So your data is clean, now what?

1. Event Related Potentials (ERPs)

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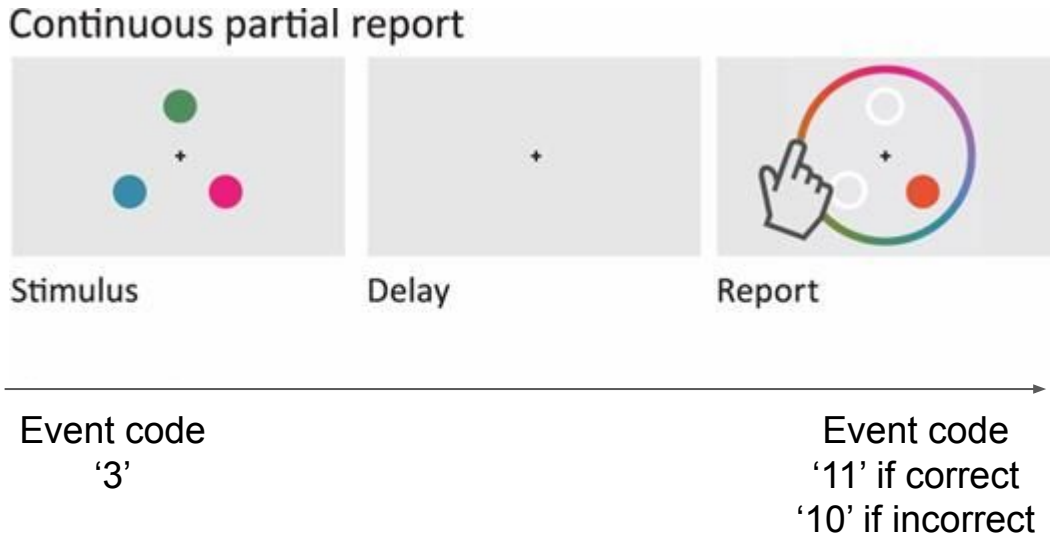
What do you mean by ‘event’?



Event related potentials

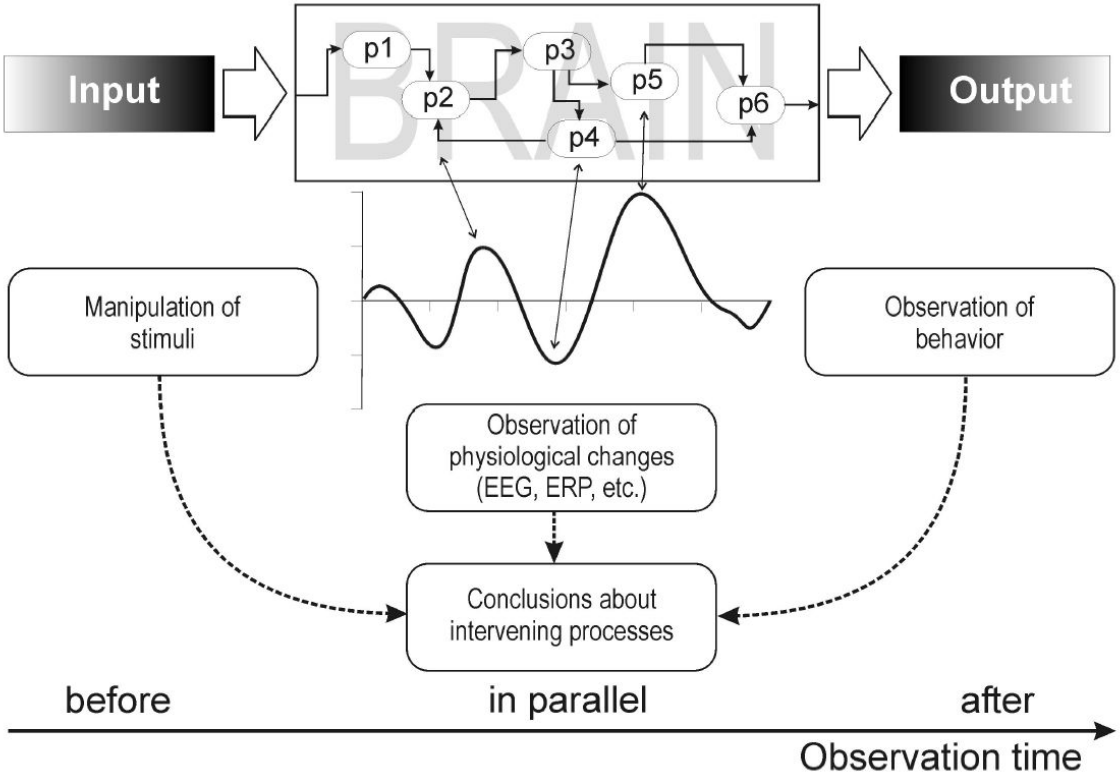
- An EEG signal that is generated when a specific computational operation is performed, related to an experimental variable/s

- **Mathematically:** The sum the voltage at each time point over trials, divided by the number of trials

