PSYC401A/501A: Principles of Psychophysiology

Spring, 2004, Mondays, 1100-150 P.M.
Room 317B Psychology

Syllabus

General Issues

- Definition
- Scope
- Problems of inference
- Problems and Prospects for the field

Definition

- Darrow (1964):
  - the science which concerns physiological activities which underlie or relate to psychic events
- Cacioppo Tassinary & Berntson (2000):
  - the scientific study of social, psychological, and behavioral phenomena as related to and revealed through physiological principles and events in functional organisms
- Allen (today):
  - The use of a particular set of physiologically-based dependent or independent variables to gain insights into psychological questions; when done well, psychophysiological methods
    - provide an independent method
    - provide information that is not accessible through other psychological methods
- Distinguished from: Physiological psychology, Behavioral Neuroscience

Scope

"Classic Measures"

- Skin Conductance (level and response)
- Cardiac measures (heart rate, variability, contractility, both SNS and PNS measures, BP, plethysmography)
- Oculomotor and pupilometric measures
- Electromyographic activity
- Respiration
- Gastrointestinal activity
- Penile and vaginal plethysmography
- Electroencephalographic oscillatory measures (frequency domain EEG and sleep psychophysiology)
- Event-related brain potentials
- Event-related frequency changes

"Newer Measures"

- Hormonal and Endocrinological measures
- Immune function
- Functional neuroimaging
  - PET
  - fMRI
  - Optical Imaging
- MEG

Manipulations

- Classical Biofeedback
- Rapid Trans cranial Magnetic Stimulation

Correlate Vs Substrate

- Is observed physiological activity a substrate of observed behavior? BEWARE
- Helpful Criteria
  - Is it necessary for behavior?
  - If removed, would behavior be altered?
- But ultimately, not easily resolved

Problems of Inference

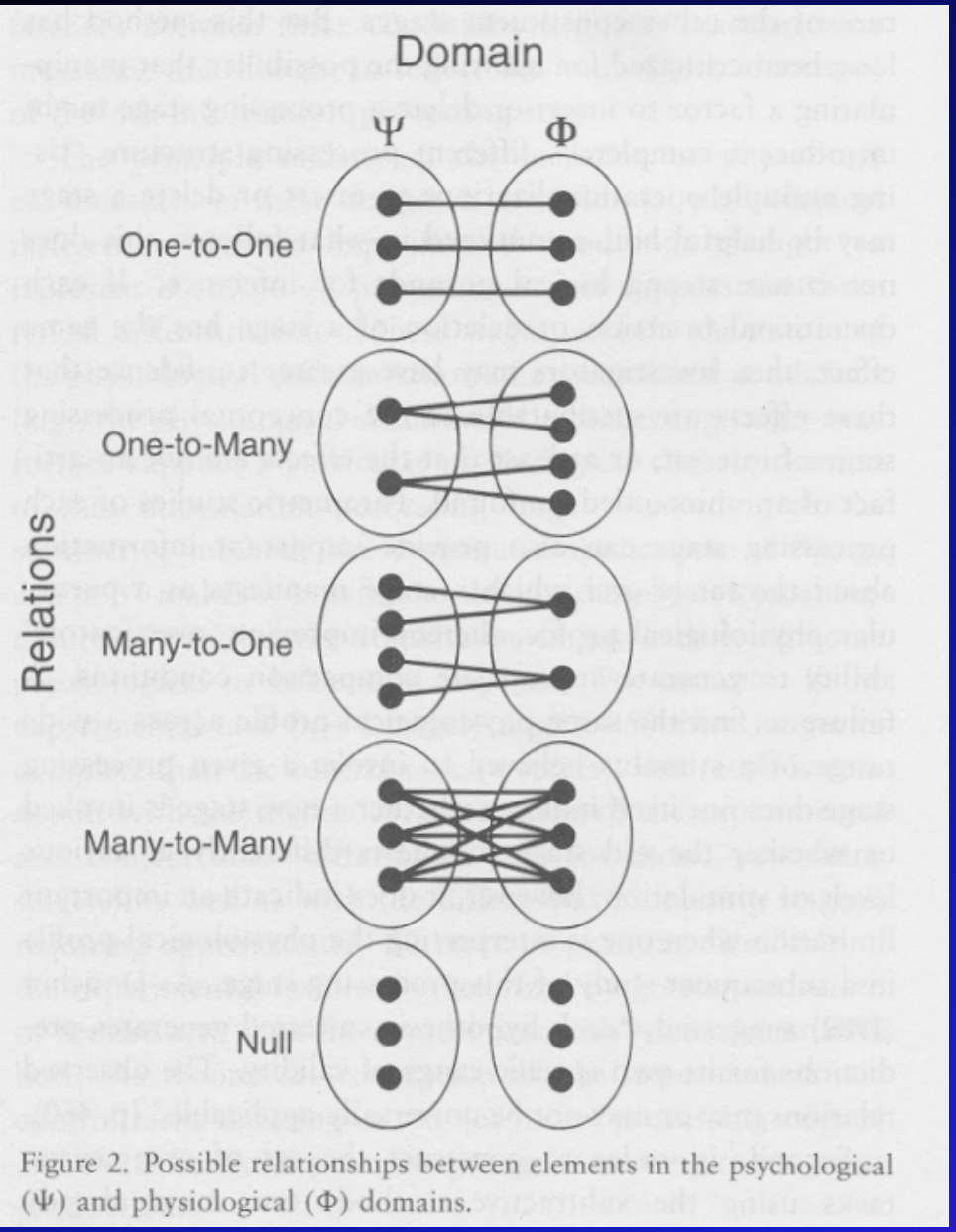


Figure 2. Possible relationships between elements in the psychological (Ψ) and physiological (Φ) domains.

From Cacioppo, Tassinary, & Berntson, 2000

Reducing the Complexity

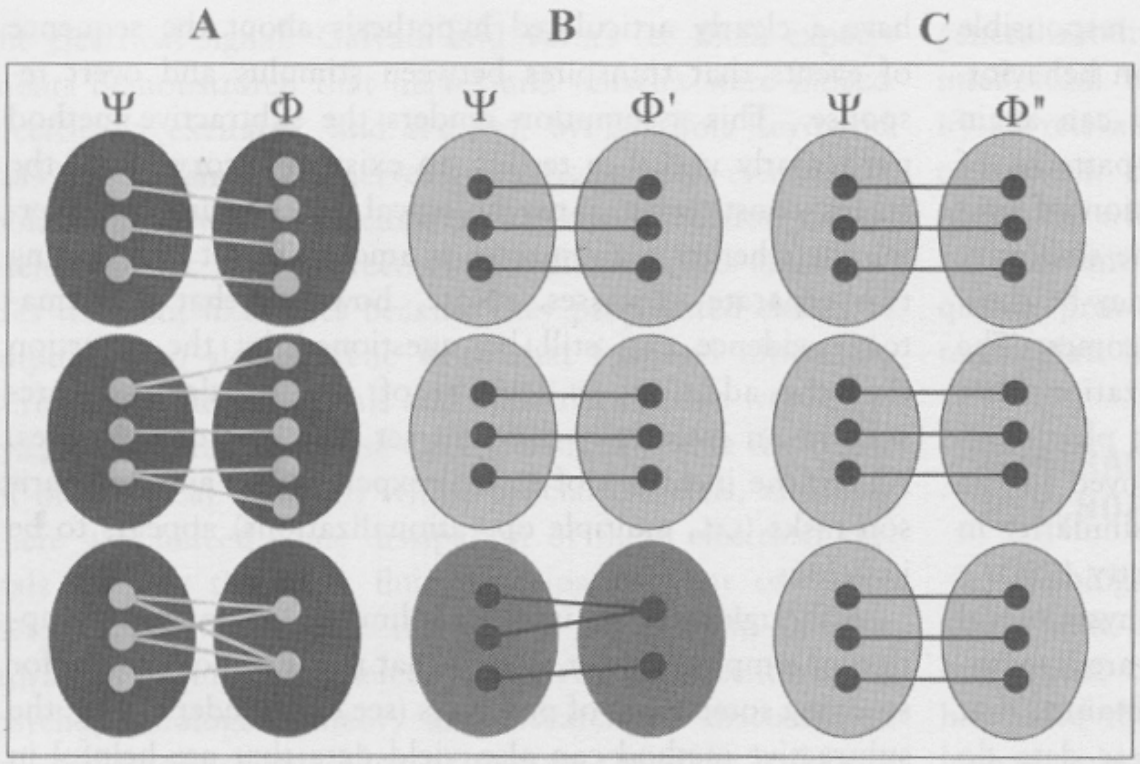


Figure 1. Depiction of logical relations between elements in the psychological (Ψ) and physiological (Φ) domains. Left panel: Links between the psychological elements and individual physiological responses. Middle panel: Links between the psychological elements and the physiological response pattern. Right panel: Links between the psychological elements and the profile of physiological responses across time.

