# EEGs and ERPs for Personnel Assessment: Reality or Fantasy?

Len Trejo*
Department of Psychology
University of Illinois at Urbana-Champaign

# Rationale

- Behavioral measures predict performance
  - Sensory and perceptual sensitivity
  - Specific cognitive abilities (spatial, verbal, etc.)
  - General intelligence
  - Training performance
- Processes link brain activity and behavior
- Brain activity predicts performance

# Linking Processes

- Perceiving
  - Detecting
  - Discriminating
  - Recognizing
  - Orienting
- Understanding
  - Identifying
  - Evaluating
  - Combining
- Interacting
  - Attending
  - Engaging
  - Searching
  - Responding
- Expecting
  - Context updating
  - Anticipating
  - Predicting

# Links to Brain Activity

- Perceiving
  - P1, N1, P2, MMN
  - Alpha blocking
  - Gamma
- Understanding
  - P300
  - N400
  - DM
- Interacting
  - Processing negativity
  - Selection negativity
  - Slow wave, ERN
  - EEG: Beta, Gamma
- Expecting
  - CNV
  - Lateralized readiness potential

# Civilian Personnel Testing

(Linn, 1982)

| | Predicitive validity for job performance proficiency | |
|---|---|---|
| Group | Training scores | Aptitude scores |
| Clerks | .47 | .27 |
| Fire, police | .35 | .23 |
| Hospital attendants | .54 | .03 |
| Vehicle operators | .15 | .14 |

# Military Personnel Testing: 1952-1982

(Vineberg & Joyner, 1982)

| Measure | Correlation with aptitude scores |
|---|---|
| Job knowledge | .40 |
| Job sample tests | .10 - .35 |
| Composite suitability | .24 |
| Global job performance | .15 |

# Case #1: IQ / Aptitude Testing

- Model #1: Speed of the EEG or ERP
  - Basic ideas
    - cortical excitability cycle (Lindsley, 1952)
    - decay of short-term or working memory
  - EEG frequency & intelligence
    - Berger (1932), Mundy-Castle (1958), Saunders (1961) (but many exceptions):
  - ERP latency & intelligence
    - Chalke & Ertle (1965), Ertle & Schafer (1969), but see Griesel (1973)

- Model #2: Complexity
  - Basic ideas
    - Errors reduce complexity of ERP
    - Higher dimensionality implies intelligence
  - "String" measure: Hendrickson & Hendrickson (1980), Hendrickson & Blinkhorn (1982)
  - EEG dimensionality (Lutzenberger et al, 1994)
- Model #3: Variability
  - Psychopathology & variability (Callaway, Jones, & Donchin, 1970; Callaway, 1975)
  - "TTV" measure and recruit classification (Lewis, Rimland, & Callaway, 1977)

- Status of IQ / aptitude testing: Fantasy
  - Significant differences appear only during passive conditions
  - During passive conditions there is no control for processing differences
- Possible new directions
  - Apply new information relating structure and function (e.g. WM and source localization in prefrontal and cingulate cortex)
  - Use tasks that demand specific processing resources

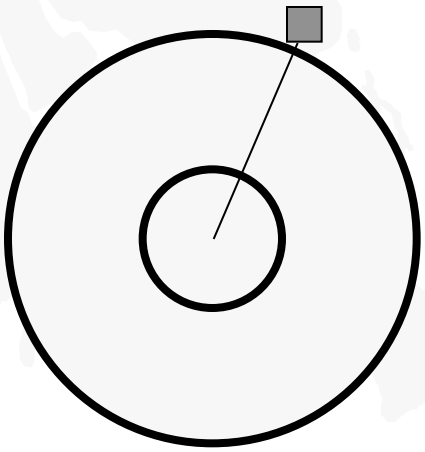
# Case #2: Performance Assessment

- Model #1: Arousal / alertness
  - Alertness detection and EEG
  - Theta suppression & vigilance (Beatty & O'Hanlon, 1979)
  - "Spectral signature" of alertness decrement (many examples, recently Makeig & Inlow, 1993)

- Model #2: Mental Resource Allocation
  - Basic idea: limited capacity of central executive (Kahneman, 1972)
  - Modern version: multiple resource pools (Wickens, 1984)
  - Applications:
    - Dual-task method (Chambana group: Donchin, Wickens, Kramer, Israel, & a cast of thousands)
    - Irrelevant-probe method (Hernandez-Peon, 1958; more recently Trejo, et al.)

