PSYC401A/501A: Principles of Psychophysiology

Spring, 2021, Mondays, 2:00-3:45 p.m.
Live-Online and maybe
Room 307 Psychology

Course Resources Online:
jallen.faculty.arizona.edu

Follow link to Courses
Administrivia

- Introductions
- Overview of Syllabus
- Class Format

Substantive Topics

- General Definition and Interpretive Issues
- Review of studies that highlight the utility of a psychophysiological approach
Main Text


[University of Chicago Tribute](http://news.uchicago.edu/article/2018-01-03/shock-as-researcher-known-for-link-between-brain-personality-dies)
General Issues

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

Psychophysiology
Definition

- Darrow (1964) Presidential Address:
  - the science which concerns physiological activities which underlie or relate to psychic events
- Ax (1964) Opening Editorial, *Psychophysiology*

Psychophysiology is a research area which extends observation of behavior to those covert proceedings of the organism relevant to a psychic state or process under investigation and which can be measured with minimal disturbance to the natural functions involved. Modern psychophysiology is a response to the challenge inherent in the full realization of the complex nature of the human organism.

Psychophysiology provides a method for bringing both physiological and psychological aspects of behavior into a single field of discourse by which truly organismic constructs may be created.
Definition

➤ Stern (1964), also in the 1st issue of Psychophysiology

I would like to offer as a working suggestion that any research in which the dependent variable is a physiological measure and the independent variable a "behavioral" one should be considered psychophysiological research.

Yet he concludes… “I wish our editor the best of luck in defining the scope of articles acceptable for our journal.”
Definition

http://neurowear.com/projects_detail/necomimi.html
Definition

- Cacioppo Tassinary & Berntson (2016):
  - the scientific study of social, psychological, and behavioral phenomena as related to and revealed through physiological principles and events in functional organisms

- Allen (2021, this very moment):
  - 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 (to behavior and self report)
    - provide information that is not accessible through other psychological methods
    - link behavior and experience to underlying systems, by using paradigms with solid theoretical foundations

- 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, blood pressure, 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
- Transcranial Magnetic Stimulation
- Transcranial Direct Current Stimulation
- Transcranial Alternating Current Stimulation
- Transcranial Ultrasound
# Thematic x Systemic Psychophysiology

<table>
<thead>
<tr>
<th>Electrodermal psychophysiology</th>
<th>Cognitive psychophysiology</th>
<th>Developmental psychophysiology</th>
<th>Clinical psychophysiology</th>
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<td>fMRI during emotion</td>
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- Lie Detection
- Cardio effects prejudice
- EEG Asym Inhibited kids
- Neurowear!
Problems of Inference: Correlate Vs Substrate

- Is observed physiological activity a substrate of observed behavior? BEWARE

- Helpful Criteria
  - Is $\Phi$ necessary for behavior?
  - If $\Phi$ removed, would behavior be altered?

- But ultimately, not easily resolved

A scientific theory is a description of causal interrelations. Psychophysiological correlations are not causal. Thus in scientific theories, psychophysiological correlations are monstrosities. This does not mean that such correlations have no part in science. They are the instruments by which the psychologist may test his theories. (Gardiner, Metcalf, & Beebe-Center, 1937, p. 385)
Problems of Inference

Only these types of relationships would allow a formal specification that psychological elements are a function of specific physiological elements.

From Cacioppo, Tassinary, & Berntson, 2000, 2007

Figure 2. Possible relationships between elements in the psychological ($\Psi$) and physiological ($\Phi$) domains.
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.

From Cacioppo, Tassinary, & Berntson, 2000
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
    - $P(\Psi|\Phi) > 0$
    - Only valid given 1:1 relationship of $\Psi$ and $\Phi$
  - Use complementary approaches; e.g.,
    - fMRI = $P(\Phi|\Psi)$
    - Lesion = $P(\Psi|\Phi)$
    - Stimulation = $P(\Psi|\Phi)$

Figure 1
A rendering of base rates of activation across 3,489 studies in the literature, increasingly bright yellow/red colors reflect more frequent activation across all studies, with the reddest regions active in more than 20% of all studies. Regions of most frequent activation included the anterior cingulate cortex, anterior insula, and dorsolateral prefrontal cortex. Reprinted with permission from Varkoni et al., 2011.
The Taxonomy of Φ and Ψ

