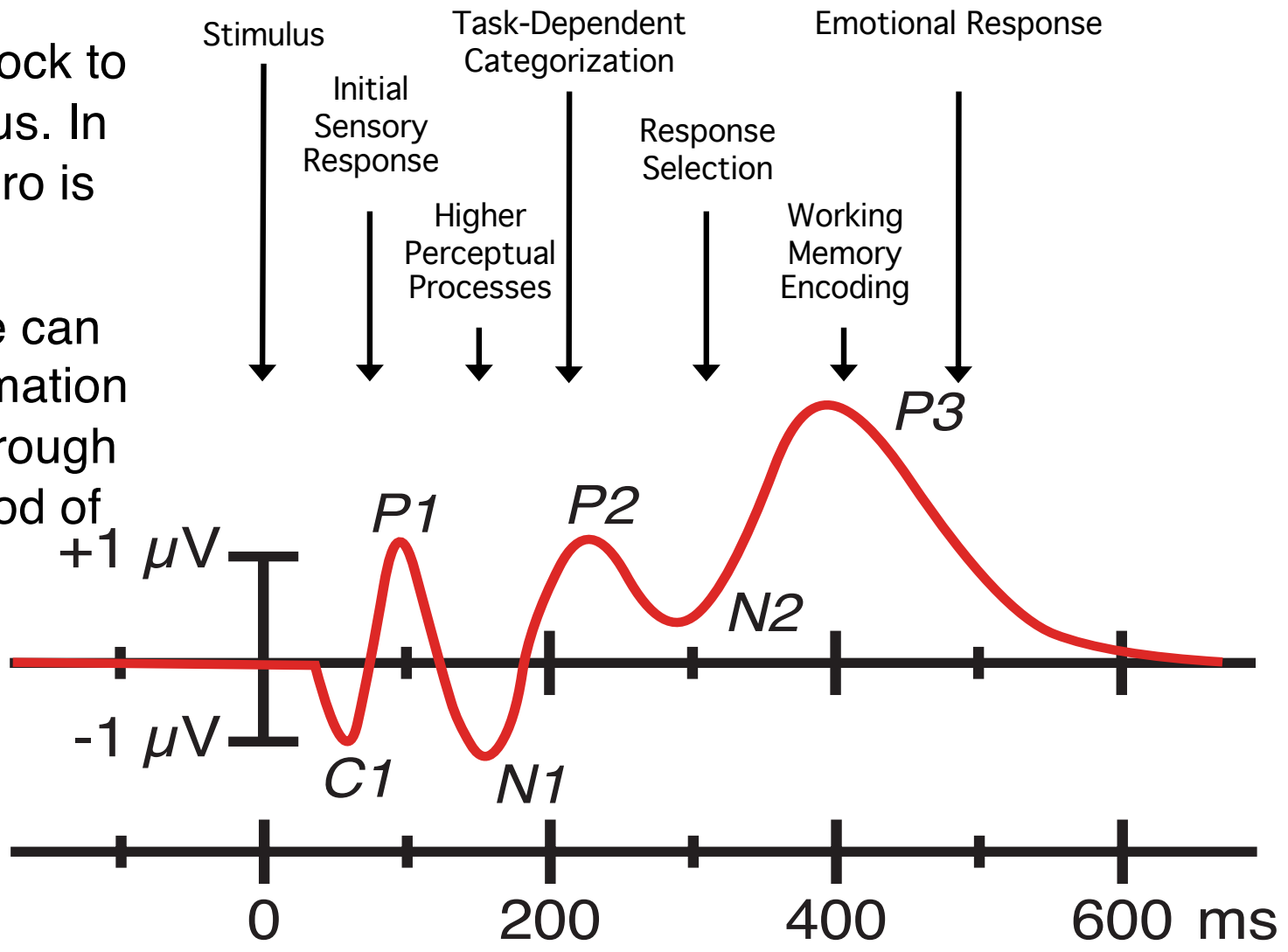


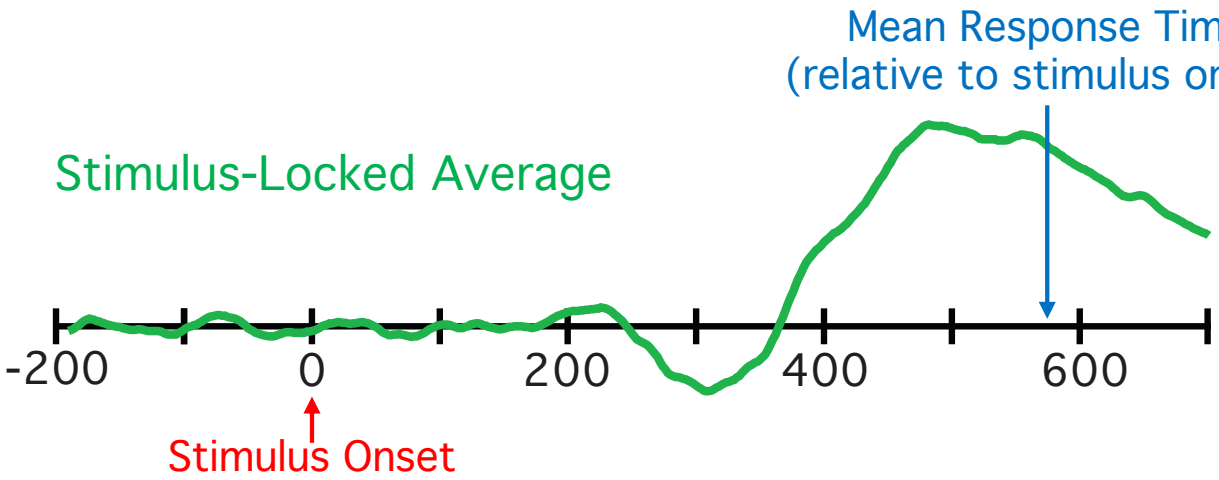
To pull out the brain's consist response to some type of event, we can simply average across the epochs for that event type.

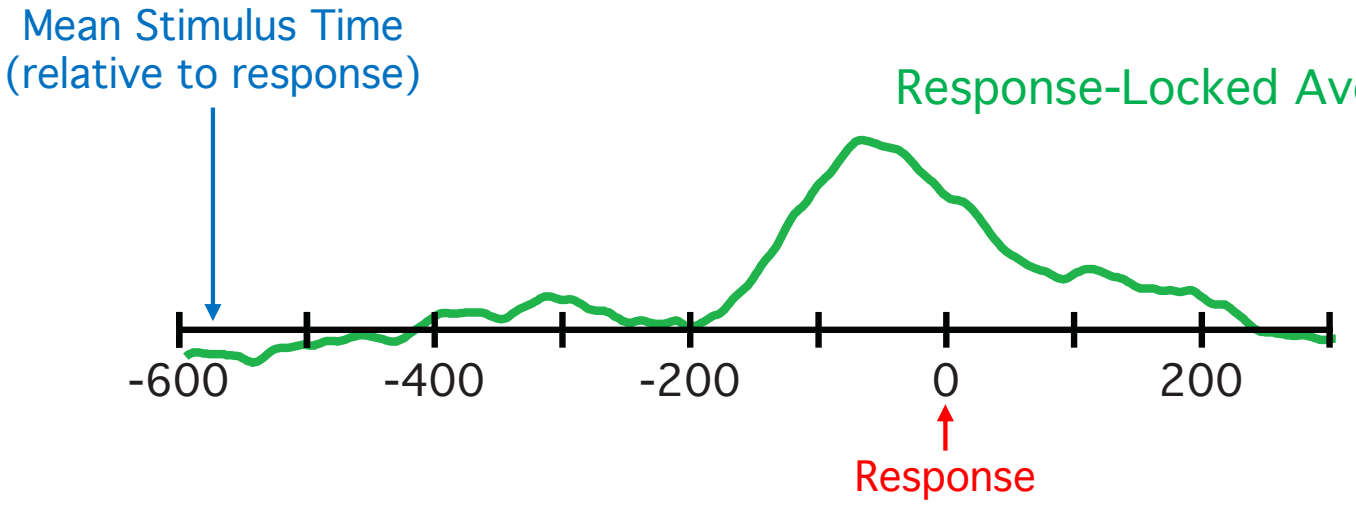
When we average across enough epochs, any activity that's consistent from trial to trial remains in the average, and any random noise simply averages out.

In a typical ERP experiment, we time-lock to the onset of a stimulus. In other words, time zero is stimulus onset.

When we do this, we can track the flow of information about the stimulus through the brain over a period of several hundred milliseconds.







Although most researchers focus on stimulus-locked averages, where time zero is stimulus onset, you can instead time-lock to the response.

This gives you a response-locked average.

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ERP Basics

Example: The N170 Component and Perceptual Experience

PSYCHOLOGICAL SCIENCE

Research Article

A NEURAL BASIS FOR EXPERT OBJECT RECOGNITION

James W. Tanaka[1] and Tim Curran[2]

[1]Oberlin College and [2]Case Western Reserve University

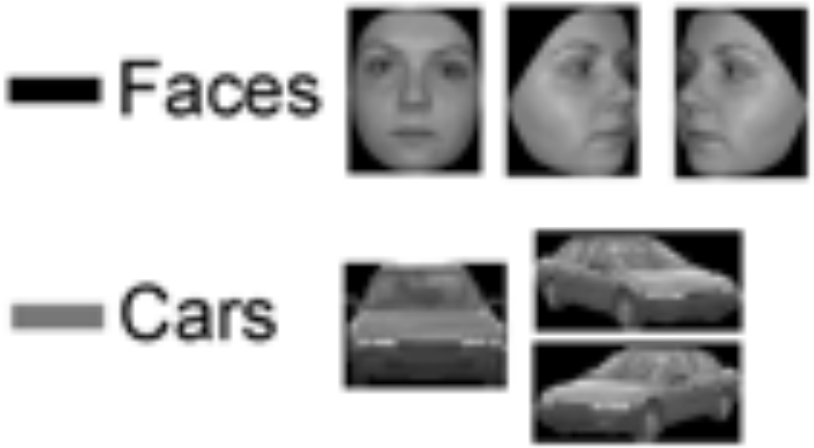
Abstract—*Although most adults are considered to be experts in the identification of faces, fewer people specialize in the recognition of other objects, such as birds and dogs. In this research, the neurophysiological processes associated with expert bird and dog recognition were investigated using event-related potentials. An enhanced early negative component (N170, 164 ms) was found when bird and dog experts categorized objects in their domain of expertise relative to when they categorized objects outside their domain of expertise. This finding indicates that objects from well-learned categories are neurologically differentiated from objects from lesser-known categories at a relatively early stage of visual processing.*

expertise by monitoring brain wave activity of bird and dog experts while they categorized pictures of common birds and dogs. The experiment was designed so that participants served as their own experimental controls in that they were expected to perform as experts when categorizing objects in their domain of expertise (e.g., bird experts categorizing birds) and novices when categorizing objects outside their domain of expertise (e.g., bird experts categorizing dogs). We expected that if the increased N170 reflects a general form of expert processing that is not unique to faces, experts would exhibit an enhanced N170 when categorizing objects in their domain of expertise relative to when they categorized objects outside their domain of expertise.

