

# The Event-Related Potential (*aka* the ERP)

# Announcements

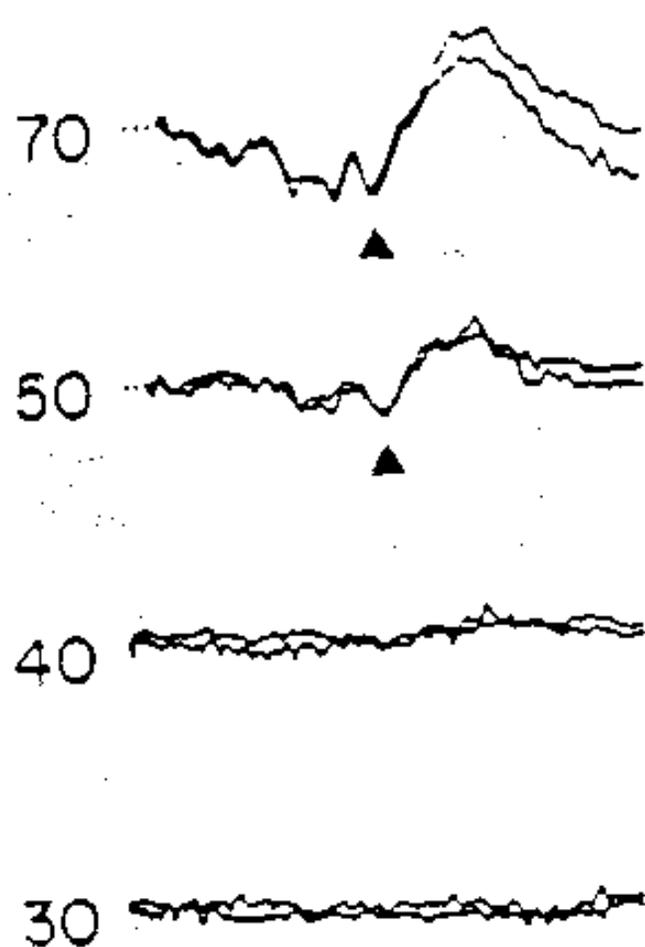
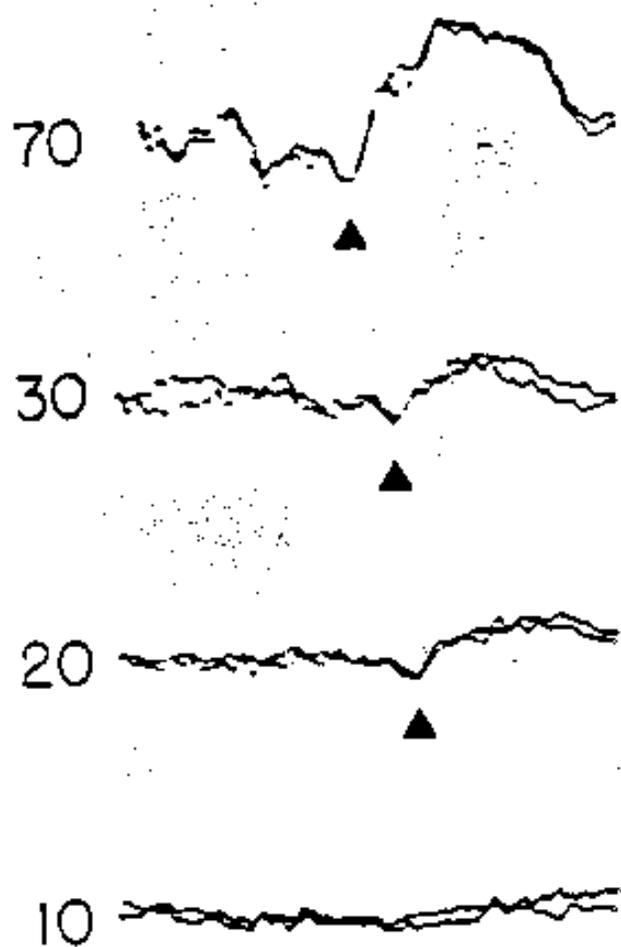
- The Home Stretch...
  - Papers due April 29
  - Take home final available April 29, due May 7
- 3x5s times three!  
(that's 9x15...)

# Applications of Early Components

- Neurological evaluation of sensory function; e.g. evaluation of hearing in infants
  - Tones of various dB intensities presented and V wave in auditory brainstem ERP examined
  - Figure 10; 4000 individual trials per average

Left Ear

Right Ear

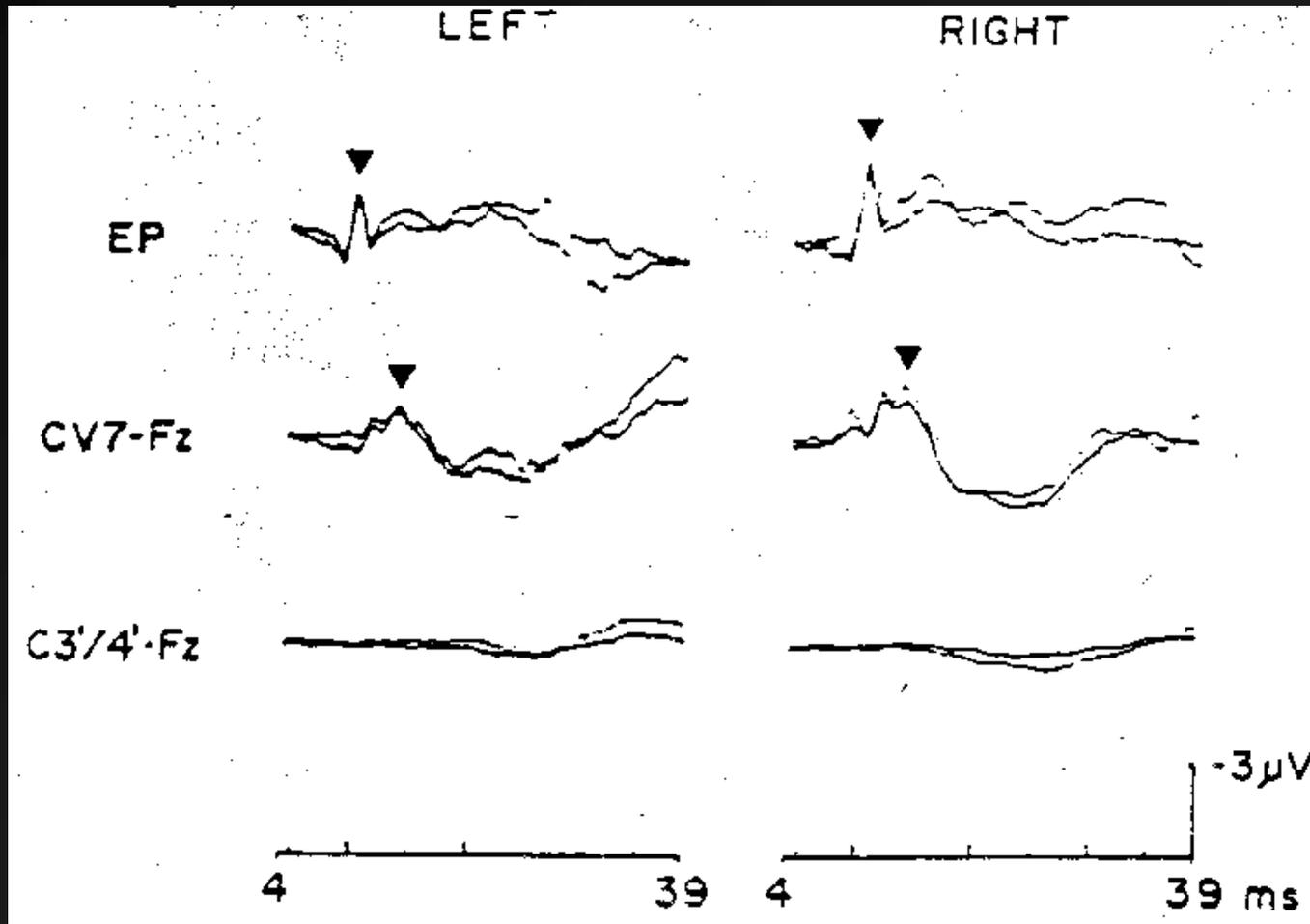


dBnHL

-0.5  $\mu$ V

15 ms

# Prediction of recovery from coma



- ❑ Somatosensory evoked potentials were recorded from a patient who was still comatose 1 week after severe closed head injury.
- ❑ Responses evoked by electrical stimulation of left and right median nerves
- ❑ Normal tracing seen at Erb's point, and from the next over vertebra prominens, but not over C3' of C4'.
- ❑ Absence of any cortical response a bad prognostic sign. Patient continued in a chronic vegetative state 1 year after accident

# Inter-Hemispheric Transfer Time (IHTT)

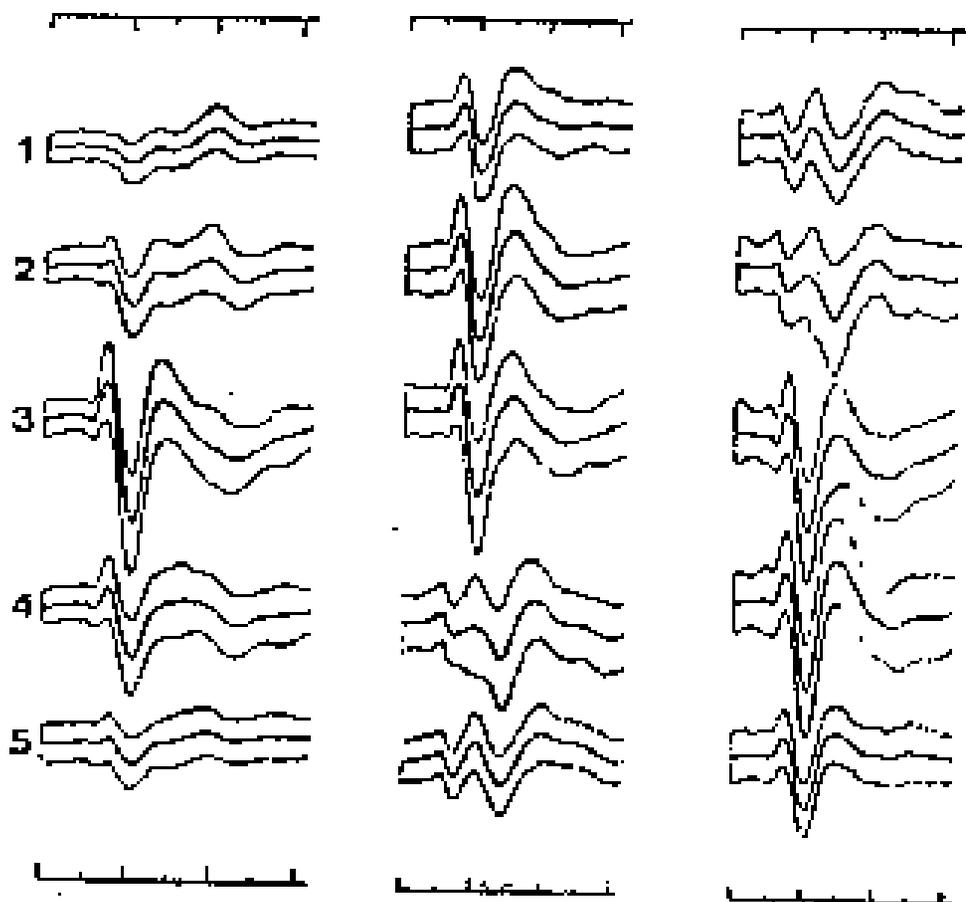
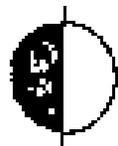
- Hypothesized that interhemispheric transfer of information may be abnormal in various disorders (e.g., dyslexia)
- Reaction Time measures contain too much variability not related to Transfer Time
- ERP early components appear promising as a measure of time required to transfer information between hemispheres

# IHTT Study (Saron)

- Checkerboards subtending  $< 1$  degree of visual angle presented 2.9 degrees from center
- ERP's recorded at O1 and O2
- Problem of lateralization and Paradoxical results possible; parafoveal regions on banks of calcarine fissure
- P100 wave latency examined; earlier latency in occiput contralateral to presentation
  - Measured by peak picking procedure
  - Also by cross-lagged correlation technique
  - Both methods suggest ~15 millisecond IHTT; found to be in expected direction predicted by anatomy for over 90% of subjects
  - Reaction time data from same task showed no reliable differences

**A**

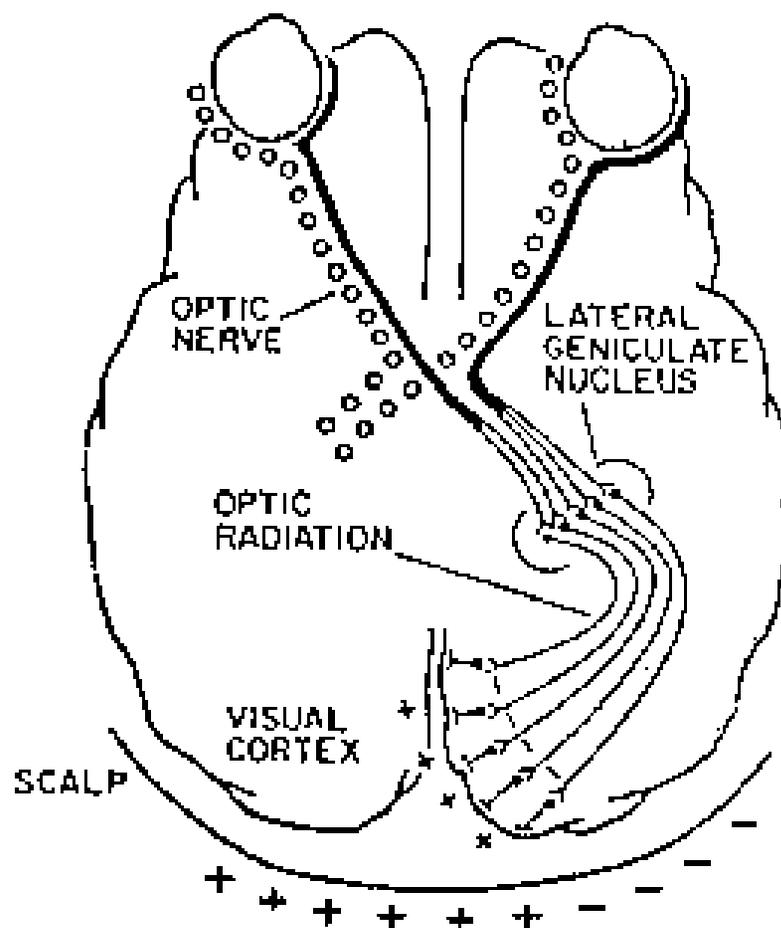
$\overline{-}$   
 $\overline{+}$  50V

**B**

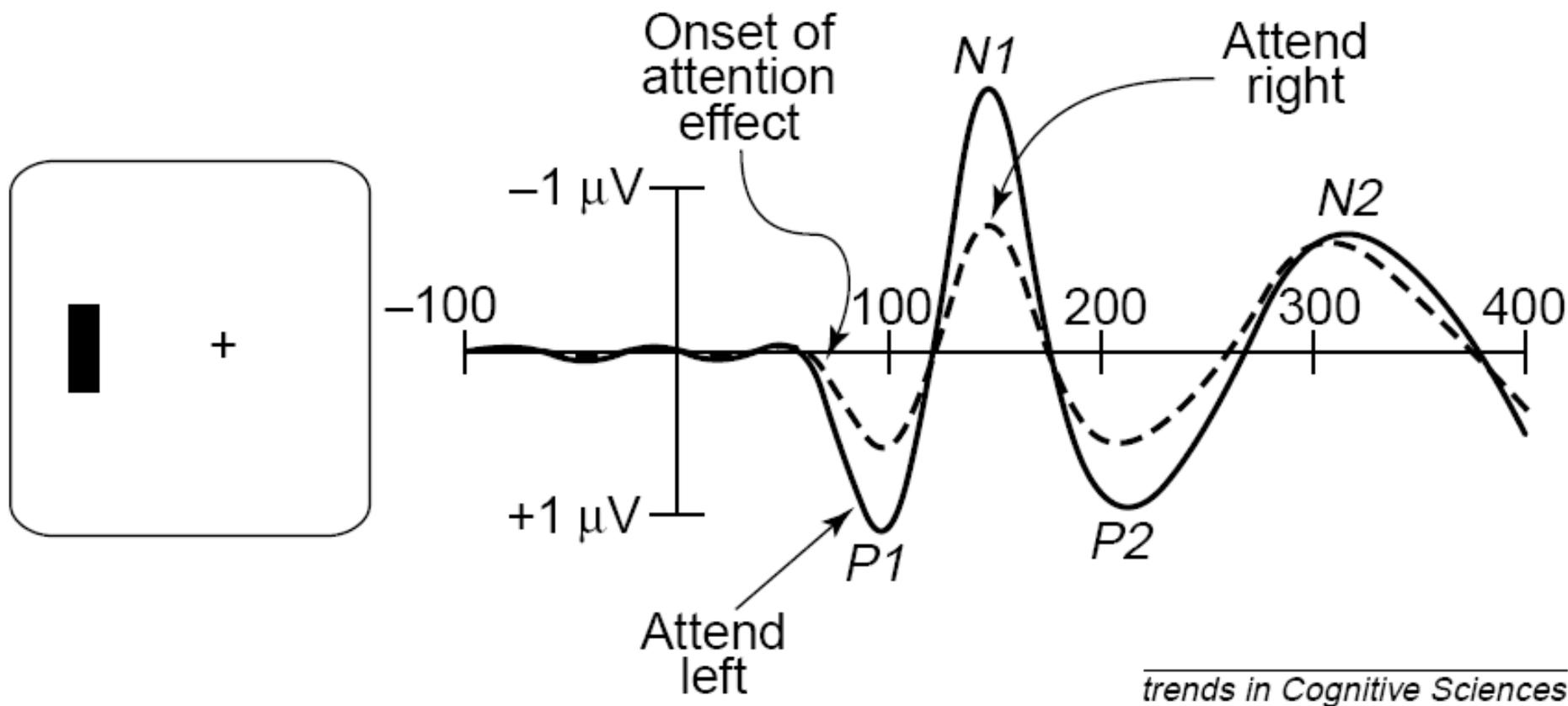
VISUAL  
 FIELDS

LEFT

RIGHT



# P1, N1, and Attention



**Fig. 1. Paradigm for using ERPs to study attention.** Stimulus display (left) and idealized results (right). Subjects fixate a central cross and attend either to the left or right visual field. Stimuli are then presented to the left and right visual fields in a rapid sequence. In this example, the ERP elicited by a left visual field stimulus contains larger P1 and N1 components when the stimulus is attended ('Attend left') than when it is ignored ('Attend right').

# More than Spatial Directed Attention

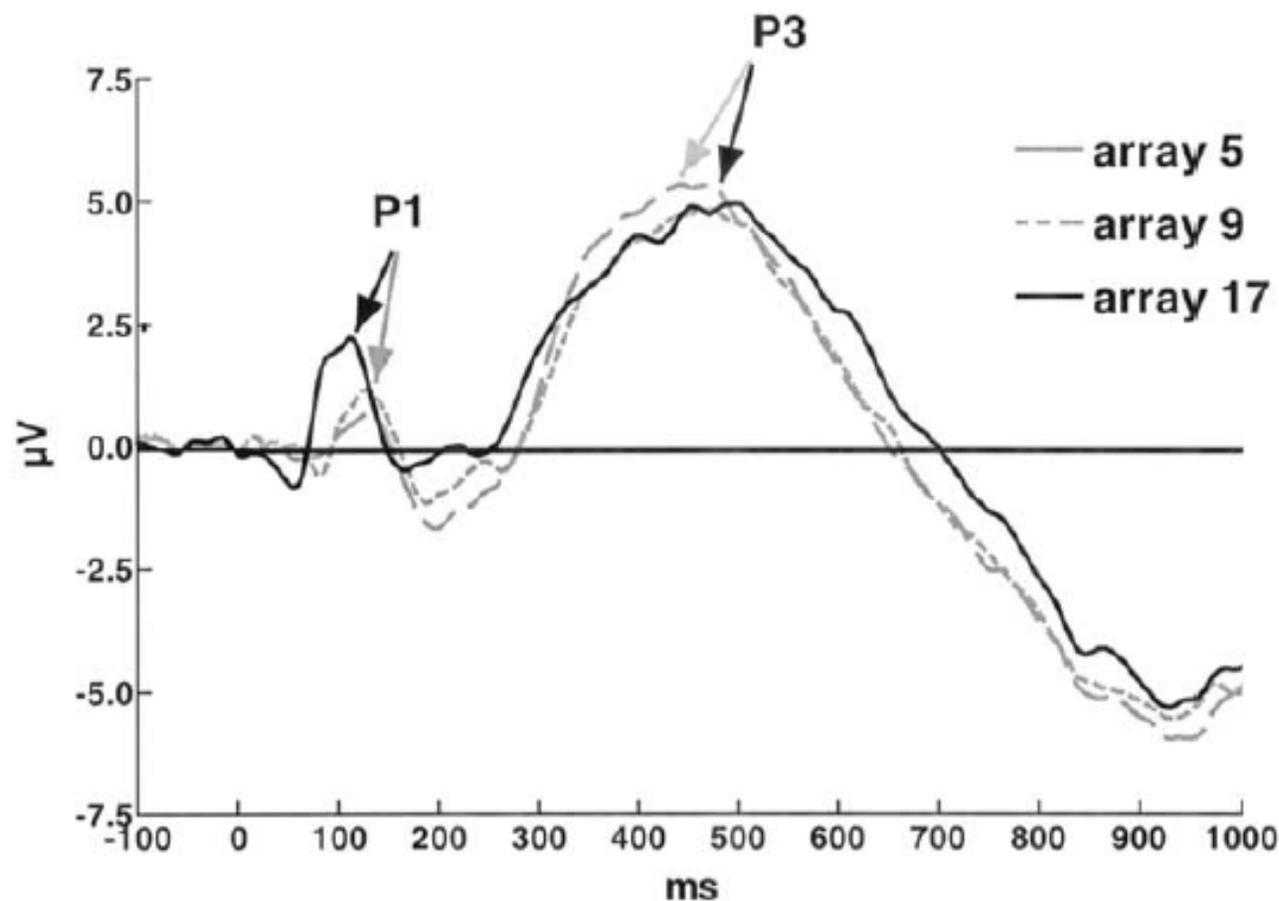


Fig. 2. Grand averaged visual ERPs at Pz electrode for the 3 array sizes, showing the shorter latencies, larger P1s for array size 17, but longer latency P3 (dark arrows) than for array sizes 5 and 9 (grey arrows). These are averaged across colour, orientation and conjunction conditions, as this ERP effect was seen regardless of whether it was a single feature or conjunction trial.