From Cacioppo, Tassinary, & Berntson, 2016

**One-to-one, Context Dependent**

**Example:** medical tests (fasting glucose)

**Inference** given Φ: yes, if conditions were met

**Utility:** with sufficient sensitivity and specificity can indicate presence of Ψ in this context; RDoC?

**Many-to-one, Context Dependent**

**Example:** affect and HR in IAPS paradigm

**Inference** given Φ: none

**Utility:** informs and tests theories; absence of Φ can be informative

**One-to-one, Context Independent**

**Example:** IT15 near end of short arm chromosome 4 and Huntington's

**Inference** given Φ: definitely Ψ

**Utility:** This is the Holy Grail that gets you the Nobel prize!

**Many-to-one, Context Independent**

**Example:** arousal and skin conductance (SC); orienting and SC; familiarity and SC

**Inference** given Φ: none

**Utility:** Limited: control the context! Might absence of Φ be informative?

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**Figure 1.1 Taxonomy of psychophysiological relationships.**
During religious recitation, self-identified religious subjects activated a frontal-parietal circuit, composed of the dorsolateral prefrontal, dorsomedial frontal and medial parietal cortex. Prior studies indicate that these areas play a profound role in sustaining reflexive evaluation of thought. Thus, religious experience may be a cognitive process which, nonetheless, feels immediate.
Earlier this year, I carried out an fMRI experiment to find out whether iPhones were really, truly addictive, no less so than alcohol, cocaine, shopping or video games. In conjunction with the San Diego-based firm MindSign Neuromarketing, I enlisted eight men and eight women between the ages of 18 and 25. Our 16 subjects were exposed separately to audio and to video of a ringing and vibrating iPhone. In each instance, the results showed activation in both the audio and visual cortices of the subjects’ brains. In other words, when they were exposed to the video, our subjects’ brains didn’t just see the vibrating iPhone, they “heard” it, too; and when they were exposed to the audio, they also “saw” it. This powerful cross-sensory phenomenon is known as synesthesia.

But most striking of all was the flurry of activation in the insular cortex of the brain, which is associated with feelings of love and compassion. The subjects’ brains responded to the sound of their phones as they would respond to the presence or proximity of a girlfriend, boyfriend or family member. In short, the subjects didn’t demonstrate the classic brain-based signs of addiction. Instead, they loved their iPhones.

“NYT Op-Ed + fMRI = complete crap”
-- Russ Poldrack
How to Interpret this?

“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.”

N=11, PET
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.
The Reverse Inference Problem

- Just because region X is active during state/process Y...
- It does not follow that activity in region X implies the existence of state/process Y
- Single region approaches unlikely to yield informative inference
- Machine-learning approaches (MVPA: multi-voxel pattern analysis) more promising
Problems and Prospects for Psychophysiology

Problems/Challenges

- Interpretive ambiguity, reverse inference
- 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.), traditional psychophysiology
  - Has generally excellent real-time resolution
  - Is flexible
  - Is cost-effective
  - Can be integrated with many of the newer technologies
  - Principles generalize across many measures
  - Newer technologies nonetheless based on fundamental principles of psychophysiology, and are in fact, psychophysiological measures
- 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 selected studies to highlight the utility of a psychophysiological approach

- Bauer (1984): Prosopagnosia
- Öhman & Soares (1993): Phobias
- Speigel (1985): Hypnosis
- Deception Detection studies
- Investigation of Persistent Vegetative State
- Brain-Computer Interfaces for assisted communication
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 for the correct name were presented auditorially
Bauer (1984): Neuropsychologia

- **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**
  - Dissociation between psychophysiological and behavioral measures - psychophysiology told us something that the patient could not
  - Patient can, at an autonomic level, properly identify faces
    - *viz.* that "prosopagnosia involves a functional defect not at the perceptual level itself, but at a stage of processing where adequate perceptual information is utilized in complex decisions about the stimulus identity" (p.463)
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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
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.
Öhman & Soares’ Conclusions

- Fear conditioning to nonprepared stimuli may involve conscious mechanisms.
- Fear conditioning to prepared stimuli may be possible through mechanisms outside of conscious/controlled information processing.
- Latter system may be fast and sensitive to danger cues.
- May also explain why exposure therapy is critical to decrease the autonomic responses.
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Hypnosis

- individual difference variable,
- assessed via responsiveness to suggestions

Two issues recurrently arise in hypnosis:

1. Do the effects have veracity?
2. If so, how are they accomplished?

ERPs 101: Signal averaging
Ongoing EEG

Stimuli

Visual Event-related Potential

Latency (msec)
The study design

- Very high or very low hypnotizable subjects selected
- Given three suggestions:
  - Hypnotic enhancement
  - Hypnotic diminution
  - Hypnotic obstruction
- An additional button-pressing control group
Figure 1. Effect of hypnotic obstructive hallucination on visual evoked potentials. (Visual evoked potentials [VEPs] recorded at leads Fz, Cz, Pz, O1, and O2 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.)
Hypnosis and Speigel continued