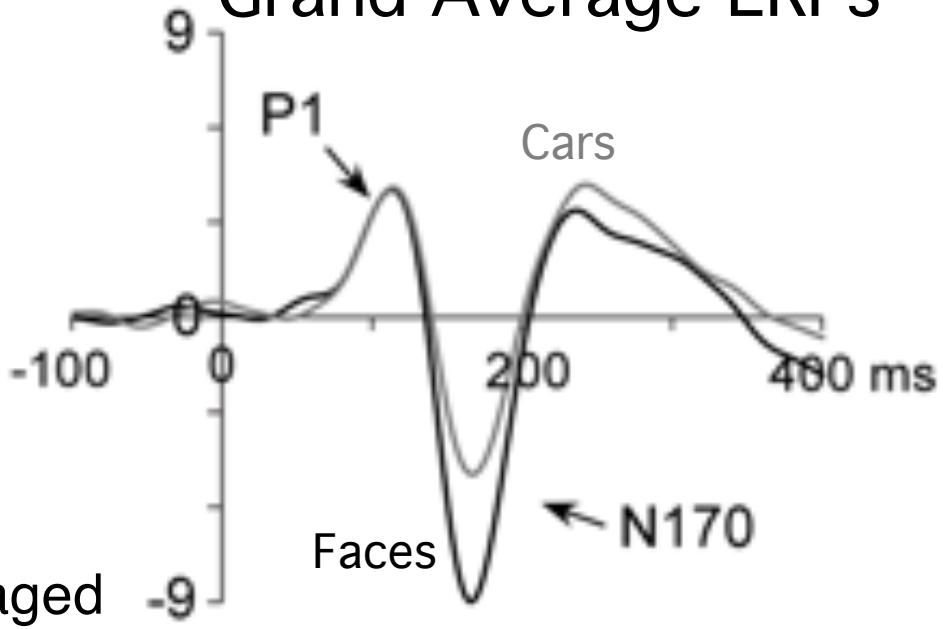
Tanaka, J. W., & Curran, T. (2001). A neural basis for expert object recognition. *Psychological Science*, *12*, 43–47.

N170 and Face Processing

Stimuli



Grand Average ERPs



The waveforms shown here are averaged across all the subjects – we call these grand averages.

The N170 wave was much bigger for the faces than for the cars.

Rossion & Jacques (2012)

Is face perception special?

Do we have domain-specific neural systems that are solely used for face perception? That might explain why inverting an image has a larger impact on the perceptibility of faces than on other sorts of objects. But maybe these effects are a consequence of the fact that virtually all humans have a lifetime of expertise in perceiving faces.

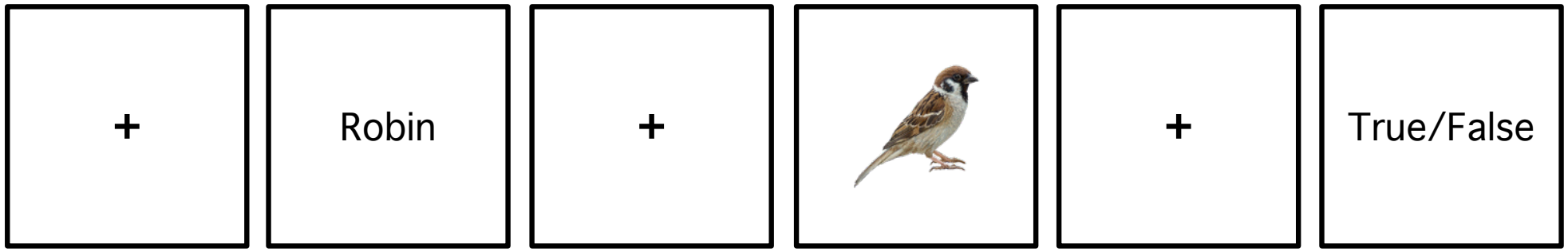
Is face perception special?

Or do we use the same processes for all stimuli that we're experts at perceiving?

Paradigm and Predicted Results

	Bird Experts	Dog Experts
Bird Stimuli	Large N170	Small N170
Dog Stimuli	Small N170	Large N170

Factor 1: Expertise of participant (Bird vs. Dog)
Factor 2: Stimulus type (Bird vs. Dog)



Fixation
1000-1500 ms

Category Name
255 ms

Fixation
570 ms

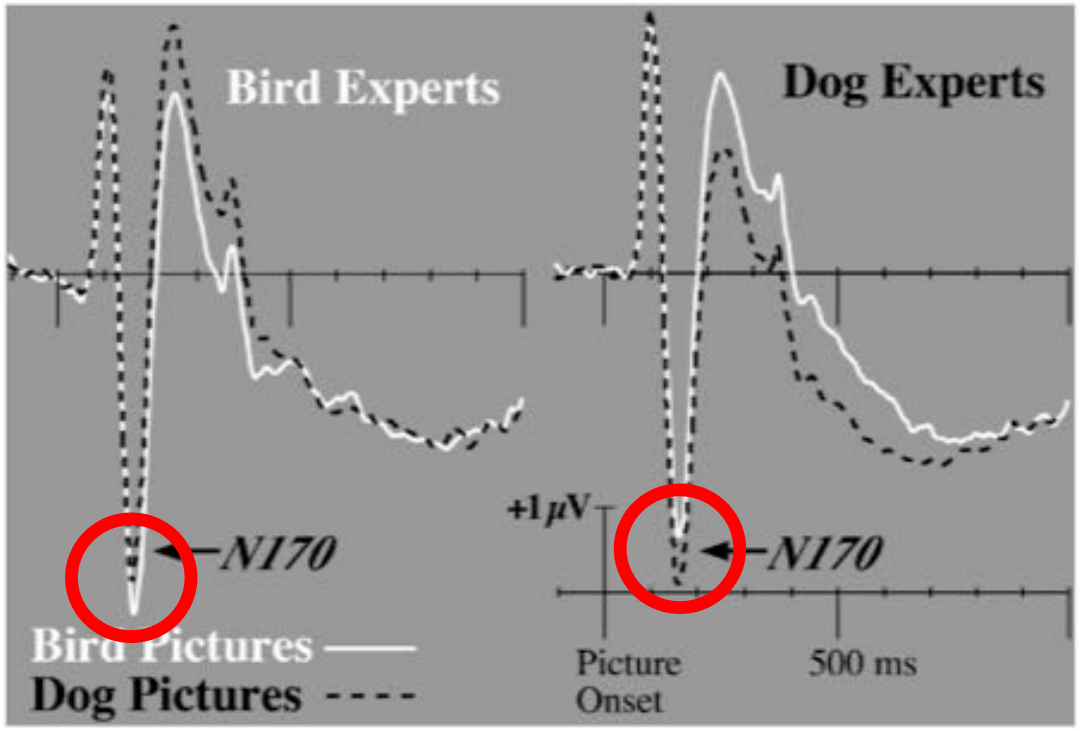
Picture
255 ms

Fixation
735 ms

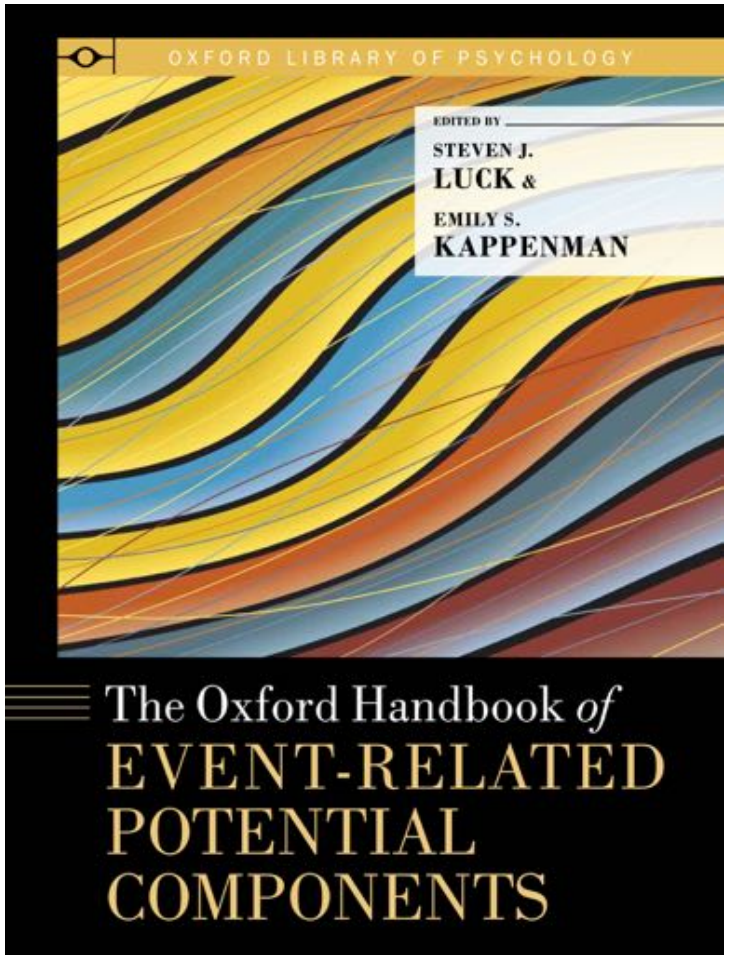
Response
???

The N170 was larger for bird pictures than for dog pictures in the bird experts. But N170 was larger for dog pictures than for bird pictures in the dog experts.

This is consistent with the idea that face perception is achieved by a set of general-purpose processes that are not face specific but depend on expertise.