Ibid.

Typical Scenarios

- Typical structure/assumption of psychophysiological or imaging study:
  - $P(\Phi|\ \Psi) > 0$
- Typical structure/assumption of biofeedback study:
  - $P(\Psi|\ \Phi\ ) > 0$
- Typical hunt for “markers” or biological substrate
  - Study begins $P(\Phi|\ \Psi) > 0$
  - Desirable (but often invalid) inference
    - $P(\Psi|\Phi) > 0$

The Taxonomy of Φ and Ψ

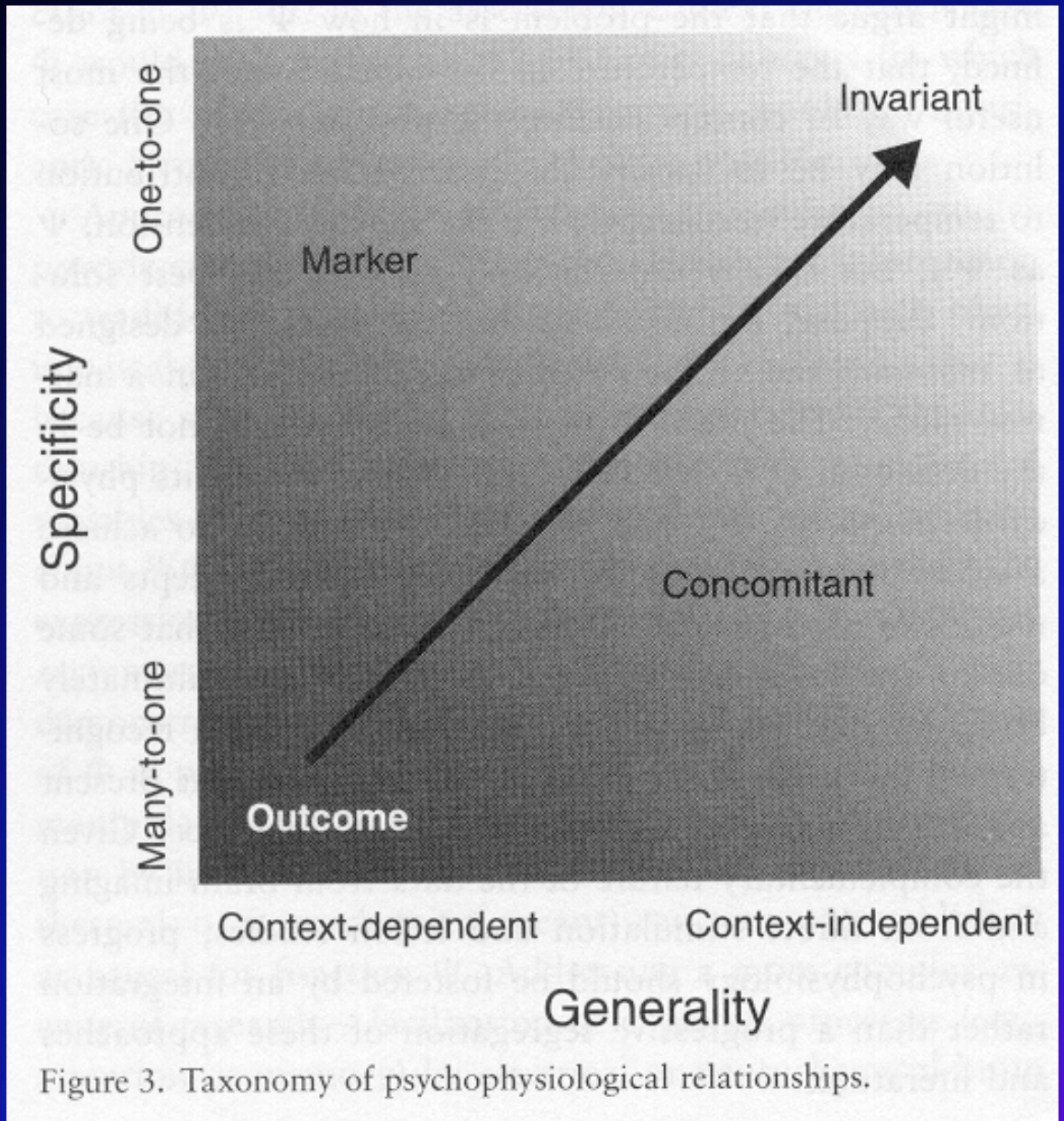
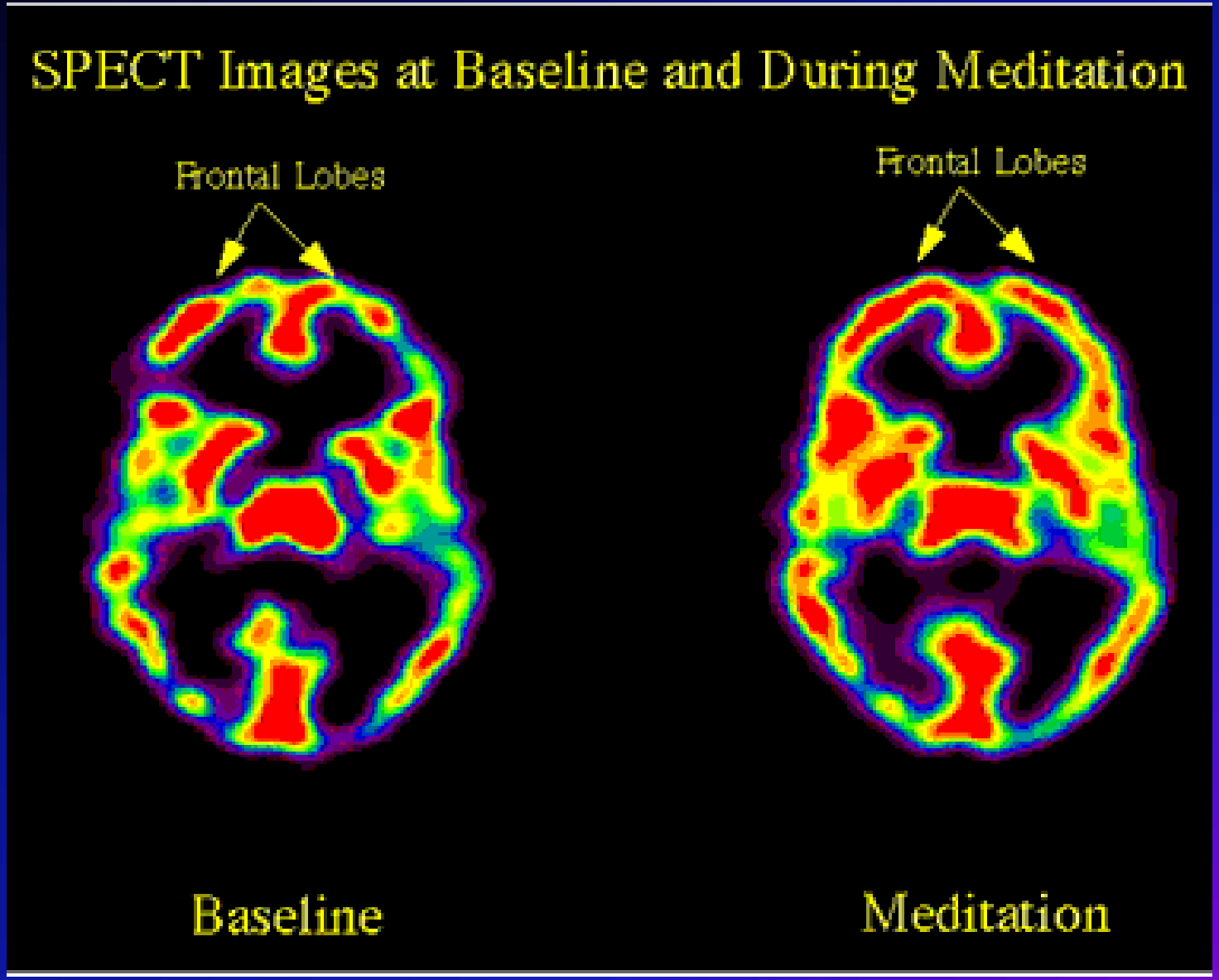


Figure 3. Taxonomy of psychophysiological relationships.