Increases stimulus complexity results in more rapid early processing

Note:  
Amplitude of P1  
Latency of P1  
Latency of N1

Taylor  
*Clinical Neurophys*  
2002

# More than Spatial Directed Attention

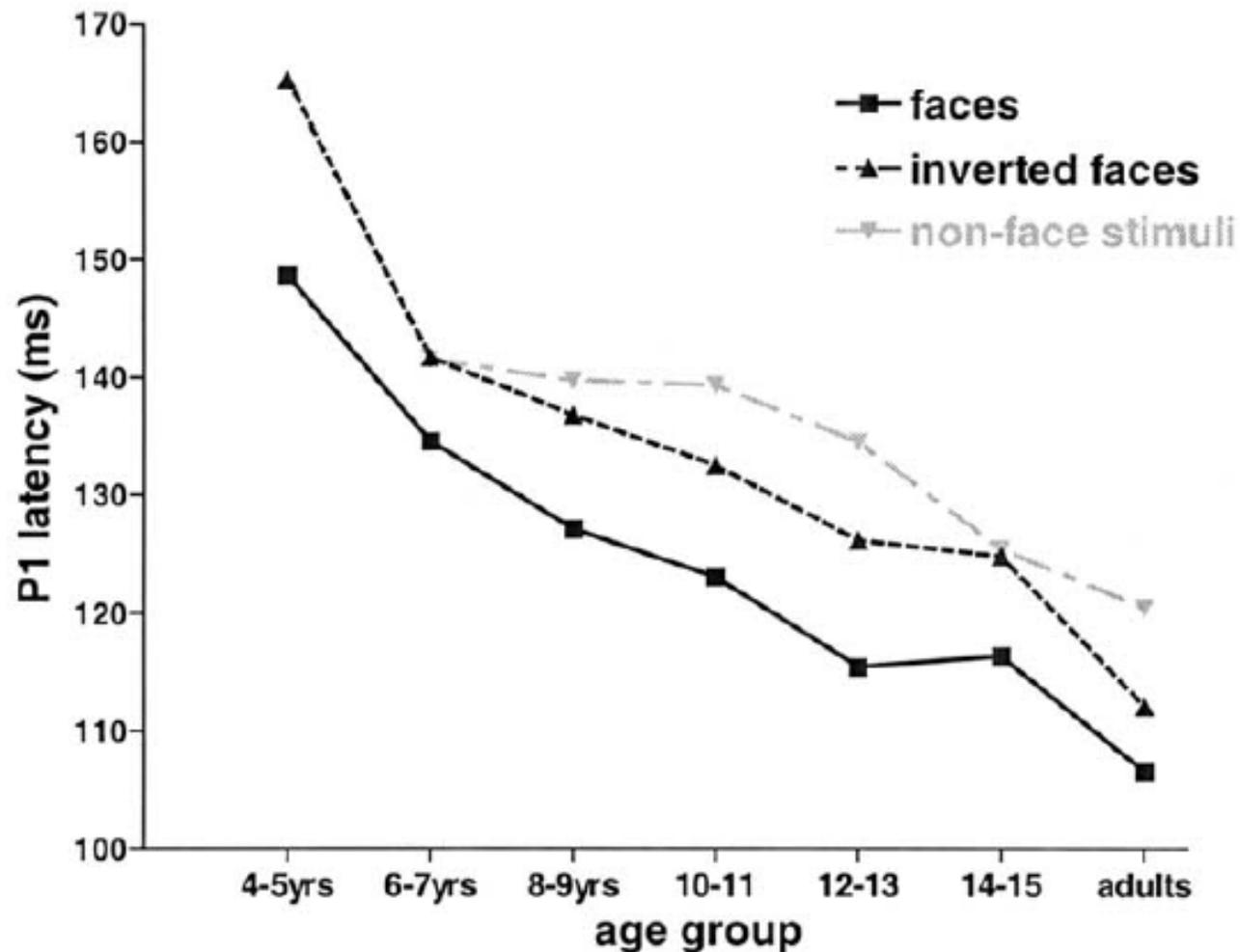
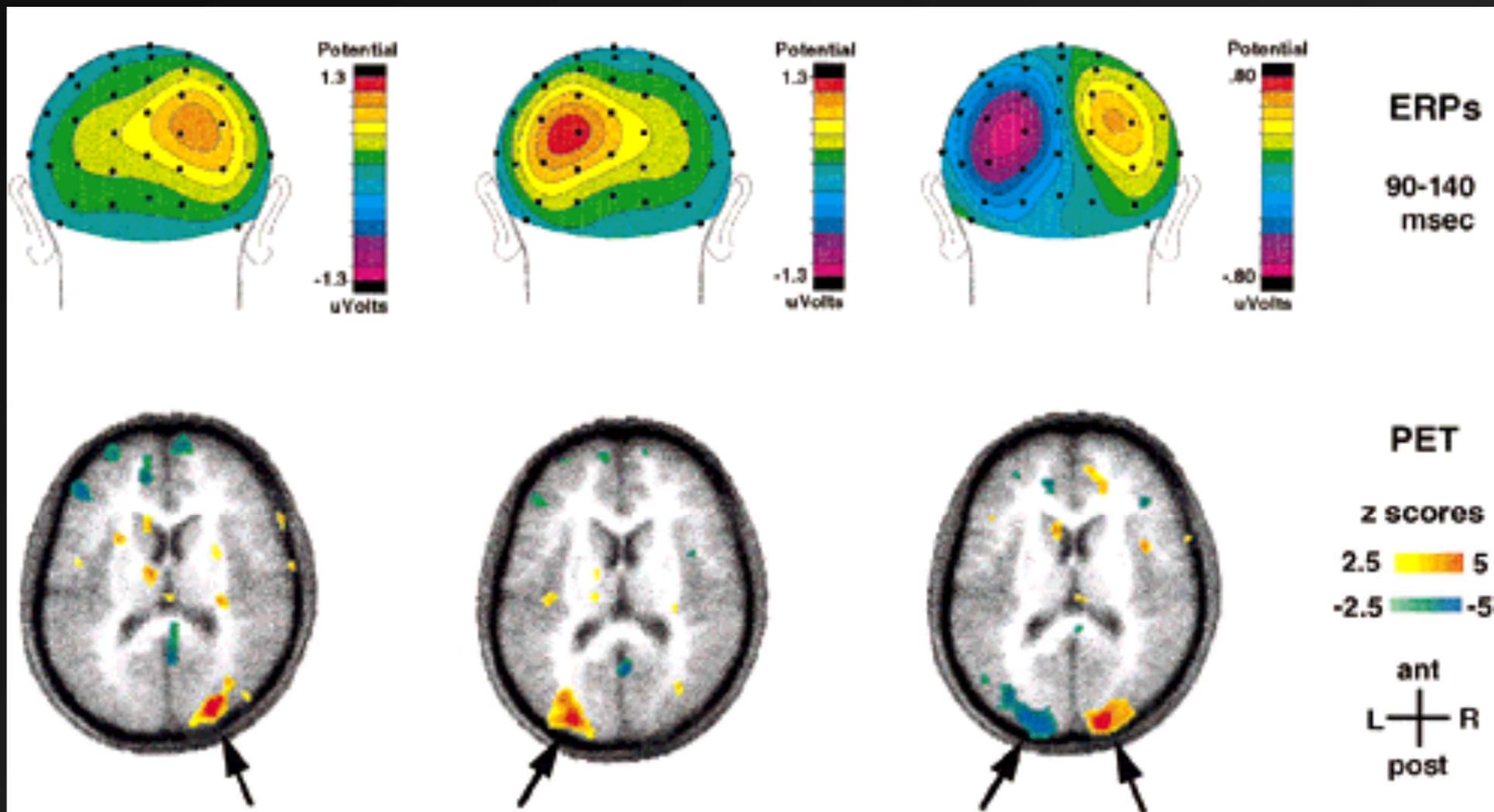


Fig. 3. Mean P1 latencies across 7 age groups, showing the consistently shorter latencies to faces compared to inverted faces and control stimuli (phase-scrambled faces and flowers). There were 15 children in each of the 6 age groups and 38 adults (adapted from Taylor et al., 2001c).

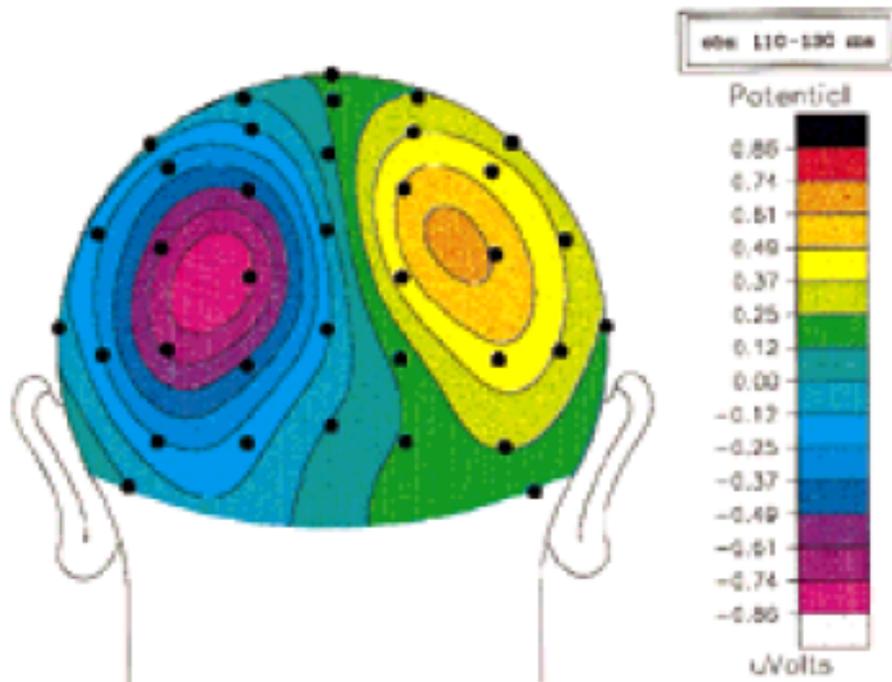
Taylor  
*Clinical Neurophys*  
2002

“These combined PET/ERP data therefore provide strong evidence that sustained visual spatial attention results in a preset, top-down biasing of the early sensory input channels in a retinotopically organized way”



# Prelude to Advance Topic: Source Localization

## Observed Potentials



## Model Potentials Dorsal Occipital PET Seeds

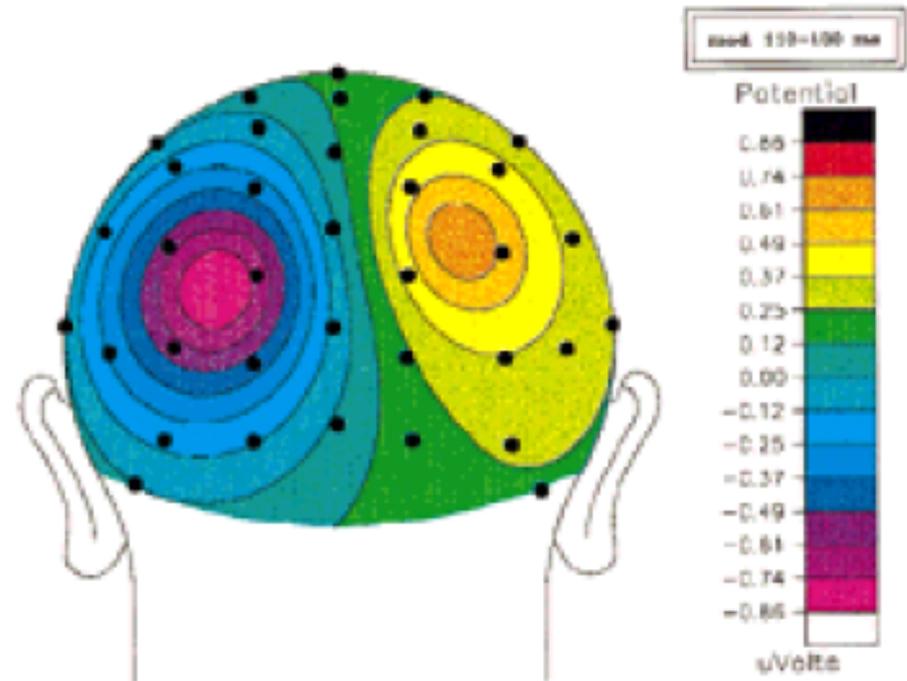
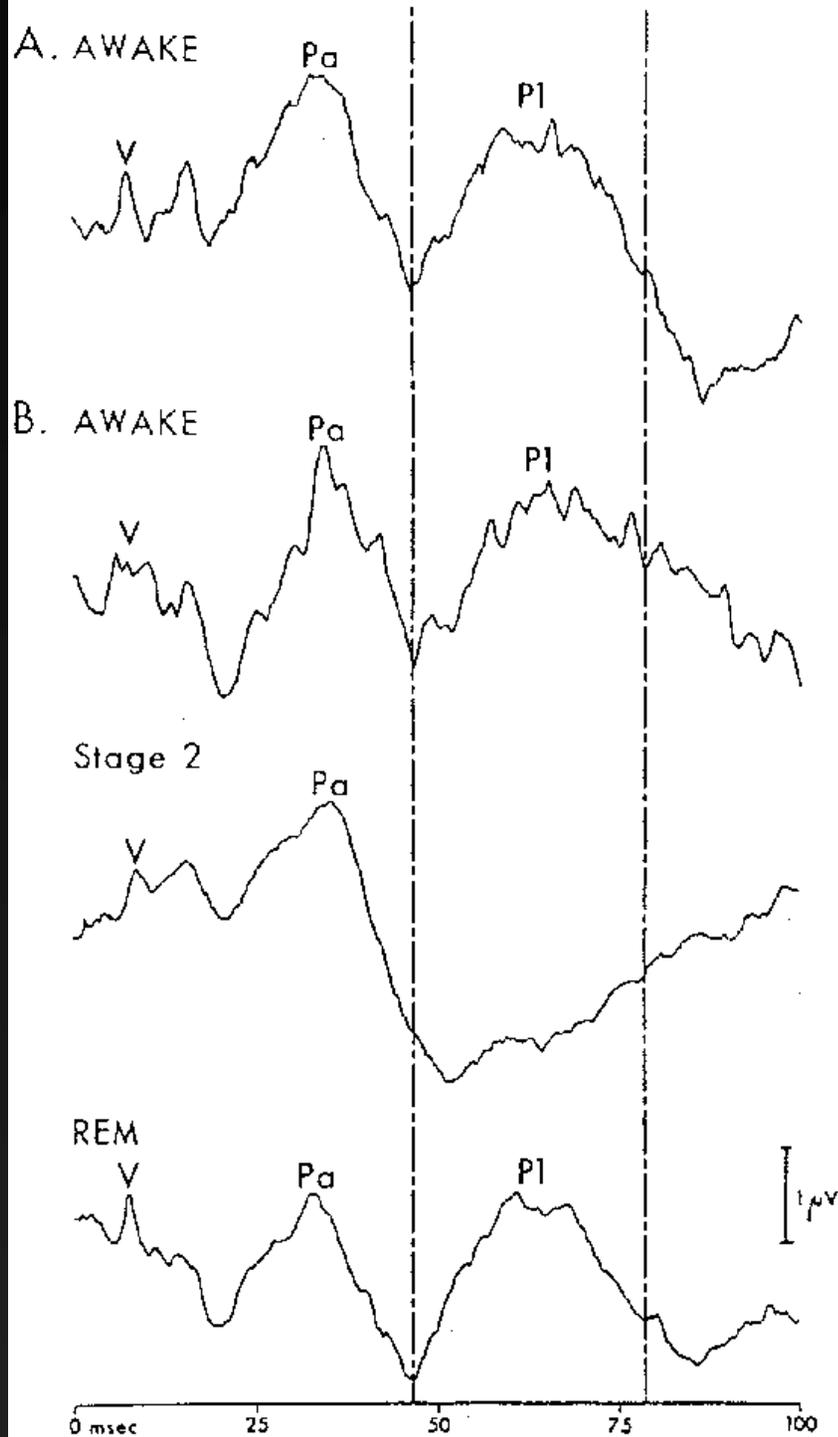


Figure 3.

**Left:** Observed potential distributions in the attend-left-minus-attend-right difference waves at the peak of the P1 attention effect (110–130 msec). **Right:** Corresponding model potential distributions seeded by the dorsal occipital PET foci, which provided an excellent fit to the P1 effect (residual variance 2%).

# P1 REAPPEARANCE DURING REM

SUBJECT K.K.



# P1 and Sleep

Note P1 disappears in Stage 2 sleep, but reemerges in REM sleep

# Construct Validity of P300 (P3, P3b)

➤ First observed by Sutton, Braren, Zubin, & John (1965)

➤ P300 Amplitude; Johnson's model is

$$\text{P300 Amplitude} = f[T \times (1/P + M)]$$

where

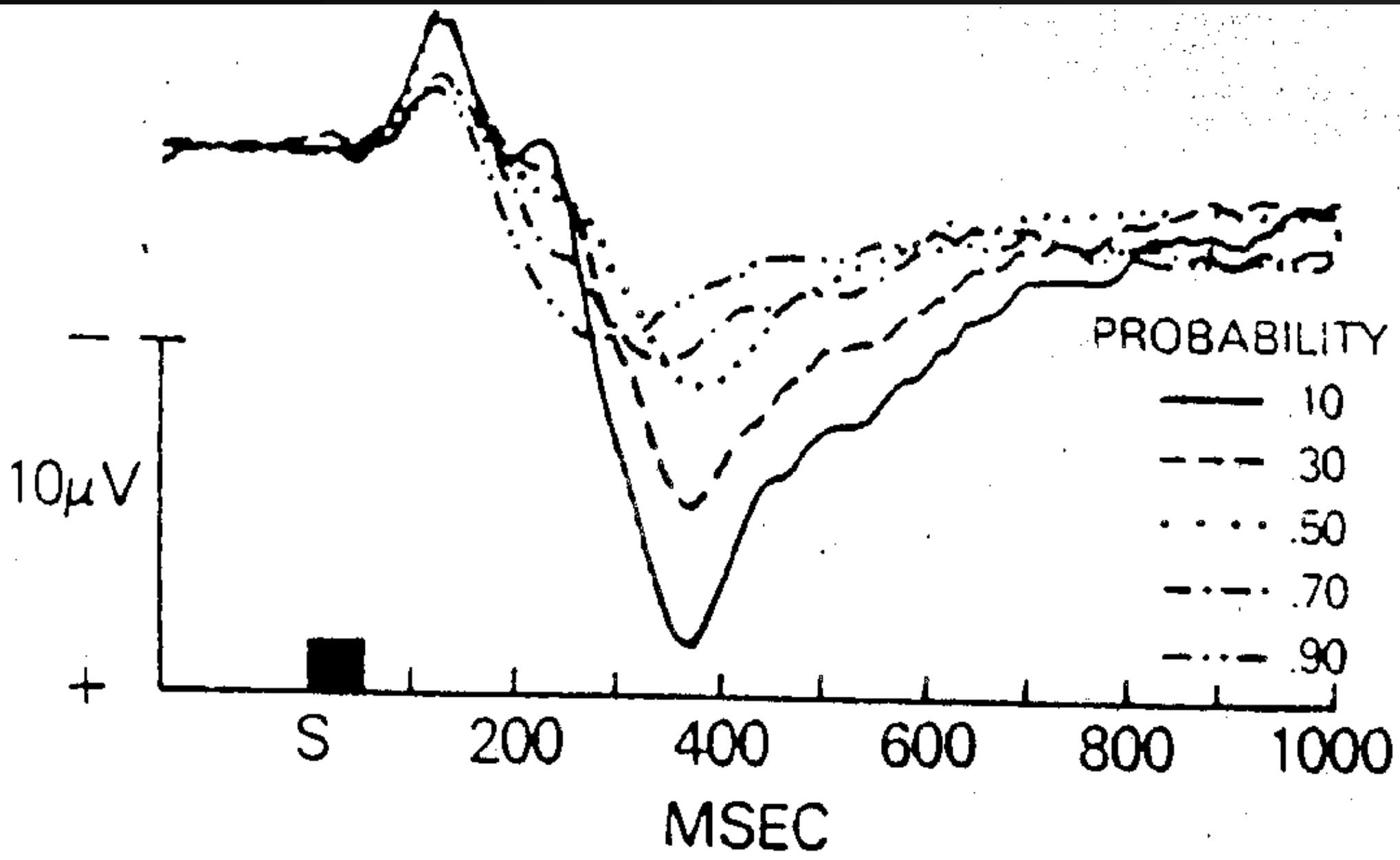
➤ P = probability of occurrence,

➤ M = Stimulus meaning, &

➤ T = amount of information transmitted

# Aspects of the Model

- **Rarity**
  - The P300 is observed in variants of the "oddball paradigm"
  - The rare stimulus almost invariantly elicits a P300: largest at parietal, then central, and then frontal sites
  - Subjective probability
- Stimulus meaning
  - Actually composed of three dimensions
    - task complexity
    - stimulus complexity
    - stimulus value
- Information Transmission (proportion 0 to 1; example)