Tanaka & Curran (2001)



CHAPTER 5

The N170: Understanding the Time Course of Face Perception in the Human Brain

Bruno Rossion *and* Corentin Jacques

Abstract

This chapter reviews the contribution of electromagnetic measures, mostly event-related potentials (ERPs), to our understanding of the time course of face processing in the normal adult brain, with a focus on the 100–200 ms time window after stimulus onset, that is, during during the occipitotemporal component termed the N170. It first describes the N170 component, how it can be defined, and its relationship to the vertex positive potential (VPP) response to faces that was reported prior to the N170 in the literature. It then addresses the question of the origin of the largest N170 to faces in terms of electroencephalographic (EEG) signal, neural sources, and functional processes that lead to this effect. It also discusses the controversial issue of whether the N170 reflects underlying processes that can be at least partly recruited for processing nonface objects following extensive visual experience with these objects. The chapter summarizes the evidence showing that the N170 reflects both the initial basic-level categorization of the stimulus as a face through the activation of neural face representations and the coding of individual face representations. It then briefly discusses why the N170 may be a critical time window for other types of face categorizations before summarizing the chapter and addressing the question of how the N170 can be taken as a tool to clarify the dynamics and the nature of early face processes in future research.

Keywords: event-related potential, N170, face perception, perceptual processing, occipito-temporal component

Rossion, B., & Jacques, C. (2012). The N170: Understanding the time course of face perception in the human brain. In S. J. Luck & E. S. Kappenman (Eds.), *The Oxford Handbook of ERP Components* (pp. 115–141). Oxford University Press.

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ERP Basics

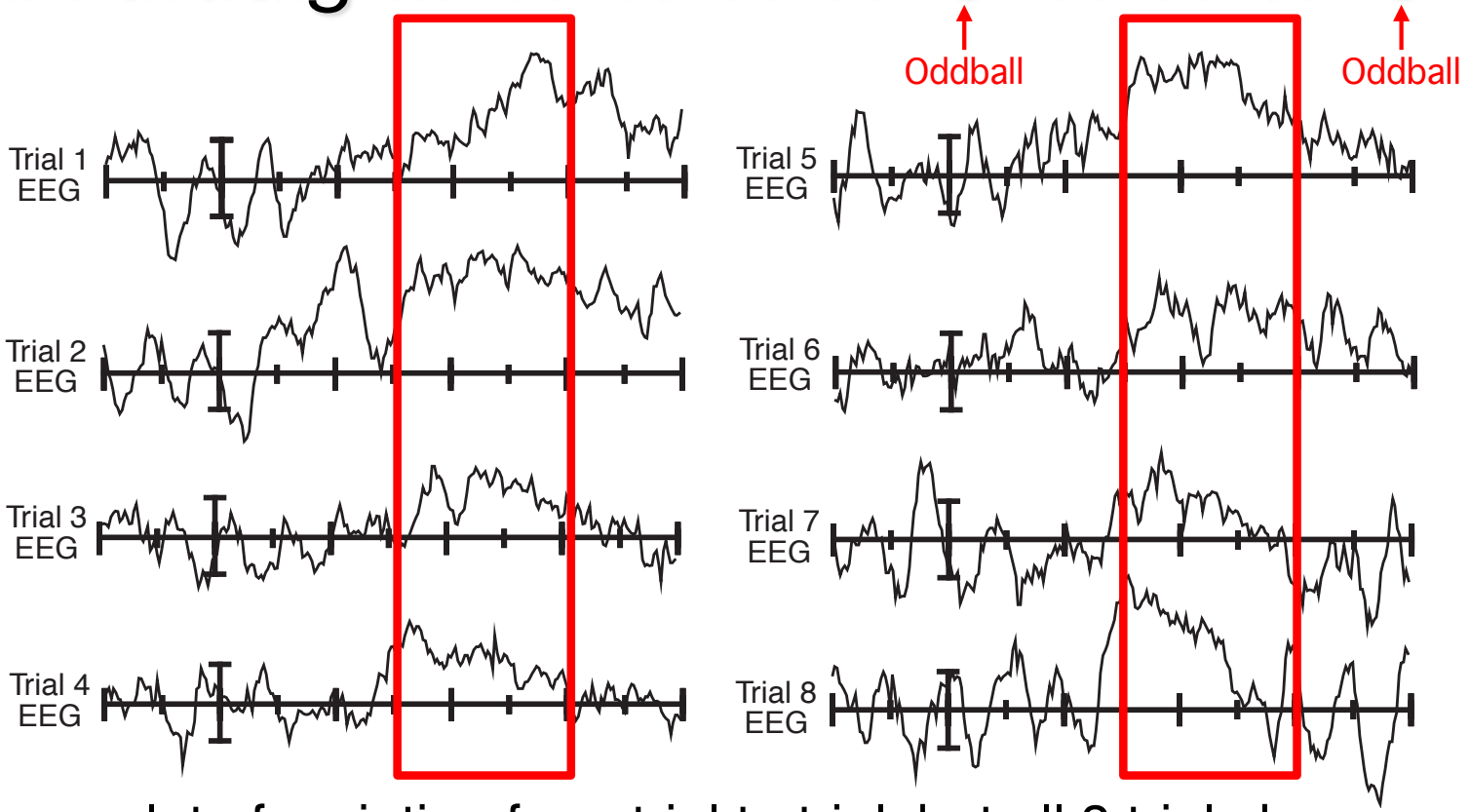
Signal-to-Noise Ratio

How many trials do you need to average together?

IT DEPENDS

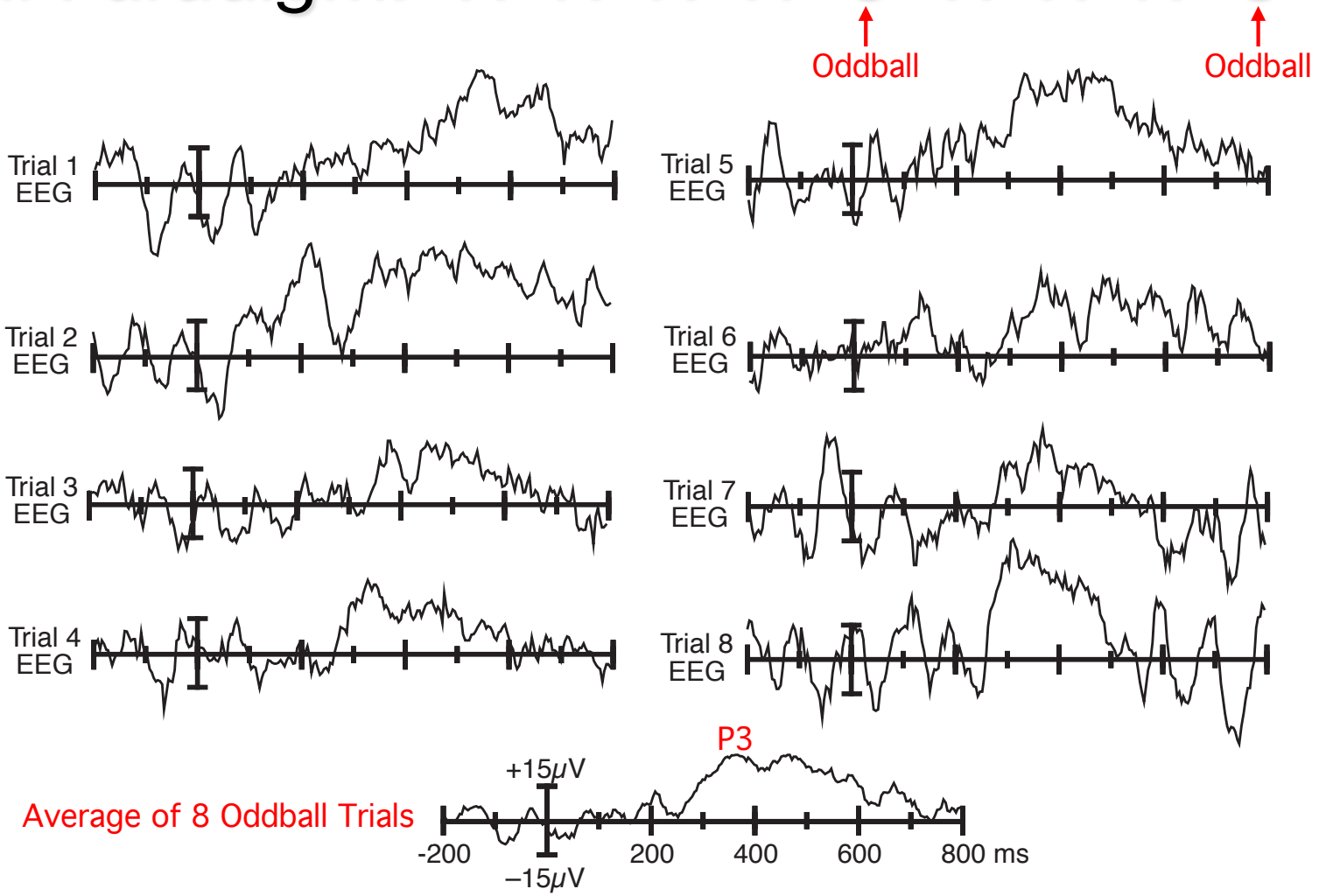
on the size of the signal relative to the size of the noise
(the signal-to-noise ratio [SNR])

