Just a bit more EMG ....and then...

The Electroencephalogram

# Announcements 3/4/13

- Electricity test Everyone has now passed!
- Papers: 1 or 2 paragraph prospectus due no later than Monday March 25
- ≻Lab Updates

≻3x5 time

## Lab Updates

EKG-EMG lab (will cover during lecture)

#### Lab Updates

#### ≻SCR GKT lab

- Should ignore first response in series and score remainder
- ≻How to make dichotomous verdict of guilty?
  - Lykken's scoringBinomial Probability
  - , Dinomia Produciny

## Lykken Method



#### **Binomial Probability**

# with Max Response (N)	Probability of exactly N	Probability of N or fewer	Probability of N or More
0	0.17	0.17	1.00
1	0.34	0.50	0.83
2	0.29	0.80	0.50
3	0.15	0.94	0.20
4	0.05	0.99	0.06
5	0.01	1.00	0.01
6	0.00	1.00	0.00
7	0.00	1.00	0.00
8	0.00	1.00	0.00

Many Options...

✓ Excel: BINOM.DIST function

✓ R: binom.test function

✓ Matlab: binocdf function

✓ SPSS: Nonparametric tests, Legacy Dialogs, Binomial

Returning to EMG....



#### Signal Recording (cont')

- ➤ Amplification
  - > Differential amplifiers with common mode rejection
- Actually double differential (ground)
- ➤ Amplify voltages 1000-20000 times
- ➤ May use on-line filter
  - ➤ Should pass 10-500 Hz
- Digitization (more in next lecture)
  - ≻ Fast, very fast
  - > Or, slower, following on-line signal processing



#### Signal Transformations

# A few Applications

#### ≻ Startle Probe

- ≻ Subtle affect
  - ≻ Mere Exposure
  - ➤ Subliminal effects
  - ➤ Mortality Salience
  - Biofeedback of EEG -- outcome measure
  - > Emotion Regulation outcome measure
  - Empathy individual difference measure

## Lab Updates

#### ≻EKG-EMG lab

- ≻EKG done in QRSTool and CMetX
- ≻EMG

Step 1 in Neuroscan Edit ➢ Filter and Rectify signals



> Get mean for each condition Convert to within-subject z-scores



 Neural Circuits Responsible for an Auditory Startle Response and for its Augmentation by Conditioned Aversive Stimulus
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Source: Adapted from Davis, M., Trends in Pharmacological Sciences, 1992, 13, 35-41

# A few Applications

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#### The Phenomenon:

- People prefer stimuli to which they have been previously exposed to unfamiliar stimuli
- ➤ In absence of any reinforcement ("mere" exposure)
- ≻ Examples:
  - >People we see incidentally in our routines >Songs
  - ≻Scientific journal preferences
- Effect size r=.26 (Meta-analysis,Bornstein, 1989)

## The logic:

- Evolutionary account Bornstein (1989)
  - $\succ$  it may be adaptive to prefer the familiar over the novel
  - > novel objects could present a potential threat
  - organisms that had a fear of the strange and unfamiliar were more likely to survive, reproduce, and pass on genetic material
  - Preferring the familiar may thus be an adaptive trait that has evolved in humans and nonhumans

#### ➤ Prediction:

- unfamiliar as compared with familiar stimuli may be associated with more negative attitudes because of the unfamiliar stimuli's association with potential danger
- Thus may see greater corrugator activity to novel than to familiar
- > No prediction for positive affect (Zygomaticus activity)



Loosely translated from Harmon-Jones & Allen, 2001

3



Figure 1. The positivity offset and negativity bias as seen in regression lines predicting mean positivity or mean negativity from mean arousal ratings of 256 positive and 216 negative items. For positivity, intercept = 2.02 and slope = 0.24. For negativity, intercept = 0.40 and slope = 1.19. (Adapted from: "Eliciting Affect Using the International Affective Picture System: Trajectories Through Evaluative Space," by T. A. Ito, J. T. Cacioppo, and P. J. Lang, 1998, *Personality and Social Psychology Bulletin*, *8*, p.872. Copyright 1998 by the Society for Personality and Social Psychology Bulletin, *8*, p.872.