Physiology of ERPs

- Summed activity of postsynaptic potentials produced when a large number of similarly oriented cortical pyramidal neurons are simultaneously active
- Two categories:
  - Early waves (peaking ~100 milliseconds after stimuli) → ‘sensory’ or ‘exogenous’
    - Reflect properties of the stimulus
  - Later waves → termed ‘cognitive’ or ‘endogenous’
    - Reflect the manner in which the subject evaluates the stimulus

A bit of history



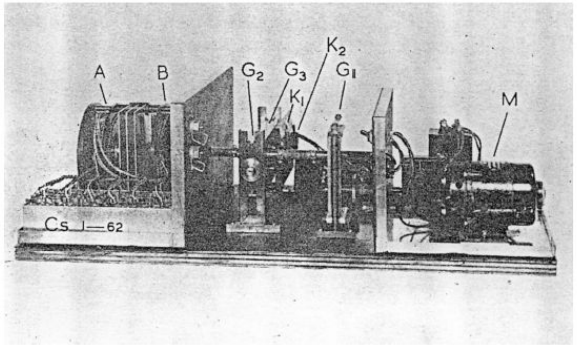


Figure 4. The first signal averager for extracting event-related potentials from the electroencephalogram. From "A Summation Technique for the Detection of Small Evoked Potentials," by G. D. Dawson, 1954, *Electroencephalography and Clinical Neurophysiology*, *6*, pp. 69 & 75. Copyright 1954 by Elsevier Science. Reprinted with permission.

Roesler (2005), *History of Psychology*

In short...

1. Each trial contains signal and noise
2. The signal (should) be relatively similar on each trial
3. The noise varies with each trial
4. Noise cancels out when many trials are averaged
5. The signal remains
6. Align your time domain EEG data to a time = 0 event

   E.g. The memory set
7. Admire your ERP

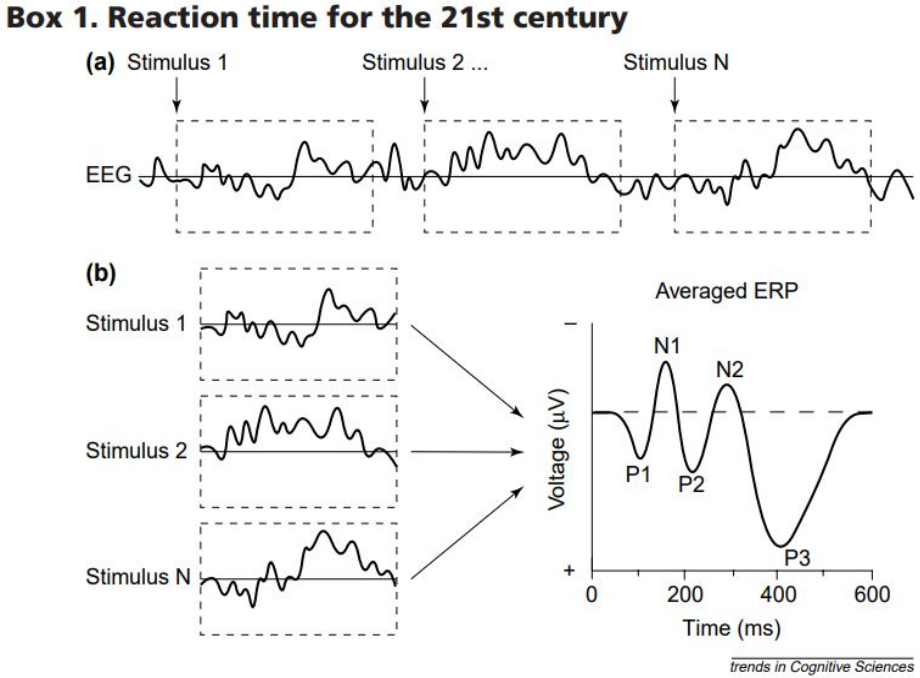
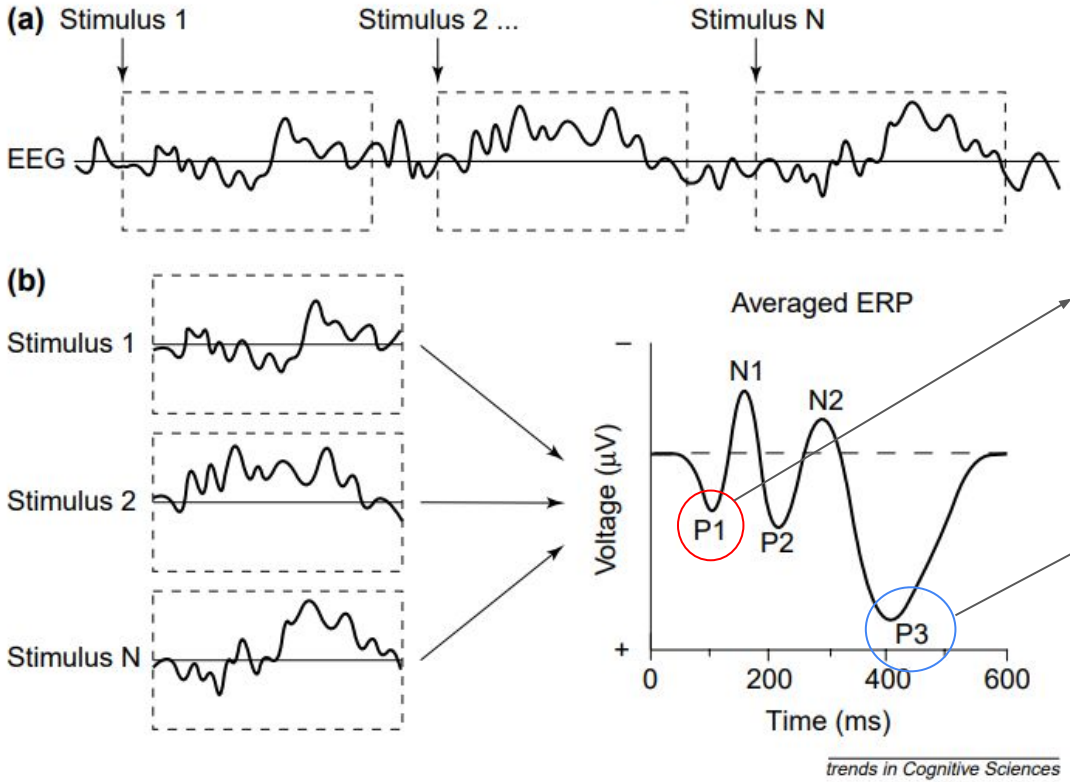


