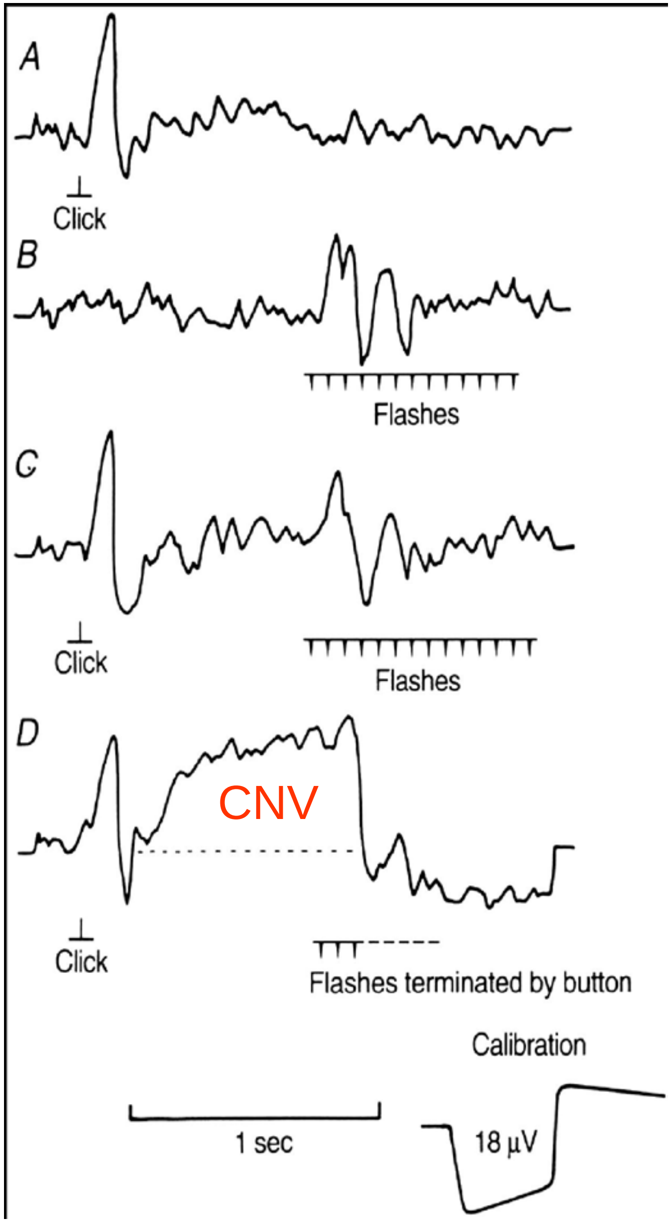


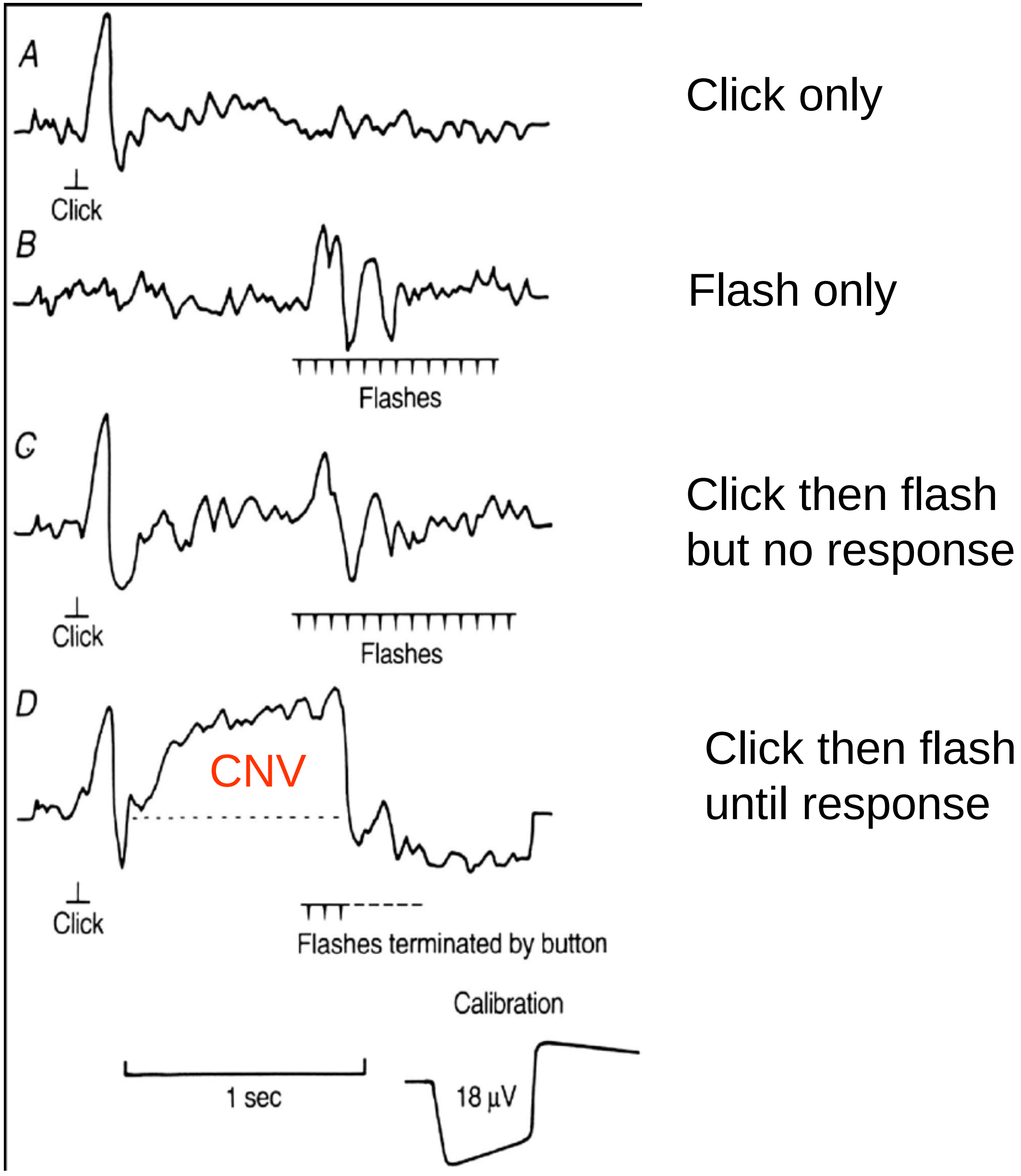
Click only

Flash only

Click then flash but no response

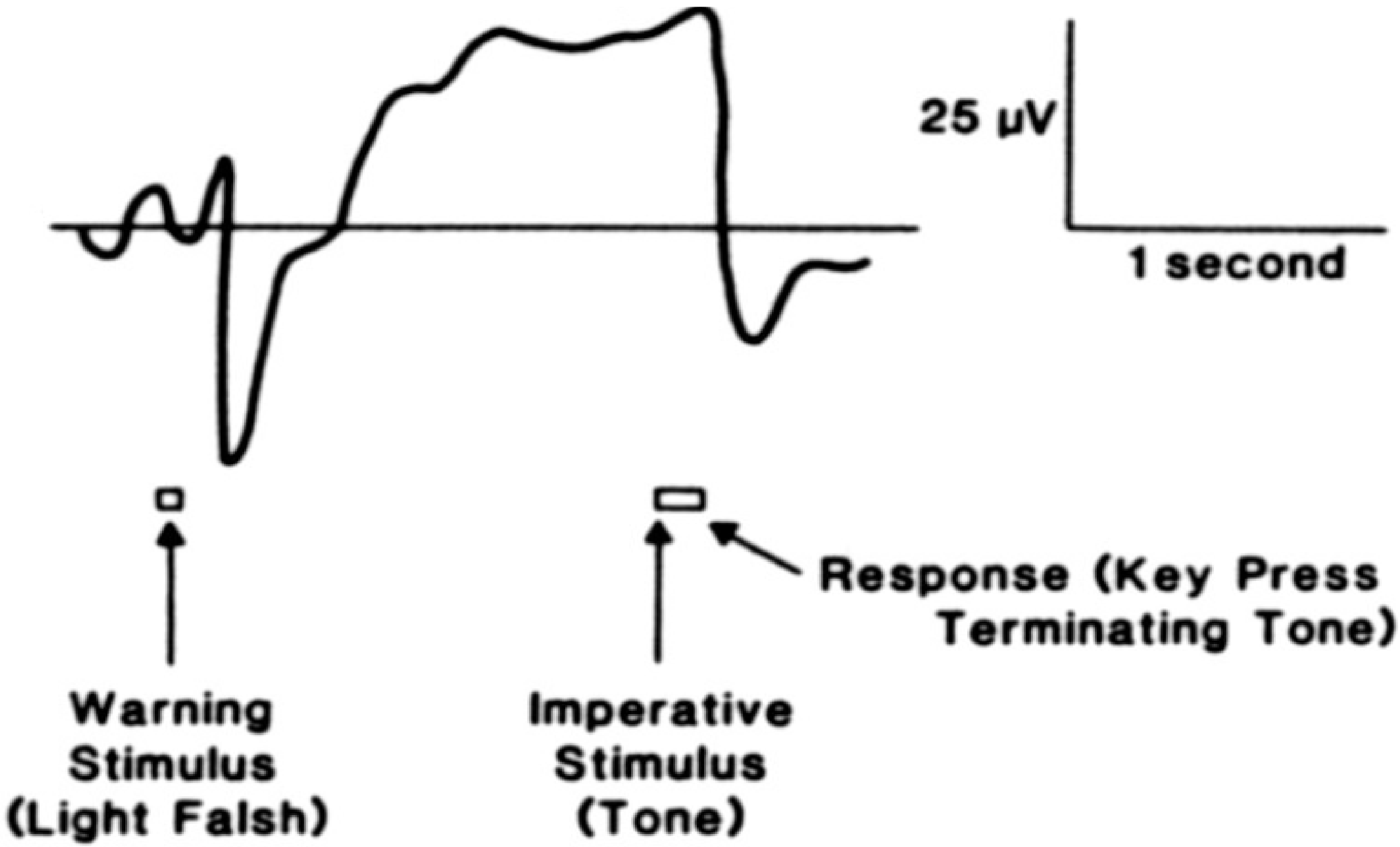
Click then flash until response