From Cacioppo, Tassinary, & Berntson, 2000

The Inference Problem -- Illustrated



d'Aquili and Newberg (1993) "Religious and Mystical States: A Neuropsychological Substrate" (Zygon 28: 177-200, 1993).

An Improvement – but still just an outcome

Azari et al. (2001). Neural correlates of religious experience. *European Journal of Neuroscience*, *13*, 1649-1652.

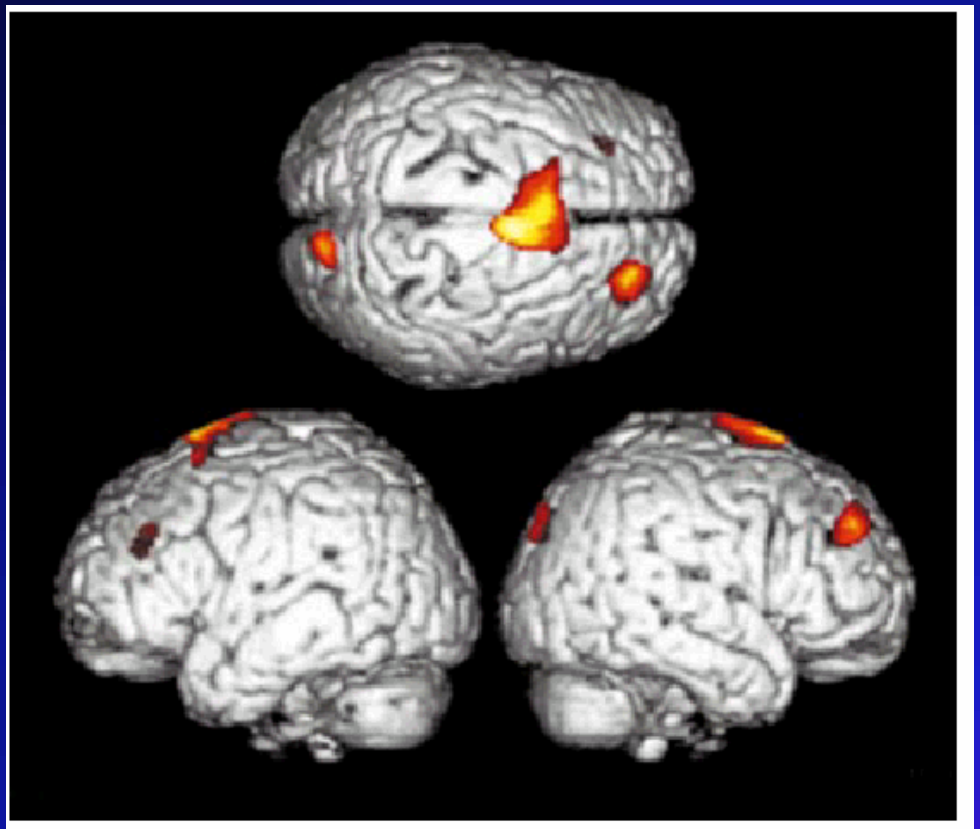


FIG. 1. Significant activations for the contrast 'religious-recite' vs. 'rest' in religious subjects, rendered onto canonical T1-weighted image of SPM97d ($P < 0.001$, uncorrected for multiple comparisons) (see also Table 2). Shown are the left, dorsal and right view of the brain. Scans for each subject were realigned and spatially normalized onto the PET template, and smoothed using an isotropic Gaussian kernel with FWHM set at 20 mm. The SPM grey matter threshold was set to its default value. For task comparisons, an ANCOVA (analysis of covariance) model was fitted to the data for each voxel.

Yet Another Example!

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NeuroImage

NeuroImage 20 (2003) 2119–2125

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One brain, two selves

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Abstract

Having a sense of self is an explicit and high-level functional specialization of the human brain. The anatomical localization of self-awareness and the brain mechanisms involved in consciousness were investigated by functional neuroimaging different emotional mental states of core consciousness in patients with Multiple Personality Disorder (i.e., Dissociative Identity Disorder (DID)). We demonstrate specific changes in localized brain activity consistent with their ability to generate at least two distinct mental states of self-awareness, each with its own access to autobiographical trauma-related memory. Our findings reveal the existence of different regional cerebral blood flow patterns for different senses of self. We present evidence for the medial prefrontal cortex (MPFC) and the posterior associative cortices to have an integral role in conscious experience.

"Our data confirm the emergence of conscious versus unconscious experience in the neural network of superior and inferior parietal lobule, left occipital cortex, precuneus, and frontal brain areas including BA 6 and BA 10." page 2124