Oddball Paradigm: X X X X O X X X O X X

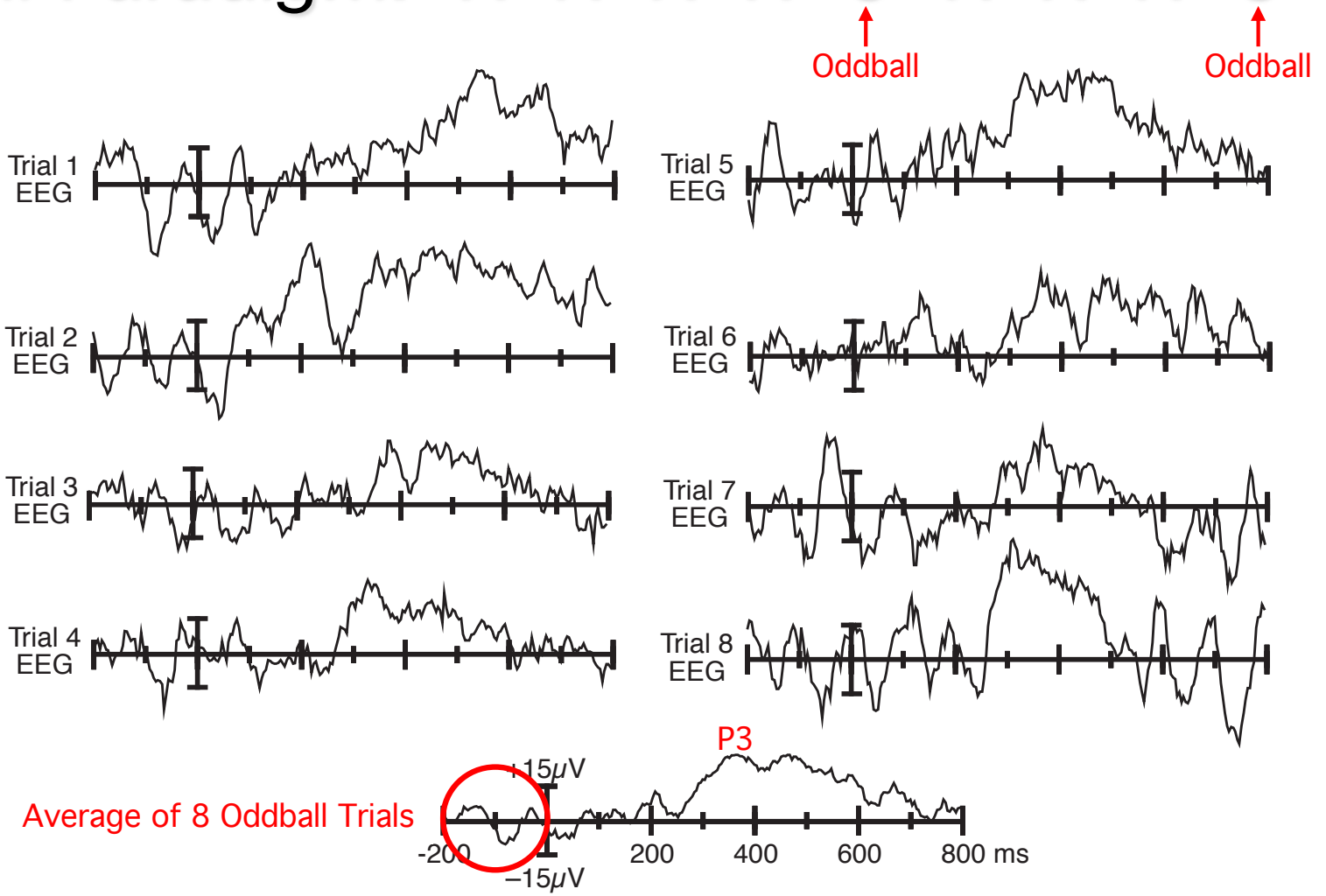


You can see a lot of variation from trial to trial, but all 8 trials have a positive voltage from approximately 300 to 600 ms. That's the P3 wave, which is a very large positive component that you get for oddballs in this paradigm.