P=0.5/0.5

High-Pitched Tone

Low-Pitched Tone

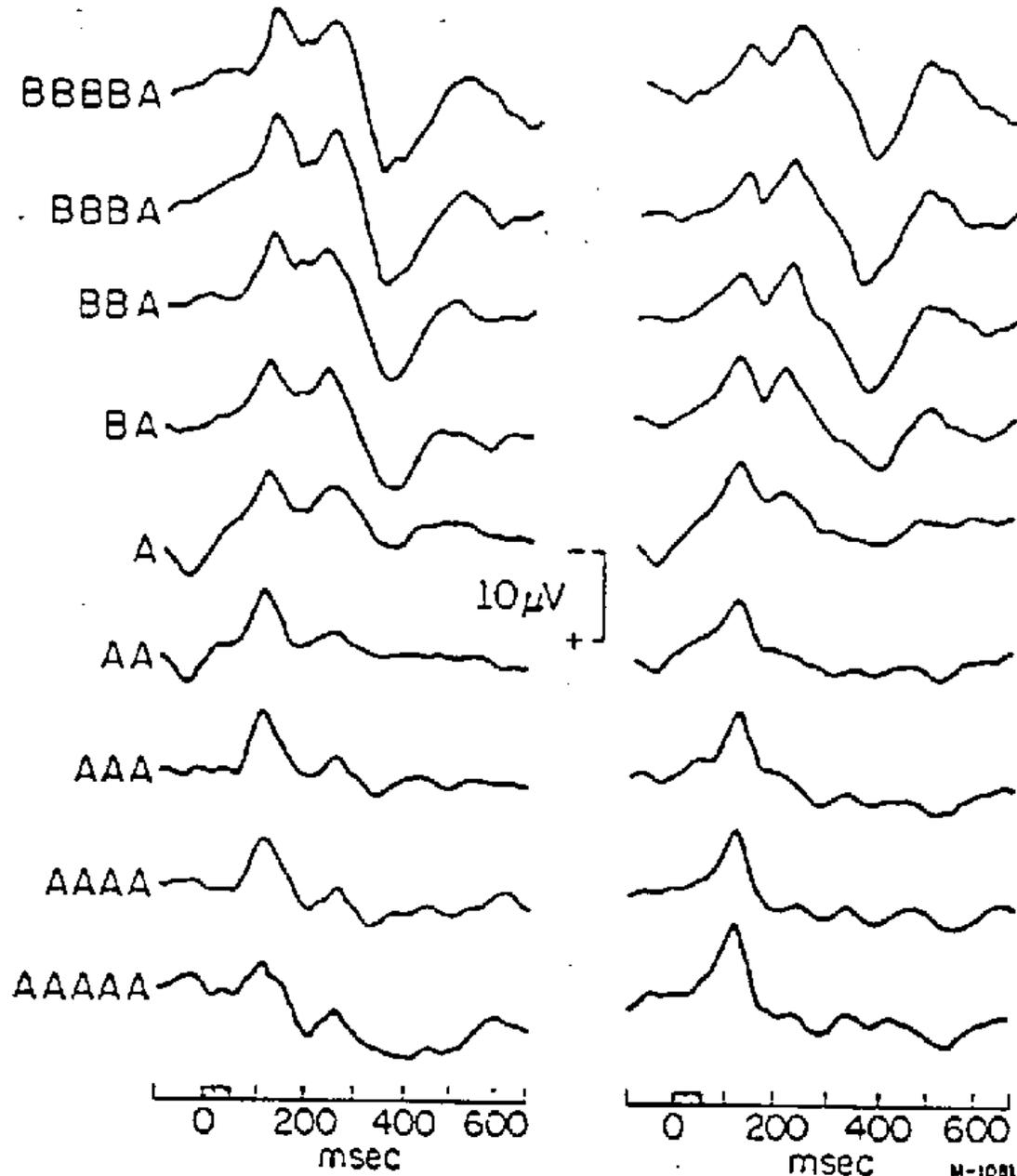
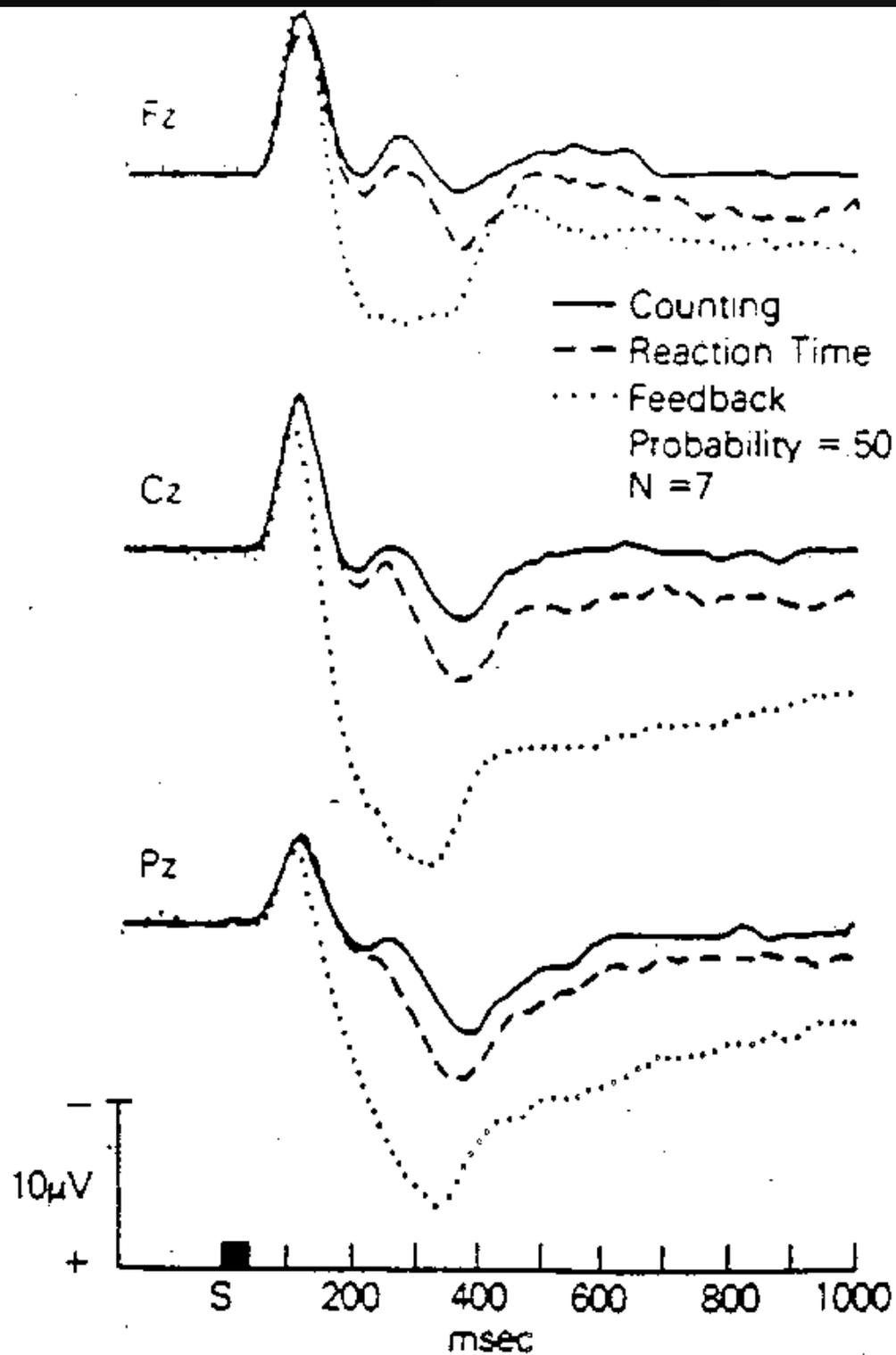


Figure 12-1. The ERPs in each column were elicited by the same physical tone; high-pitched tones were used for the left column and low-pitched tones for the right column. Both were presented in a Bernoulli series in which the probability of the two stimuli were equal. In the middle of each column (labeled "A") is the ERP elicited by all the presentations of the stimulus. The curve labeled "AA" was obtained by averaging together all the tones of one frequency that were preceded on the previous trial by tones of the same frequency. On the other hand, the curves labeled "BA" were elicited by stimuli preceded on the previous trial by the tones of different frequency. Similar sorting operations were applied to all other curves in this figure. It can be seen that the same physical tone elicited quite different ERPs, depending on the events that occurred on the preceding trials. Whenever a tone terminated a series of tones from the other category, a large P300 was elicited, and its magnitude was a function of the length of the stimulus series. (From "Effect of Stimulus Sequence on the Waveform of the Cortical Event-Related Potential," by K. C. Squires, C. D. Wickens, N. K. Squires, and E. Donchin. *Science*, 1976, 193, 1142-1146. Copyright 1976 by the AAAS.



**Figure 2.** Grand-mean waveforms ( $N = 7$ ) from  $F_z$ ,  $C_z$ , and  $P_z$  from three different tasks. The ERPs elicited in an oddball paradigm run under two different task conditions, Counting (solid line) and Reaction Time (dashed line), are superimposed on the ERP elicited when the same stimulus signified correct performance in a feedback paradigm (dotted line). The waveforms were all elicited by a 1000 Hz, 50dB SL tone ( $p = .50$ ).

# Information Transmission

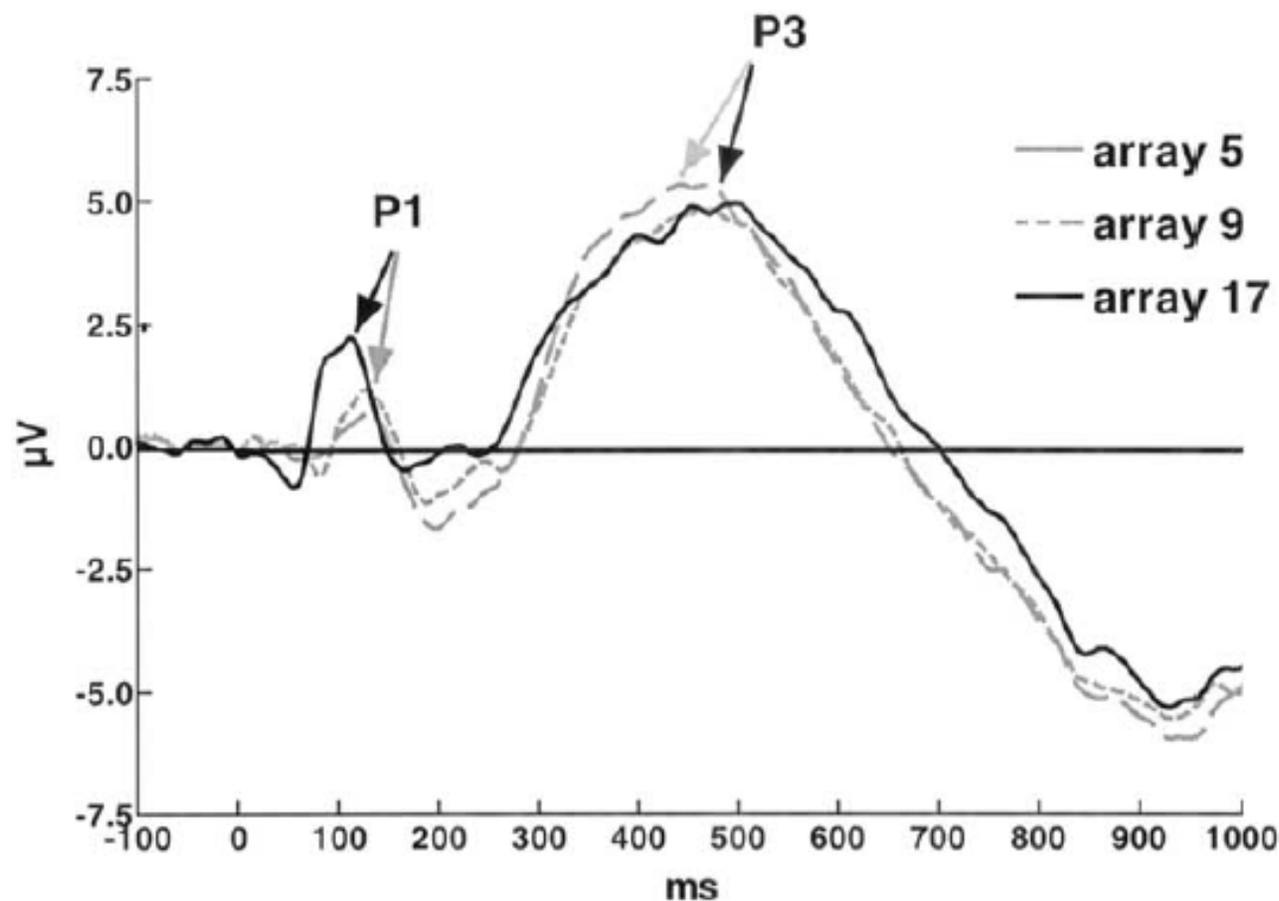


Fig. 2. Grand averaged visual ERPs at Pz electrode for the 3 array sizes, showing the shorter latencies, larger P1s for array size 17, but longer latency P3 (dark arrows) than for array sizes 5 and 9 (grey arrows). These are averaged across colour, orientation and conjunction conditions, as this ERP effect was seen regardless of whether it was a single feature or conjunction trial.

Taylor  
*Clinical Neurophys*  
2002

# P3 Latency

- An index of processing time, independent of response requirements
  - RT measures confounds the two
  - McCarthy & Donchin (1981) experiment:
    - The words "RIGHT" or "LEFT" embedded in a matrix of letters of X's
    - Compatible condition: respond with hand indicated in matrix; Incompatible condition: respond with opposite hand (e.g., LEFT signals right hand response);
    - Results:
      - P300 latency delayed when discriminability more difficult
      - Response compatibility had no effect on P300 latency
      - **Note amplitude reduction as function of noise--information transmission)**

