Neural Oscillations: The popular ones!

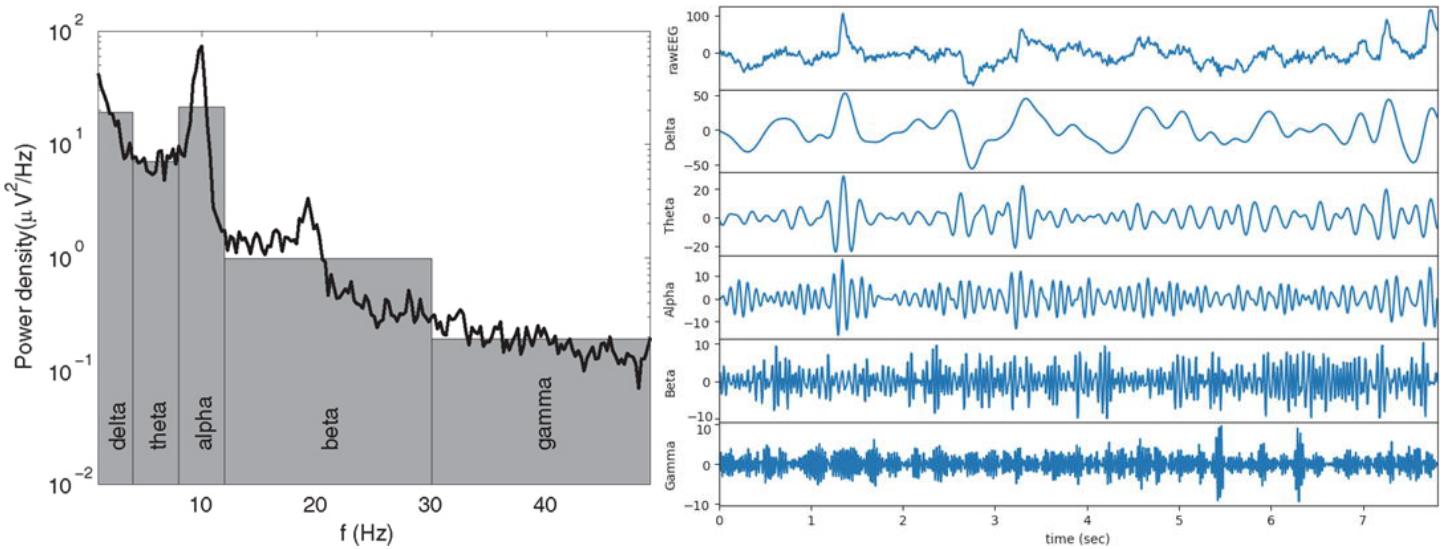
Lecture 5

October 13, 2022

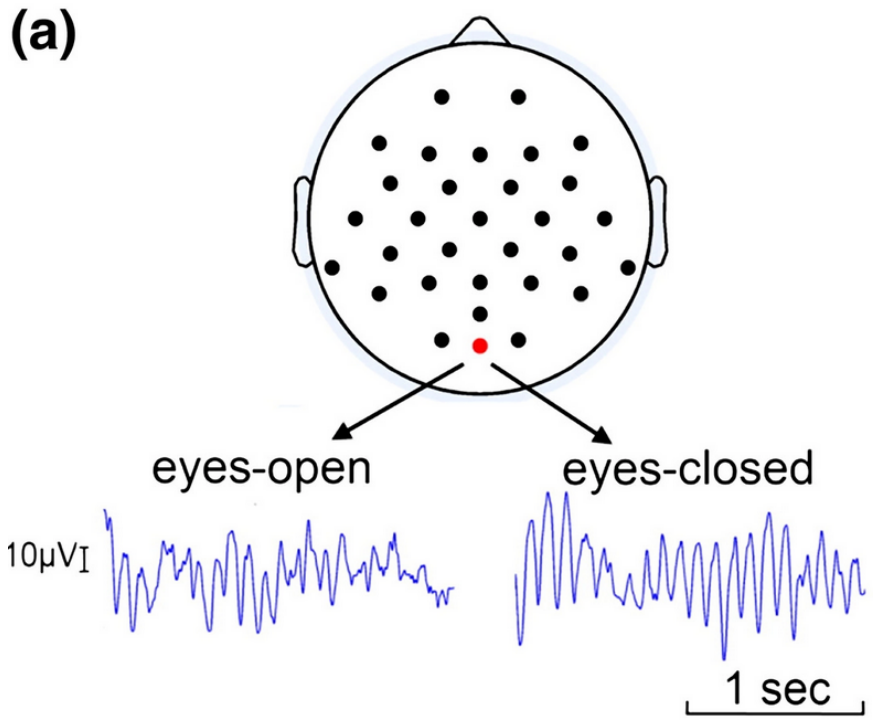
Sections