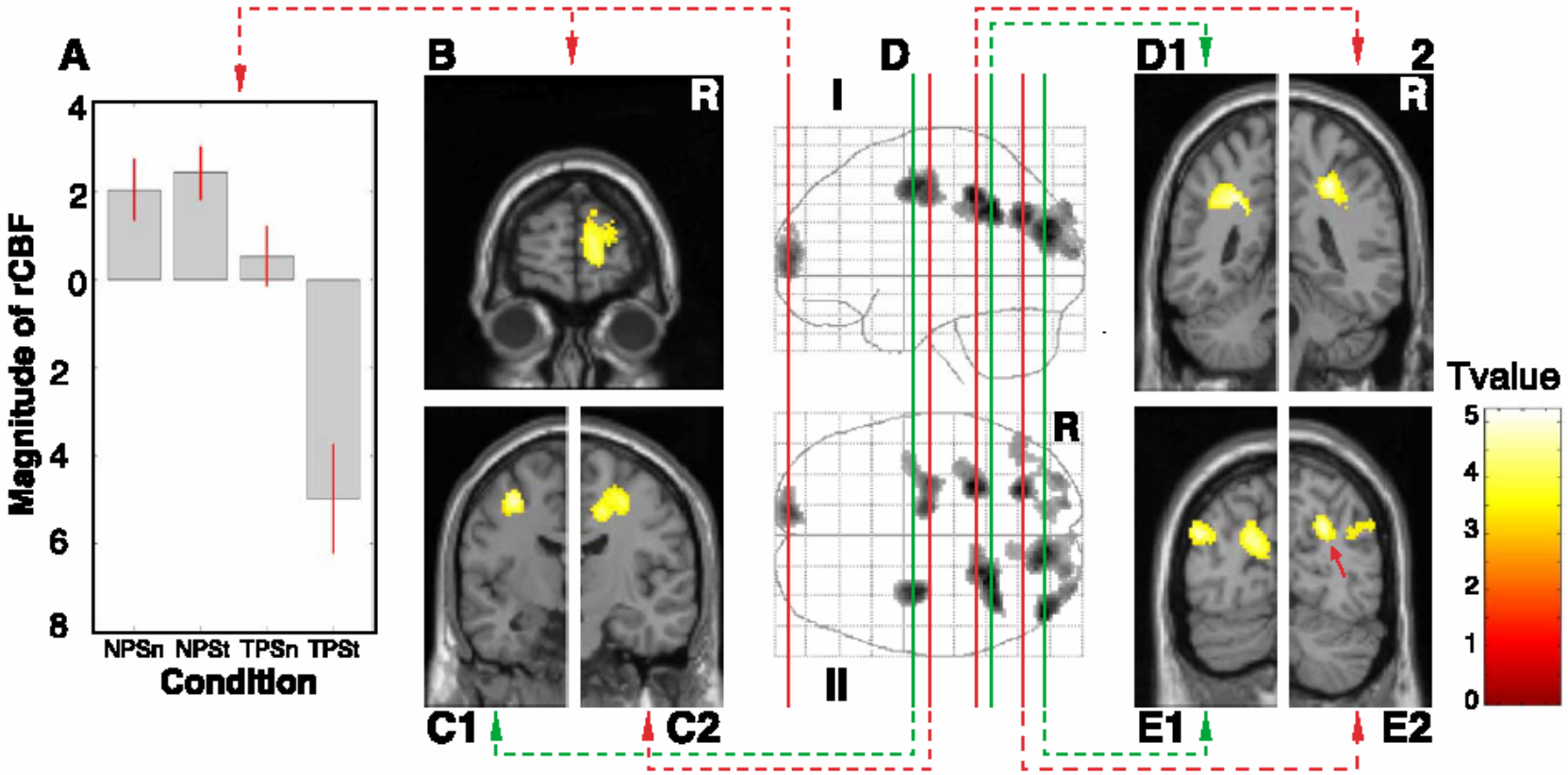


Fig. 1. Brain regions showing a significant response on the autobiographical trauma-related script in Neutral Personality State (NPS) as compared to Traumatic Personality State (TPS). (A) Mean regional cerebral blood flow (rCBF) changes at the voxel of maximum activation ($x = 12$, $y = 63$, $z = 8$) in the right medial prefrontal cortex (MPFC, Brodmann's area (BA) 10) for the four conditions of our study, i.e., exposure to a neutral (minor character n) and trauma (minor character t) memory script while remaining in NPS or TPS. Bars represent standard errors. The response shown is typical for the areas depicted in parts B through E. (B, C, D, E) Coronal slices of the brain regions involved in the functional neural network of autobiographical self-awareness. Slices are shown at the level of the most significant activation: part B (right BA 10; $x = 12$, $y = 63$, $z = 8$), C1 (left BA 6; $x = -30$, $y = -4$, $z = 46$), C2 (right BA 6; $x = 30$, $y = -11$, $z = 47$), D1 (left BA 7/40; $x = -24$, $y = -45$, $z = 37$), D2 (right BA 7/40; $x = 28$, $y = -37$, $z = 42$), E1 (left BA18/precuneus; $x = -8$, $y = -76$, $z = 24$ and BA19; $x = -44$, $y = -76$, $z = 30$), and E2 (right BA18/precuneus; $x = 26$, $y = -62$, $z = 33$ (as indicated with the small red arrow)). See also Table 1. (I and II) Parts I (sagittal view) and II (transaxial view) show the statistical parametric maps (the glass brains) of significant areas. Red and green lines represent the various brain levels, where the activations depicted in parts B through E of the figure have their peak significance value. Red lines are used for clusters located in the right hemisphere, while green lines are used for clusters in the left hemisphere. The letter R indicates the right side of the brain.

Problems and Prospects for Psychophysiology

Problems/Challenges

- Interpretive ambiguity
- Time resolution and time courses of various systems/measures differ substantially
- Spatial resolution
- What is the functional significance of the observed physiological measure?

Problems and Prospects for Psychophysiology

Prospects

- Non-invasive
- Measures of real-time information
- May be sensitive to things that we ourselves cannot be
- Ideally suited for populations that have limited verbal/cognitive capacity
- May tap function at roughly the proper level of the nervous system to be useful to psychological investigators
- Psychophysiology is now more integrated into psychology as a whole -- you will see it in "nonspecialty" journals
- More and more “canned” packages make it accessible to the novice, but novices need advice and consultation!
- Even though there will always be newer technologies (e.g., PET, SPECT, MEG/SQUID, MRI, Functional MRI, etc.), psychophysiology
  - Has real-time resolution
  - Is flexible
  - Is cost-effective
  - Can be integrated with many of the newer technologies
- When you tell folks at a party that you are a psychophysiologist rather than a psychologist, you are spared hearing the history of peoples' family pathology

A few of my favorite findings in psychophysiology

- Bauer (1984): Prosopagnosia
- Öhman & Soares (1993): Phobias
- Speigel (1985): Hypnosis
- Farwell & Donchin (1991): “Brain fingerprinting”
- Farwell & Donchin (1988): “Brain Prosthesis”
- Dikman & Allen (2000): Psychopathy

Bauer (1984): Neuropsychologia

- Prosopagnosia
- Administered a version of the Guilty Knowledge Test (GKT)
  - As administered to the prosopagnosic patient
    - Set A consisted of 10 photographs of very famous folks; Set B consisted of 8 family members
    - During the display, five choices of the correct name were presented auditorially
- Results
  - Patient naming: 0/10 famous faces, 0/8 family members
  - Controls naming = 9/10 famous, 0/8 of patient's family members
  - Electrodermally, patient produced largest SCR to correct alternative
    - for 60% of famous faces (controls 80%, *ns* difference),
    - for 62.5% of family members (controls 37.5%)
- Conclusions

Öhman & Soares (1993)
Journal of Abnormal Psychology

- Hypothesize that information processing of the phobic stimulus is rooted in archaic information processing mechanisms outside of the control of conscious intentions
- Use a CS+/CS- paradigm for fear-relevant and fear-irrelevant stimuli
  - Fear relevant is snake/spider; irrelevant is a flower or mushroom
  - During acquisition trials, CS+ is shocked, CS- is not
  - This leads to larger SCR to CS+ than CS- , and when stimuli are presented above threshold (with awareness), no difference between fear-relevant and fear-irrelevant
  - After acquisition, masked presentations (30 msec, followed by 100 msec mask)
  - Electrodermally, masking effectively eliminates the difference between CS+ and CS- for fear-irrelevant stimuli, but the difference between CS+/CS- is preserved for fear-relevant stimuli

Öhman & Soares (1993)
Journal of Abnormal Psychology

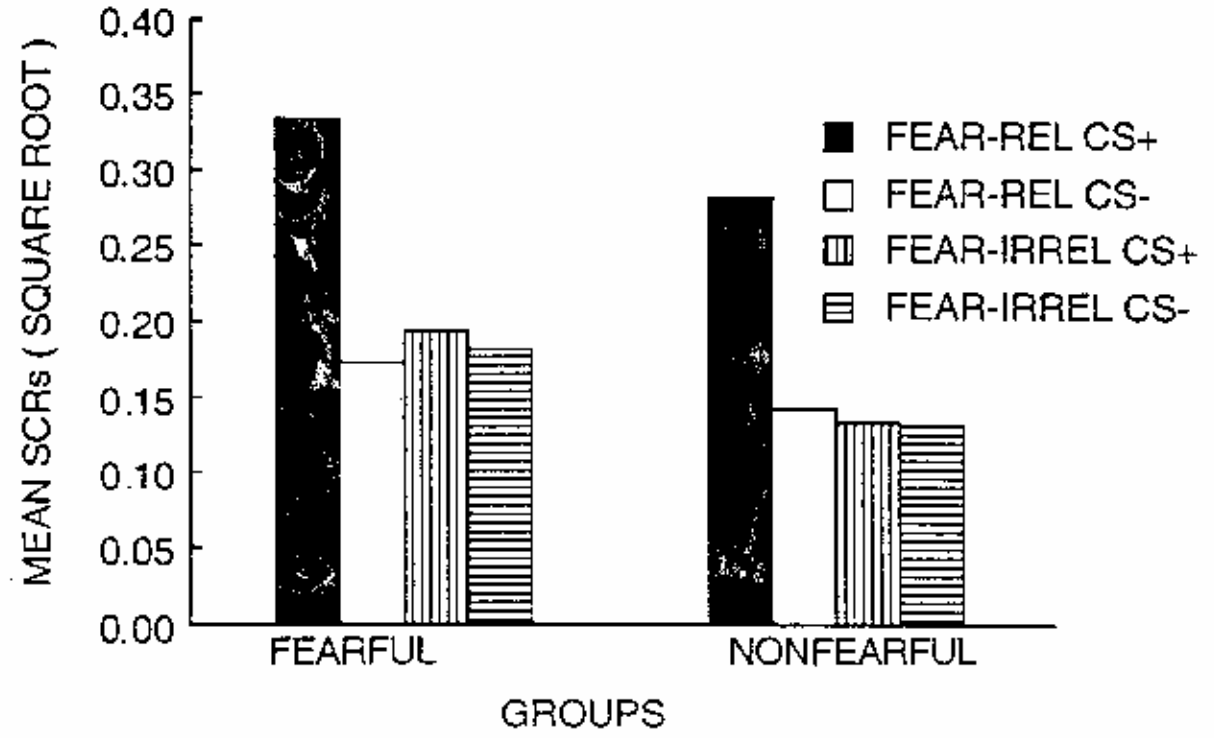
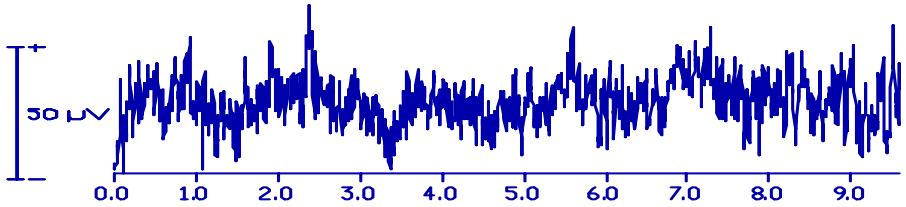