- Subsequent study using somatosensory ERPs found that suggestion to block mildly painful stimulus reduce P1 and P3 amplitudes in high- but not low-hypnotizable subjects.
- Also found that suggestions to increase intensity resulted in increase in P1 amplitude, but again, only in the high hypnotizable subjects.
- Collectively these studies may suggest alterations at the level of signal detection, not simply interpretation of the signal.
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- Brain-Computer Interfaces for assisted communication
Farwell & Donchin (1991) Psychophysiology

- Conventional Polygraphy unacceptably inaccurate
- Rather than rely on autonomic arousal, could rely on a cognitive response of recognition
- Mock Crime Scenario, multiple choice (variant of Guilty Knowledge Test)
  - Clothing of contact ("Green Hat")
  - Name ("Tim Howe")
  - Operation codename ("Op Pig")
  - Location ("Shark Street")
  - ...
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.
Allen, Iacono, & Danielson (1992)
Psychophysiology
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Persistent Vegetative State

- PVS patients typically are not non-responsive
  - But responses to varied stimuli lack:
    - voluntary components
    - cognitive aspects
    - evidence of awareness of self
    - evidence of awareness of surroundings.
  - No meaningful communication
- MCS (Minimally Conscious State) by contrast:
  - Minimal, if even highly inconsistent, signs of conscious behavior can be observed
Persistent Vegetative State

- Diagnostic errors in PVS up to 40% (Andrews et al., 1996)
- Might psychophysiological assessment help?
  - How best to validate such new measures against some gold standard when diagnostic errors are so common?
- Create continuous measure and link to physiology (Wijnen, van Boxtel, Eilander, & de Gelder (2007) Clinical Neurophysiology)
- Range from complete non-response to normal consciousness
<table>
<thead>
<tr>
<th>Level</th>
<th>Score</th>
<th>Description of the levels</th>
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<tr>
<td>Coma</td>
<td>1</td>
<td>Eyes are closed all the time. No sleep-wake cycles present. All major body functions such as breathing, temperature control, or blood pressure can be disturbed. Generally, no reactions are noticed after stimulation. Sometimes reflexes (stretching or flexing) can be observed as a reaction when strong pain stimuli have been applied. No other reactions present.</td>
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<td>Vegetative State (VS)</td>
<td>2</td>
<td>Patient has some sleep-wake cycles, but no proper day-night rhythm. Most of the body functions are normal. No further ventilation is required for respiration. Very little response (hyporesponse) Generally no response after stimulation. Sometimes delayed presentation of reflexes is observed.</td>
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<td>3</td>
<td>Reflexive state Often stimuli result in massive stretching or startle reactions, without proper habituation. Sometimes these reactions evolve into massive flexing responses. Roving eye movements can be seen, without tracking. Sometimes grimacing occurs after stimulation.</td>
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<td>4</td>
<td>High active level and/or reactions in stimulated body parts Generally spontaneous undirected movements. Retracting a limb following stimulation. Orienting towards a stimulus, without fixing. Following moving persons or objects, without fixing.</td>
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<td>Minimally Conscious State (MCS)</td>
<td>5</td>
<td>Patient remains awake most of the day. Transitional state Following and fixing of persons and objects. Generally more directed reactions to stimuli. Behaviour is automatic, i.e. opening of the mouth when food is presented, or reaching towards persons or objects. Sometimes emotional reactions are seen such as crying or smiling towards family or to specific (known) stimuli.</td>
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<td>6</td>
<td>Inconsistent reactions Sometimes, but not always, obeying simple commands. Totally dependent. Patient has profound cognitive limitations; neuropsychological testing is impossible. Level of alertness is fluctuating, but in general low.</td>
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<td>7</td>
<td>Consistent reactions Patient obeys simple commands. The level of alertness is high and stable. Many cognitive disturbances remain. Patient is totally dependent.</td>
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<td>Consciousness</td>
<td>8</td>
<td>Patient is alert and reacts to his/her environment spontaneously. Functional understandable mutual communication is possible, sometimes with technical support. As yet, cognitive and behavioural disturbances can be present.</td>
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Mismatch Negativity

- Discovered by Näätänen, Gaillard, & Mäntysalo, 1978
- Rare deviant ("Afwigkend geluid") elicits sustained negative voltage at scalp, maximal at fronto-central sites
  - Regardless of whether the stimuli are attended
  - Can vary in pitch, loudness, duration
Longitudinal Study

- Create continuous measure and link to physiology (Wijnen, van Boxtel, Eilander, & de Gelder (2007) Clinical Neurophysiology)
- Ten severely brain-injured patients (age 8-25)
- Longitudinal assessment starting 9 days after admission (and then every 2 weeks)
Fig. 2. Grand averages of MMN (Fz-linked Mastoids, 0.15-30 Hz, 48 dB/octave) for each Level of Consciousness according to the levels in Table 2 versus the norm group. Potentials related to the standard stimuli, potentials related to the deviant stimuli, and the MMN (difference between the deviant and standard).