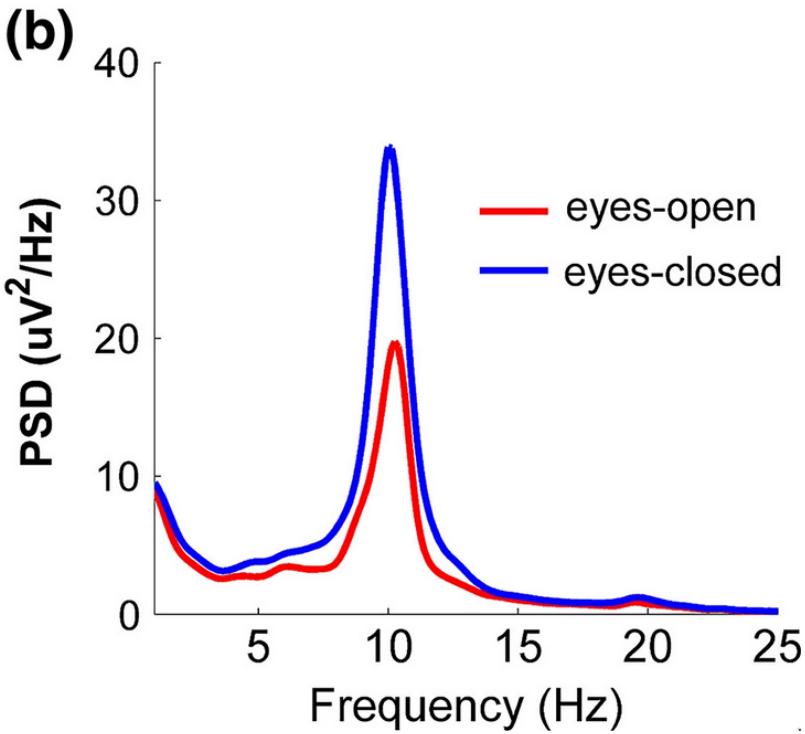
Neural Oscillations

Naming Conventions for EEG oscillations

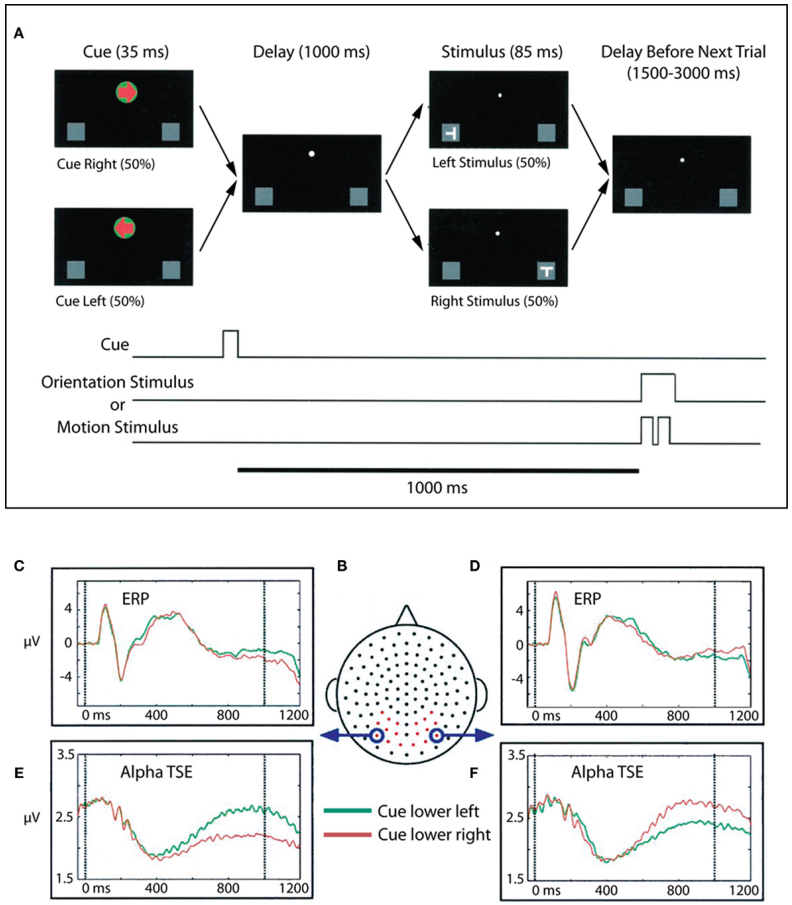


Alpha-band oscillations

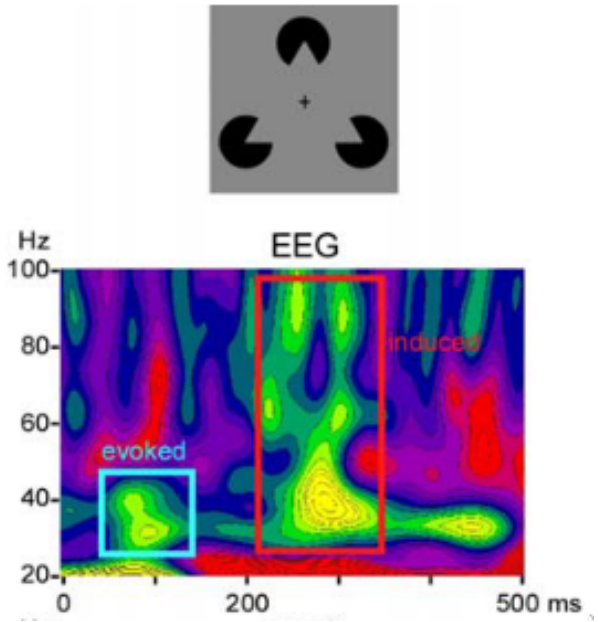