Figure 1. Mean skin conductance responses (SCRs) (square-root transformed) to fear-relevant (snakes, spiders, and rats) or fear-irrelevant (flowers and mushrooms) stimuli previously followed (CS+) or not followed (CS−) by an electric shock unconditioned stimulus among the fearful and nonfearful groups of subjects during extinction.

Speigel, Cutcomb, Ren, & Pribram. (1985) Journal of Abnormal Psychology

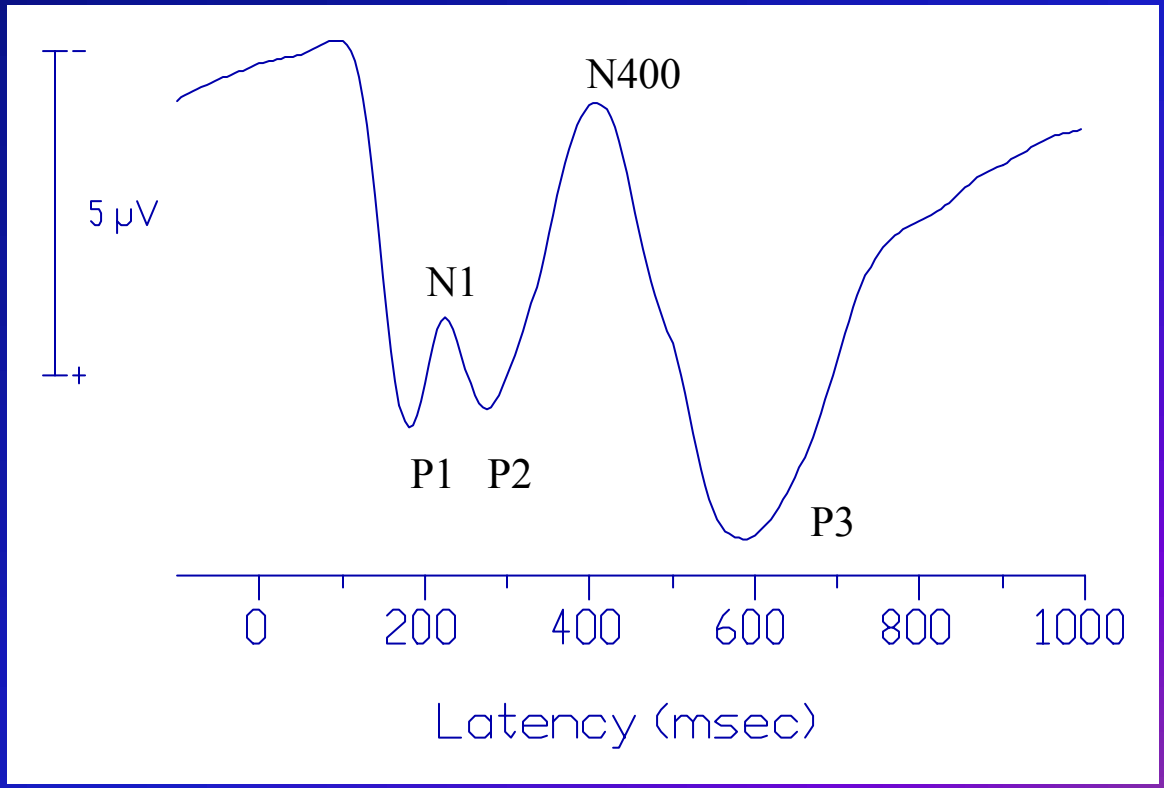
- Hypnosis
- ERPs 101: Signal averaging

Ongoing EEG



Stimuli

Visual Event-related Potential



Speigel, Cutcomb, Ren, & Pribram. (1985) Journal of Abnormal Psychology

- The study design
  - Very high or very low hypnotizable subjects selected
  - Given three suggestions:
    - Hypnotic enhancement
    - Hypnotic diminution
    - Hypnotic obstruction
  - An additional control group