# Example #1: Radar Monitoring Workload

- Air Defense Radar Simulation @ three levels of difficulty
  - N=30 subjects
  - Diffuse visual probes
  - 40% reduction in ERP amplitude
  - Fz-Cz @ 127 ms
  - Fz-Cz @ 330 ms



# Example #2: Signal Detection Performance

- Navy technicians
- Baseline condition
- Active condition
  - Detect NTDS symbols
  - 3 contrast levels
  - 2.5-3.5 s ITI
  - Classify
- Probes
  - Brief, diffuse
  - 526-1576 ms SOA

# Results

## Symbol ERPs

- Baseline vs. active
  - Slow wave larger in active condition
- Active condition
  - P3 larger on correct, fast, confident trials

## Probe-ERPs

- Baseline vs. active
  - N2 larger in baseline condition
  - P3 larger in baseline condition
- Active condition
  - No effect

# Discussion

Symbol ERPs

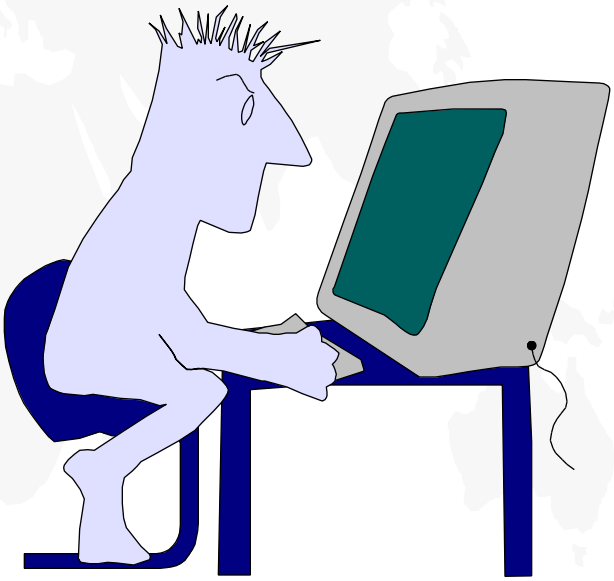
- Slow wave reflects engagement
- P3 reflects quality or quantity of task-relevant information

Probe ERPs

- N2-P3 reflect disengagement

# Example #3: EW simulation

- 10 experienced EWs
- Baseline
  - Auditory oddball
  - Distraction
- 1-hr mission scenario
  - OTD
  - Auditory probes
  - North Atlantic scenario



# Results

## Baseline task

- Deviant tones
  - Large N1, N2
  - P3 elicited only by target deviants
- Deviant vs. standard
  - Mismatch negativity for both deviants

## Scenario

- Standard tones
  - Reduced N1, N2
- Deviant tones
  - No P3
  - Reduced N1, N2
  - Reduced MMN
- Both
  - reductions covary with scenario complexity

# Discussion

P3

- Reflects engagement in the scenario
- Similar results in Boeing helicopter study

N1, N2, MMN

- Reflect attention to the probes
- Covary with scenario complexity
- Why attend to probes?
  - Attention is captured by transient stimuli
  - Except when focused

# Schemas and performance: Some hypotheses

- Engagement means schema selection
  - Slow waves reflect schema selection
- Schemas are compared to situation data
  - Mismatch between schema and situation forces a schema update
  - P3 reflects schema update

# Attention capture and performance: Some more hypotheses

- When attention is not focused...
  - A schema is not selected
  - Transient stimuli capture attention
  - Probes elicit N1, N2, and MMN
  - No P3
    - Processing aborted before schema selection
  - P3/slow wave elicited
    - Schema selection and activation

# Conclusions

- Status of performance assessment: Reality
- ERPs tell us about performance
  - When performance fails due to inattention
  - When demands of the task exceed the resource allocations
- EEG measures tell us about alertness
- Future directions:
  - Adaptive systems
  - Job performance aids
  - Adaptive training