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facial reactions to emotional facial



Dimberg et al Psychological Science 2000



Dimberg et al Psychological Science 2000

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Another loose translation: Arndt, J., Allen, J.J.B., & Greenberg, J. (2001). Traces of terror: Subliminal death primes and facial electromyographic indices of affect. *Motivation and Emotion*, 25, 253-277.

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From Allen, Harmon-Jones, and Cavender (2001) Allen, Cavender, Harmon-Jones, *Psychophysiology* 2001

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Figure 1. Self-reported negative affect on a 7-point Likert scale, where 0 = "not negative at all" and "7" = "strongly negative."

Ray, McRae, Ochsner, & Gross, Emotion, 2010



Figure 2. Standardized (A) corrugator EMG and (B) startle magnitude (averaged over Times 1 and 2). Ray, McRae, Ochsner, & Gross, Emotion, 2010

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Dimberg & Thunberg (2012) PsyCh Journal

### The Electroencephalogram

Basics in Recording EEG, Frequency Domain Analysis and its Applications

# Electroencephalogram (EEG)

- The EEG--an oscillating voltage recorded on scalp surface
  - Reflects Large # Neurons
  - ➤ Is small voltage
- > Bands of activity and behavioral correlates
  - ≽ Gamma 30-50 Hz
  - ≻ Beta 13-30 Hz
  - ≻ Alpha 8-13 Hz
  - ≻ Theta 4-8 Hz
  - ≻ Delta 0.5-4 Hz



## Utility of EEG

- Relatively noninvasive
- ➢ Excellent time resolution

## Sources of scalp potentials

- Glial Cells minimal, some DC steady potentials
- ➤ Neurons
  - Action Potentials NO, brain tissue has strong capacitance effects, acting as Low Pass filter
  - ➤ <u>Slow waves</u>
    - Synaptic potentials YES, both IPSPs and EPSPs from functional synaptic units are major contributors
    - Afterpotentials May contribute to a lesser extent



# Alpha and Synchronization

- ➤ Why Alpha?
  - It is <u>obvious</u> and hard to miss!
  - $\blacktriangleright~$  Accounts for ~70% of EEG activity in adult human brain
- From where, Alpha?
  - Historically, thought to be thalamocortial looping
  - Adrian (1935) demolished that theory
    - Recorded EEG simultaneously in cortex and thalamus
      Damage to cortex did not disrupt thalamic alpha rhythmicity
    - Damage to cortex and not disrupt maranne appla myunincity
      Damage to thalamus DID disrupt cortical alpha rhythmicity
  - Thalamic rhythmicity remains even in decorticate preparations
  - (Adrian, 1941)
    Removal of ½ thalamus results in ipsilateral loss of cortical alpha

. .

Next





# Alpha and Synchronization

- ➤ Andersen and Andersen (1968)
  - Cooling of Cortex resulted in change in amplitude but not frequency of Alpha



# Alpha and Synchronization

- Andersen and Andersen (1968)
  - Cooling of Thalamus resulted in change in amplitude and frequency of Alpha at both thalamus and cortex



# Alpha and Synchronization

- ➢ In sum, Thalamus drives the alpha rhythmicity of the EEG
  - Cortex certainly does feedback to thalamus, but thalamus is responsible for driving the EEG
  - Particularly the Reticularis nucleus (Steriade et al. 1985)
- What causes change from rhythmicity to desynchronization?
  - > Afferent input to thalamic relay nuclei
  - > Mode-specific enhancement observed

# Recording EEG









# Systems are surface-based, not anatomically-based



Automated cortical projection of EEG sensors: Anatomical correlation via the international 10–10 system L. Koesster<sup>Ab</sup>, L. Maillard<sup>b</sup>, A. Benhadid<sup>a</sup>, J.P. Vignal<sup>b</sup>, J. Felblinger<sup>a</sup>, H. Vespignani<sup>b</sup>, M. Braun<sup>A,CA,B</sup> <sup>1</sup> Sandig Rytermon, University International States, Internat

## Electrodes, Electrolyte, Preparation

- Ag-AgCl preferred, Gold OK if slowest frequencies not of interest
  - Polarizing electrodes act as capacitors in series with signal
- Electrolyte: ionic, conductive
- ➤ Affixing
  - Subcutaneous needle electrodes (OUCH)
  - Collodion (YUCK)
  - EC-2 paste; lesser of the evils
  - ➤ Electrocap