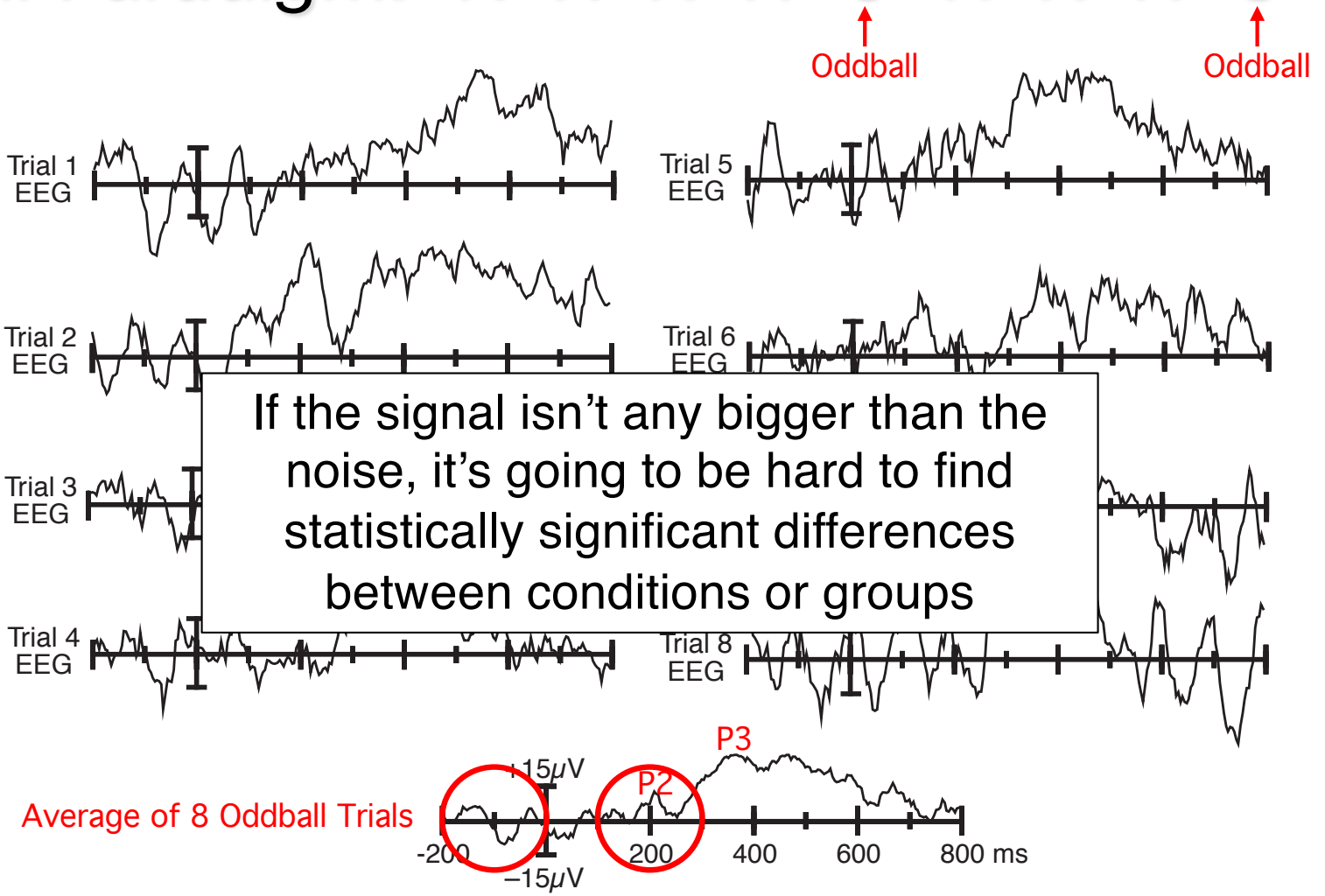
Oddball Paradigm: X X X X O X X X O X X



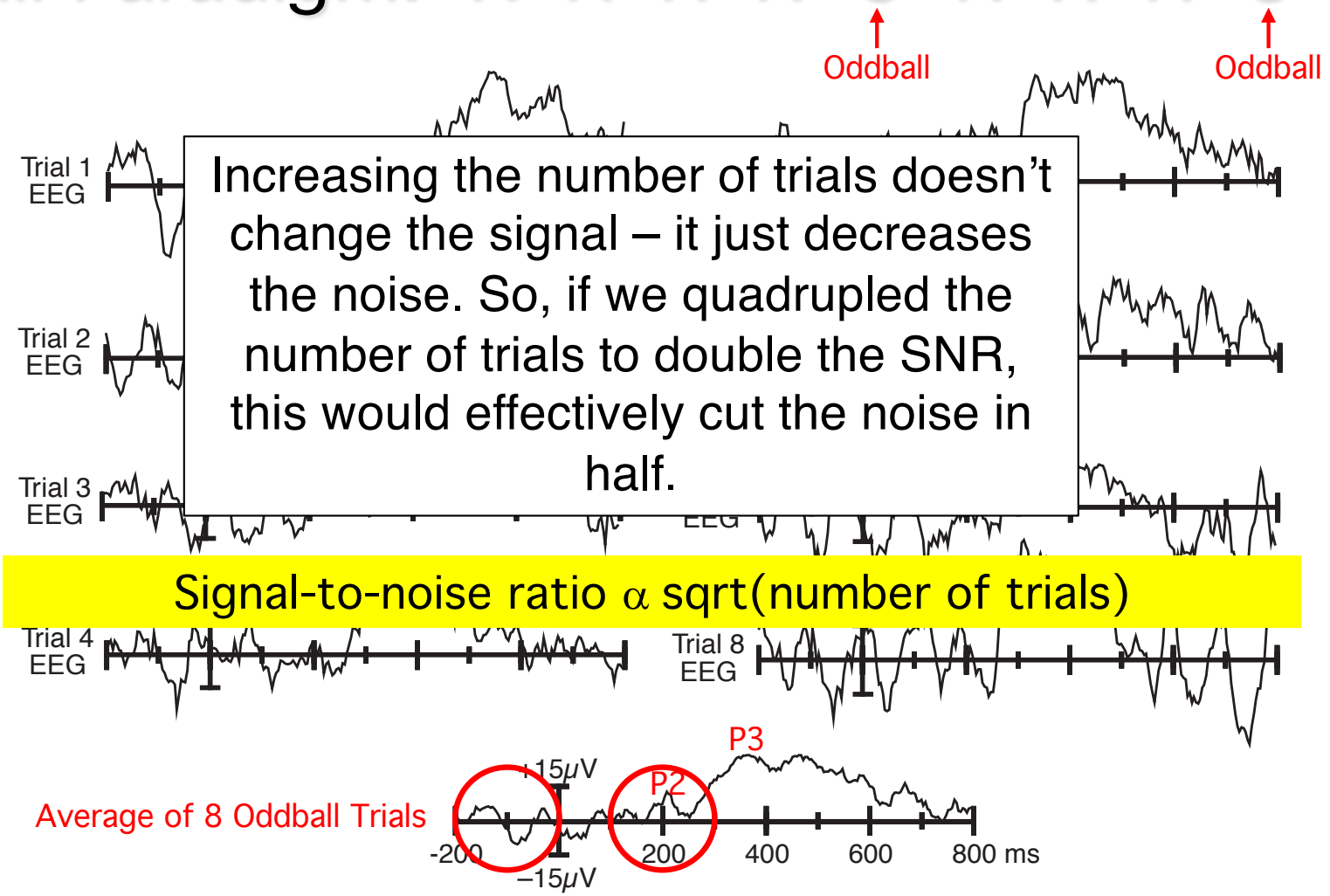
Oddball Paradigm: X X X X O X X X O X X



Oddball Paradigm: X X X X O X X X O X X



Oddball Paradigm: X X X X O X X X O X X



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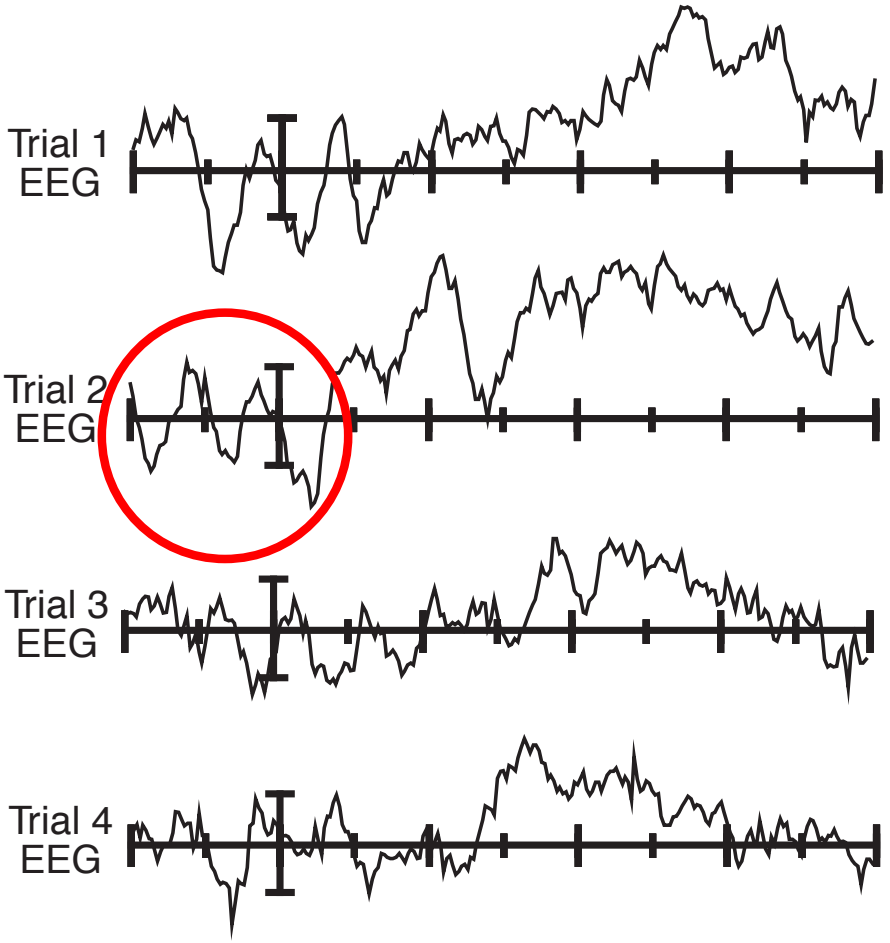
ERP Basics

Sources of Noise

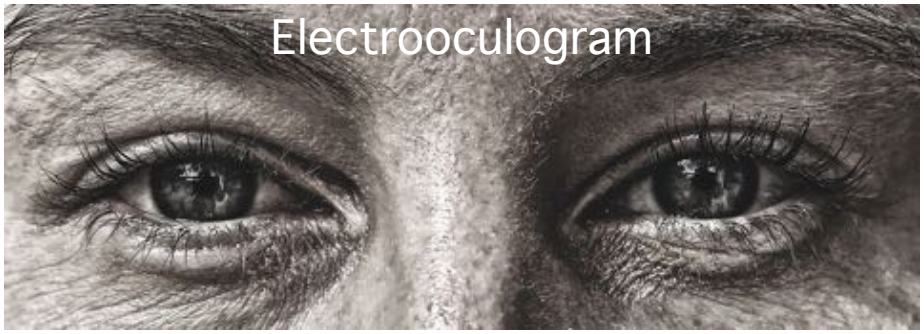
Where does the noise come from?

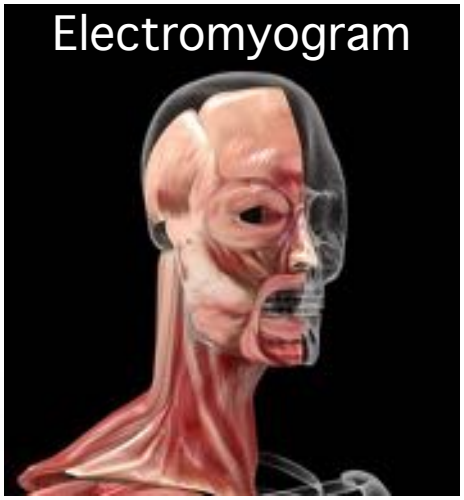
1: Brain activity that is not time-locked to the event of interest

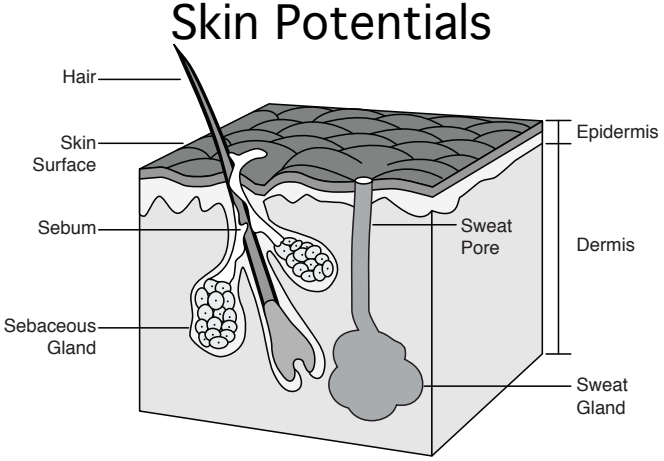


Where does the noise come from?

2: Biological artifacts

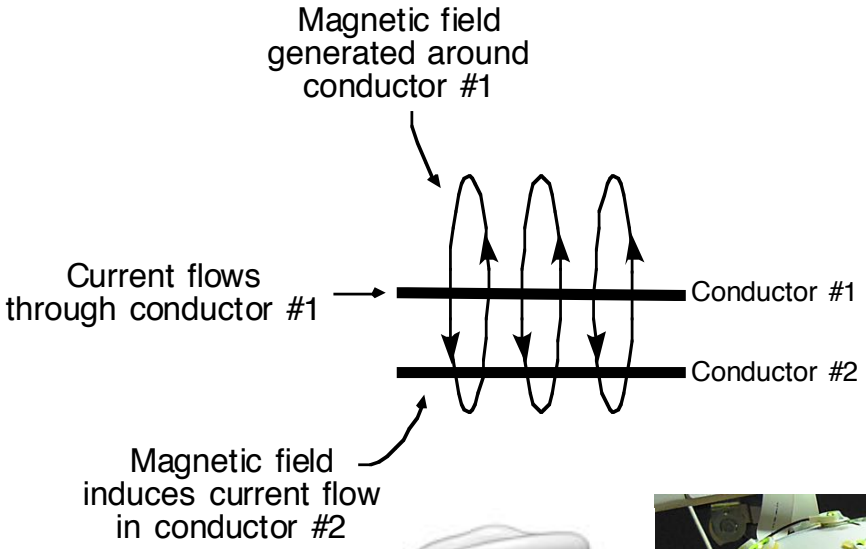






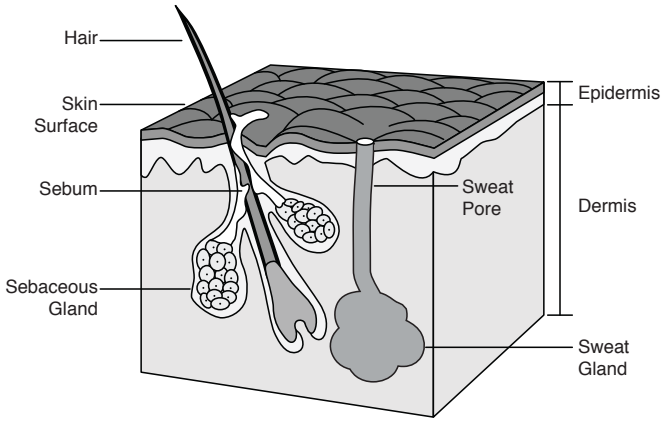
Where does the noise come from?

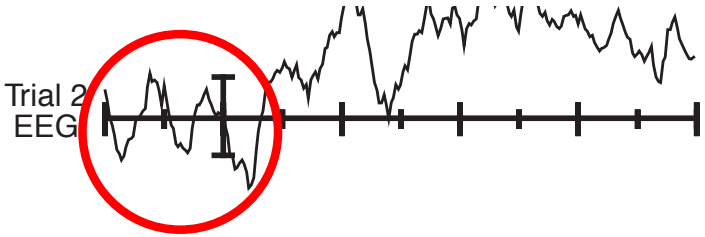
3: Induced electrical activity from the recording environment



Where does the noise come from?
What do we mean by noise, anyway?

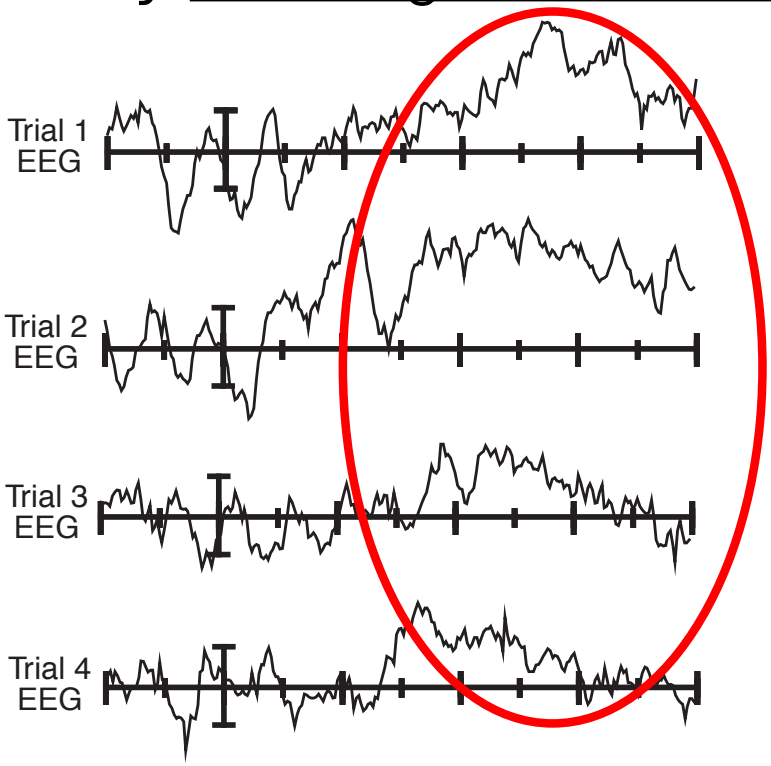
Noise: any source of uncontrolled variability in the signal of interest





Where does the noise come from? What do we mean by noise, anyway?