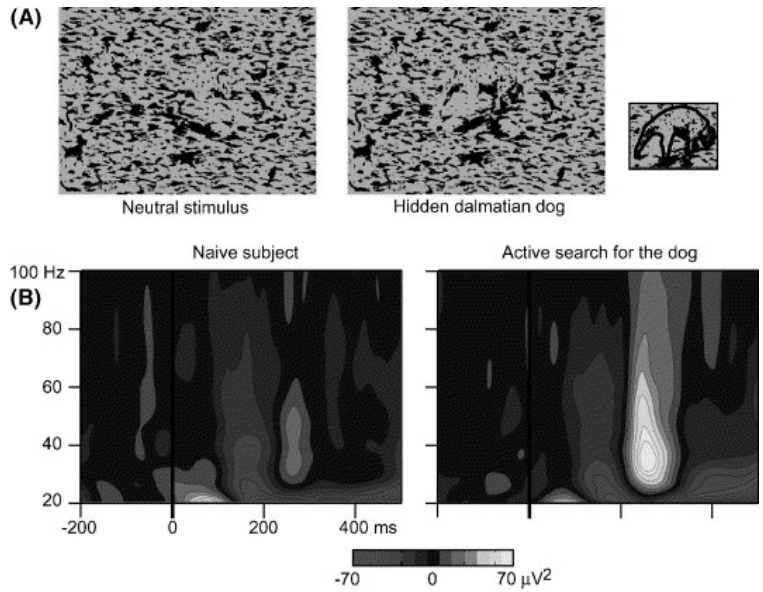


Alpha desynchronization and attention

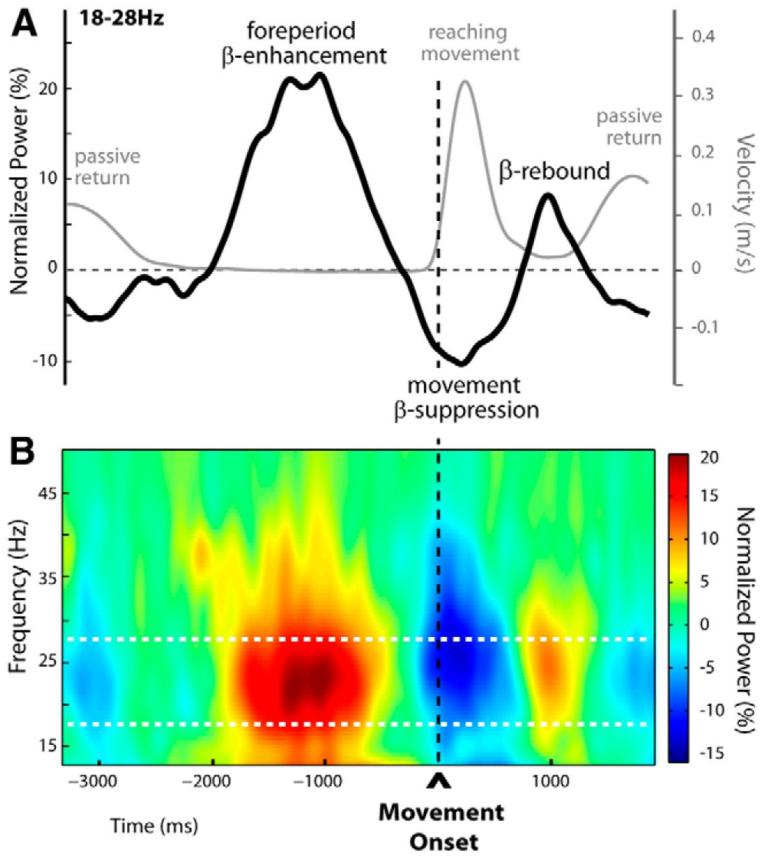


Gamma-band oscillations - Object representation