HYPNOTIC HALLUCINATION ALTERS EVOKED POTENTIALS

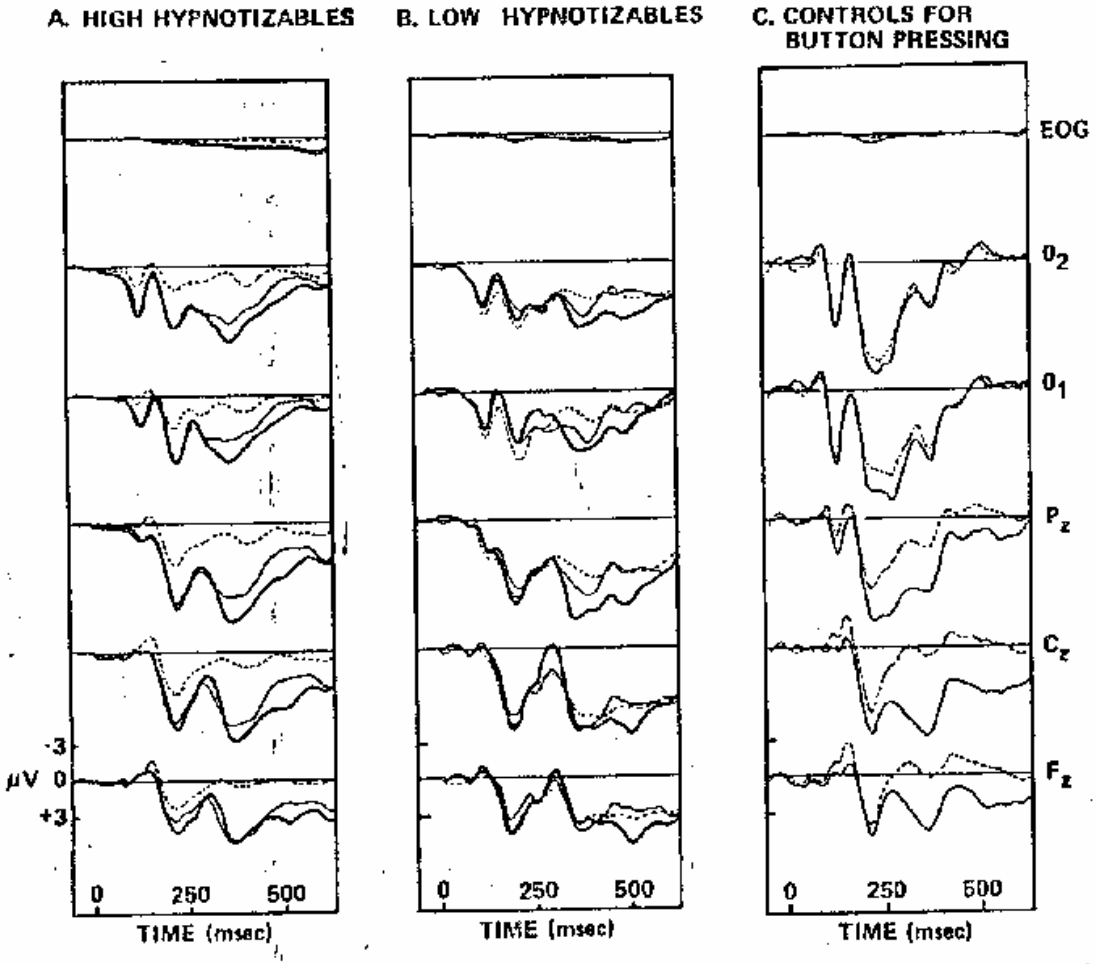
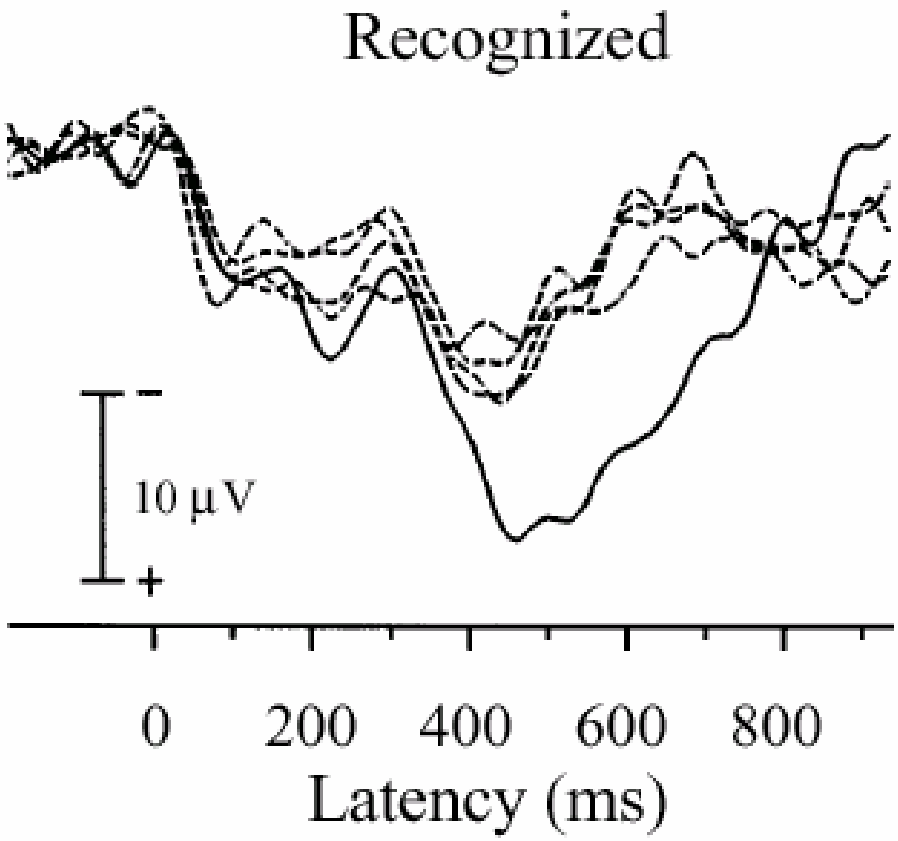


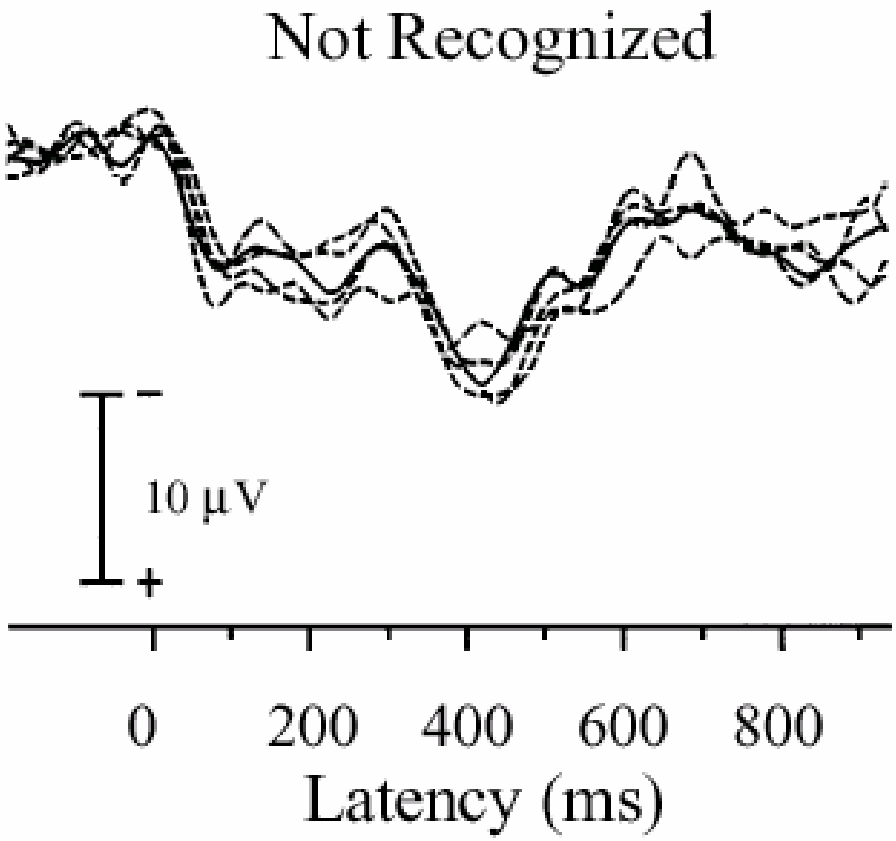
Figure 1. Effect of hypnotic obstructive hallucination on visual evoked potentials. (Visual evoked potentials [VEPs] recorded at leads Fz, Cz, Pz, O_1, and O_2 are expressed as the mean of recordings in each condition from 6 individuals per group yielding approximately 1,800 VEPs per waveform. In A and B, high hypnotizable and low hypnotizable group data shown are VEPs to stimuli observed in the hypnotic enhancement condition [thick solid lines], the hypnotic diminution condition [thin solid lines], and the hypnotic obstructive hallucination condition [dotted lines]. In C, control subjects for button pressing, solid lines are VEPs to stimuli that were all treated as button-pressing targets. Dotted lines are VEPs in a passive attention condition in which all stimuli were treated as standards and required no button pressing.)

Farwell & Donchin (1991) Psychophysiology

- Conventional Polygraphy unacceptably inaccurate
- Rather than rely on autonomic arousal, could rely on a cognitive response of recognition

Rationale


Recognized
10 µV
0
200
400
600
800
Latency (ms)


Not Recognized
10 µV
0
200
400
600
800
Latency (ms)