Noise: any source of uncontrolled variability <u>in the signal of interest</u>



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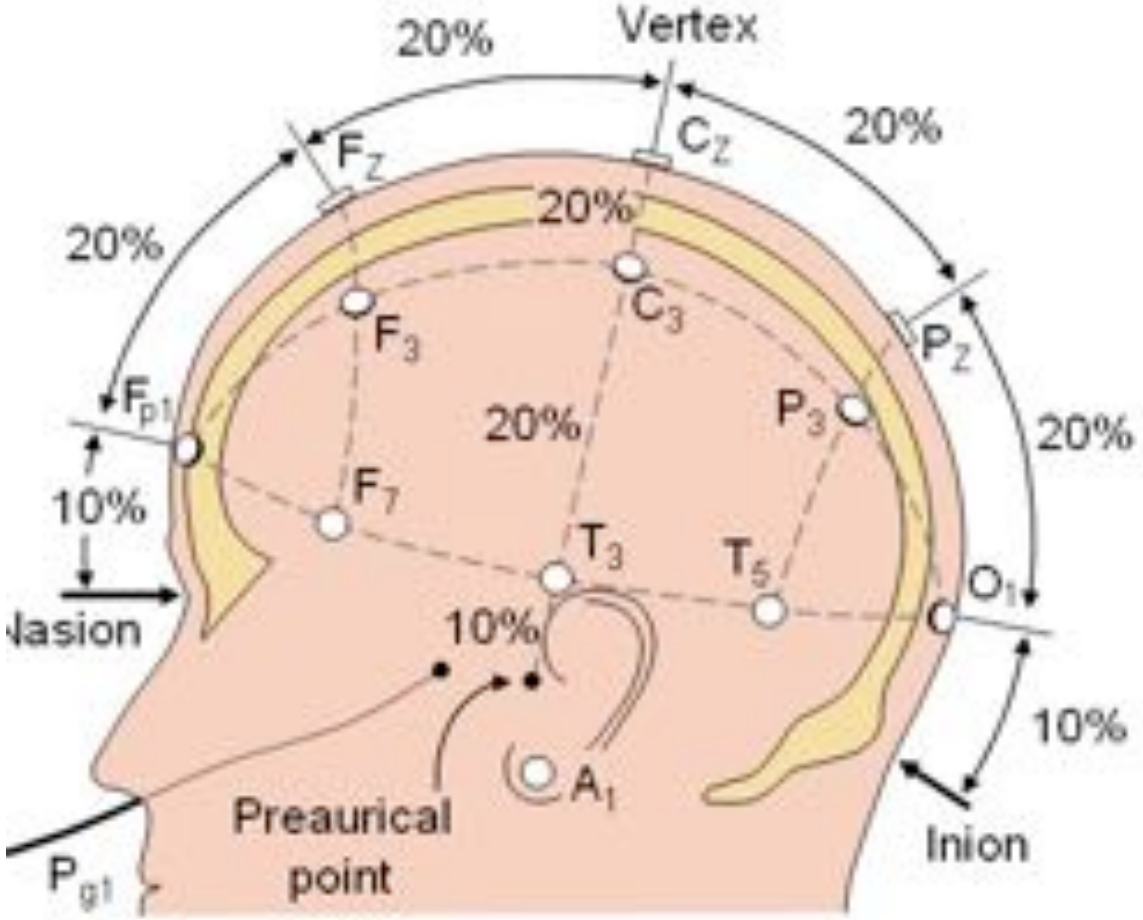
ERP Basics

Common Conventions in ERP Research

The International 10/20 System

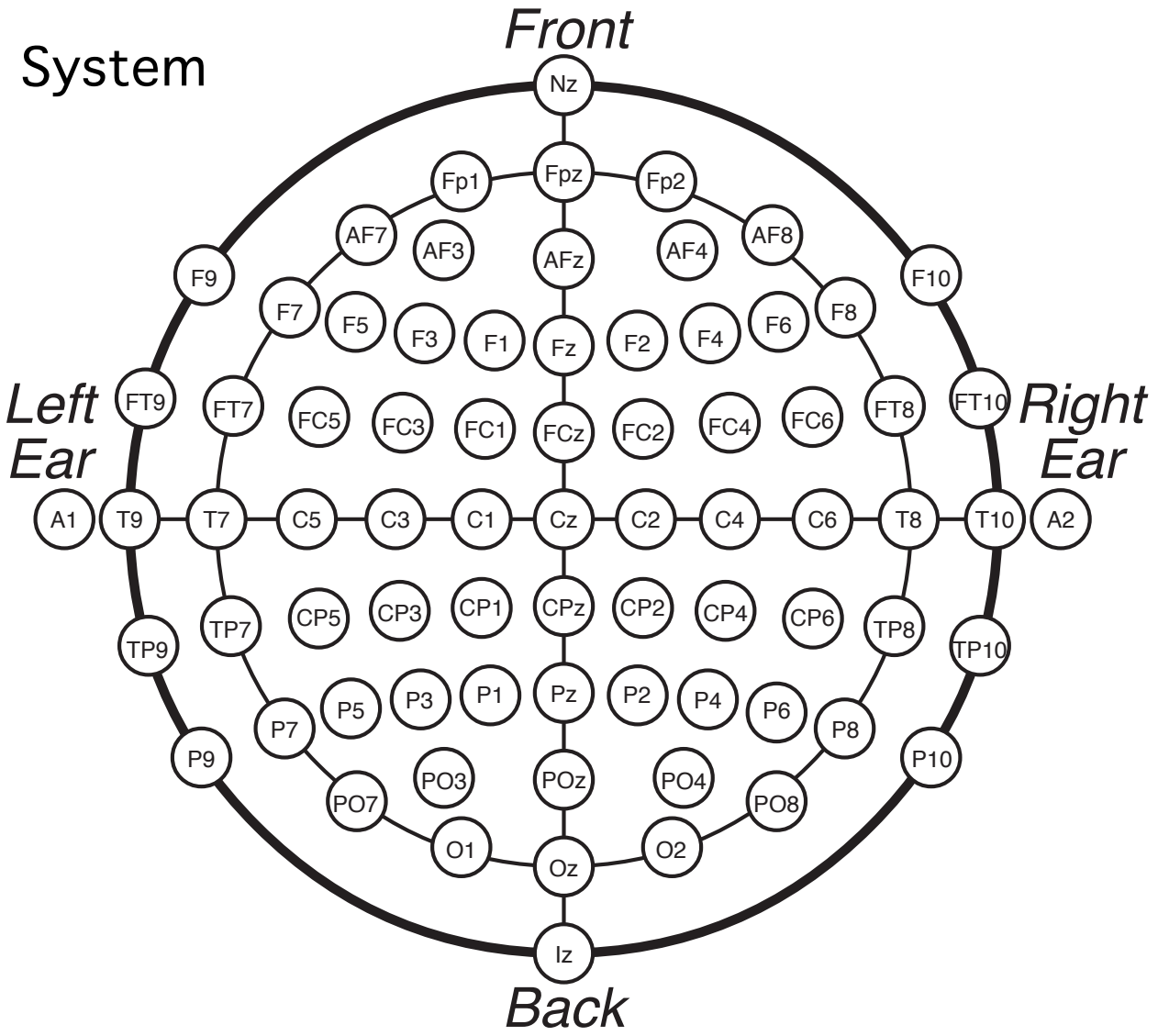


From Malmivuo, J. & Plonsey, R. (1995)

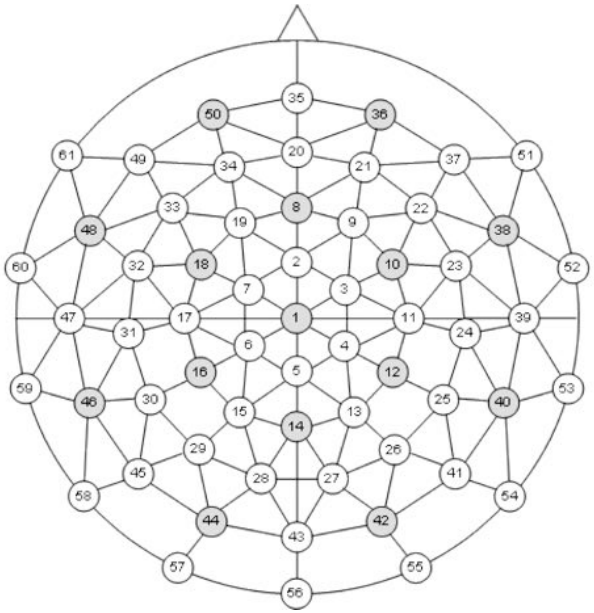
The International 10/20 System

Fp: Frontal Pole
F: Frontal
C: Central (Vertex)
P: Parietal
O: Occipital
T: Temporal