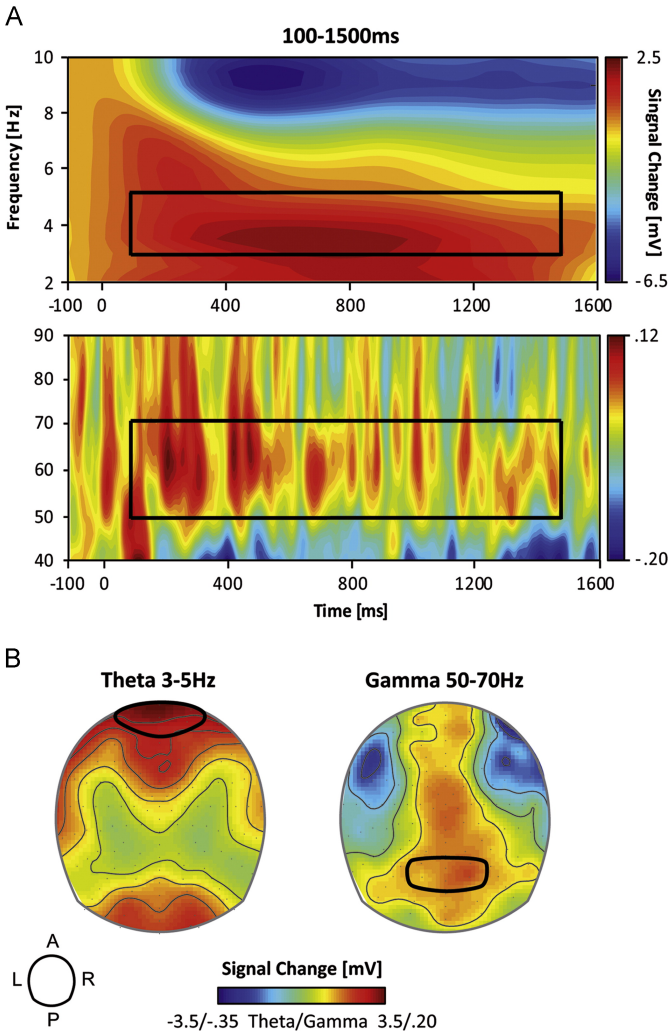


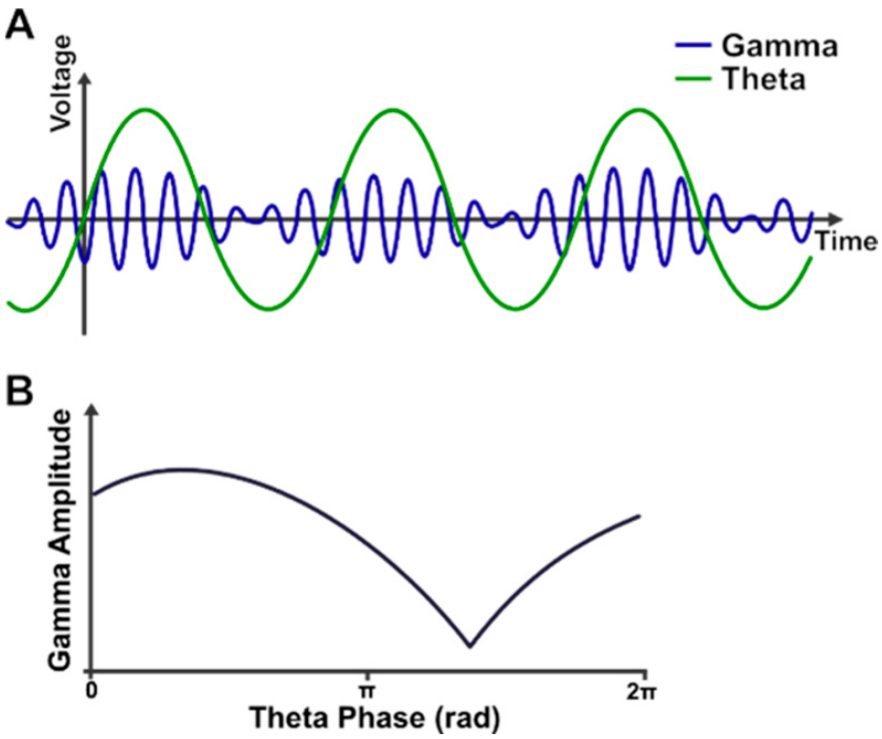


Beta-band oscillations - Motor Functions

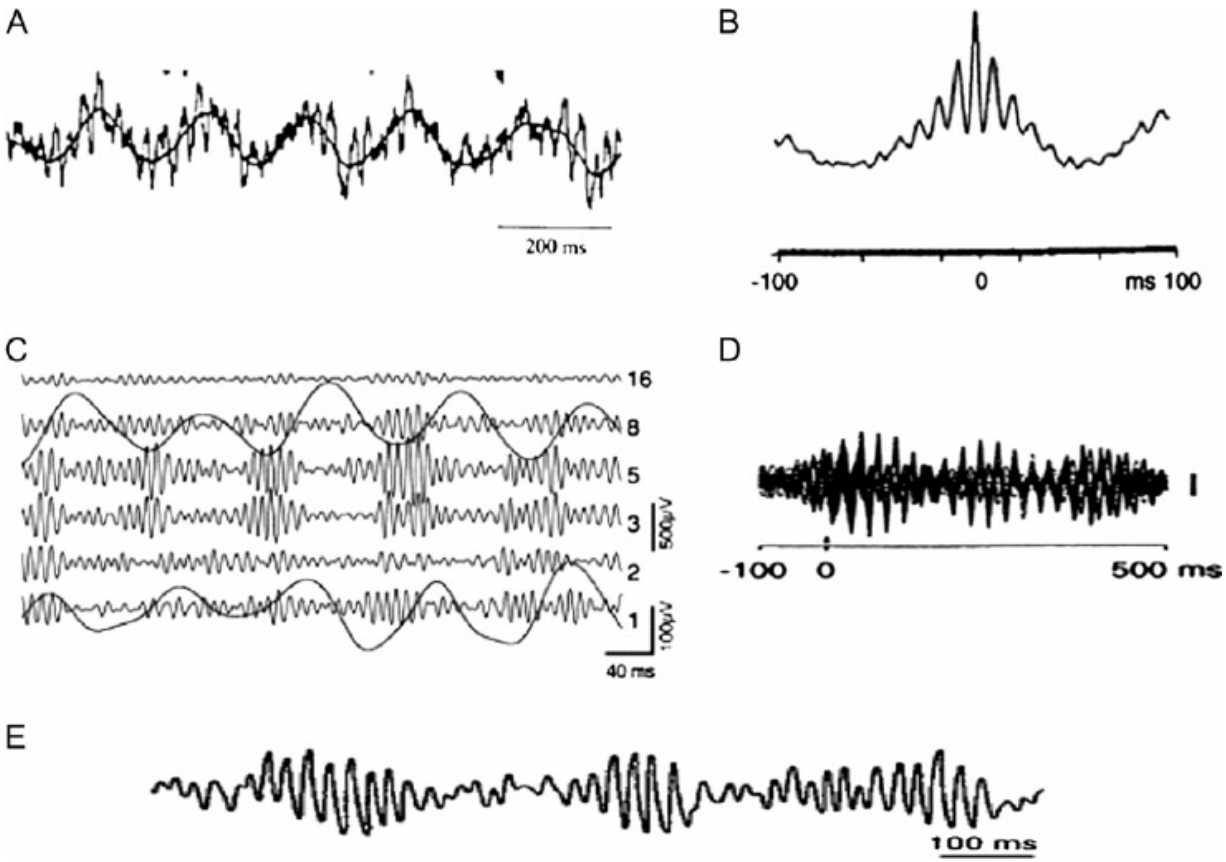


Theta-band oscillations - Memory





Theta-band oscillations - Memory



What are the measurable properties of EEG oscillations for statistical testing or machine learning?