A

No noise

## ## ##

## ## ##

#R I G H T

## ## ##

## ## ##

## L E F T

## ## ##

## ## ##

a

b

Noise

NR I G H T

KWSMNT

BMJUKM

UYRMUD

EQÈIKM

VTFMZS

KEHEHG

ILEFTA

c

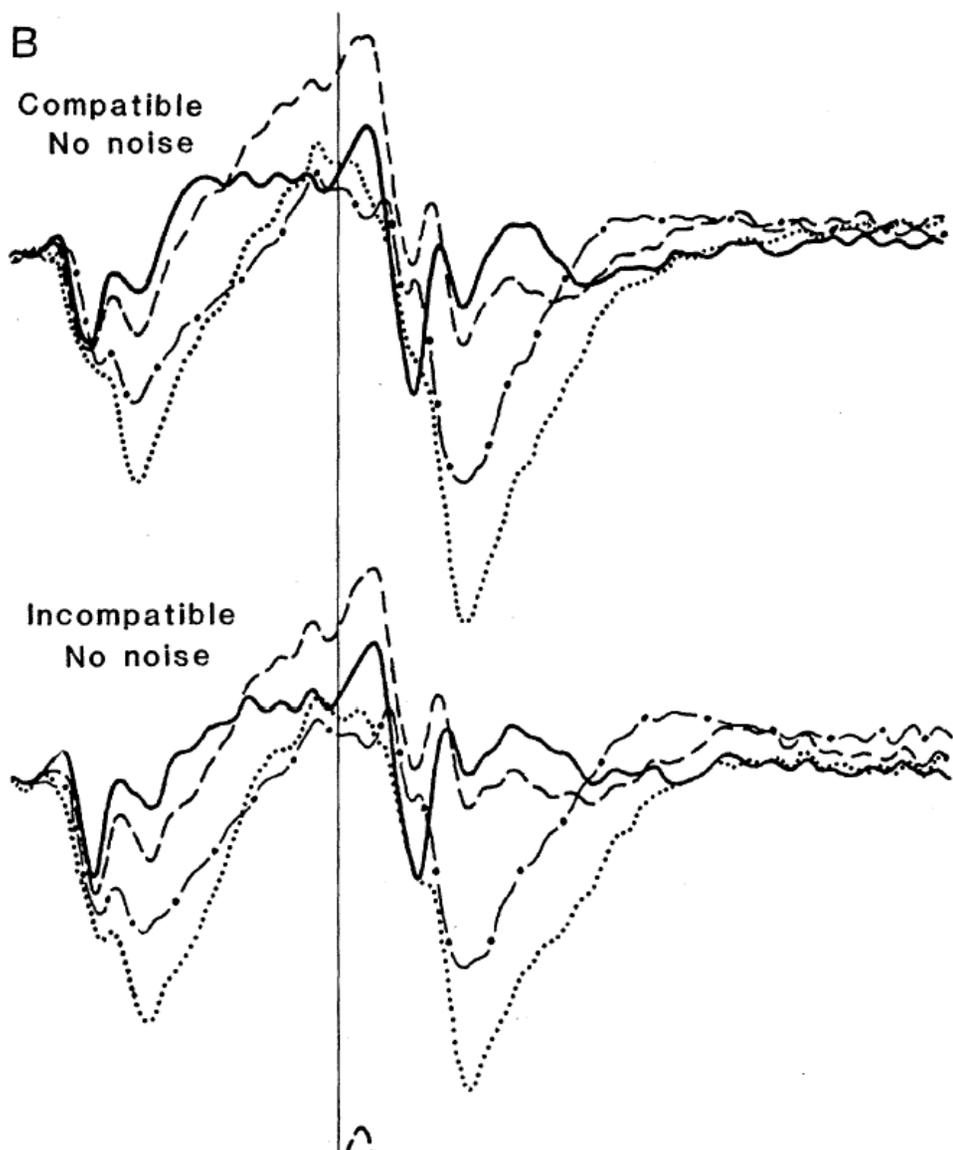
d

1°

**B**

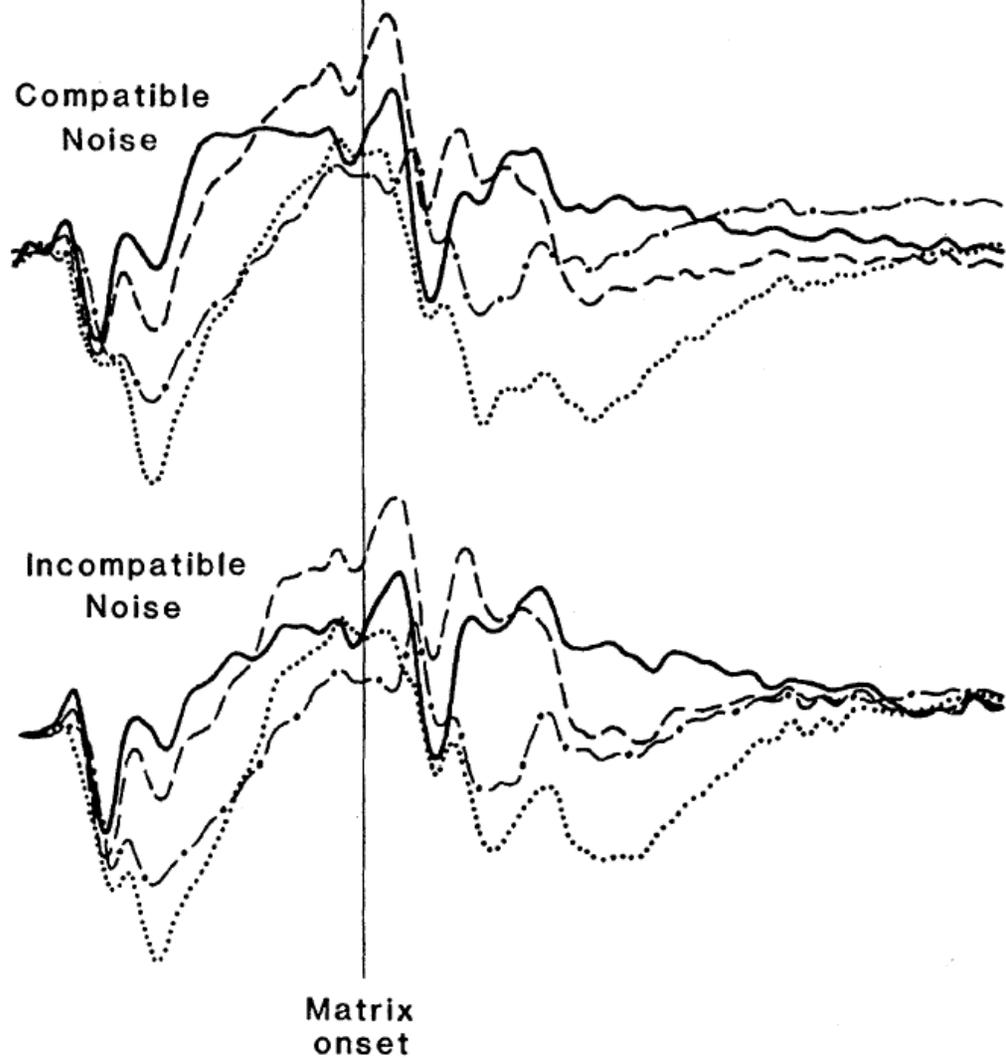
Compatible  
No noise

Incompatible  
No noise



Compatible  
Noise

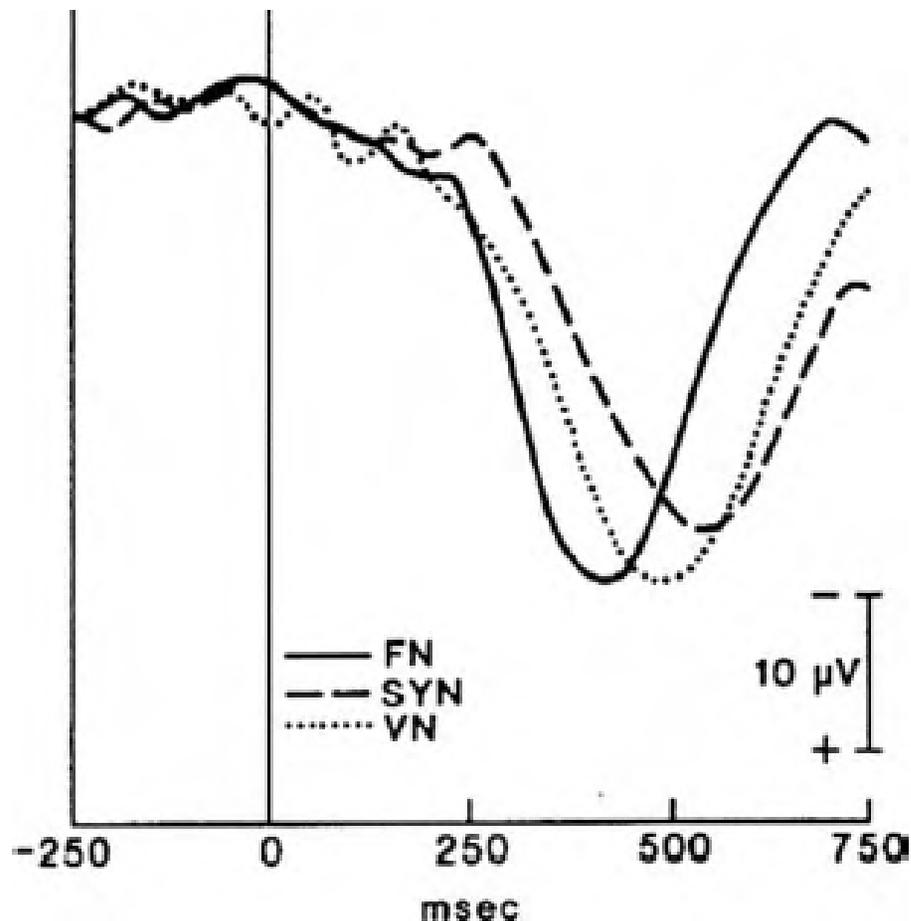
Incompatible  
Noise



Matrix  
onset

— F<sub>z</sub>  
- - - C<sub>z</sub>  
... P<sub>z</sub>  
- · - O<sub>z</sub>

5  $\mu$ V  
400 msec



Not only difficulty in physical discrimination, but difficulty in cognitive categorization

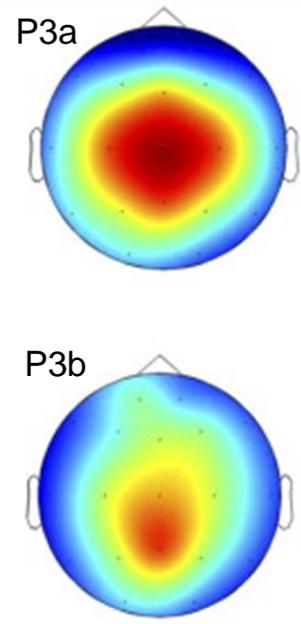
Figure 4.10. ERP waveforms at Pz averaged across subjects for three different semantic categorization tasks. The solid line indicates ERPs obtained during a task in which the subjects had to distinguish between the word DAVID and the word NANCY (the FN condition). The dotted line indicates ERPs obtained during a task in which the subjects had to decide whether a word presented was a male or a female name (the VN condition). The dashed line indicates ERPs obtained during a task in which the subjects had to decide whether a word was or was not a synonym of the word PROD (SYN condition). These three tasks were considered to involve progressively more difficult discriminations. Note the latency of P300 peak is progressively longer as the discrimination is made more difficult. (Copyright 1977, AAAS. Adapted with permission of the author and publisher from Kutas, McCarthy, & Donchin, 1977.)

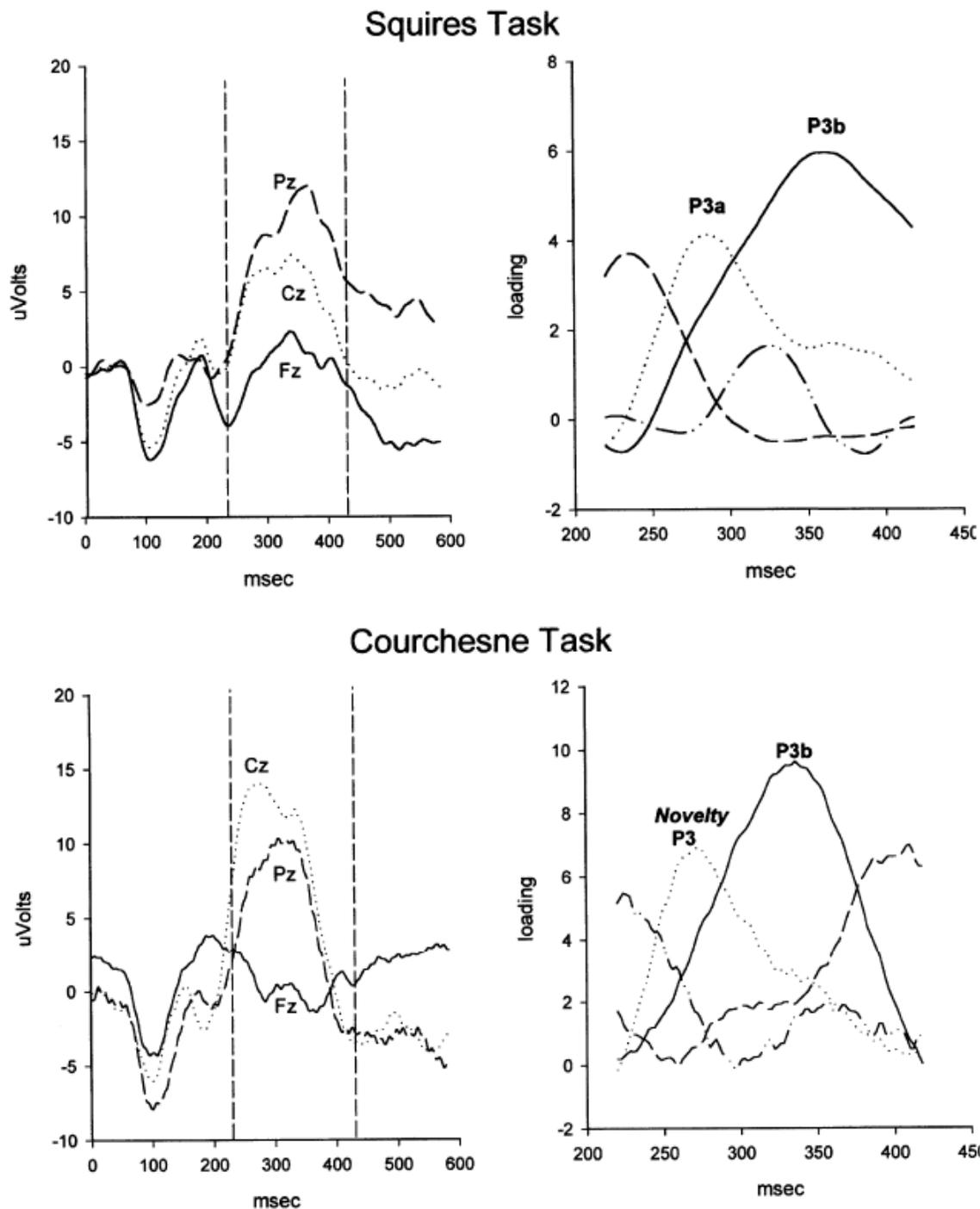
# Construct Validity?

- What, then, does the P300 mean in very general terms?
  - A stimulus (or class of stimuli) is "important"; denotes information that is necessary or useful to the task
  - Stimulus is meaningful, important, noticeable
  - Evaluated within context of working memory? (cf. Donchin & Coles, 1988; Verlager 1988; Polich, 2007; Verlager, 2008)
- The P3a (Squires, Squires, and Hillyard, 1975): P3-like component with a frontal maximum and occurs to improbable stimuli in the "to-be-ignored" class of stimuli; a novelty response.

# How Many P3s?

- The Classic P3/P300
  - Parietal Central Maximum
  - Largest when stimuli rare and task-relevant
- The P3a (Squires et al., 1975) or Novelty P3 (Courchesne et al., 1975)
  - More anterior scalp distribution
  - Slightly earlier latency
  - Responsive to rare, unexpected, unattended stimuli





Simons et. al, 2001

- Squires Task was tones (two tones)
- Courchesne task was digitized speech (“me” “you” and collection of naturally occurring sounds)
- In all cases subjects merely counted Tones

Fig. 1. ERP waveforms (left) and PCA basis waves (right) obtained from infrequent targets during the Squires (top) task and infrequent nontargets/novels during the Courchesne (bottom) task. PCA was conducted during the 220–420 ms epoch following stimulus onset and four factors were extracted from each data set.

# P3a – Can you see it?

- Some inconsistencies in finding P3a following the initial Squires, Squires and Hilyard 1975 report
- Comerchero & Polich (1998) may have resolved the enigma
  - P3a highly dependent on foreground discrimination

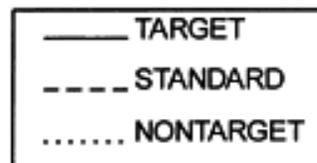
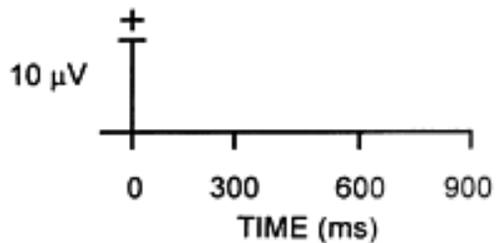
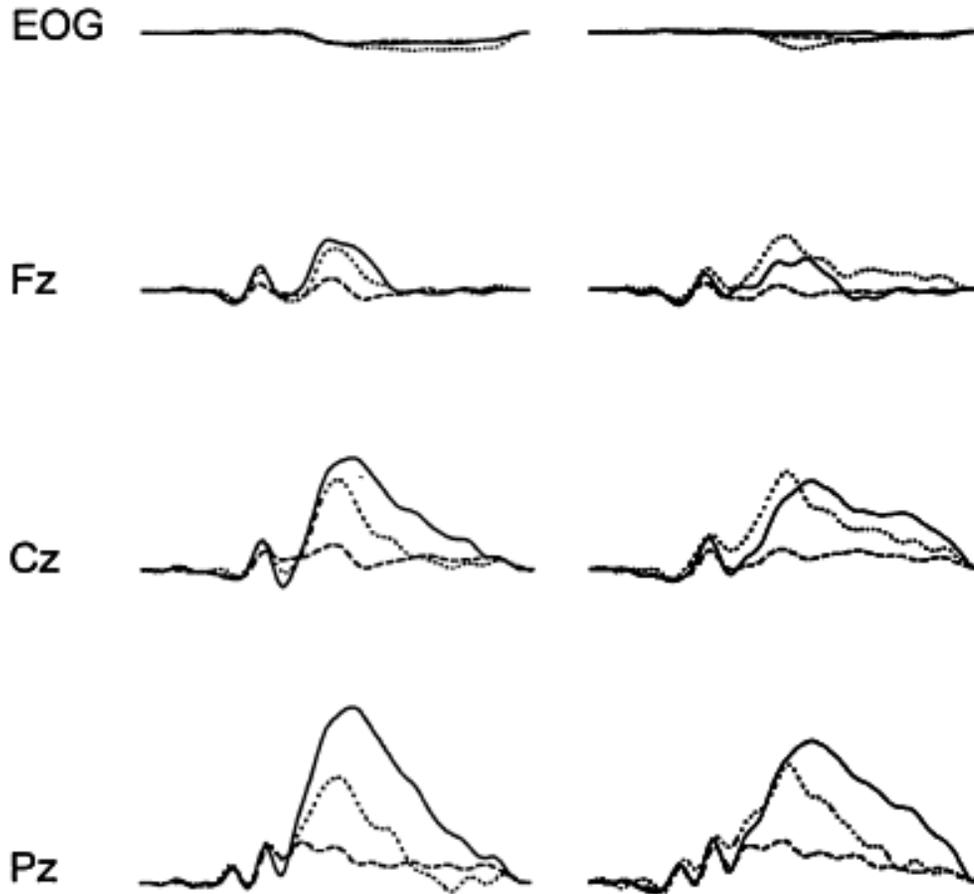
Table 1  
 Stimulus type (probability) for each task condition and modality (auditory = frequency and intensity, visual = area and shape-color)

Modality	Auditory		Visual	
	Low	High	Low	High
Nontarget distinctiveness				
Target (0.10)	2000 Hz 75 dB	2000 Hz 75 dB	12.57 cm <sup>2</sup> ● Blue	12.57 cm <sup>2</sup> ● Blue
Standard (0.80)	1940 Hz 75 dB	1940 Hz 75 dB	10.18 cm <sup>2</sup> ● Blue	10.18 cm <sup>2</sup> ● Blue
Nontarget (0.10)	500 Hz 75 dB	4000 Hz 90 dB	12.57 cm <sup>2</sup> ■ Blue	12.57 cm <sup>2</sup> ■ Fuchsia

# VISUAL

EASY

DIFFICULT



Note: Nontarget peak amplitude was earlier and larger at the frontal electrodes than those from the target stimuli, but especially when foreground discrimination is difficult

Comerchero & Polich (1998),  
*Clinical Neurophysiology*

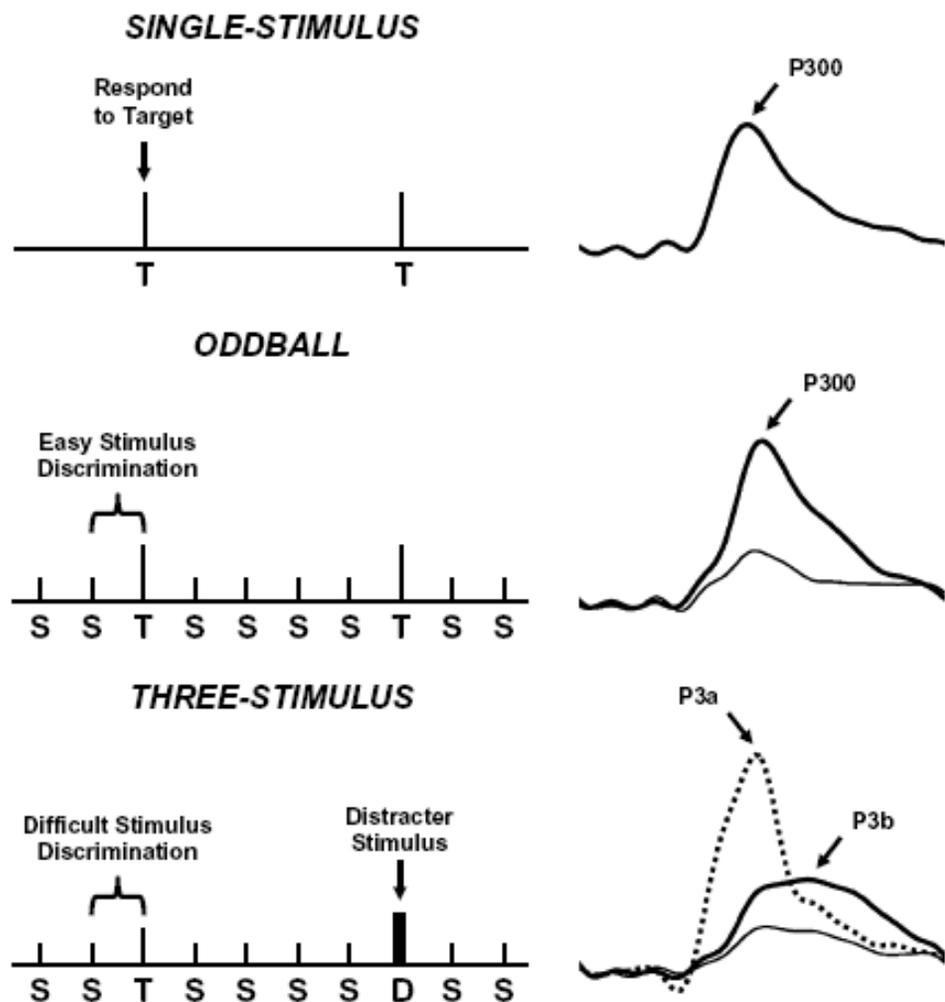


Fig. 1. Schematic illustration of the single-stimulus (top), oddball (middle), and three-stimulus (bottom) paradigms, with the elicited ERPs from the stimuli of each task at the right (Polich and Criado, 2006). The single-stimulus task presents an infrequent target (T) in the absence of any other stimuli. The oddball task presents two different stimuli in a random sequence, with one occurring less frequently than the other (target = T, standard = S). The three-stimulus task is similar to the oddball with a compelling distracter (D) stimulus that occurs infrequently. In each task, the subject is instructed to respond only to the target and otherwise to refrain from responding. The distracter elicits a P3a, and target elicits a P3b (P300). Reprinted with permission of the authors and from Elsevier (Copyright 2006).

# Synopsis

“...the manipulation of target-standard stimulus discriminability produced a stimulus environment in which the infrequently occurring nontarget engaged focal attention in a manner similar to that observed previously for ‘novel’ stimuli.

However, all stimuli in the present study were employed because of their ‘typical’ characteristics, so that the results imply that an anterior P3a component can be produced without using ‘novel’ stimuli per se.

If stimulus context is defined primarily by a difficult target-standard discrimination, attentional redirection to the nontarget would occur because of the frontal lobe activation that generates P3a.”