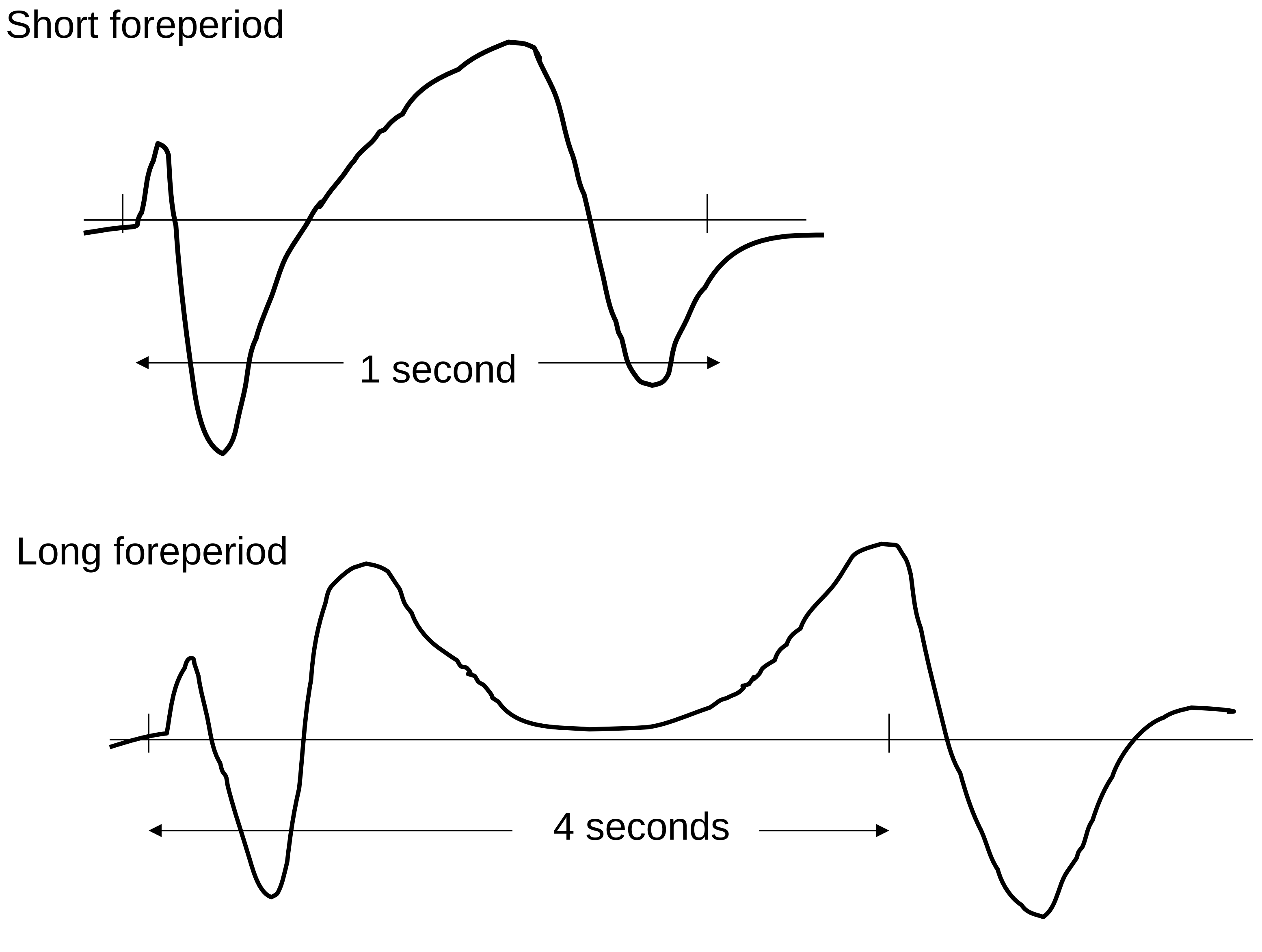
Same stimuli in C,D– different task demands → different ERPs



CNV – contingent negative variation only elicited when S1 and S2 were predictably related