Quantitative Metrics

- Amplitude - magnitude (absolute value) of Fourier coefficient

$$Amplitude = |X_f|$$

If EEG is in $\mu Volts$ then Amplitude units are $\frac{\mu Volts}{bin}$

$$Amplitude = \frac{|X_f|}{\Delta f}$$

If $= \frac{1}{T}$ where 'T' is the length of the data, then Δf has units Hz/bin and the normalized Amplitude has units $\frac{\mu Volts}{Hz}$

- Power - squared magnitude of Fourier coefficients

$$Power = \frac{|X_f|^2}{\Delta f}$$

Power has units $\frac{\mu Volts^2}{Hz}$

Event-related Potentials

Naming Conventions for Event-Related Potentials

Table 1
Summary of Event-Related Potential Components Using a Variety of Nomenclatures During a Simple Visual–Manual Task Similar to That of Figure 1

Nomenclature	Ordinal	Latency (Peak)	Scalp Distribution	Task/Stimulus Specificity	Hypothesized Process(es) Indexed	Useful Reference
Components preceding a stimulus				CNV (O- & E-waves)	anticipation, cognitive & motor preparation	Brunia, van Boxtel, & Böcker (in press)
Components following a stimulus	C1	P/N50–70			sensory processing	Pratt (in press)
	P1	P90–100			sensory/perceptual processing	Pratt (in press)
	N1	N170–200	posterior versus anterior N1	N170 for faces	perceptual processing, expert recognition, visual discrimination	Hillyard, Vogel, & Luck (1998); Rossion & Jacques (in press); Vogel & Luck (2000)
	P2				not well understood	Crowley & Colrain (2004)
	N2	N225–250			object recognition, categorization	Folstein & Van Petten (2008); Pritchard et al. (1991)
	N2pc		PCN		deployment of covert attention	Luck (in press)
	P3	P300	P3a/P3b	P3a/P3b	stimulus evaluation time, categorization, context (working memory) updating, cognitive load	Polich (in press)
			SPCN	CDA	maintenance in visual working memory	Perez & Vogel (in press)
				LRP	response preparation	Smulders & Miller (in press)
Components following a response			medial frontal negativity	ERN/Ne & FBN	error processing, reinforcement learning or response conflict signal	Gehring, Liu, Orr, & Carp (in press)
				Pe	affective or conscious assessment of task performance	Falkenstein et al. (2000)

Note—This list is focused on visual components and neglects components from the auditory, language, and memory literatures. CNV, contingent negative variation; O- & E-waves, orienting & expectancy waves; C1, Component 1; N, negative; P, positive; N2pc, N2 posterior contralateral; PCN, posterior contralateral negativity; CDA, contralateral-delay activity; SPCN, sustained posterior contralateral negativity; LRP, lateralized readiness potential; ERN/Ne, error-related negativity/error negativity; FBN, feedback negativity; Pe, error positivity.