# ERPs and Memory

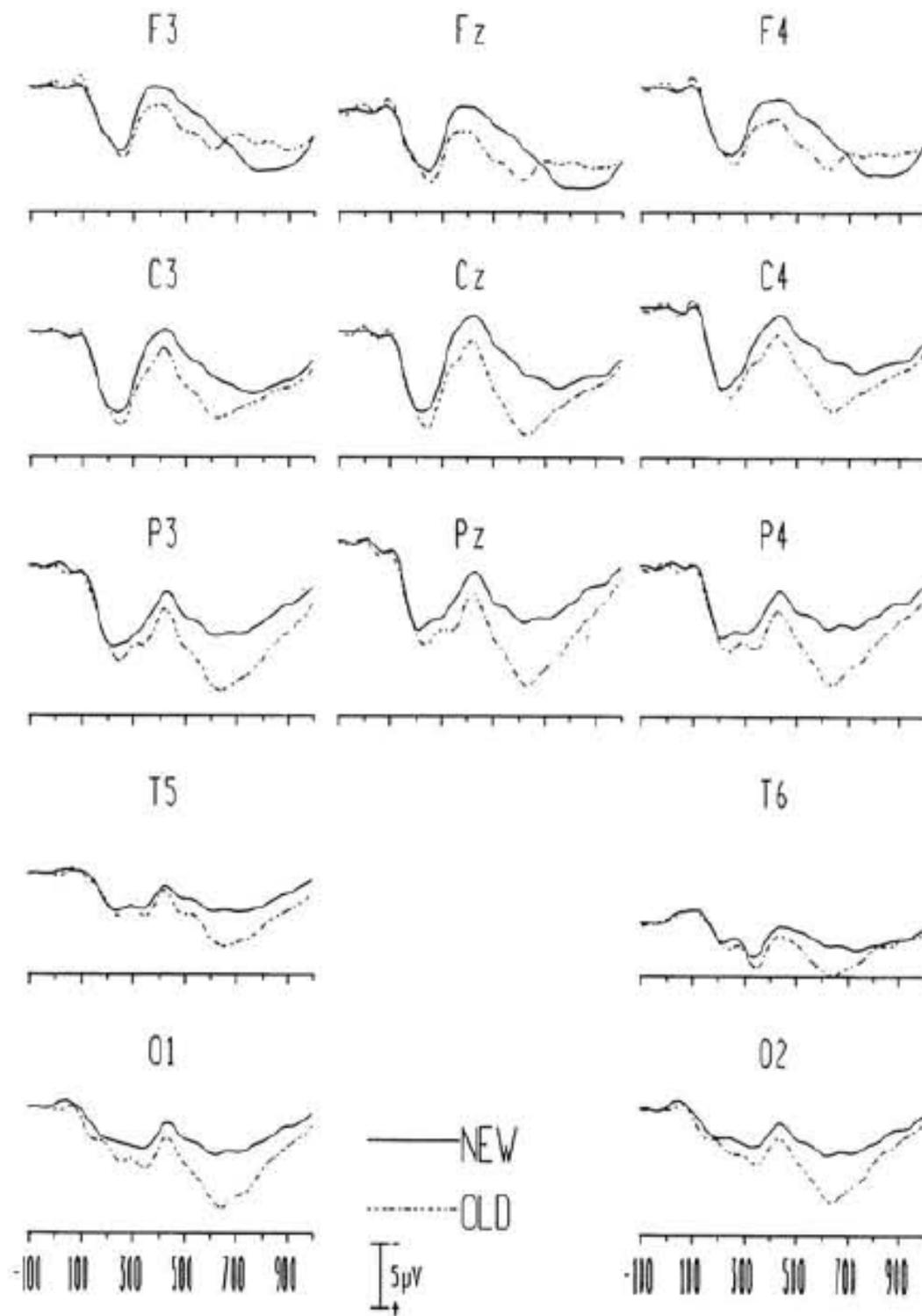
- Sensitive to both Recognition
  - Likely episodic recollection
- Sensitive to Encoding

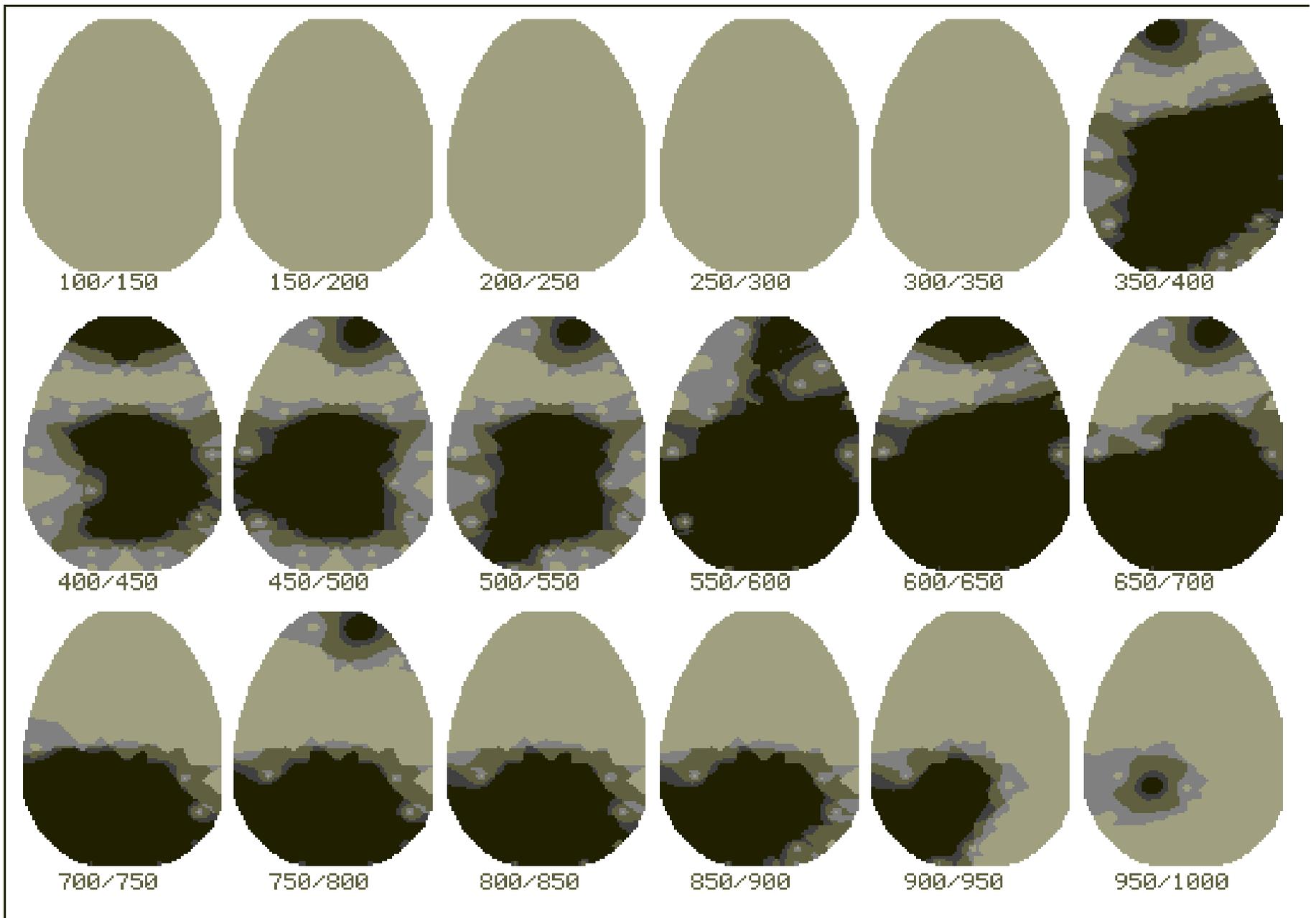
# Repetition Priming Effects

- Robust effect that repeated items produce an enhanced late positivity across a broad latency range
- Magnitude of effect related to strength of memory trace

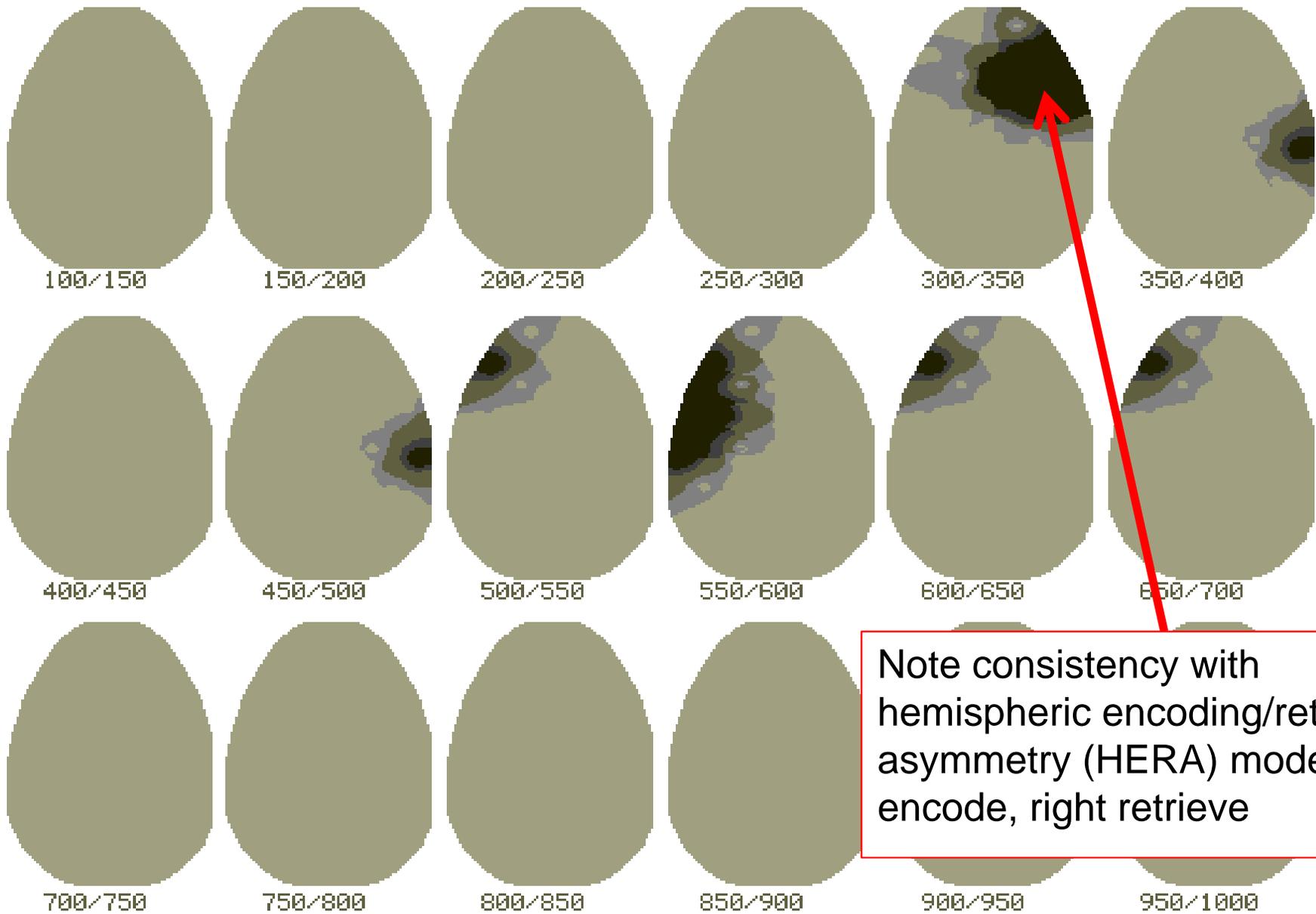
# Repetition Priming

- Are there repetition effects that do not depend on the subjective awareness of the subject?
  - Can use Masked Priming to examine (Schnyer, Allen, Forster, 1997)



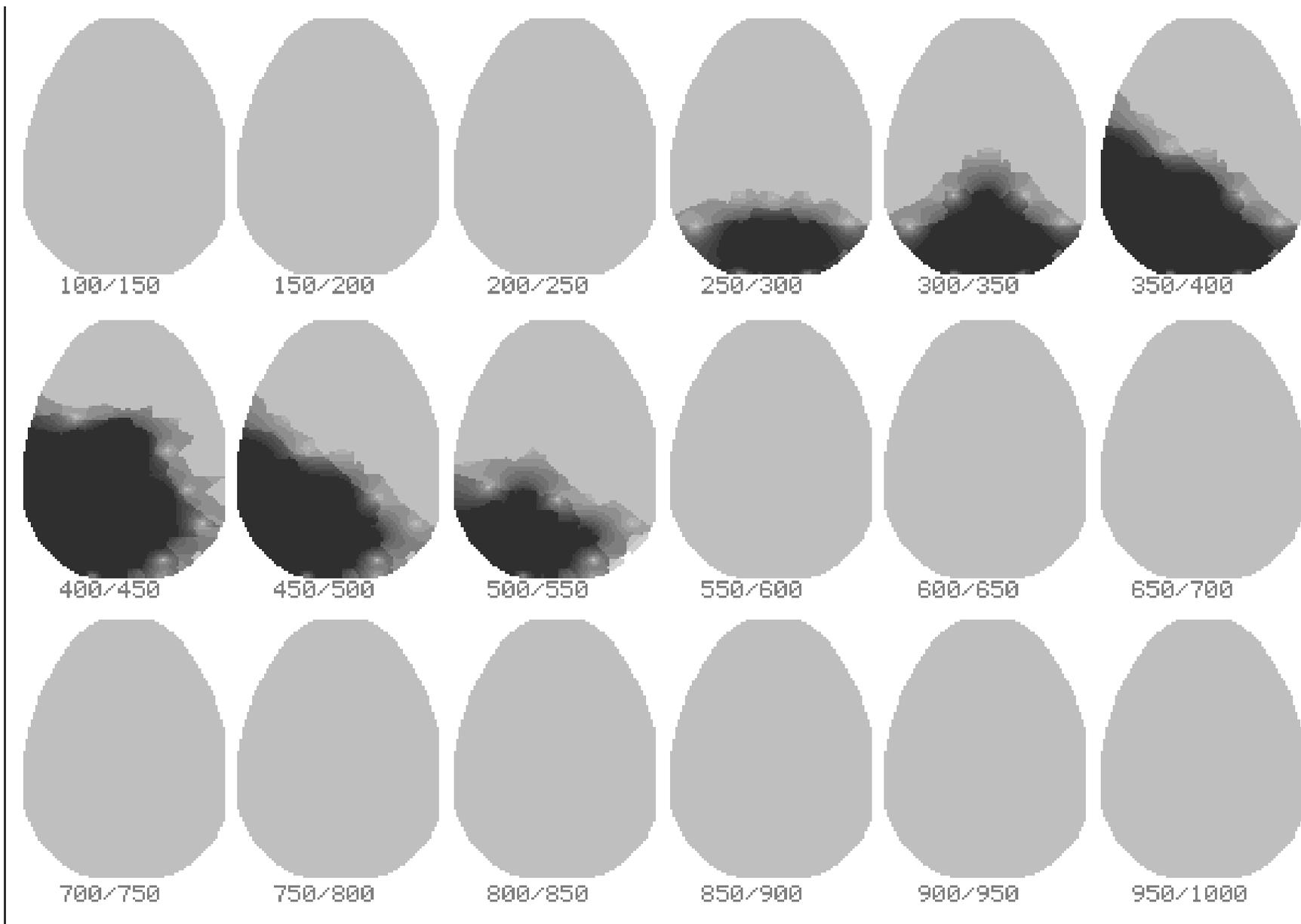


Standard Repetition Effect for Words Seen Unmasked in Previous Blocks  
 Task is to make OLD-NEW decision



Note consistency with hemispheric encoding/retrieval asymmetry (HERA) model: left encode, right retrieve

Standard Repetition Effect for Words Seen Unmasked in Previous Blocks  
 But Task is to make WORD-NONWORD decision



Masked Repetition Priming Effect for Words Presented only a Trial Previously

# Memory Encoding

- Words subsequently remembered show enhanced positivity at encoding
- Strategy interacts, however

Isolated Words

Group 1 (N=3)

Group 3 (N=3)

High von Restorff Index ( $\bar{x}=31$ )

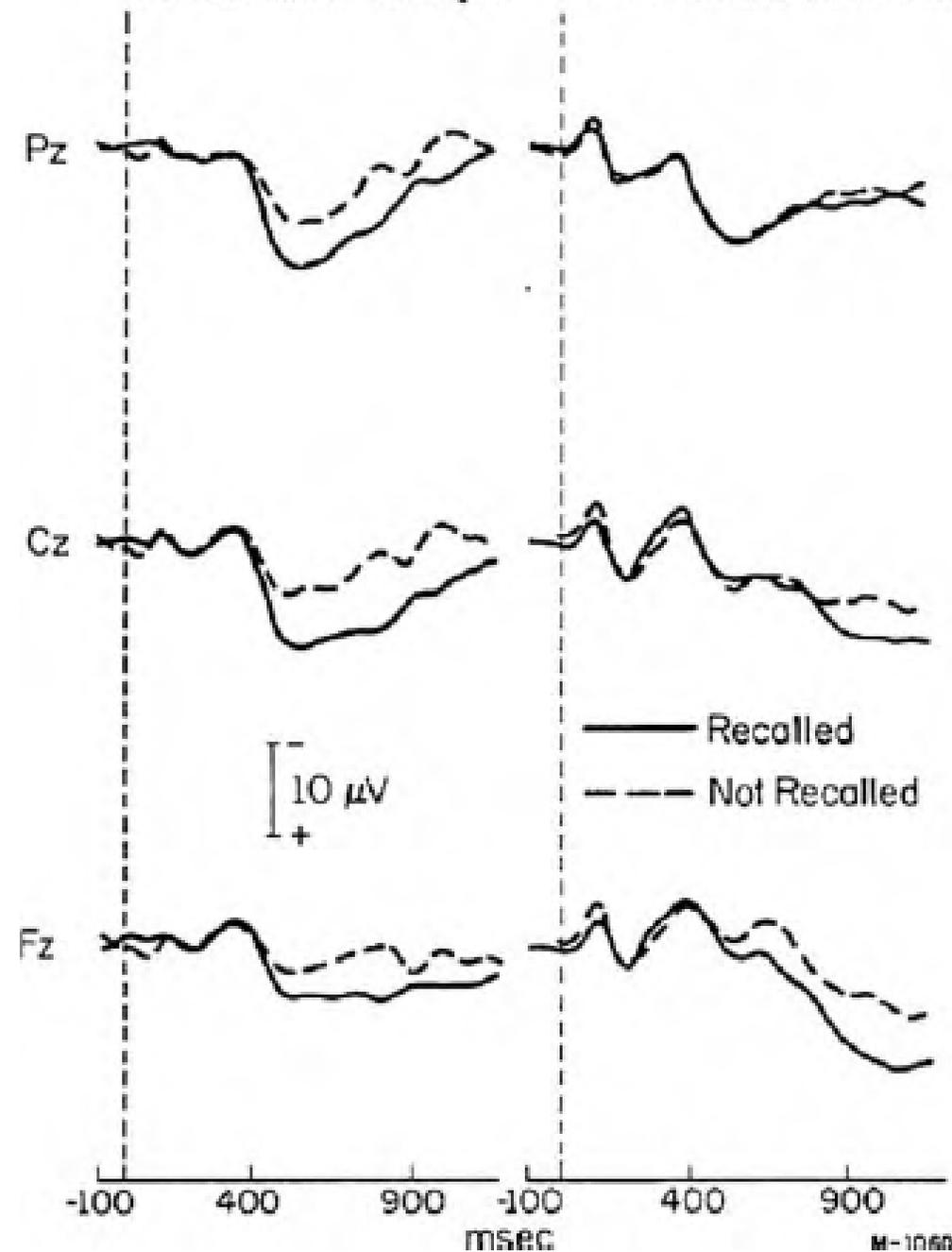
Low von Restorff Index ( $\bar{x}=-1$ )

Low Performance ( $\bar{x}=39\%$ )

High Performance ( $\bar{x}=63\%$ )

Rote Mnemonic Strategies

Elaborate Mnemonic Strategies



Note prototypic DM effect on left, but not on right for those that used elaborative strategies. Note enhancement over frontal lead for these latter subjects.

Figure 4.12. ERPs elicited by "isolated" words that were later recalled (solid line) or not-recalled (dashed line). The left column shows ERPs for subjects who used rote mnemonic strategies; the right column shows ERPs for subjects who used elaborative strategies. Note that the amplitude of P300 is related to subsequent recall for the rote memorizers, but not for elaborators. (Copyright 1986, Elsevier Science Publishers. Reprinted with permission of the publisher from Fabiani, Karis, & Donchin, 1986b.)

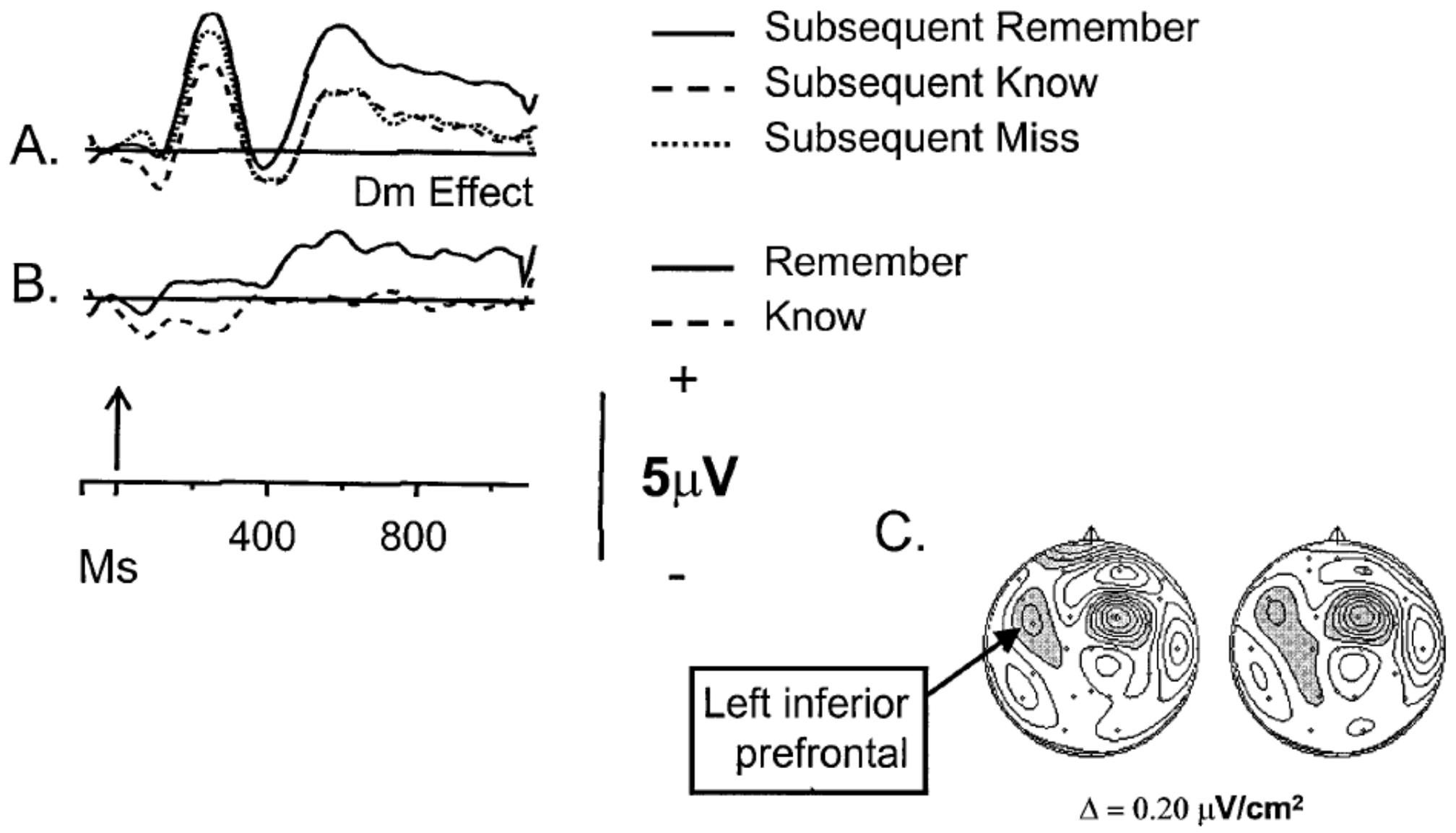


Fig. 3. **A:** Grand mean ERPs elicited by study items that were subsequently associated with remember or know judgments (hits) or were unrecognized (misses) during the subsequent recognition test. **B:** Grand mean difference waveforms computed by subtracting the ERPs to study items subsequently missed from those that were subse-

quently associated with either a remember or know judgment (Modified from Friedman and Trott, 2000). **C:** CSD maps for 2 intervals (500–800; 810–1,100 ms) measured in the Dm waveform associated with a subsequent Remember judgment. Data in A and B recorded at a left inferior prefrontal scalp site.