CNV eliciting paradigm




Short foreperiod
1 second
Long foreperiod
4 seconds

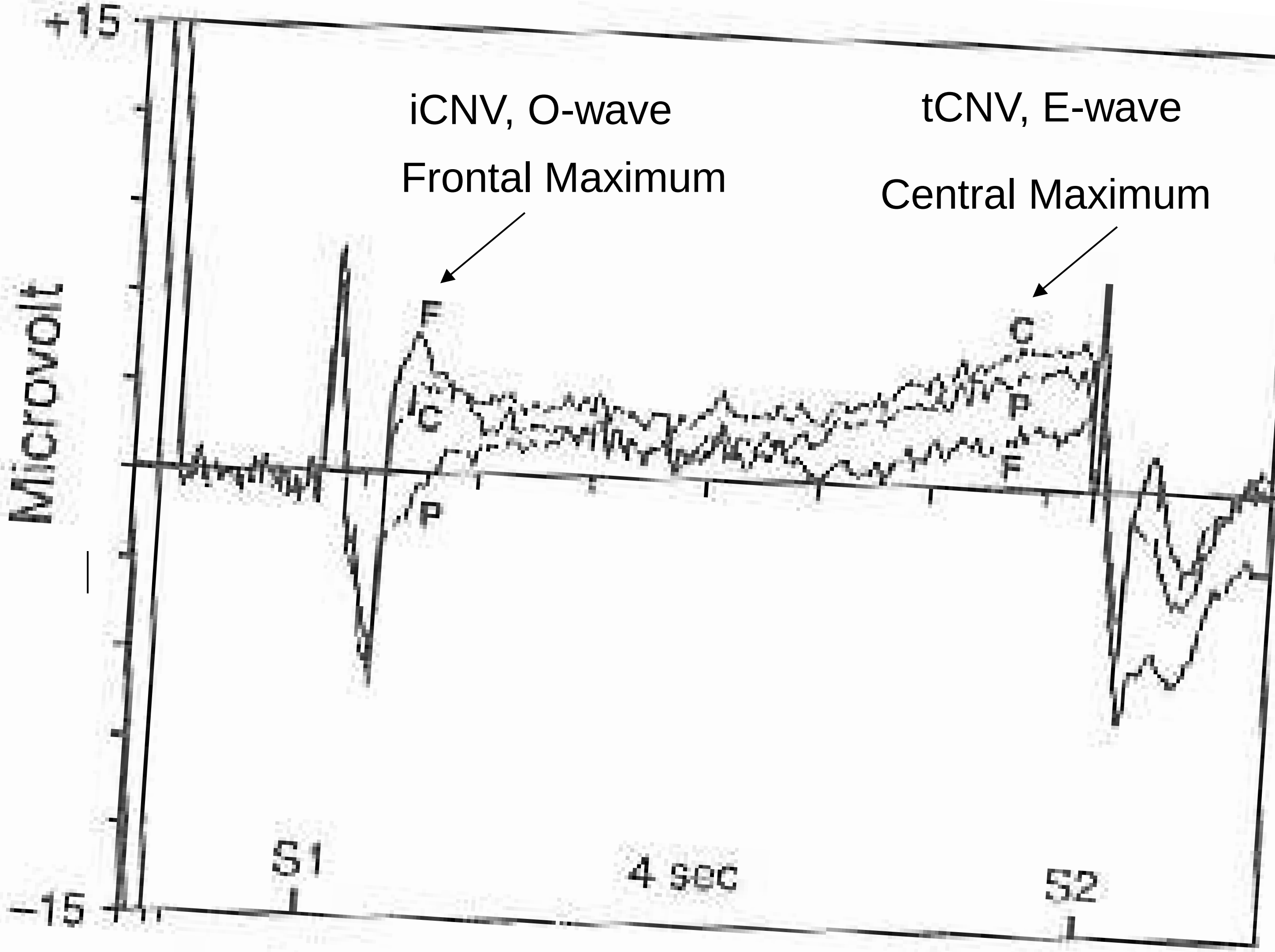


Figure 6. Contingent negative variation recorded during a foreperiod of 4 sec. The early wave after the first stimulus has a frontal maximum decreasing toward more posterior sites. The late wave increases up to the second stimulus and