# **Recording References**

- Measure voltage potential differences
  Difference between what and what else?
- ≻"Monopolar" versus Bipolar
  - ➢ No truly inactive site, so monopolar is a relative term
  - Relatively monopolar options
    - ➢ Body BAD IDEA
    - ≻ Head
      - Linked Ears or Mastoids
      - Tip of Nose
- Reference choice nontrivial (more later) as it will change your ability to observe certain signals



#### **Recording References**

- ➢ Bipolar recording
  - ≻Multiple active sites
    - Sensitive to differences between electrodes
    - With proper array, sensitive to local fluctuations (e.g. spike localization)
- Off-line derivations
  - Averaged Mastoids
  - Average Reference (of EEG Leads)
    - With sufficient # electrodes and surface coverage, approximates inactive site (signals cancel out)
       Artifacts "average in"
  - Current Source Density (more in advance topics)

## Dreaded Artifacts

#### Three sources

- ➢ 60-cycle noise
  - ➤ Ground subject
  - ➢ 60 Hz Notch filter
- ➤ Muscle artifact
  - ≻ No gum!
  - ➤ Use headrest
  - Measure EMG and reject/correct for influence
- ➢ Eye Movements
  - Eyes are dipoles
  - Reject ocular deflections including blinks
  - Use correction procedure (more in advance lecture)

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# AC Signal Recording Options

Time Constant/HP filter
 Low frequency cutoff is related to TC by:

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Where F = frequency in Hz, TC = Time Constant in Seconds

Time Constant (sec)	Frequency (Hz)
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5.00	.032
1.00	.159
.30	.531
.10	1.592
.01	15.915





# Hi Frequency/LP Settings

- ➢ Do not eliminate frequencies of interest
- > Polygraphs have broad roll-off
- characteristics ➢ Be mindful of digitization rate (more info soon!)



# **Digital Signal Acquisition**

- > Analog Vs Digital Signals
  - ➤ Analog
    - > Continuously varying voltage as fxn of time
  - ➢ Discrete Time
    - > Discrete points on time axis, but full range in amplitude
  - > Digital
    - > Discrete time points on x axis represented as a limited range of values (usally  $2^x$ , e.g  $2^{12} = 4096$ )

#### A/D converters

- ➤ Schmidt Trigger as simple example
- > The A/D converter (Schematic diagram)
  - > Multiplexing (several channels); A/D converter is serial processor Result is a vector [1 x n samples] of digital values for each channel ( [x(t0), x(t1), x(t2), ..., x(tn-1)]
  - ▶ 12 bit converters allow 212 = 4096 values
  - ▶ 16 bit converters allow 216 = 65536 values

#### ➤ 12 bit is adequate for EEG

- ▶ 4096 values allow 1 value for each ~0.02 µvolts of scalp voltage (depending upon sensitivity of amplifier, which will amplify signal ~20,000 times before polygraph output)
- ≽ e.g.
  - > 2.1130 μvolts => 2481 D.U.'s (2480.74) > 2.1131 µ volts => 2481 D.U.'s (2480.76)
  - $> 2.1250 \,\mu \text{ volts} => 2483 \text{ D.U.'s} (2483.20)$



#### The Problem of Aliasing

- Definition To properly represent a signal, you must sample at a fast enough rate.
- Nyquist's (1928) theorem A sample rate twice as fast as the highest signal frequency will capture that signal perfectly
   Stated differently, the highest frequency which can be accurately represented is one-half of the sampling rate
- This frequency has come to be known as the Nyquist frequency and equals ½ the sampling rate ≻Comments
- > Wave itself looks distorted, but frequency is captured
- Wave itself looks distorted, but frequency is capture adequately.
  Frequencies faster than the Nyquist frequency will not be adequately represented
  Minimum sampling rate required for a given frequency signal is known as Nyquist sampling rate



Harry Nyquist

#### Aliasing and the Nyquist Frequency

- ► In fact, frequencies above Nyquist frequency represented as frequencies lower than Nyquist frequency
  - > F<sub>Nv</sub> + x Hz will be seen as F<sub>Nv</sub> x Hz
  - ➤ "folding back"
    - ➤ frequency 2F<sub>Ny</sub> seen as 0,
    - ≻ frequency 3F<sub>Ny</sub> will be seen as F<sub>Ny</sub>
    - ▶accordion-like folding of frequency axis