# Indirect Assessments of Recognition

- Can the ERP detect recognition, independent of subjects' overt responses?
- Two applications
  - Clinical Malingering
  - Forensic Assessment

# ERP Memory Assessment Procedures

- Learn a list of words
- Learn a second list of words
- Task: Concealed (1<sup>st</sup> list) and Nonconcealed (2<sup>nd</sup> list) words appear infrequently

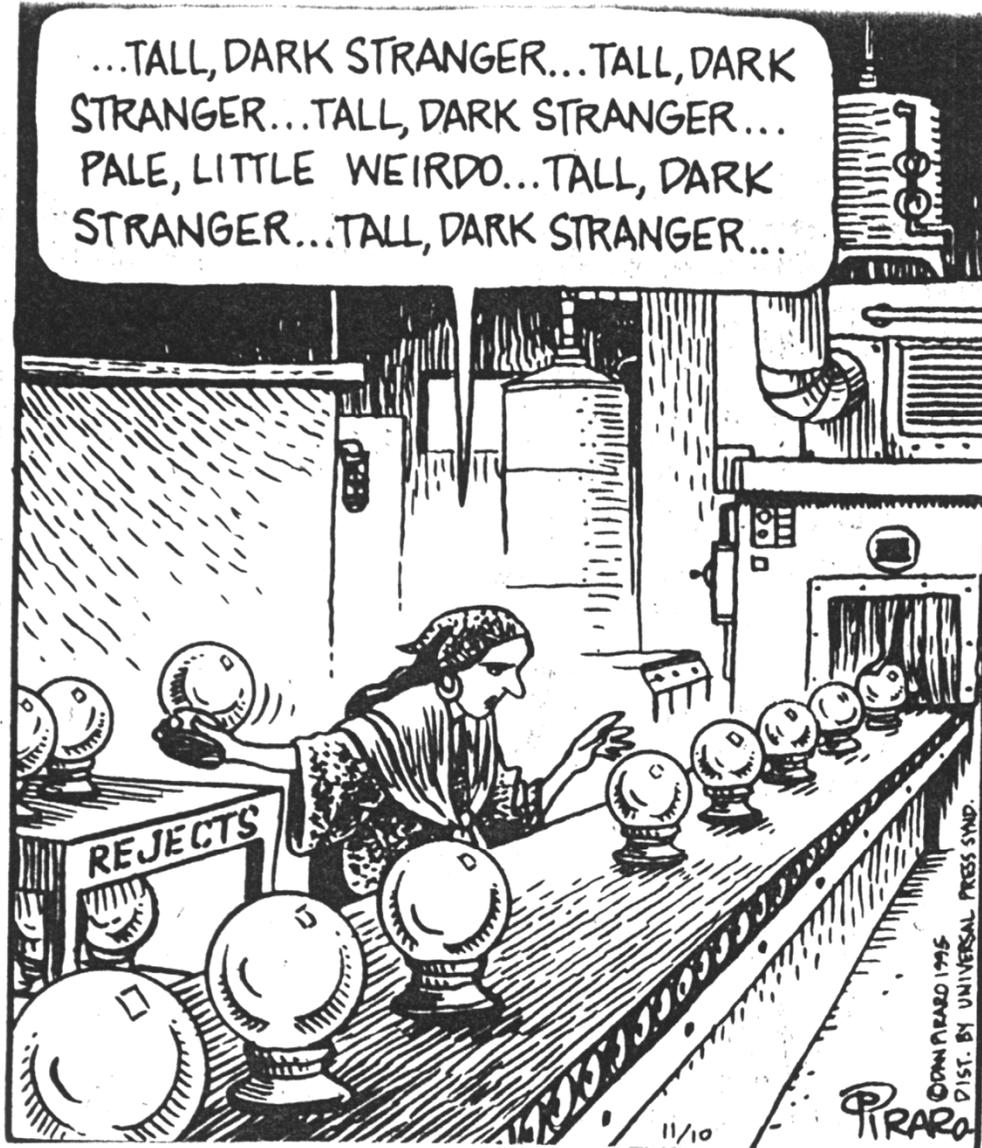
Item Type	Probability	Response	P3 Amplitude
Nonconcealed	1/7	“Yes”	Large
Concealed	1/7	“No”	Large if Recognized Small if not Recognized
Unlearned	5/7	“No”	Small

- Similar to procedures by Rosenfeld et al, Farwell & Donchin

# The Classic Oddball Experiment

Bizarro

...TALL, DARK STRANGER...TALL, DARK STRANGER...  
STRANGER...TALL, DARK STRANGER...  
PALE, LITTLE WEIRDO...TALL, DARK STRANGER...  
STRANGER...TALL, DARK STRANGER...



# Motivational Variations

## Conceal

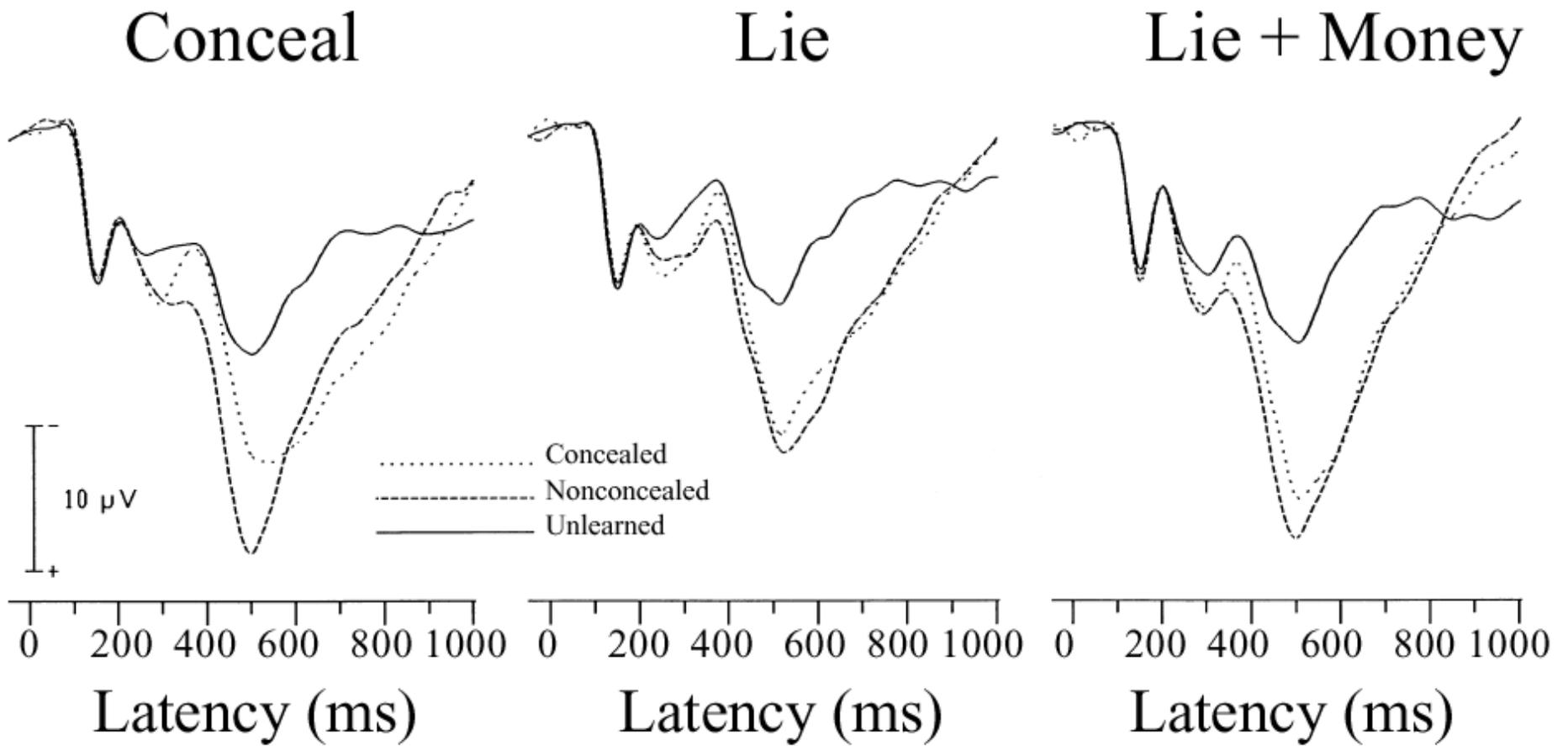
- "YES" for words JUST learned, "NO" for all others
- *Try to hide the fact that you learned the first list of words I taught you*

## Lie

- "YES" for words learned
- *Lie about words from the first list I taught you*

## Lie + \$\$

- "YES" for words learned
- *Lie about words from the first list I taught you*
- *\$5.00 incentive*



After Allen & Iacono, 1997

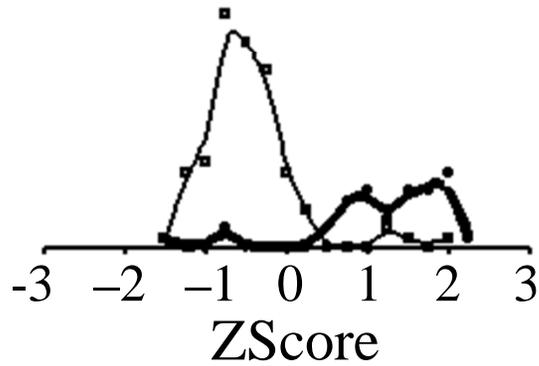
# The Challenge

*To provide statistically supported decisions for each and every subject, despite considerable individual variability in ERP morphology*

### P3 Amplitude

Sensitivity = .925

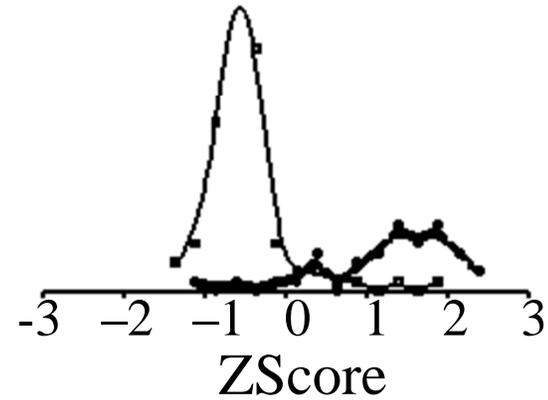
Specificity = .920



### Raw ERP H<sup>2</sup>

Sensitivity = .950

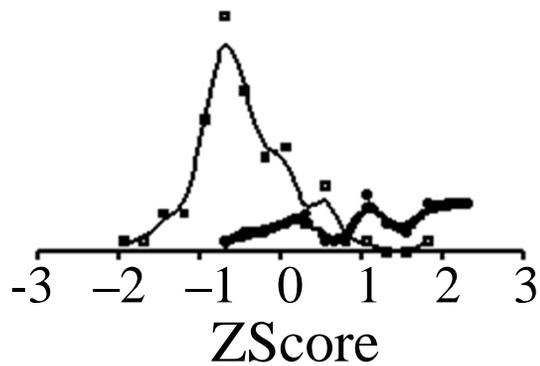
Specificity = .920



### 1<sup>st</sup> Derivative H<sup>2</sup>

Sensitivity = .875

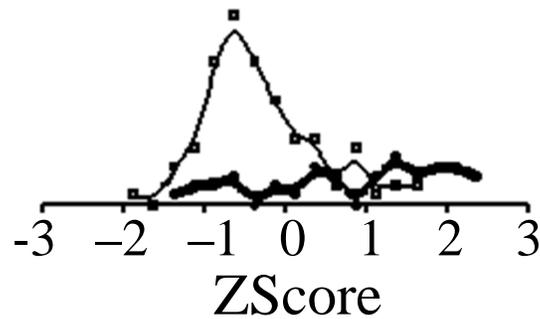
Specificity = .810



### 2<sup>nd</sup> Derivative H<sup>2</sup>

Sensitivity = .750

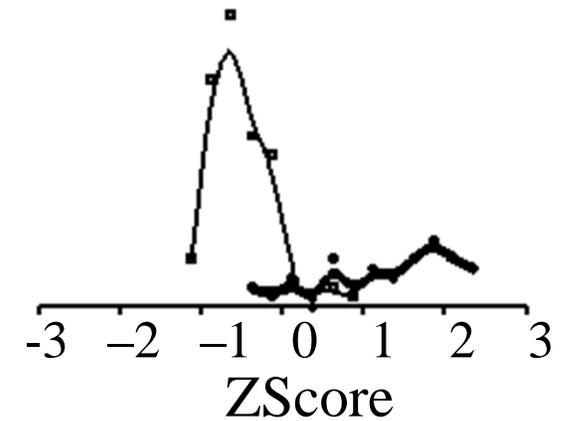
Specificity = .740



### Deviation H<sup>2</sup>

Sensitivity = .925

Specificity = .920



# Bayesian Combination of ERP Indicators: Probability that an ERP was elicited by Learned Items

Subject	Learned		List				
	NonConceal	Conceal	U1	U2	U3	U4	U5
#01	1.0	0.999	0.000	0.000	0.000	0.000	0.001
#02	1.0	1.0	0.000	0.000	0.000	0.000	0.000
#03	1.0	0.999	0.000	0.000	0.000	0.002	0.000
#04	1.0	1.0	0.000	0.001	0.002	0.000	0.000
#05	1.0	0.971	0.002	0.000	0.000	0.000	0.000
#06	1.0	0.999	0.000	0.000	0.000	0.000	0.000
#07	0.983	1.0	0.000	0.000	0.000	0.000	0.000
...							
#18	0.996	0.983	<b>0.874</b>	0.001	0.000	0.000	0.000
#19	<b>0.009</b>	<b>0.214</b>	<b>0.971</b>	0.000	0.002	0.189	<b>0.983</b>
#20	1.0	0.999	0.002	0.000	0.009	0.000	0.214

Note: Only trials in which subjects did not acknowledge concealed items included

# Classification Accuracy based on ERPs

	Learned (true pos)	Unlearned (true neg)
Conceal	0.95	0.96
Lie	0.93	0.94
Lie + \$\$	0.95	0.98
Combined	0.94	0.96

# **Brain Fingerprinting: A New Paradigm in Criminal Investigations and Counterterrorism**

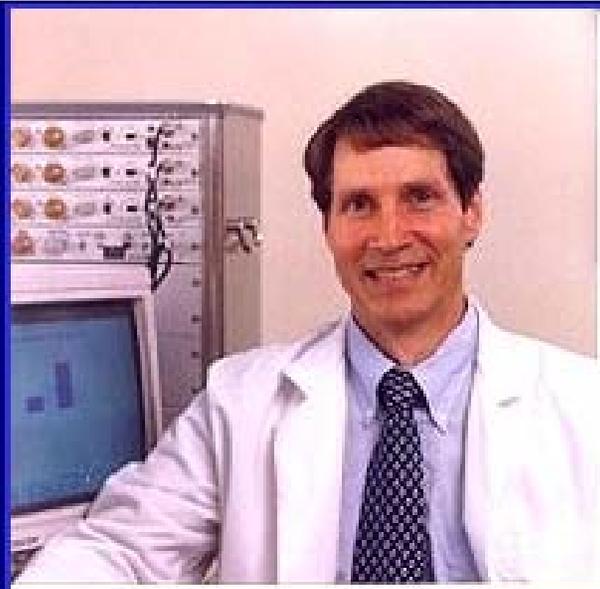
## Executive Summary

Farwell Brain Fingerprinting is a revolutionary new technology for investigating crimes and exonerating innocent suspects, with a record of 100% accuracy in research on FBI agents, research with US government agencies, and field applications.

The technology is proprietary and patented. Brain Fingerprinting fulfills an urgent need for government, law enforcement agencies, corporations, and individuals. Over a trillion dollars are spent annually on crime fighting worldwide.

Brain Fingerprinting solves the central problem by determining scientifically whether a suspect has the details of a crime stored in his brain. It has received extensive media coverage around the world. The technology is fully developed and available for application.

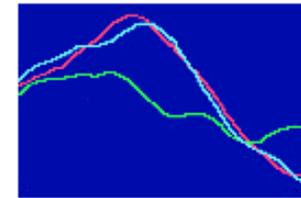
Brain Fingerprinting is a powerful tool for the investigation of suspected terrorists. Measuring the brain wave activity while suspects are shown words or pictures related to specifics of the September 11, 2001 attacks can help determine if they are members of terrorist cells. Brain Fingerprinting can identify trained terrorists before they strike



**Larry Farwell, PhD**

**Chairman & Chief Scientist  
Brain Wave Science  
Human Brain Research Laboratory, Inc.**

# Brain Fingerprinting Laboratories a new paradigm....



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## Counterterrorism Applications

How do we determine if a person is a terrorist or spy? There is a new technology, that for the first time, allows us to measure scientifically if specific information is stored in a person's brain. Brain Fingerprinting technology can determine the presence or absence of specific information, such as terrorist training and associations. This exciting new technology can help address the following critical elements in the fight against terrorism:

Aid in determining who has participated in terrorist acts, directly or indirectly.

Aid in identifying trained terrorists with the potential to commit future terrorist acts, even if they are in a "sleeper" cell and have not been active for years.

Help to identify people who have knowledge or training in banking, finance or communications and who are associated with terrorist teams and acts.

Help to determine if an individual is in a leadership role within a terrorist organization.



# HOMELAND SECURITY ADVISORY SYSTEM

SEVERE

SEVERE RISK OF ATTACK ON CIVIL LIBERTIES

HIGH

HIGH RISK OF ATTACK ON CIVIL LIBERTIES

SUBSTANTIAL

SIGNIFICANT RISK OF ATTACK ON CIVIL LIBERTIES

GUARDED

GENERAL RISK OF ATTACK ON CIVIL LIBERTIES

LOW

LOW RISK OF ATTACK ON CIVIL LIBERTIES

US GOES TO CODE ORANGE

ACLU

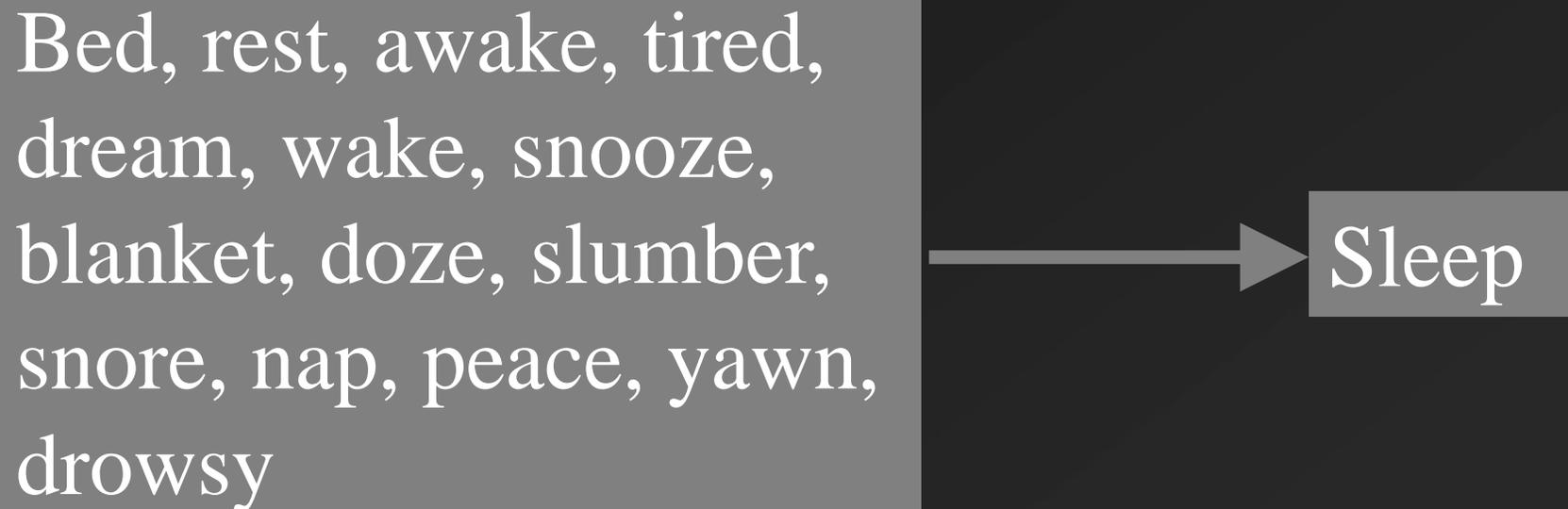
# The Claim

- Brain Fingerprinting can determine “scientifically whether a suspect has details of a crime stored in his brain”
- Thus these ERP-procedures should be able to identify memories in laboratory studies
- Two tests of the robustness of this procedure:
  - False recollections
  - Virtual Reality Mock Crime

# A Laboratory Paradigm for False Recollections: DRM

- Subjects presented with 15 words highly associated with an omitted critical item