Fig. 1. Longitudinal measurements: mean MMN-amplitude (Fz) and standard error for each Level of Consciousness according to the levels in Table 2 versus the norm group. For number of measurements see Table 3.
Longitudinal Study

- Predictive value?
- MMN during first assessment strongly predicted level of consciousness at discharge ($\beta = -.94$, $p < .00001$)
- Also predicted functional outcome two years later
Another approach

“These results confirm that, despite fulfilling the clinical criteria for a diagnosis of vegetative state, this patient retained the ability to understand spoken commands and to respond to them through her brain activity, rather than through speech or movement.”

“… suggests a method by which some noncommunicative patients, including those diagnosed as vegetative, minimally conscious, or locked in, may be able to use their residual cognitive capabilities to communicate their thoughts to those around them by modulating their own neural activity.”

See also:

Fig. 1. We observed supplementary motor area (SMA) activity during tennis imagery in the patient and a group of 12 healthy volunteers (controls). We detected parahippocampal gyrus (PPA), posterior parietal-lobe (PPC), and lateral premotor cortex (PMC) activity while the patient and the same group of volunteers imagined moving around a house. All results are thresholded at $P < 0.05$ corrected for multiple comparisons. $X$ values refer to distance in mm from the midline in stereotaxic space (SOM text).
A few selected studies to highlight the utility of a psychophysiological approach

- Bauer (1984): Prosopagnosia
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- Brain-Computer Interfaces for assisted communication
Syndromes where interaction with environment difficult or impossible

- Amyotrophic lateral sclerosis (ALS)
- Vegetative States
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

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<td>R</td>
<td>X</td>
<td>SPL</td>
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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.
P300-BCI. Rows and columns of letter strings are lighted in rapid succession. Whenever the desired letter (P) is among the lighted string, a P300 appears in the EEG (after Sellers & Donchin 2006; Piccione et al.2006).

Figure from Birbaumer, 2006
Can’t we speed things up?

http://www.youtube.com/watch?v=2KtMCX7FfZ0

https://www.youtube.com/watch?v=zqYJQGk5I4M
Fig. 4. A monkey is feeding himself with the aids of a robotic arm by producing the same pattern of neural activity in the motor cortex as would be required to move his own limb. The trajectory of the robot arm is depicted sequentially. In expectancy of the piece of an apple, the monkey protrudes his tongue. From the monkey only the head is visible. (We thank Dr. Andrew Schwartz, from the School of Medicine, University of Pittsburgh, Pittsburgh, USA, for this picture and for the permission of reproduction.)
Brain-Computer Communication and Slow Cortical Potentials
Thilo Hinterberger*, Stefan Schmidt, Nicola Neumann, Jurgen Mellinger, Benjamin Blankertz, Gabriel Curio, and Niels Birbaumer
Top right: Senso-motor-rhythm (SMR) oscillations from sensorimotor cortex during inhibition of movement and imagery or execution of movement (EEG trace below). On the left part of the picture is the feedback display with the target goal on the right side of the screen indicating the required SMR increase (target at bottom) or SMR decrease (target at top). The cursor reflecting the actual SMR is depicted in red moving from the right side of the screen toward the target goal.
Patients’ task is to move the cursor into the target.

Cursor movement is indicated by the squares (only one square is visible).

The cursor moves steadily from left to right, vertical deflections correspond to the SMR amplitude.

EEG frequency power:

- Bold line: frequency power spectrum when the cursor had to be moved toward the top target
- Dashed line: cursor had to be moved toward the bottom target.

Slow Cortical Potentials (SCP)

- Targets are presented at the top or bottom of the screen.
- Patients’ task is to move the cursor (yellow dot) toward the target.
- Cursor moves steadily from left to right and its vertical deflection corresponds to the SCP amplitude.
- A negative SCP amplitude (dashed line) moves the cursor toward the top, positive SCP amplitude (bold line) toward the bottom target.
- Before each trial, a baseline is recorded indicated by the green bar.
- At time point -2 s the task is presented, at -500 ms the baseline is recorded and at zero cursor movement starts.

BCI using slow cortical potentials (SCP depicted at the top). Patient selects one letter from the letter string on screen (right below) with positive SCPs, the spelled letters appear on top of the screen

Many Methods

- Many EEG DVs
- Many features to extract
- Many classification algorithms
- Meta-analysis of main methods


- Commercial implementation:
  https://www.youtube.com/watch?v=XPWMpU1VuKU
Coming Up:

- Next session … Reviews of:
  - Basic Electricity
  - Basic Neurophysiology and Neuroanatomy

- Don’t forget to turn in your comment/questions on class webpage
  https://jallen.faculty.arizona.edu/Psychophysiology_401_501