exhibits a central maximum. (Adapted from Brunia & Haagh 1986.)

Multiple component view of CNV

Early phase

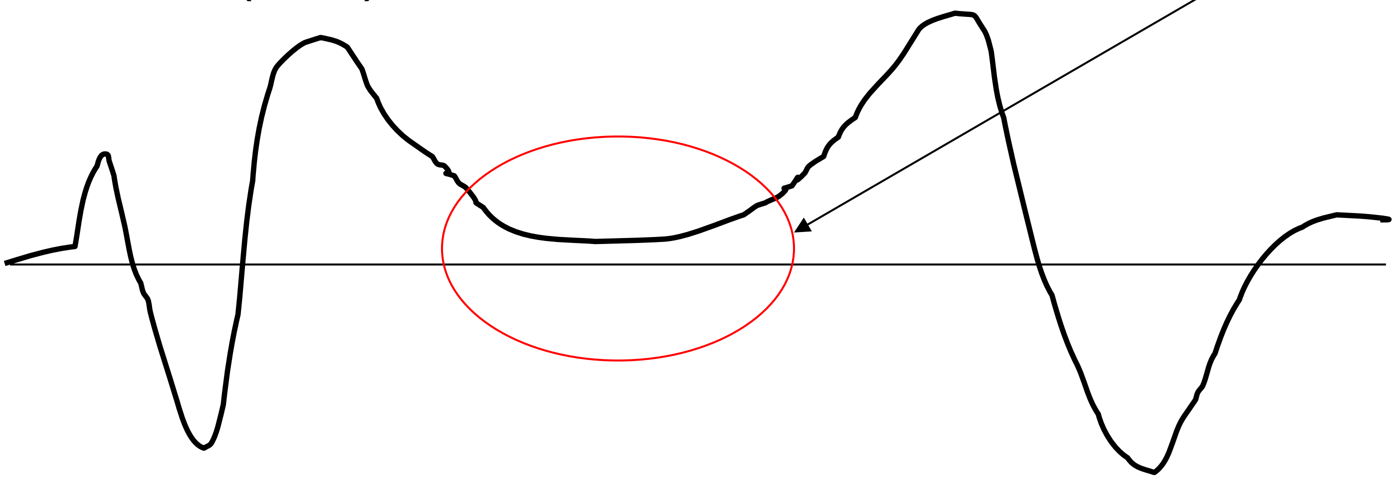
iCNV
O-wave
(SNW)

\+

Late phase

tCNV
E-wave
RP

\+ ?



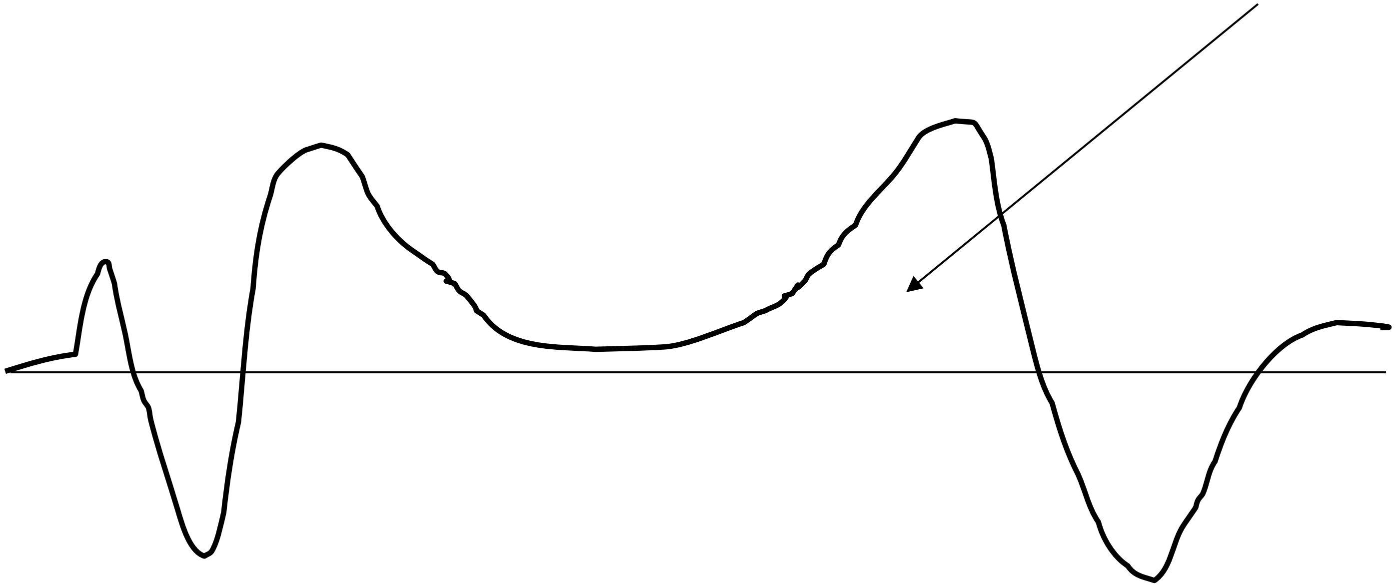
Response to S1 + SPN – stimulus preceding negativity
Response to S1 + MPN – movement preceding negativity