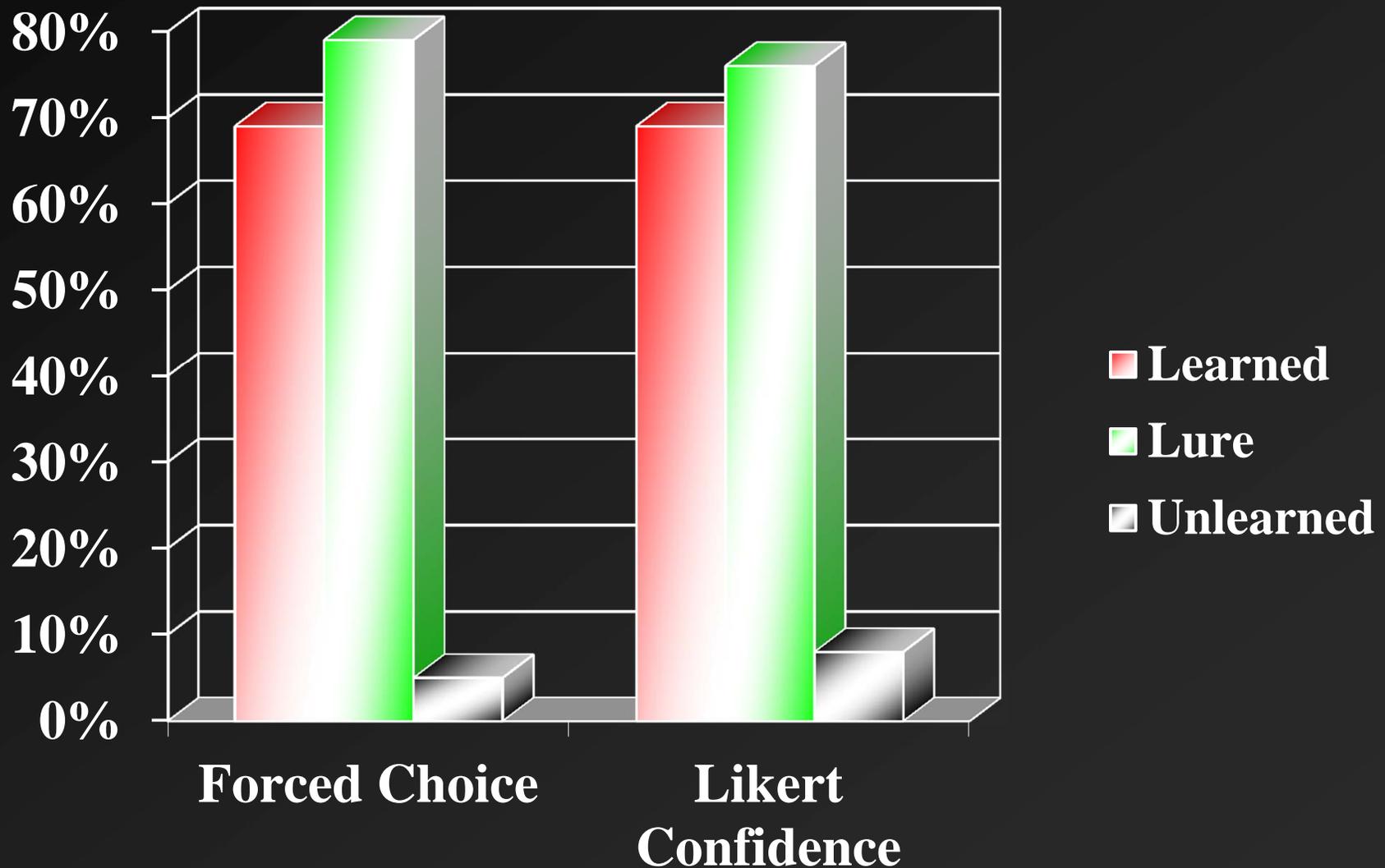
Bed, rest, awake, tired,  
dream, wake, snooze,  
blanket, doze, slumber,  
snore, nap, peace, yawn,  
drowsy

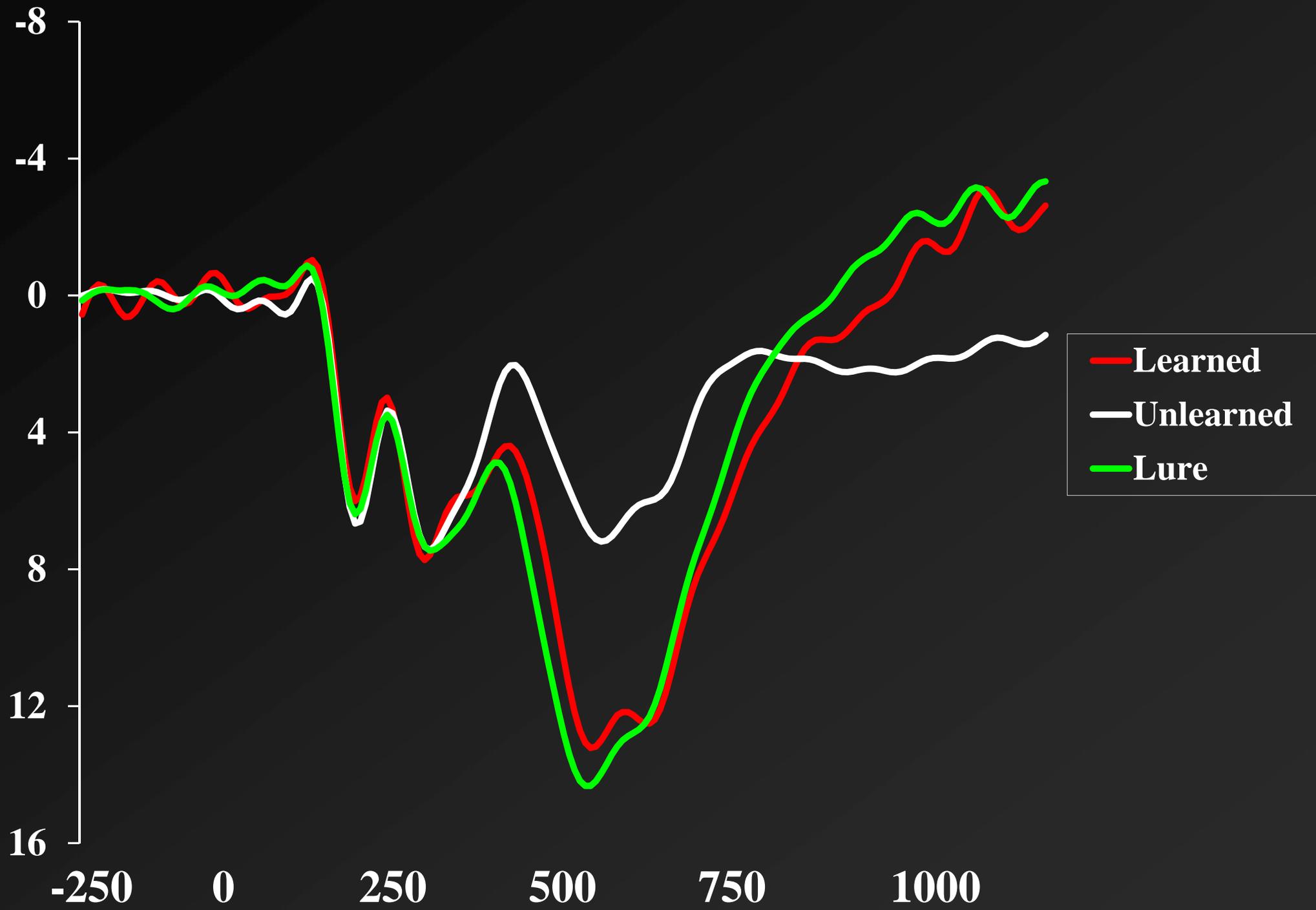


Sleep

The diagram consists of a large grey rectangular box on the left containing a list of 15 words. A horizontal arrow points from the right side of this box to a smaller grey rectangular box on the right containing the word 'Sleep'.

# Reported Rates of Recognition





# The Box Score Blues

Ground Truth	Test Verdict
	Recognized
Actually Learned	56%
Critical Lure	72%
Unlearned	4%

- ❑ Highlights the need to have memorable items in the test
- ❑ Suggests limited utility in substantiating disputed memories; e.g., claims regarding recovered memories
- ❑ Still has low false positive rate when person denies knowledge

# Virtual Reality Mock Crime

- Subjects received email detailing their “Mission”
- Sneak into graduate student office to break in to virtual apartment
- Apprehended and interrogated using ERP-based procedure
- Some subjects given details about utilizing countermeasures
- Innocent subjects tour the same virtual apartment, but with different objects and details.



UA News

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- Basketball
- Football

Opinions

Features

Go Wild

Police Beat

CatCalls

Comics

Crossword

Online Crossword

WildChat

Classifieds

THE WILDCAT

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Browse the Wildcat archives

## POLICE BEAT

### Police Beat

By **David Halperin**  
Arizona Daily Wildcat  
Friday December 6, 2002

#### Suspicious e-mail sent

An employee reported that he received an e-mail Wednesday stating he is supposed to commit a crime today, reports stated.

At about 11:35 a.m., the employee told police he had received the suspicious e-mail while in his office at the Arizona Health Sciences Center, 1501 N. Campbell Ave.

The employee told police he did not know the sender of the message or why he received it. He decided to report the incident after his supervisor advised him to do so.

The message read: "This message is simply a reminder of the crime you are to commit on December 6th at 9:00a.m. You should have carefully read over your mission plan and memorized all relevant information in order to carry out your mission. Remember, do not bring materials with you related to the crime and maintain your innocence at all times. Good luck. Dispose of this message once understood," reports stated.



#### ARTICLES

Grad students may quit over tuition hike

Bike riders dodge some road rules

Eastside tech park to expand with hotel, golf course, offices

On the Spot

Art Briefs

Policebeat

CatCalls



# Results of Mock Crime Brainwave Procedure

Group	N	Verdict	
		Guilty	Innocent
Guilty	15	47%	53%
Guilty (countermeasure)	45	17%	83%
Innocent	15	6%	94%

Note: Using Bootstrapping approach, Guilty detection drops to 27%, but innocent subjects classified correctly in 100% of cases. Allows indeterminate outcomes

# ERPS and Affective Processing

- IAPS = International Affective Picture System
  - Pleasant, Neutral, Unpleasant
  - Vary in Arousal: Pleasant and Unpleasant tend to be more arousing
- Predict more significant stimuli produce larger P3

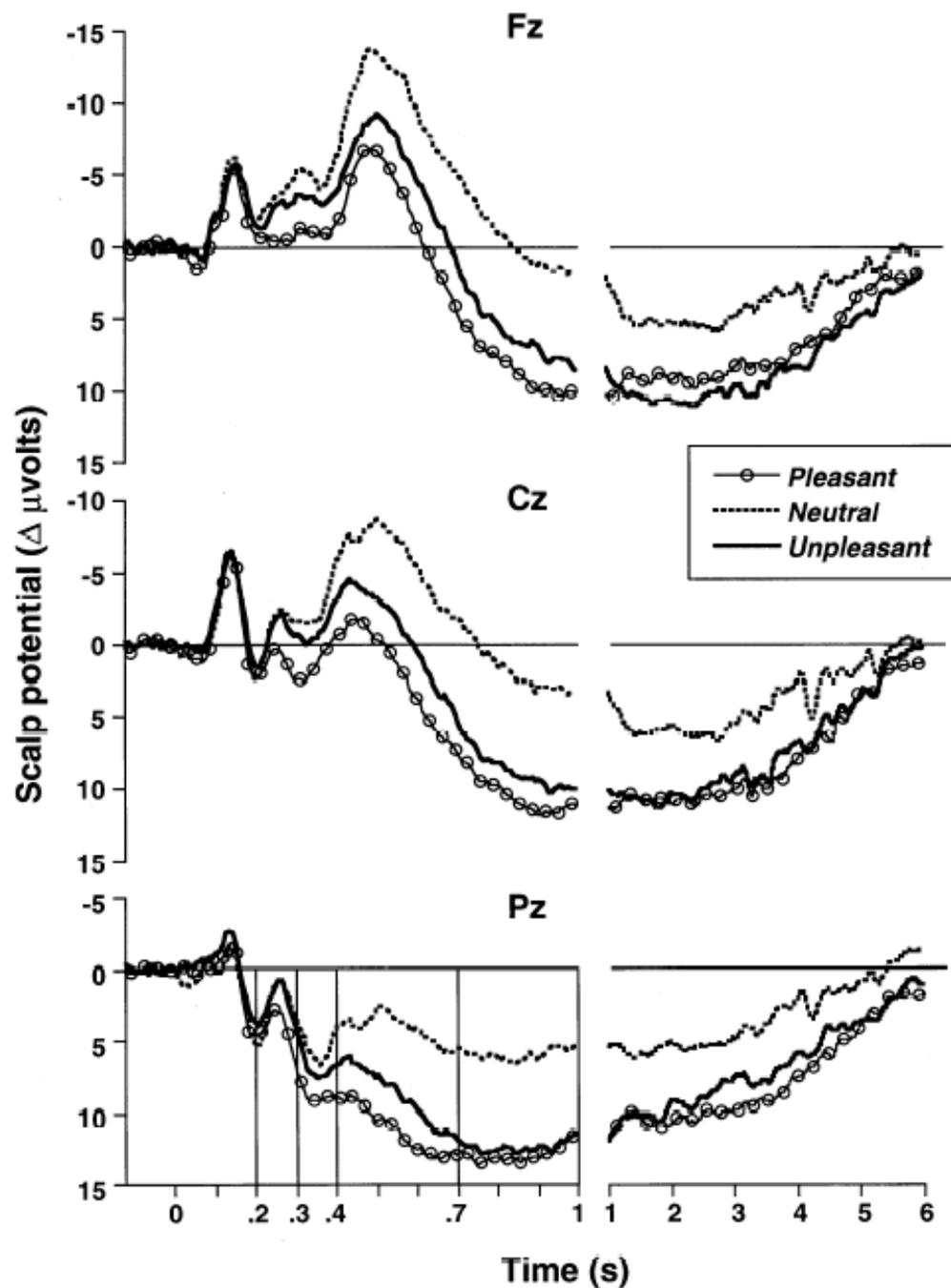
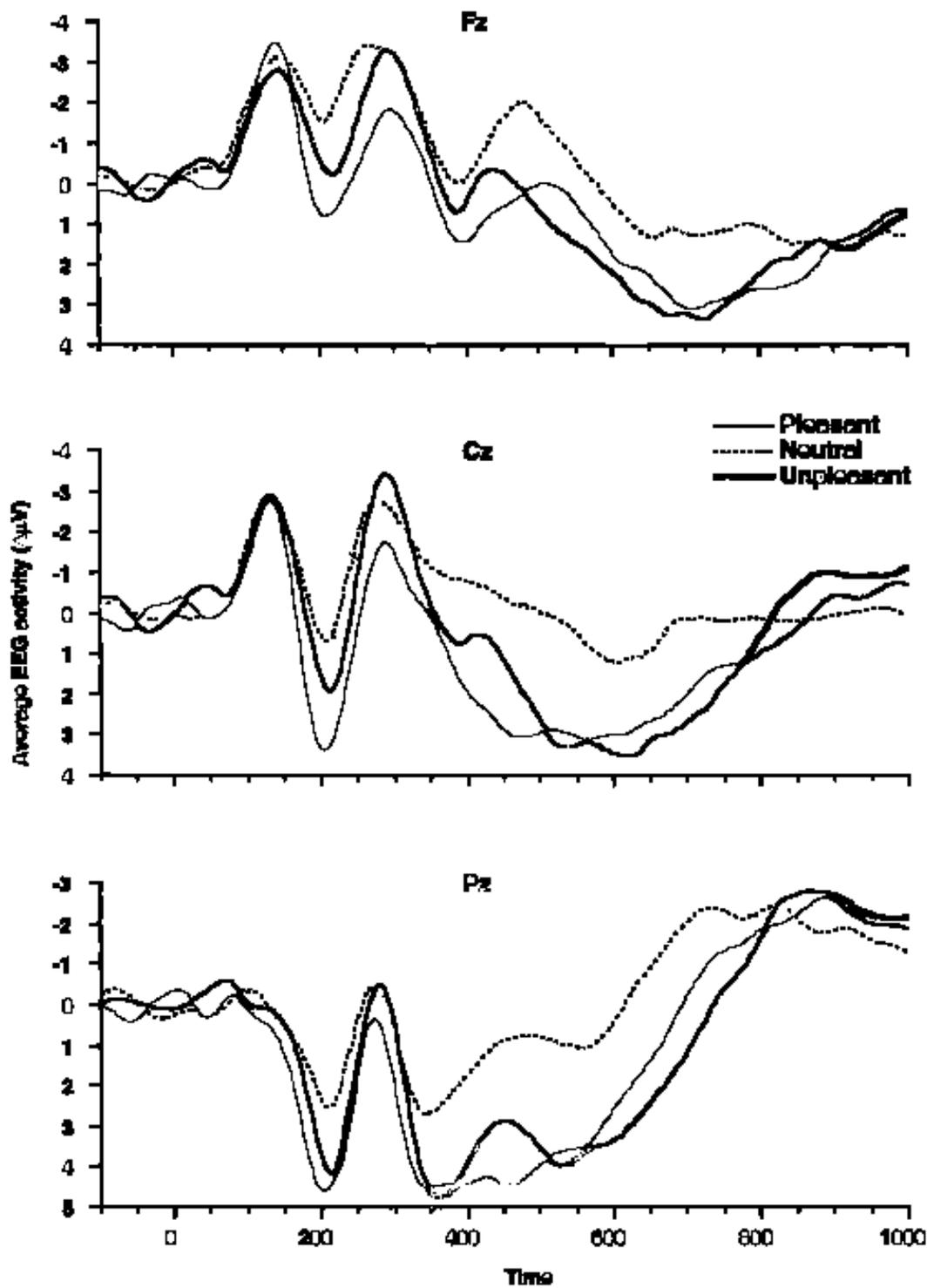


Fig. 1. Stimulus synchronized grand average ERP waveforms for Fz, Cz, and Pz electrodes during viewing of affective pictures, separately for each valence category (pleasant, neutral and unpleasant). The left panel illustrates the picture onset potentials on a finer time scale, and the vertical lines at Pz illustrate the time areas subjected to statistical analysis (i.e. 200–300, 300–400, 400–700, 700–1000 ms). The right panel shows the subsequent 5 s of slow potential change.

Long (6 sec)  
Presentation Duration

Schupp et al (2000),  
*Psychophysiology*



1.5 sec Presentation  
Duration

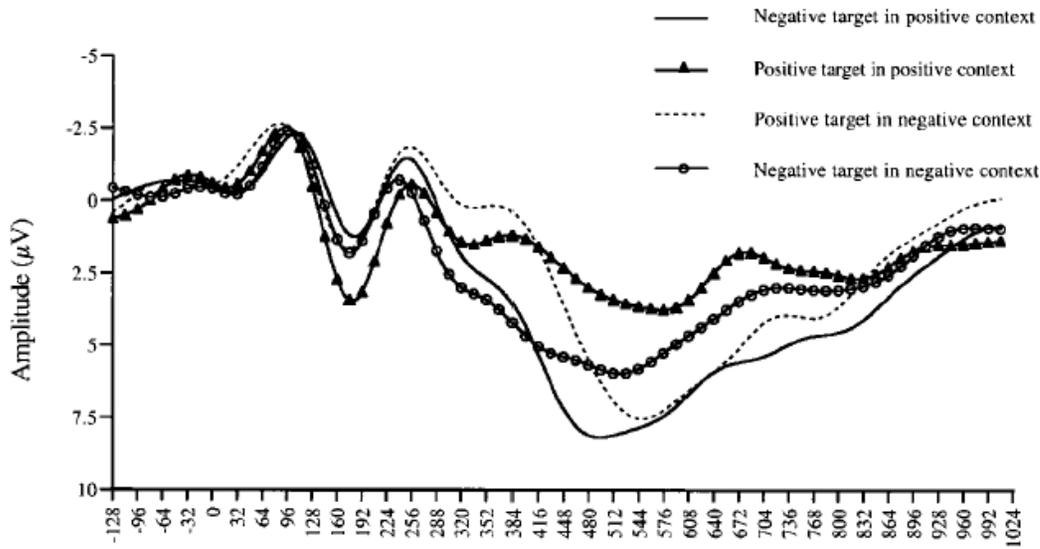
Cuthbert et al (2000),  
*Biological Psychology*

Figure 1. Picture onset synchronized grand-average event-related potential (ERP) waveforms for each valence category (pleasant, neutral, and unpleasant) from midline electrodes Fz, Cz, and Pz.