Time course of auditory brain activity

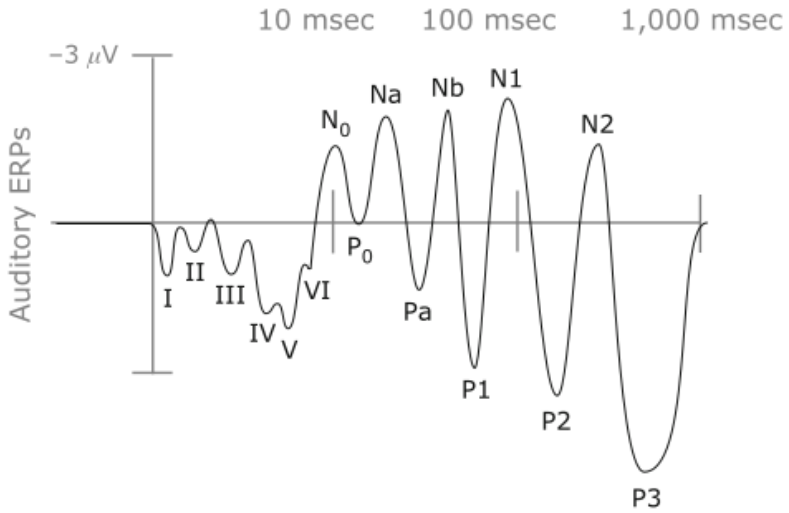
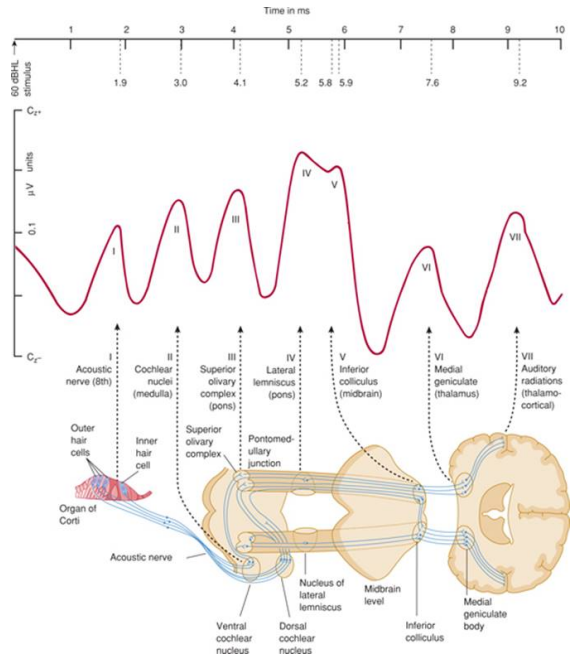
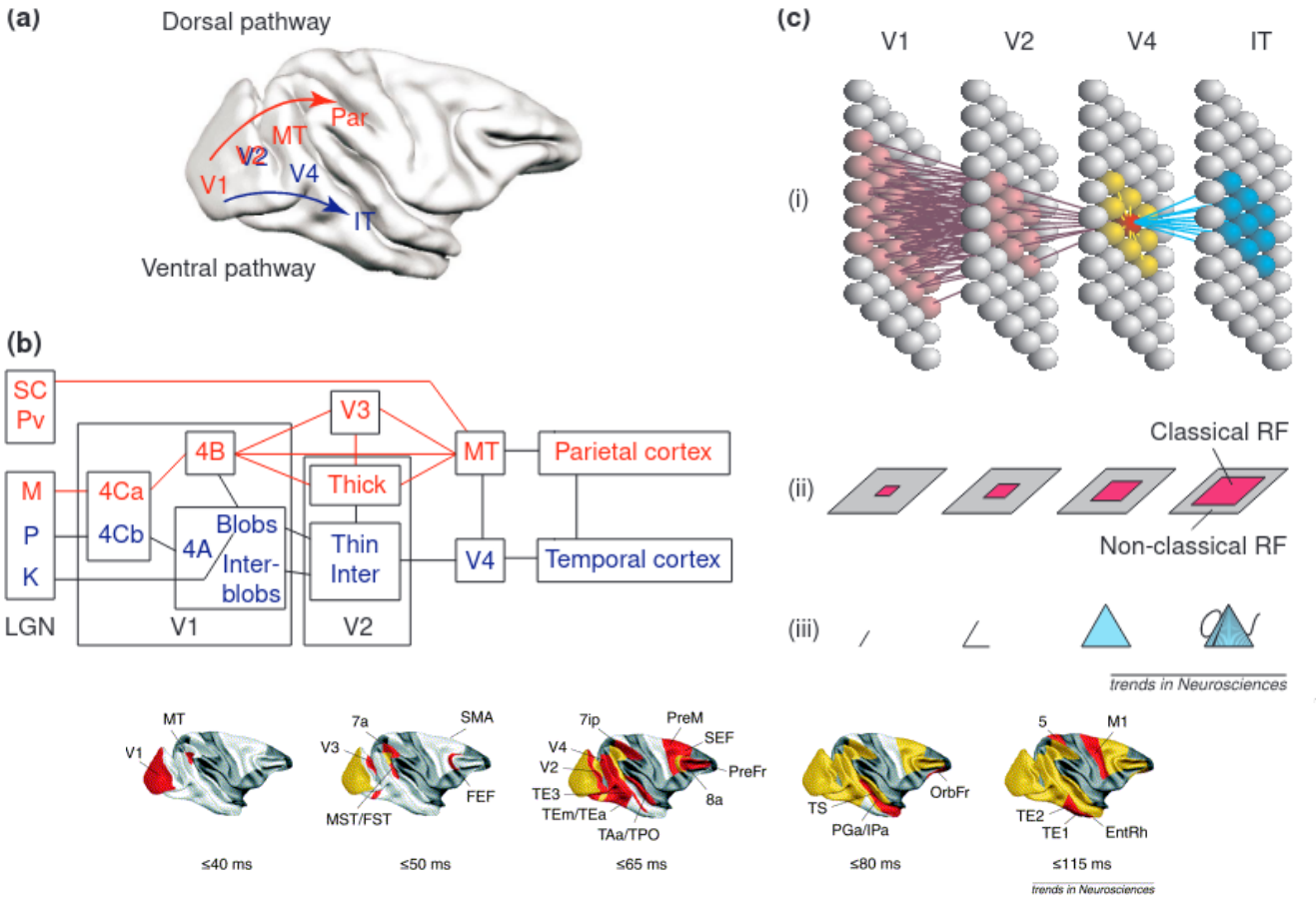