(prep brain for upcoming event/action)

Two (+) component view of CNV

Early phase		Late phase		
iCNV O-wave (SNW)	+	tCNV E-wave RP	+	?
		SPN MPN		

Contemporary research focus on SPN



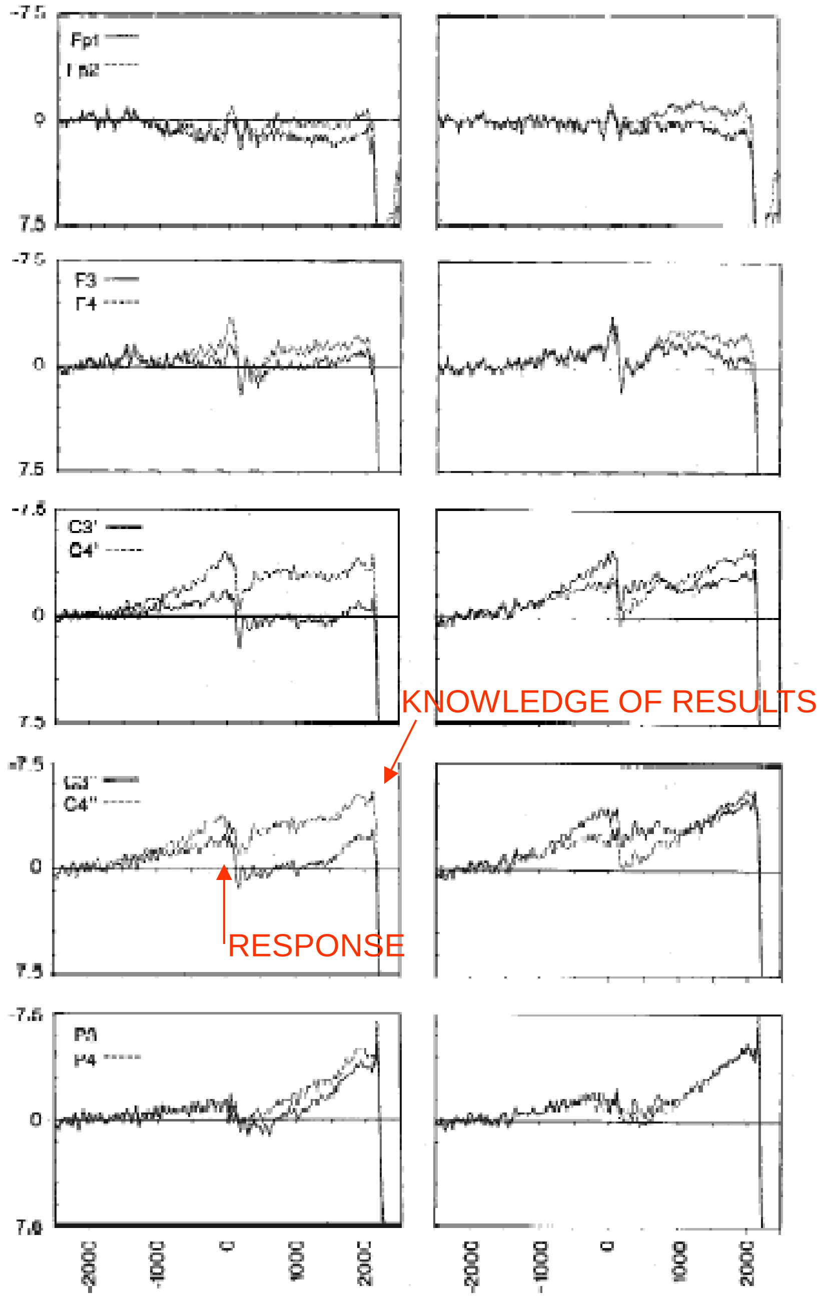
Response to S1	+	SPN – stimulus preceding negativity
Response to S1	+	MPN – movement preceding negativity

STIMULUS-PRECEDING NEGATIVITY (SPN)

The SPN has been measured in relation of four types of anticipation:

(1) anticipation of KR – knowledge of results (feedback) about past performance
(2) anticipation of an instruction about future task performance
(3) anticipation of probe stimuli in arithmetic tasks, against which result of actual performance should be matched
(4) anticipation of emotional stimuli (electric shock, nudes, etc)