Left: Odd Numbers
Right: Even Numbers
Midline: z for zero

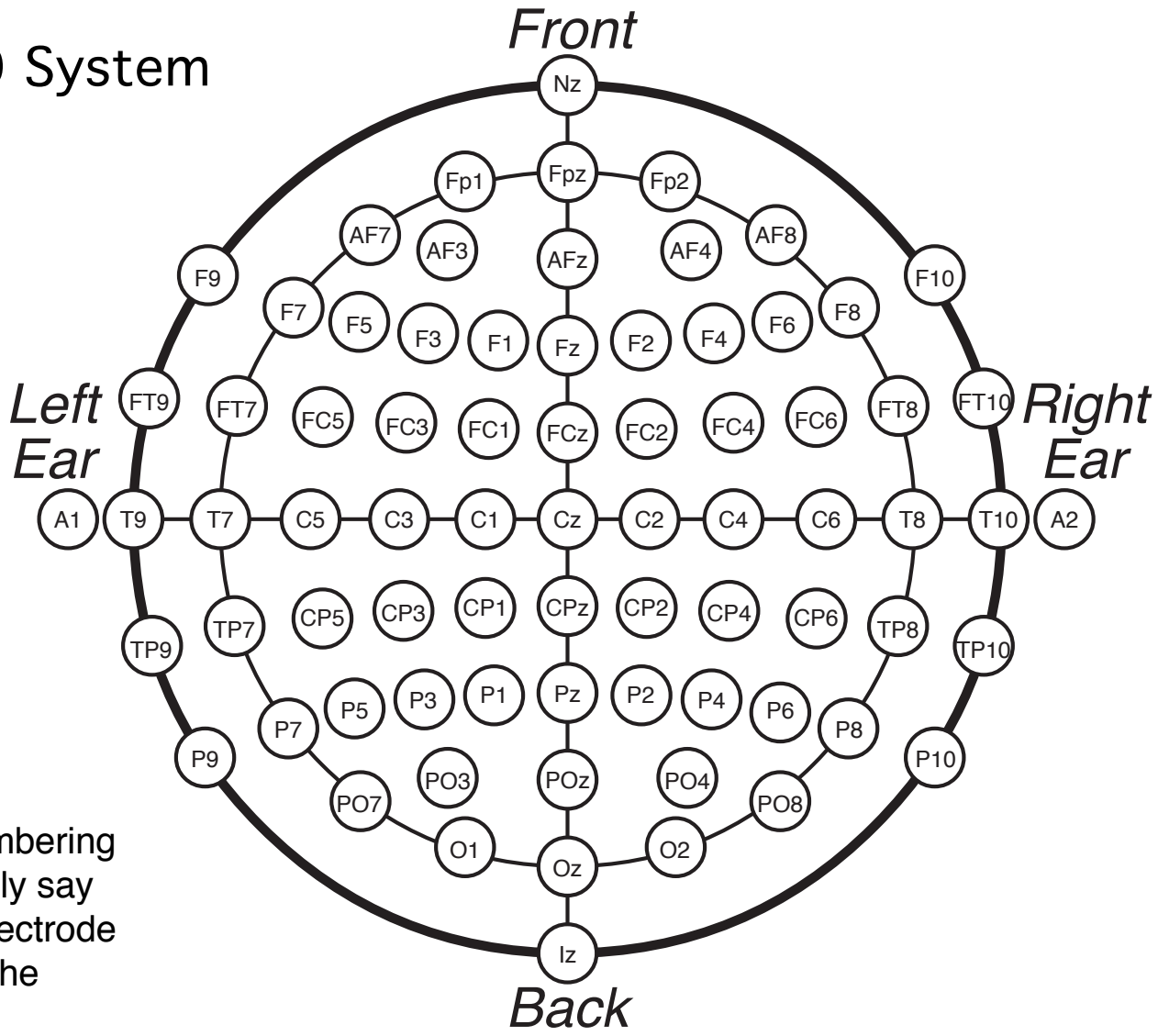


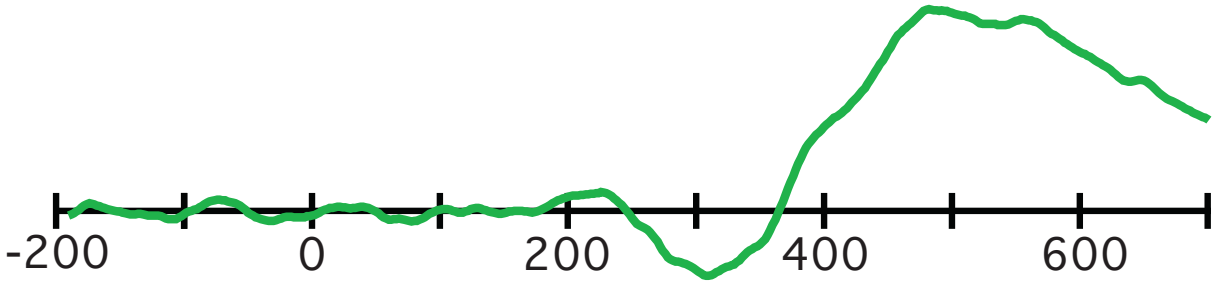
The International 10/20 System

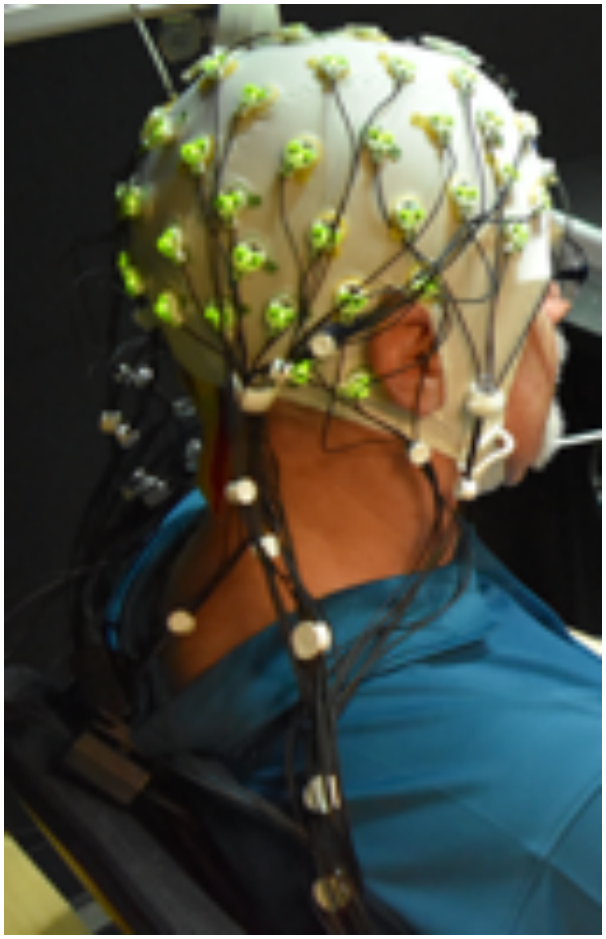


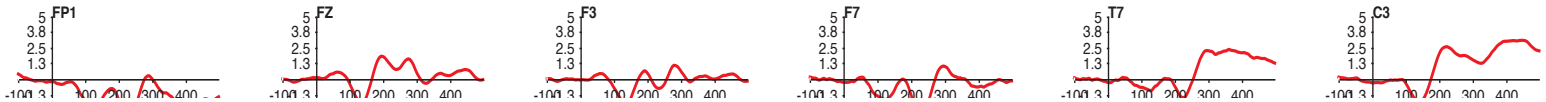
Alternative: Geodesic electrode configuration

Geodesic layouts use idiosyncratic numbering systems, and a publication will typically say something like “These are data from electrode 27, which near the P2 location in the International 10/20 system.

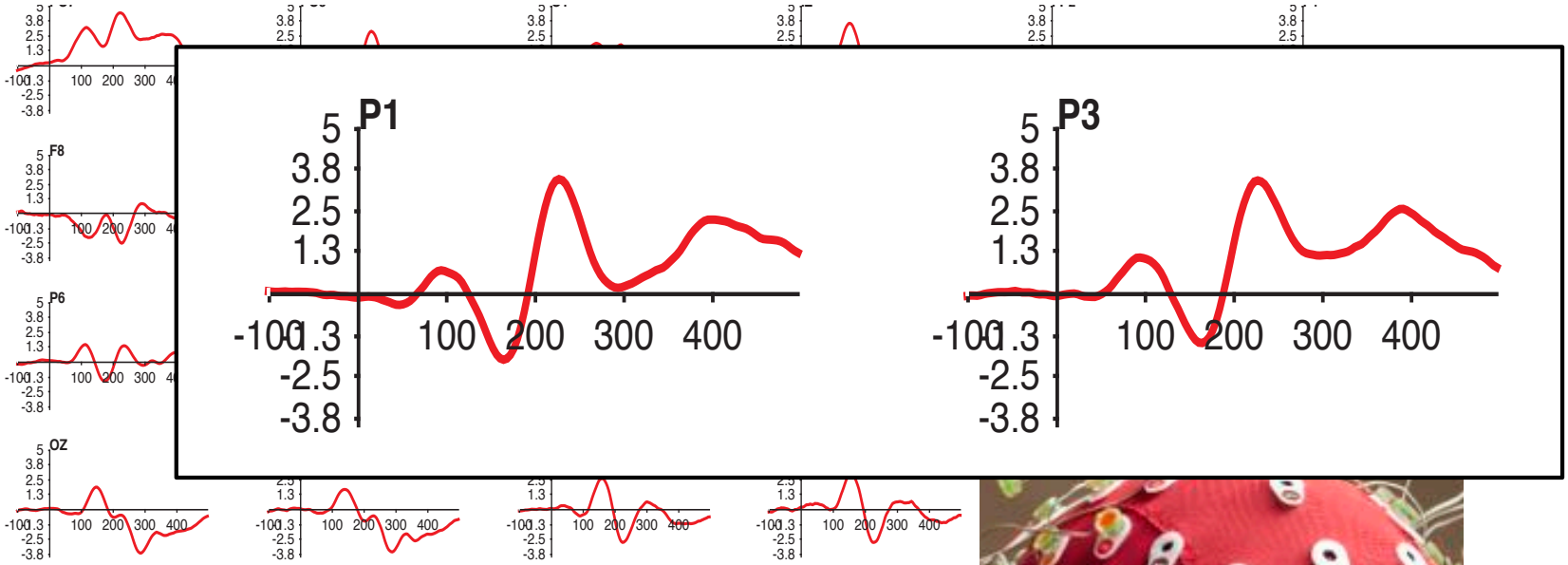



-200
0
200
400
600



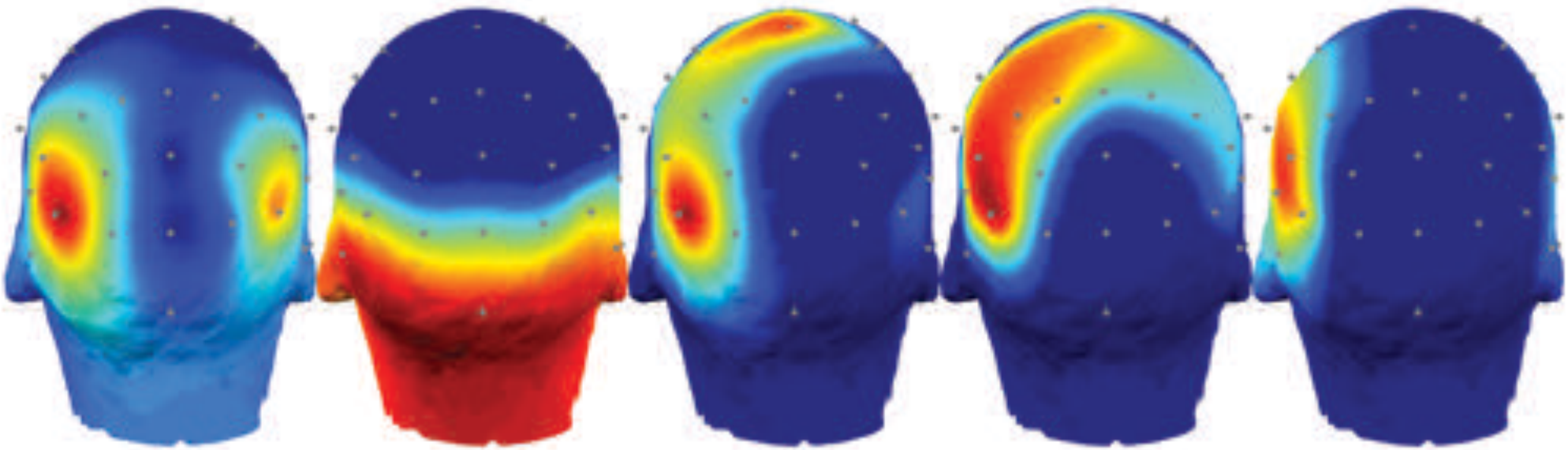


We record from many electrode sites simultaneously. But the waveforms at nearby sites are typically quite similar, so there's usually no point in showing all of the electrode sites in a journal article.