Fig. I. Extraction of the ERP waveform from the ongoing EEG. (a) Stimuli (1… N) are presented while the EEG is being recorded, but the specific response to each stimulus is too small to be seen in the much larger EEG. **(b)** To isolate the ERP from the ongoing EEG, the EEG segments following each stimulus are extracted and averaged together to create the averaged ERP waveform.

Luck et al. (2000), *Trends in Cognitive Sciences*

Box 1. Reaction time for the 21st century



P1: Early visual response

P3: Oddball

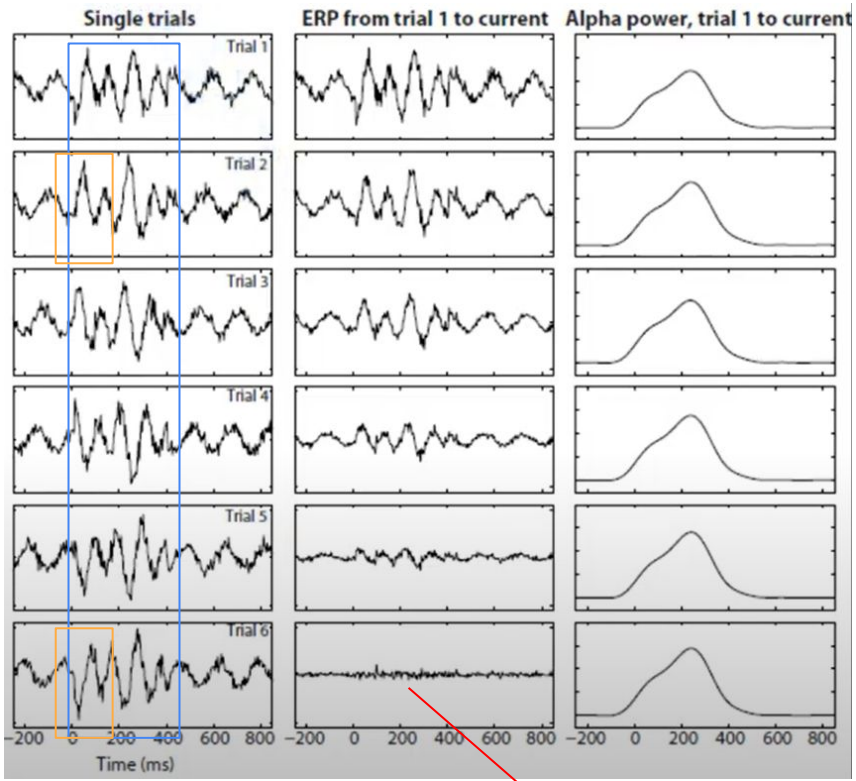
Fig. I. Extraction of the ERP waveform from the ongoing EEG. (a) Stimuli (1… N) are presented while the EEG is being recorded, but the specific response to each stimulus is too small to be seen in the much larger EEG. **(b)** To isolate the ERP from the ongoing EEG, the EEG segments following each stimulus are extracted and averaged together to create the averaged ERP waveform.

Uses for ERPs

- Investigating perceptual, cognitive, etc phenomena
- Data quality control
  - Does this look normal?
  - When are my triggers coming through?

What do we lose in time domain averaging?

- Seems like something is happening in the blue box at the single trial level
- ERP averaging loses this detail because the activity is **non-phase locked**
  - The activity is kind of happening around 0, but the deflections differ slightly
  - Positive and negative deflections cancel out = flatlining
- But time frequency analysis, however...



Cohen (2019)

Did the participant die from boredom…?

Time Domain vs Frequency Domain