Time estimation task



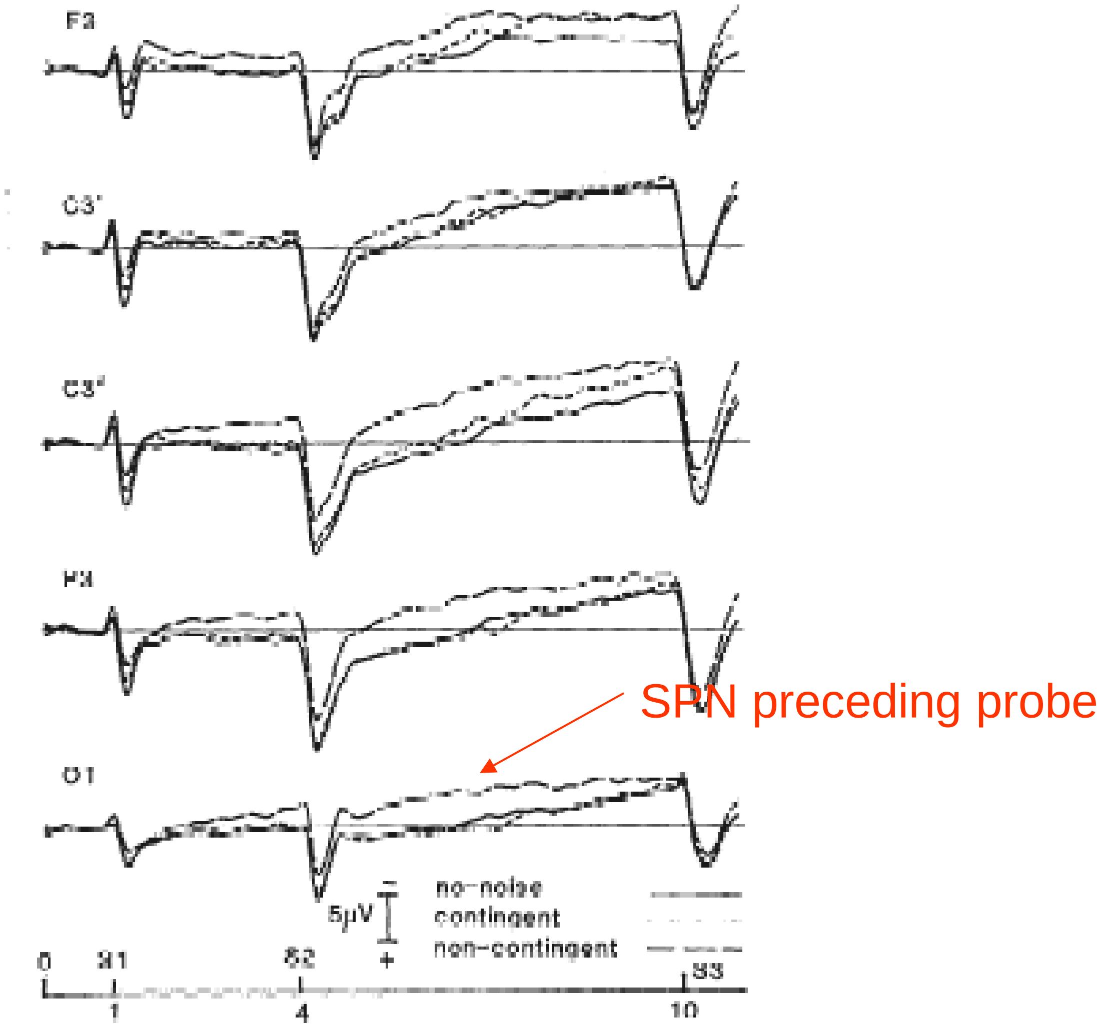
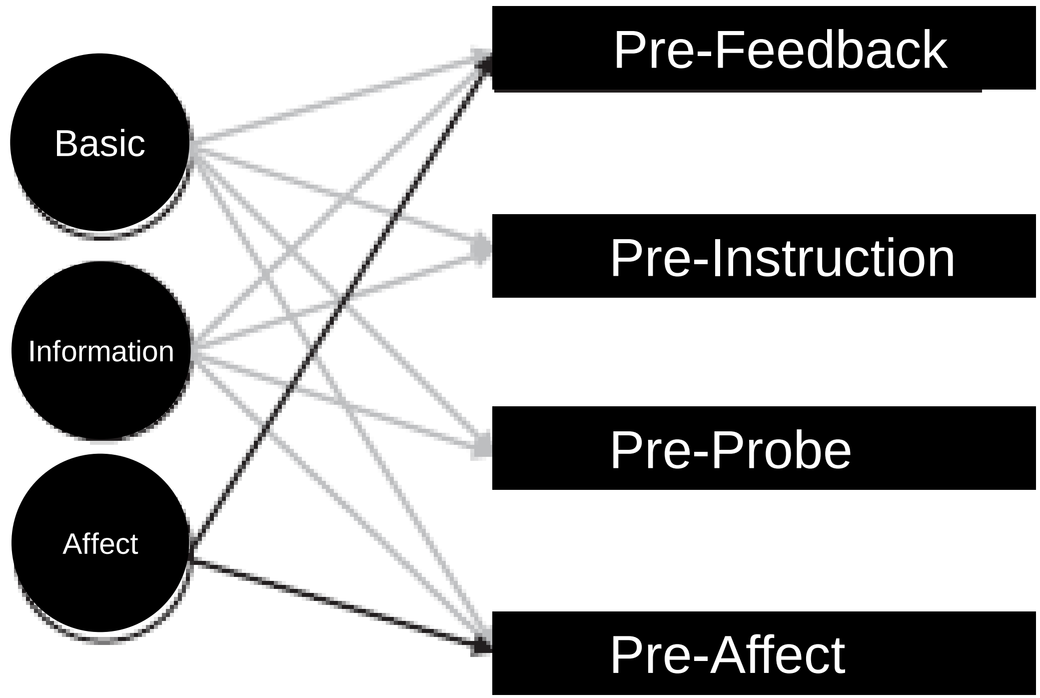


Figure 3. Example of the SPN preceding probe stimuli (S3) in an arithmetic task. Adapted from Chwilla and Brunia (1992).