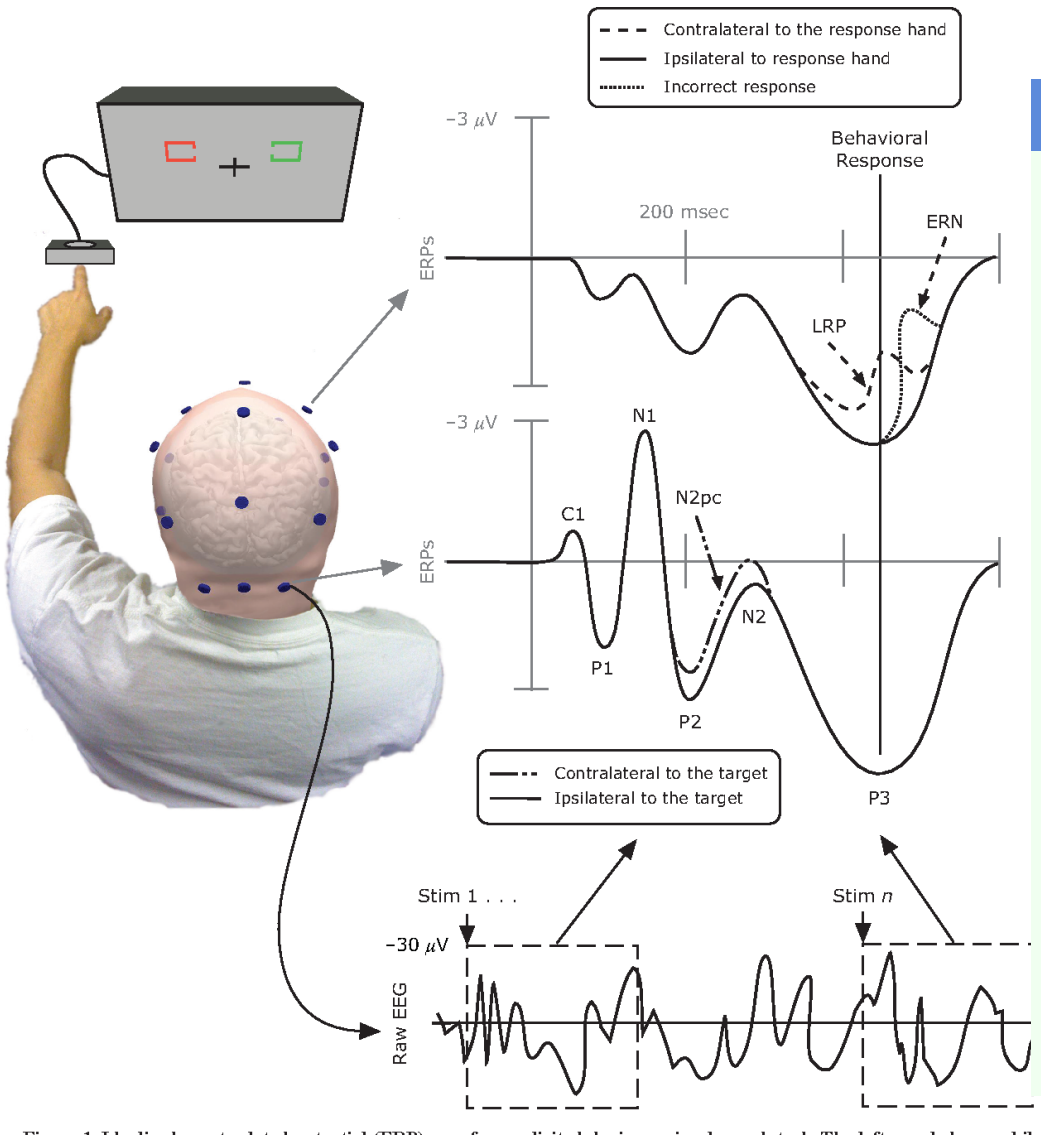
Figure 2. Idealized event-related potential (ERP) waveform evoked by a brief auditory stimulus. Waveforms shown would be expected from a central electrode site (i.e., Cz). Note that the waveforms are plotted as a function of log time.



Time course of visual information processing



Stimulus-locked and Response-locked event-related potentials



Event-related potentials

- In Behavioral experiments, we present a stimulus and collect a response.
- These events organize our analysis of the EEG data.
- The data can be analyzed in relation to the stimulus onset as shown in the lower trace.
- The stimulus can be analyzed in relation to the response as shown in the upper trace.

What are the measurable properties of Event related potentials for statistical testing or machine learning?

Quantitative Metrics

- Peak Amplitude - highest magnitude of the ERP signal within some window of time.
- Peak Latency - when is that peak detected.
- ERP onset/slope - when does the rise (or descent) begin, and how fast does it rise.