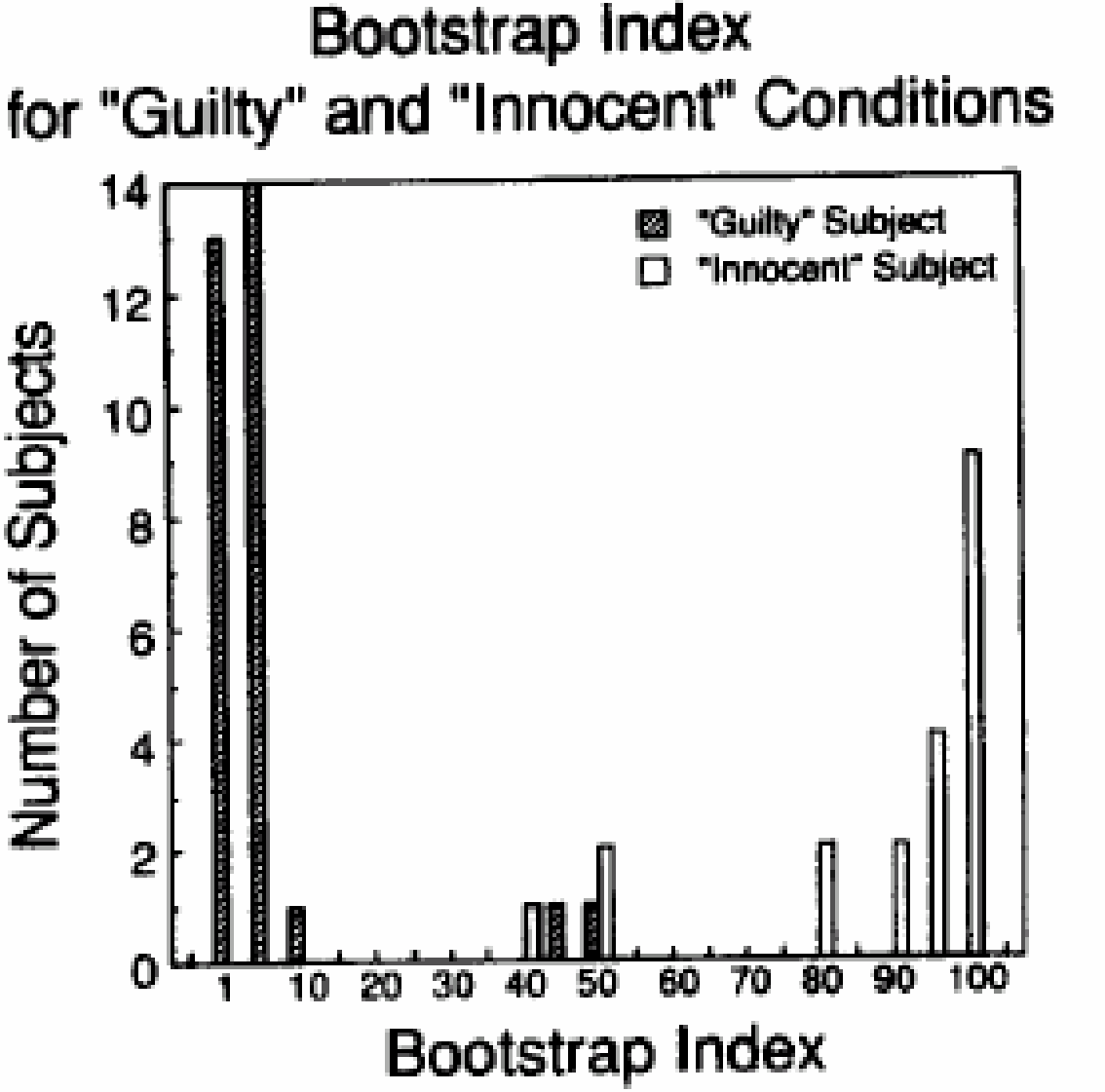


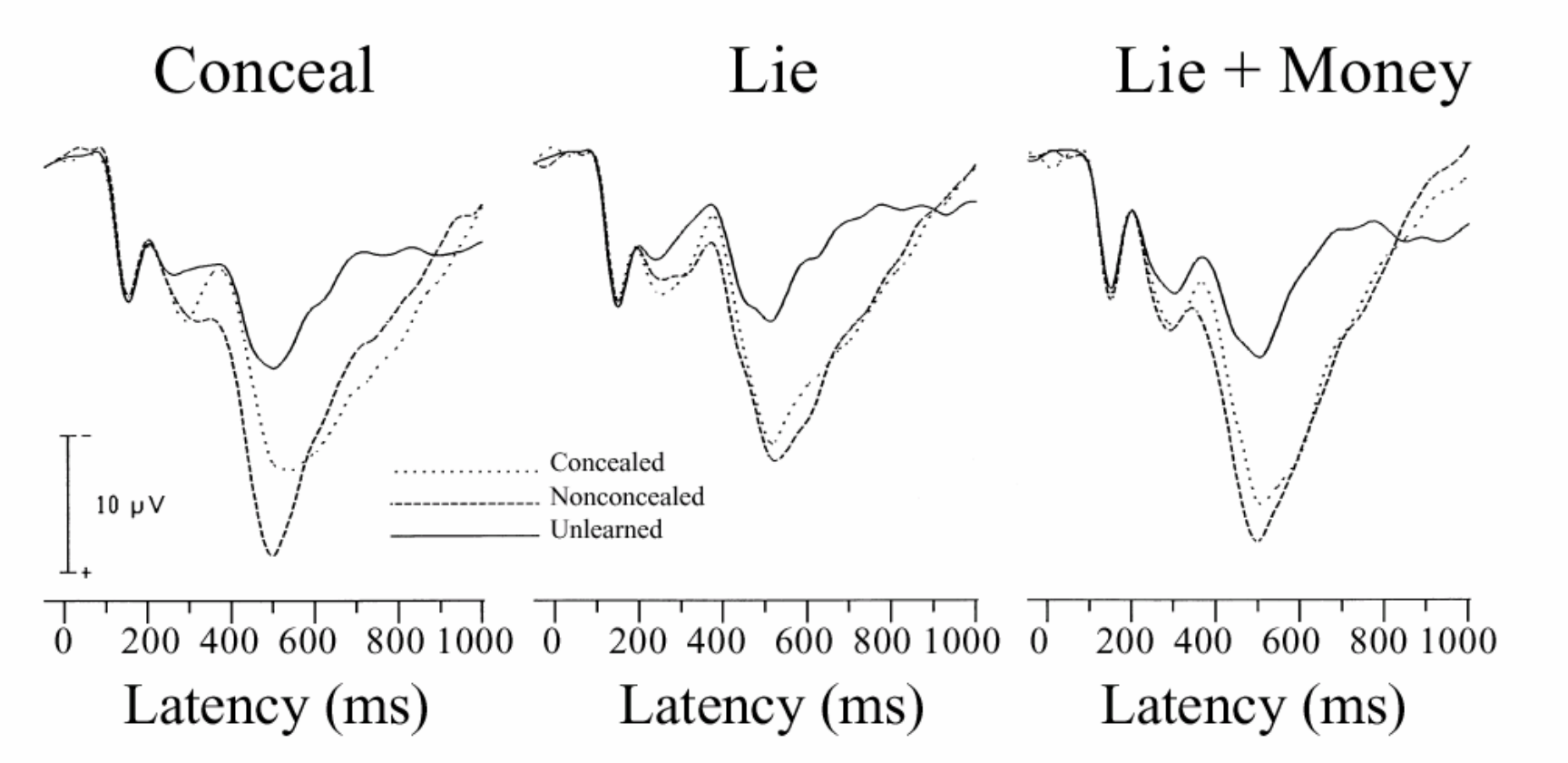
Figure 2. The distribution of the bootstrap statistic for all 40 tests conducted in Experiment 1. Dark bars indicate the number of subjects who were "guilty" and were assigned a given bootstrap value. Light bars show the same data for the "innocent" subjects.

Table 2

2A: ACCURACY OF DETERMINATIONS

Decision	Subject State: Guilty	Subject State: Innocent	Total
Guilty	18	0	18
Innocent	0	17	17
Indeterminate	2	3	5
Total	20	20	40

Allen, Iacono, & Danielson (1992) Psychophysiology



Farwell & Donchin (1988) *Electroencephalography and clinical Neurophysiology*)

- Attempted to develop an applied ERP system for communication without motor system involvement
- For “locked in” patients