Stimulus Preceding Negativity (SPN)



Van Boxtel & Bocker: three overlapping components underlying SPN:
1) general anticipation of impending stimulus (modality specific)
2) anticipation of information content of the stimulus (bilateral parietal areas)
3) emotional anticipation

Slow potentials due to change (presumably excitatory) in cortical areas that will be included in the processing of the future event

CNV and resource mobilization

Cortical resources are (capacity)-limited, so must be allocated for task at hand. Negativity reflects the "cortical priming" – allocation of resources leading to the readiness of neural system that will soon be active to do what needs to be done. CNV amplitude reflects "preparedness of cortical networks"

CNV thus appears in interval during which there is need to allocate resources, e.g., to take in information, to make a decision, to prepare a response – in a task that requires cortical involvement

Implies:

-- different cortices depending on the specific task – different scalp distributions

-- amplitude varies with cognitive load/demand

Best predictor of CNV amplitude is level of effortful involvement (motivation, task relevance, task difficulty); it is reduced by distraction.

-- spontaneously occurring slow potentials should influence information processing and task performance.

In brief, these ubiquitous negativities reflect the preparation of the brain ("cortical priming') for an upcoming stimulus, event, or action.

PRE-paradigm: potential related event paradigm, aka Brain trigger paradigm

Stimulus presentation and response execution are contingent on polarity and amplitude of spontaneous negative shifts.

Trials presented during negative (vs positive) shifts (30-40 uV) are faster and more accurate and results are area specific.

Key words: SCP – surface /scalp cortical potentials

Sample data for learning to control slow potentials via biofeedback. Can be done!

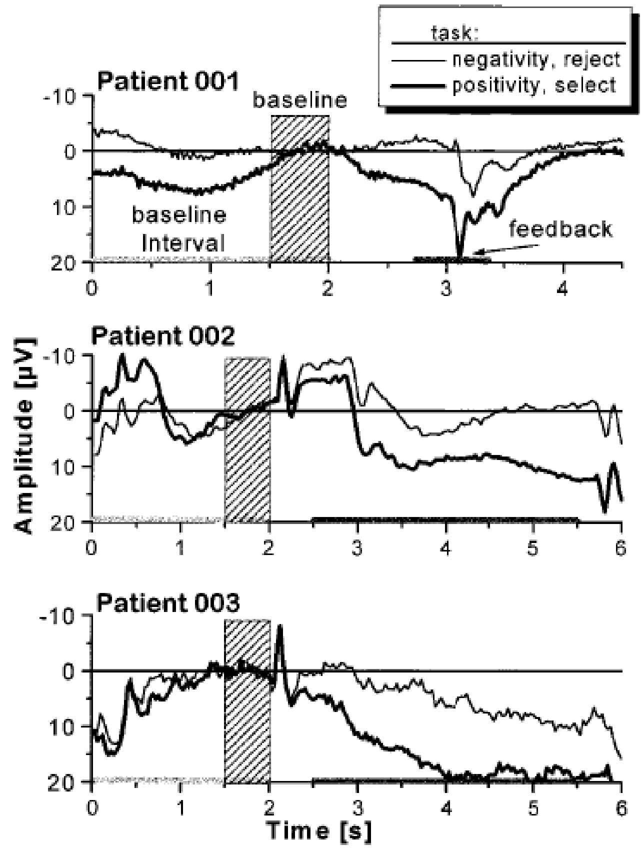


Fig. 2. Averaged SCP's of the patients of Fig. 1. Representative averages over 700 trials each during baseline, baseline interval and feedback interval separated for trials where selection of a letter was required with a cortical positivity (solid line) and trials where rejection of a letter was required with no positivity or negativity (thin line). Appearance and disappearance of the light-ball feedback is indicated by the bottom dark line during the feedback interval. Different waveforms develop during training which remain highly stable within each individual patient.

CHRONOMETRIC PARADIGM

FOREPERIOD

WS | IS | EMG, RESPONSE, RT

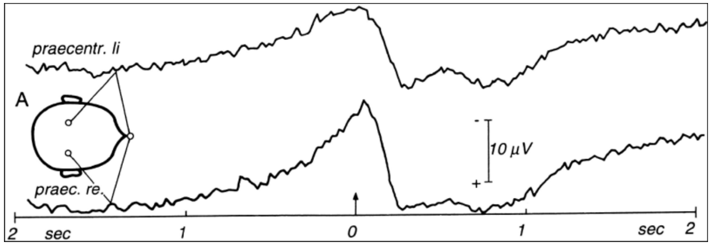
Stimulus evaluation
Preparation to respond
Preparation to intake information

Response Translation
Response Selection
Response Execution

Response Evaluation
Error Monitoring
Error Remediation

CNV

MPN-RP/LRP (CMA)



ERN or Ne, Pe

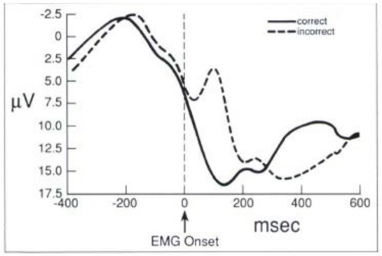


Fig. 1. Comparison of response-locked event-related potential activity, recorded at the C_z electrode, for correct and incorrect trials.