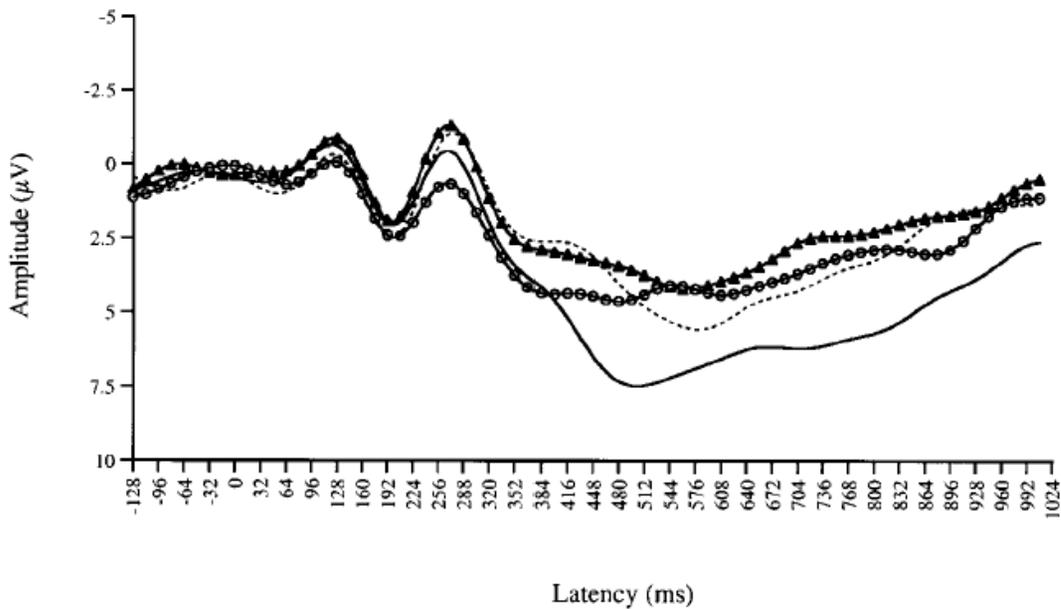
# ERPS and Implicit Affective Processing

- Ito & Cacioppo (2000) *JESP*
  - Evaluative Processing (positive vs negative)
  - Nonevaluative (people vs no-people)

Explicit Evaluative Effects  
(Evaluative Categorization Task Condition)



Implicit Evaluative Effects  
(Nonevaluative Categorization Task Condition)



Ito & Cacioppo (2000) *JESP*

**FIG. 2.** Averaged event-related potential waveforms at electrode Pz as a function of target and context valence. The top panel depicts explicit evaluative categorization effects (data from participants in the evaluative task condition). The bottom panel depicts implicit evaluative categorization effects (data from participants in the nonevaluative task condition). The late-positive potential is the positive (downward) deflection peaking at approximately 450–550 ms.

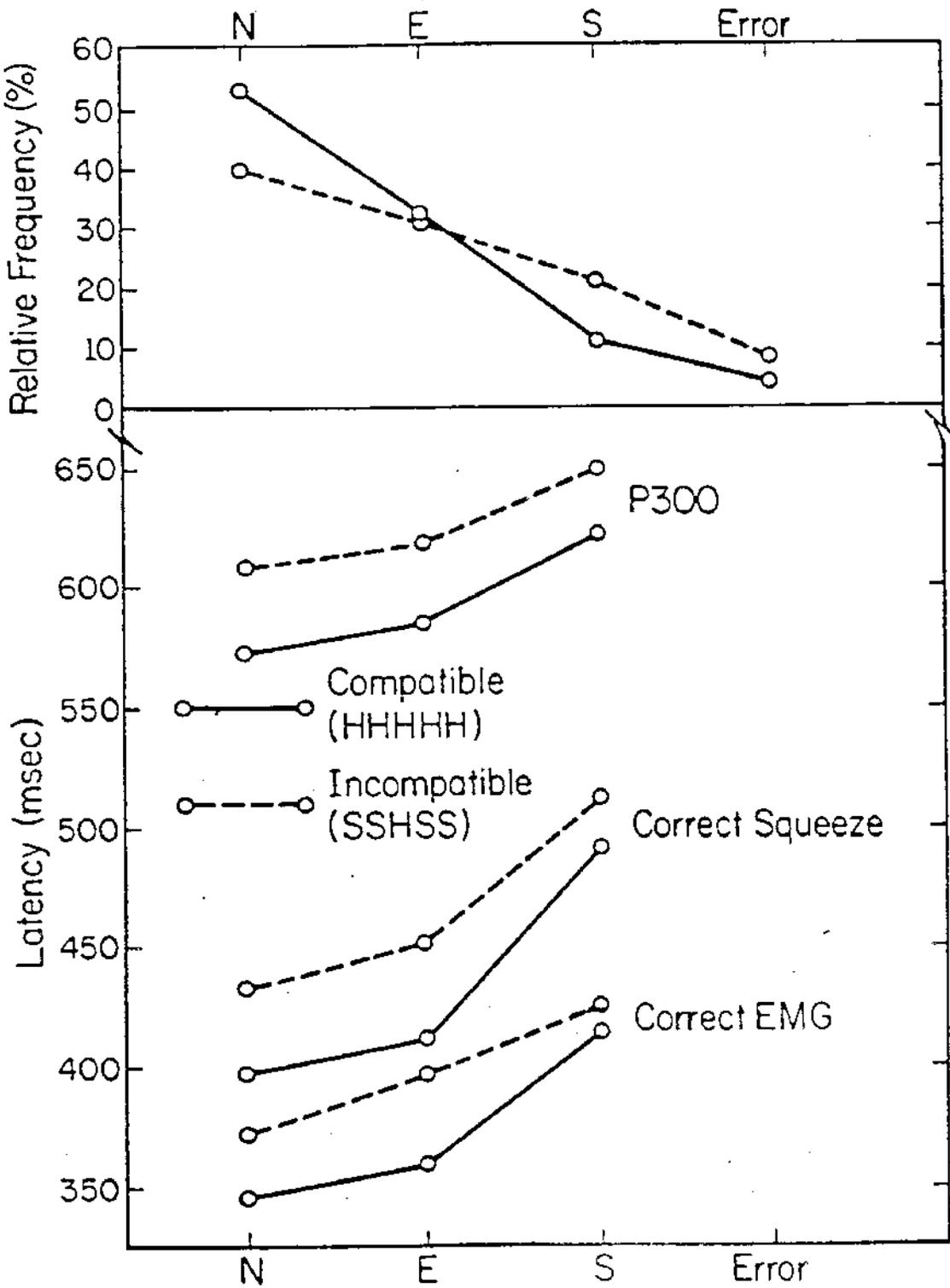
# ERPs and Mental Chronometry

- “Correctness” not dichotomous
- The continuous flow model of human information processing (Coles, Bashore, Eriksen, & Donchin, 1985)
- Measure response using hand dynamometer and EMG activity to compatible and incompatible arrays:

HHHHH V<sub>s</sub> HSHHH

SSSSS V<sub>s</sub> SSHSS

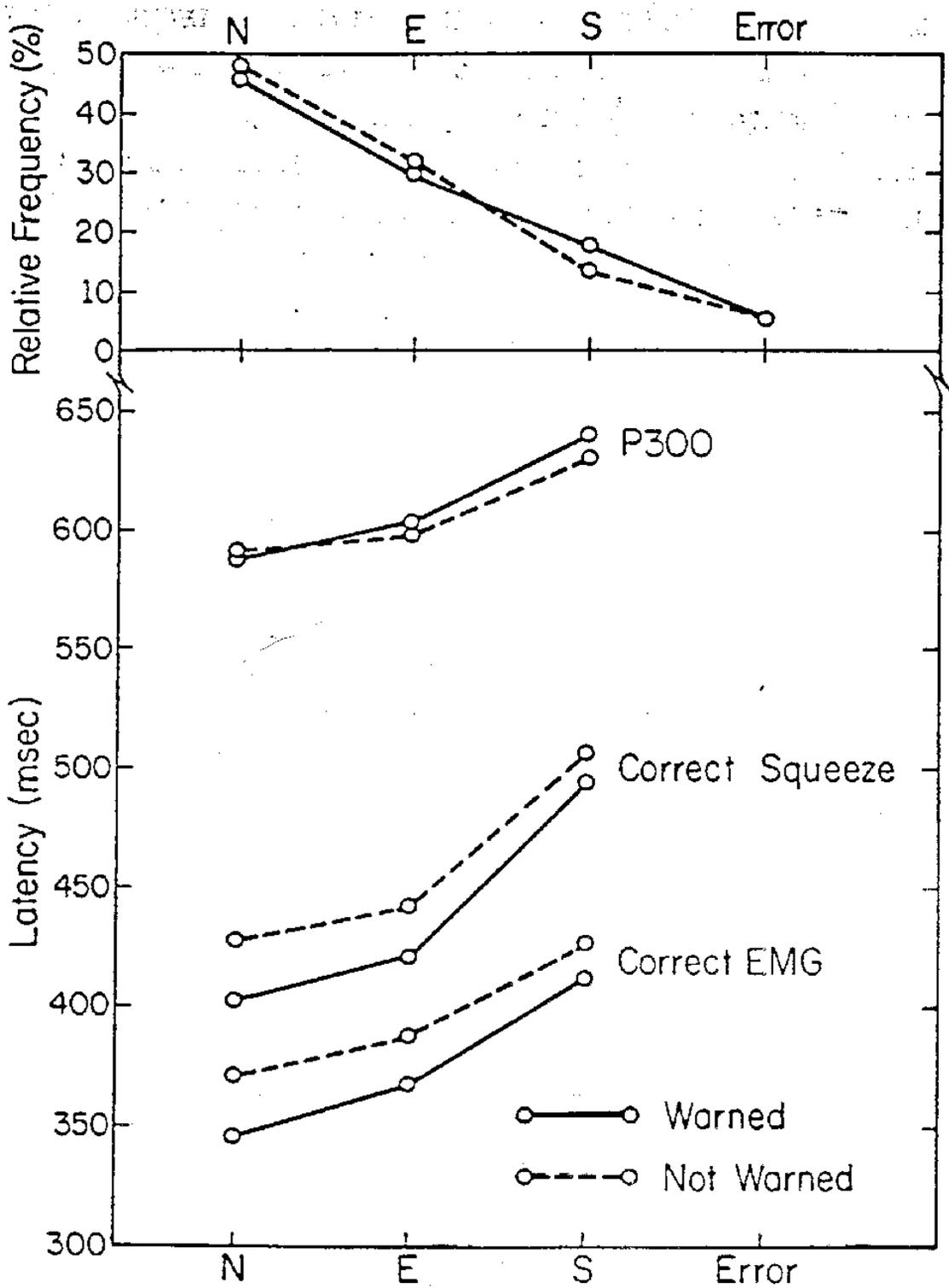
### Compatibility Effect



N = No Incorrect Activity  
 E = Some EMG activity on incorrect response channel  
 S = EMG and squeeze on both correct and incorrect channels  
 Error = no correct response, may be some EMG in correct channel

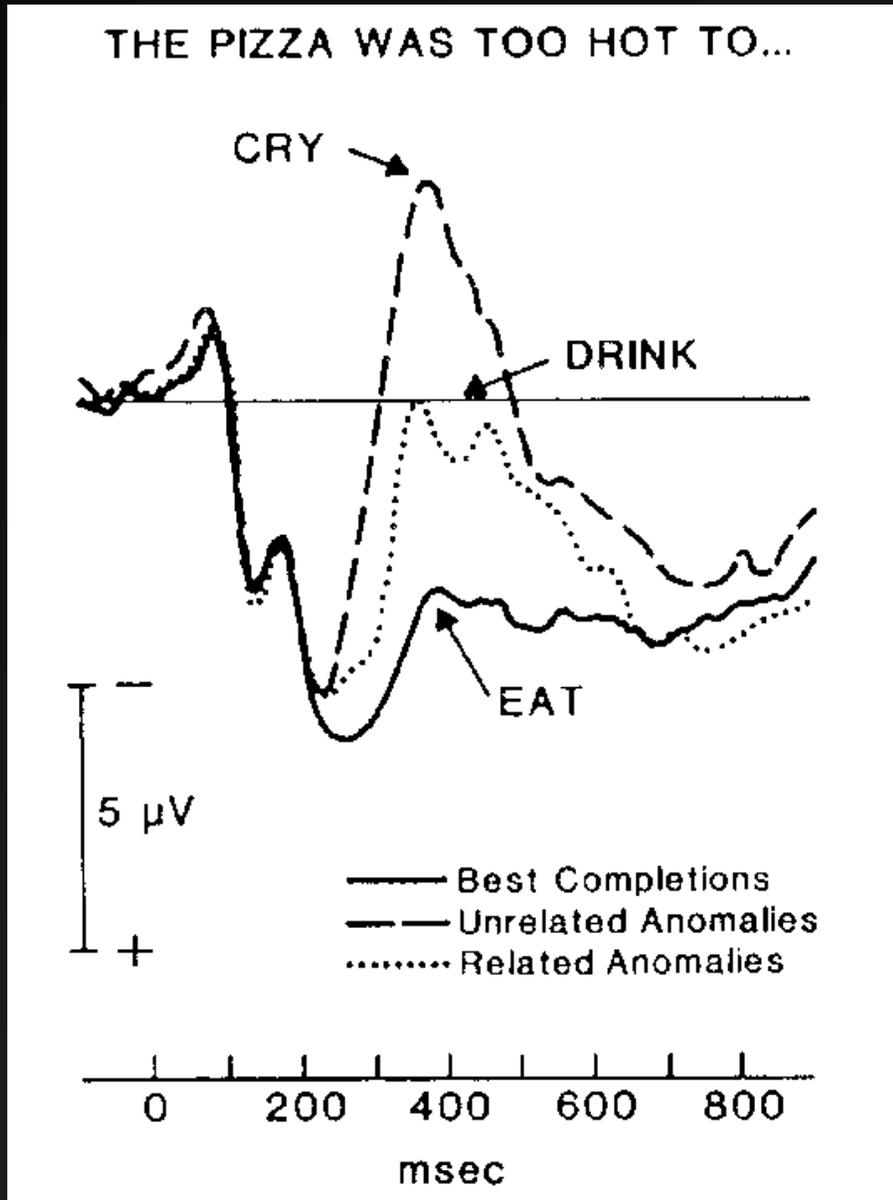
Latency of activity on correct side increased as a function of activity on incorrect side

# Warning Effect



Effect of Warning seen only in response measures, but not central evaluation

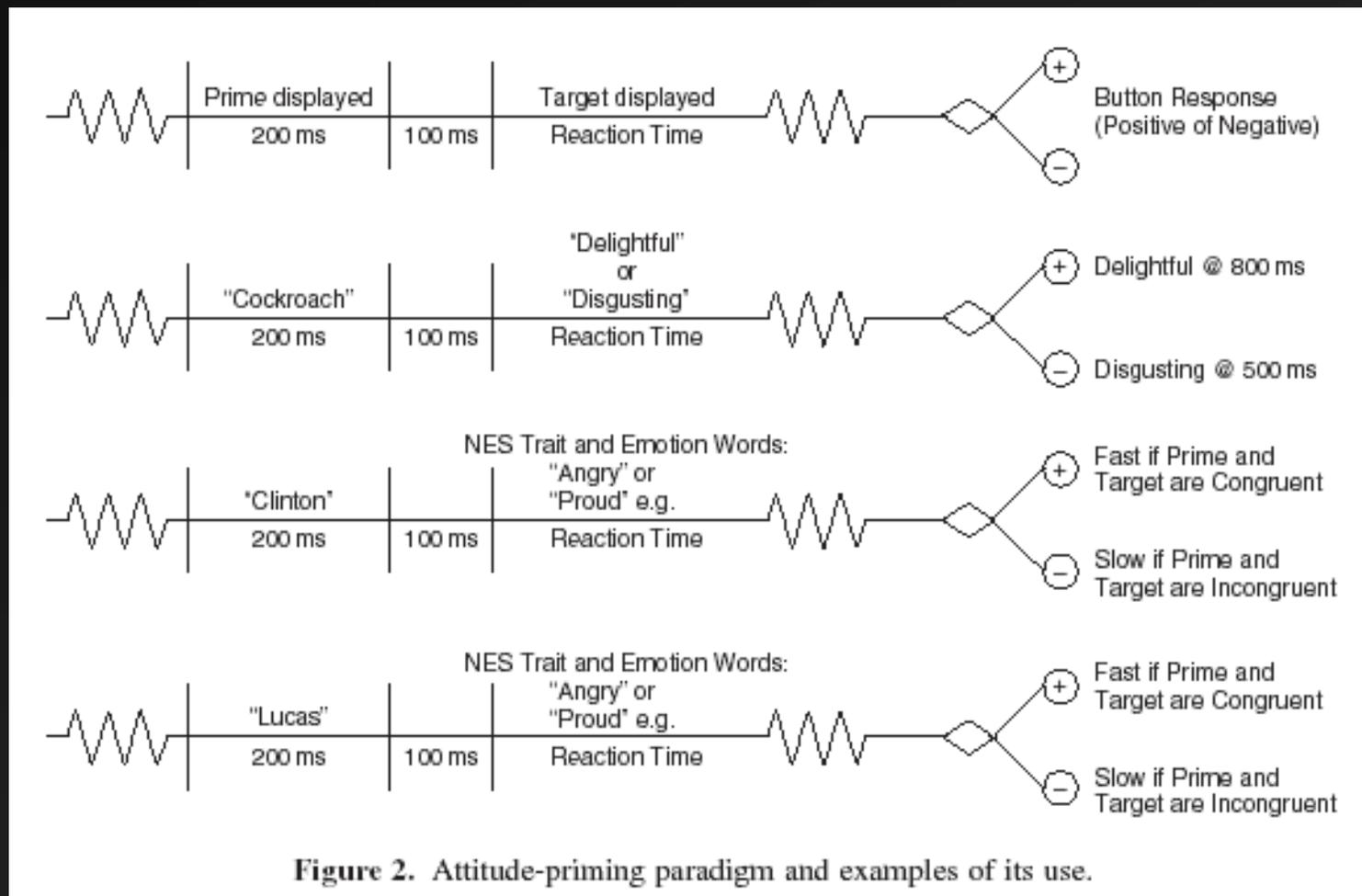
# N400 and Language



- Originally reported by Kutas & Hillyard, 1980.
- Semantic Incongruity is separable from other forms of deviations (e.g. large font)
  - N400 Semantic Deviation
  - P300 Physical Deviation
- Also seen in semantic differentiation tasks (Polich, 1985); APPLE, BANANA, ORANGE, MANGO, *TRUCK*
- Subject-Object mismatch (the Florida group)
- NOTE: N400 will appear before P3 (which will be ~P550 in word tasks)

# Political Evaluations!

➤ Morris Squires et al. *Political Psychology* 2003



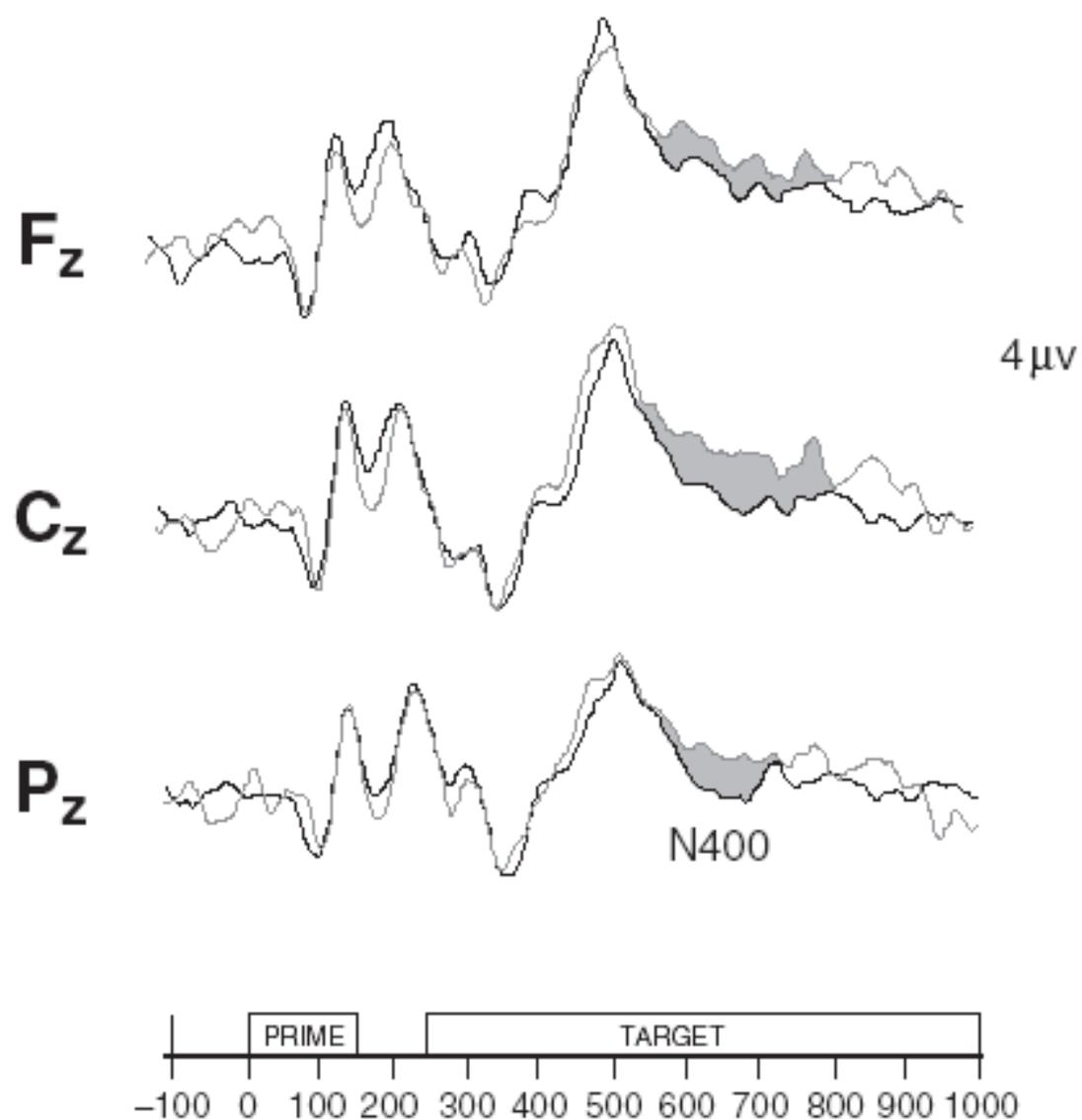
**CONGRUENT  
INCONGRUENT**

Figure 4. ERPs to congruent and incongruent prime/target pairs.

Congruent or incongruent defined based on idiographic data from pretest

Morris Squires  
et al. *Political  
Psychology* 2003