CRT Display Used in the Mental Prosthesis

MESSAGE

BRAIN

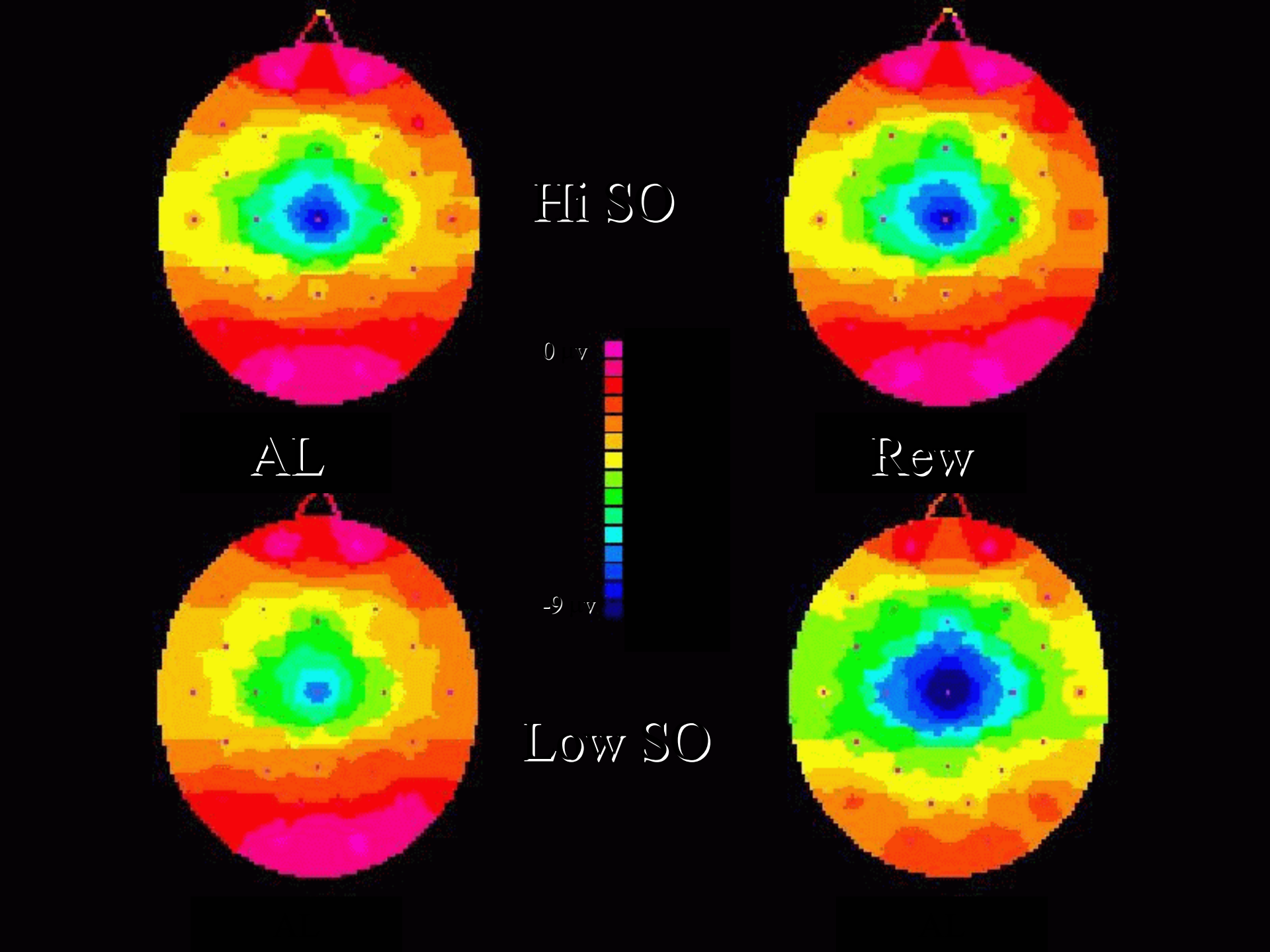
Choose one letter or command

A	G	M	S	Y	*
B	H	N	T	Z	*
C	I	O	U	*	TALK
D	J	P	V	FLN	SPAC
E	K	Q	W	*	BKSP
F	L	R	X	SPL	QUIT

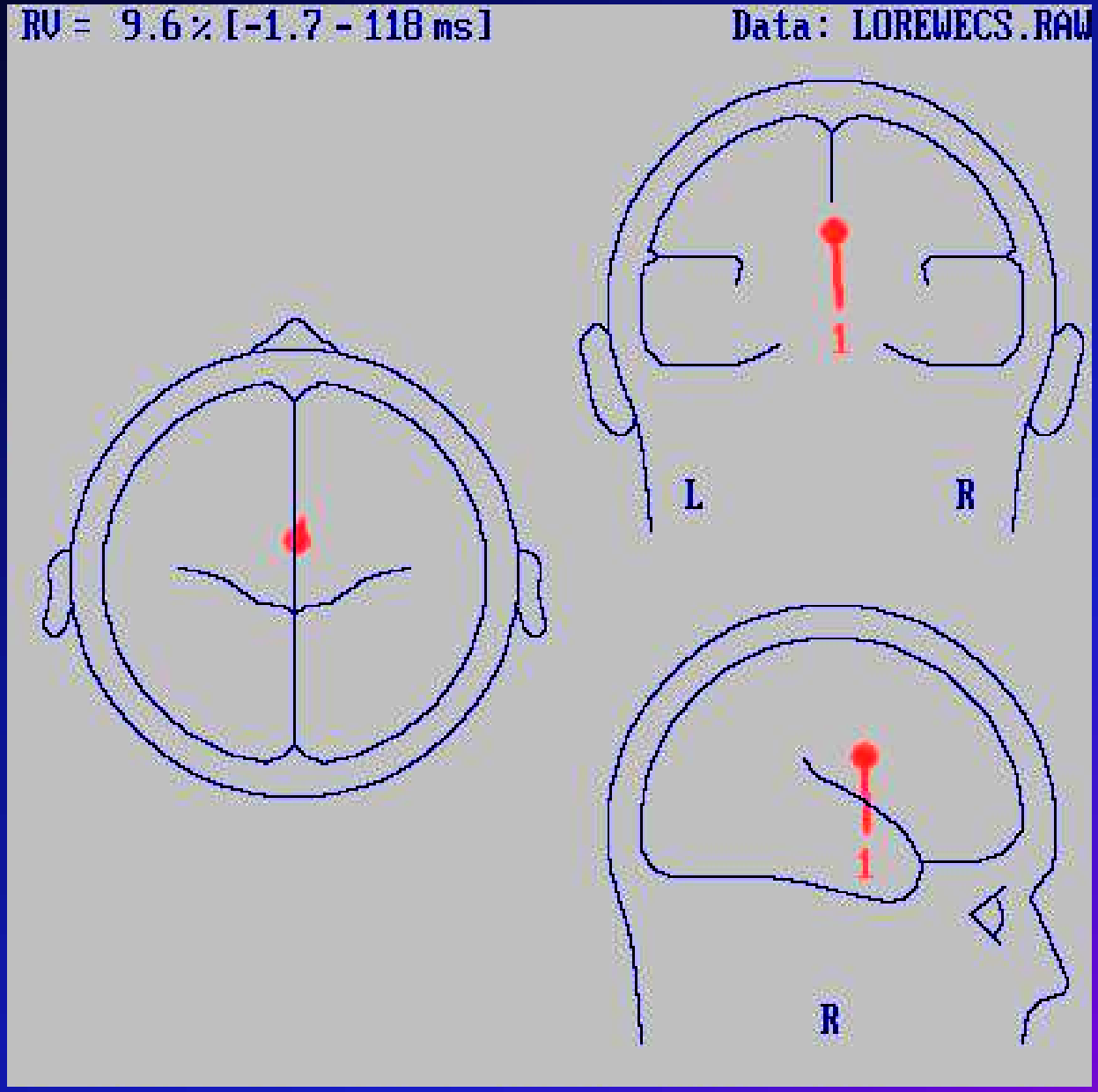
Fig. 1. CRT display used in the mental prosthesis. The rows and columns of the matrix were flashed alternately. The letters selected by the subject ('B-R-A-I-N') were displayed at the top of the screen in the pilot study.

Dikman and Allen (2000) Psychophysiology

- Avoidance Learning deficits well documented in Psychopathy
- Ascribed by some (e.g. Lykken) to deficient antipatory anxiety in face of potential punishment; ascribed by others (e.g. Kosson) to overfocus on reward
- Autonomic measures (e.g. SCR during countdown to shock task) corroborate the deficient anticipatory anxiety hypothesis
- Would similar phenomenon be evident at level of CNS (i.e. at what stage of processing is there a deficit?)
- Analog Psychopaths participated under conditions of reward and punishment


Hi SO
0 v
AL
Rew
-9 v
Low SO

BESA Modeling



Coming Up:

- Next Monday: Reviews of
  - Basic Electricity
  - Basic Neurophysiology and Neuroanatomy
- Don’t forget to turn in your 3x5 cards