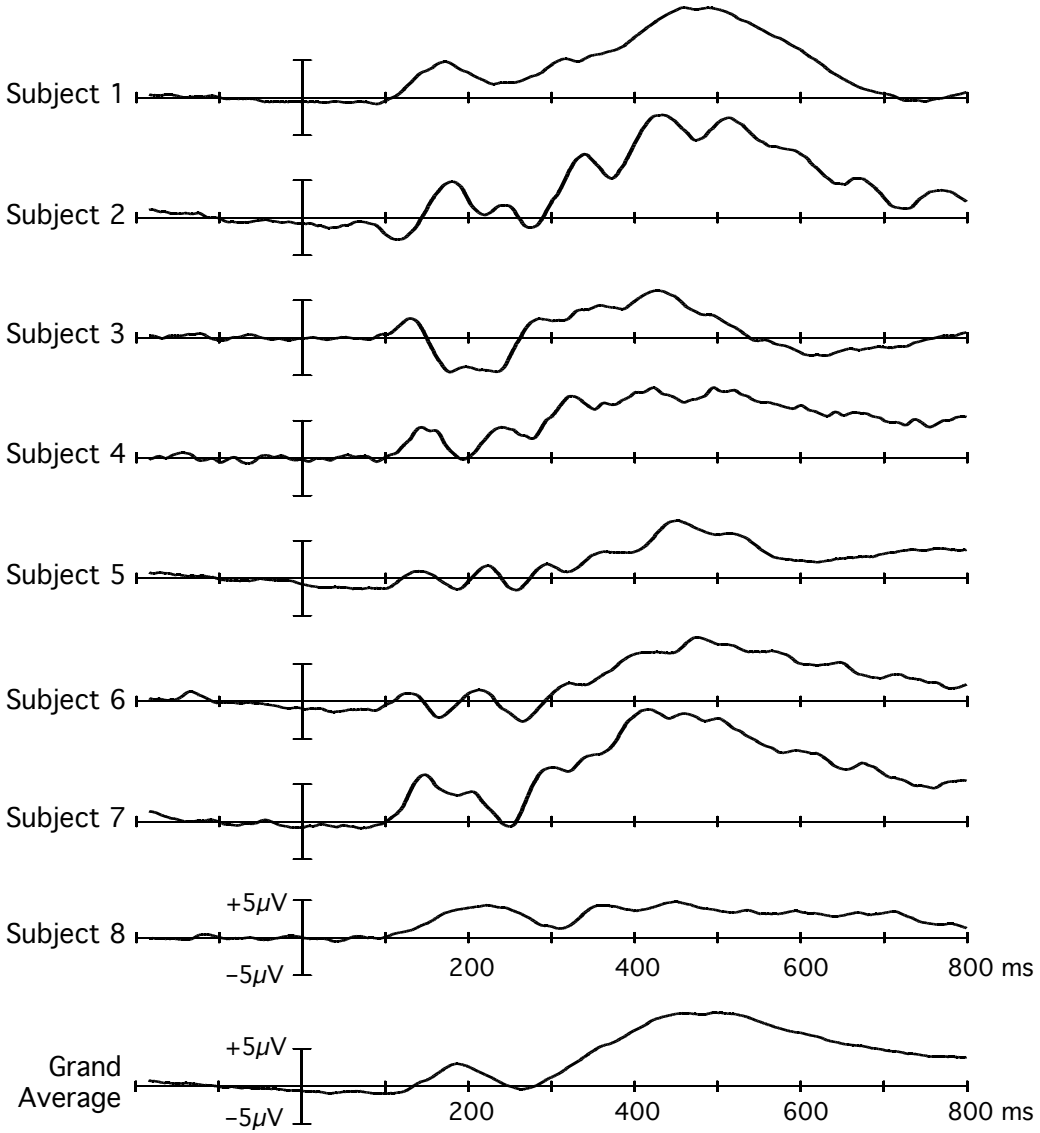


Simultaneous recordings from many electrode sites

These maps use interpolation to show voltage over the entire scalp, even though we only have measures at the discrete electrode sites.



100 ms 150 ms 200 ms 250 ms 300 ms



ERP papers don't usually show single-subject ERP waveforms.

Instead, we usually take the single-subject averaged ERP waveforms and average them together into a Grand Average waveform.

However, the statistical analysis is done using the single-subject waveforms, not the grand averages.

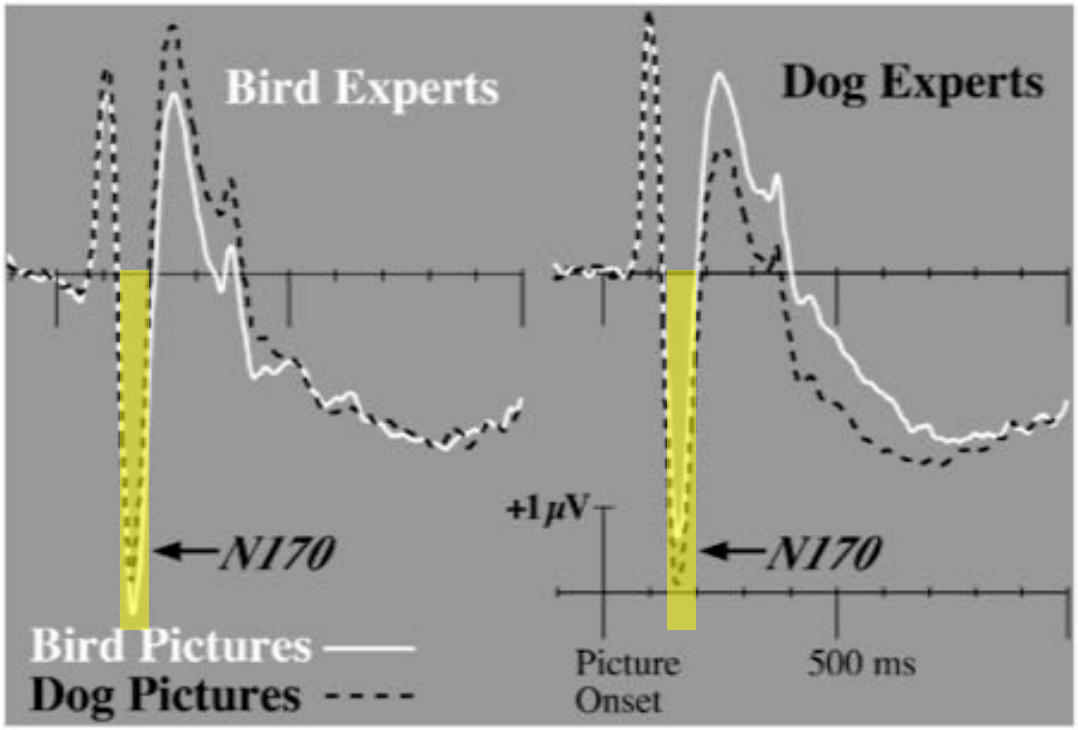
PSYCHOLOGICAL SCIENCE

Research Article

A NEURAL BASIS FOR EXPERT OBJECT RECOGNITION

James W. Tanaka[1] and Tim Curran[2]

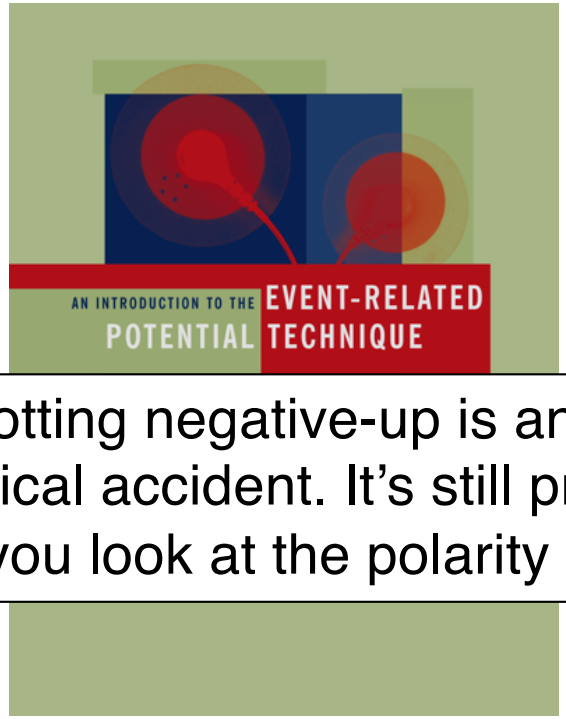
[1]Oberlin College and [2]Case Western Reserve University



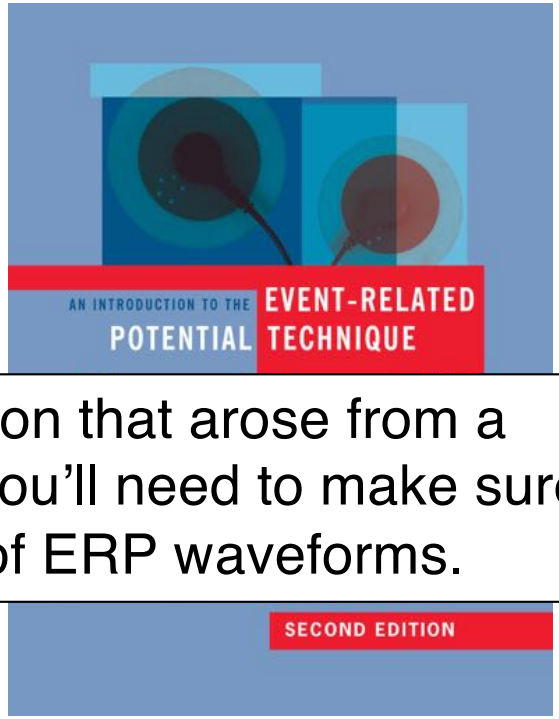
This study measured the mean amplitude in the N170 time range for each individual subject's averaged ERP waveform in each condition and then put those single-subject amplitude values into a simple ANOVA.

Tanaka & Curran (2001)

2005



2014



Plotting negative-up is an outdated convention that arose from a historical accident. It's still pretty common, so you'll need to make sure you look at the polarity indicators in plots of ERP waveforms.