Multiple dependent variables

EEG/ERPs
EMG
Response parameters

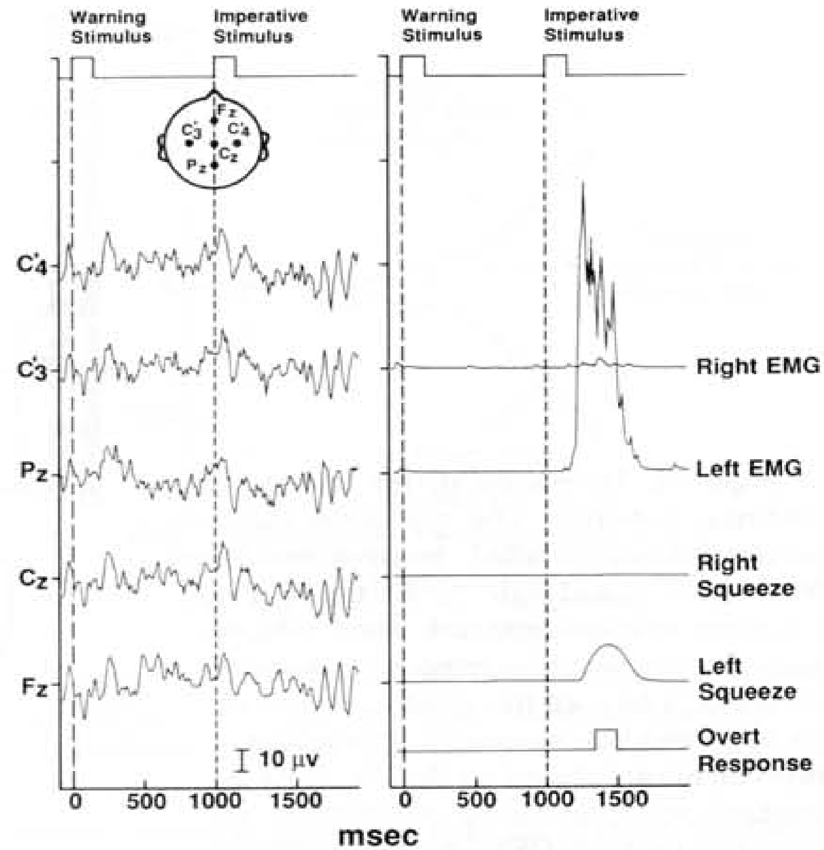


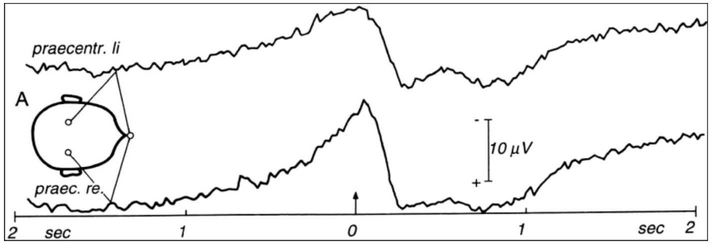
Figure 3. Cognitive psychophysiology and the chronometric paradigm. We present warning and imperative stimuli and record overt behavioral responses. However, we also measure electrical brain activity (in this case from five scalp locations, F_Z, C_Z, P_Z, C'_3, and C'_4) and electromyographic activity (EMG) from muscles involved in the overt behavioral response, and we require our subjects to squeeze zero-displacement dynamometers to indicate their responses. The overt response is defined in terms of the force-output of the dynamometers, with a criterion generally set at 25% of maximum force.

LATERALIZED READINESS POTENTIAL

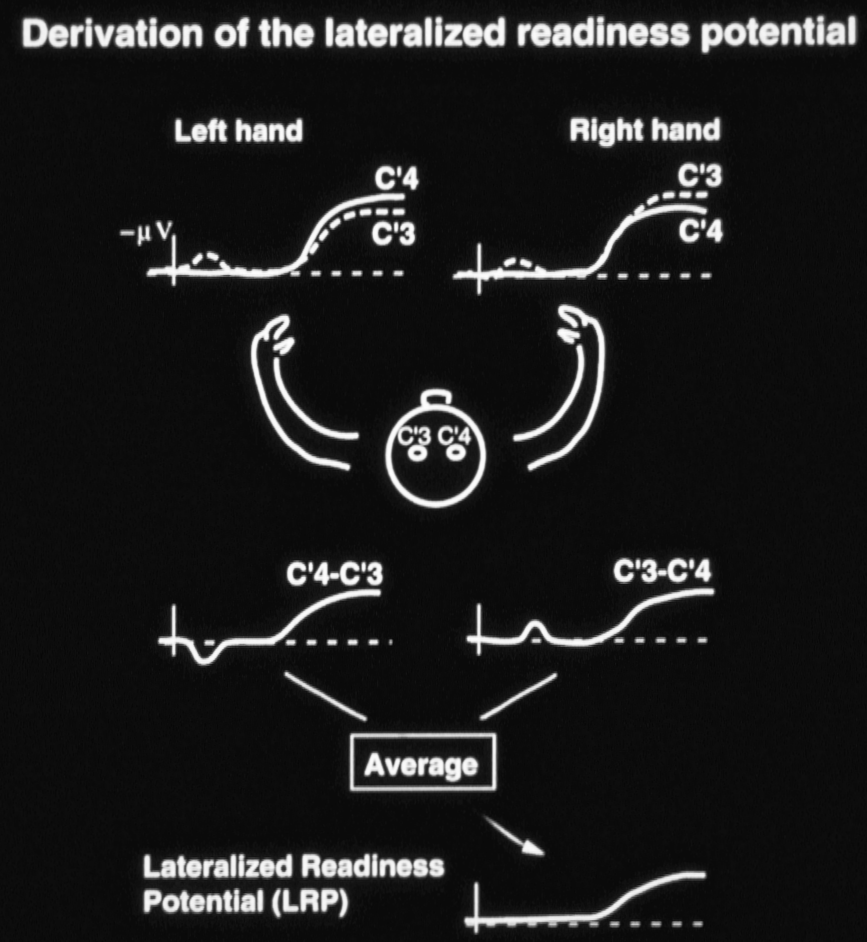
- double subtraction method
- subtraction averaging method
- bipolar recordings

Experimental setup must be such that half the time L hand is correct and other half the time R hand is correct, and subtractions are with reference to hand that should be used to execute correct response on that trial.

Voluntary movement w/ left hand



SUBTRACTION AVERAGING PROCEDURE FOR DERIVING LRP



Asymmetry = activation of either the correct or incorrect response, depending on direction (up correct, down incorrect)

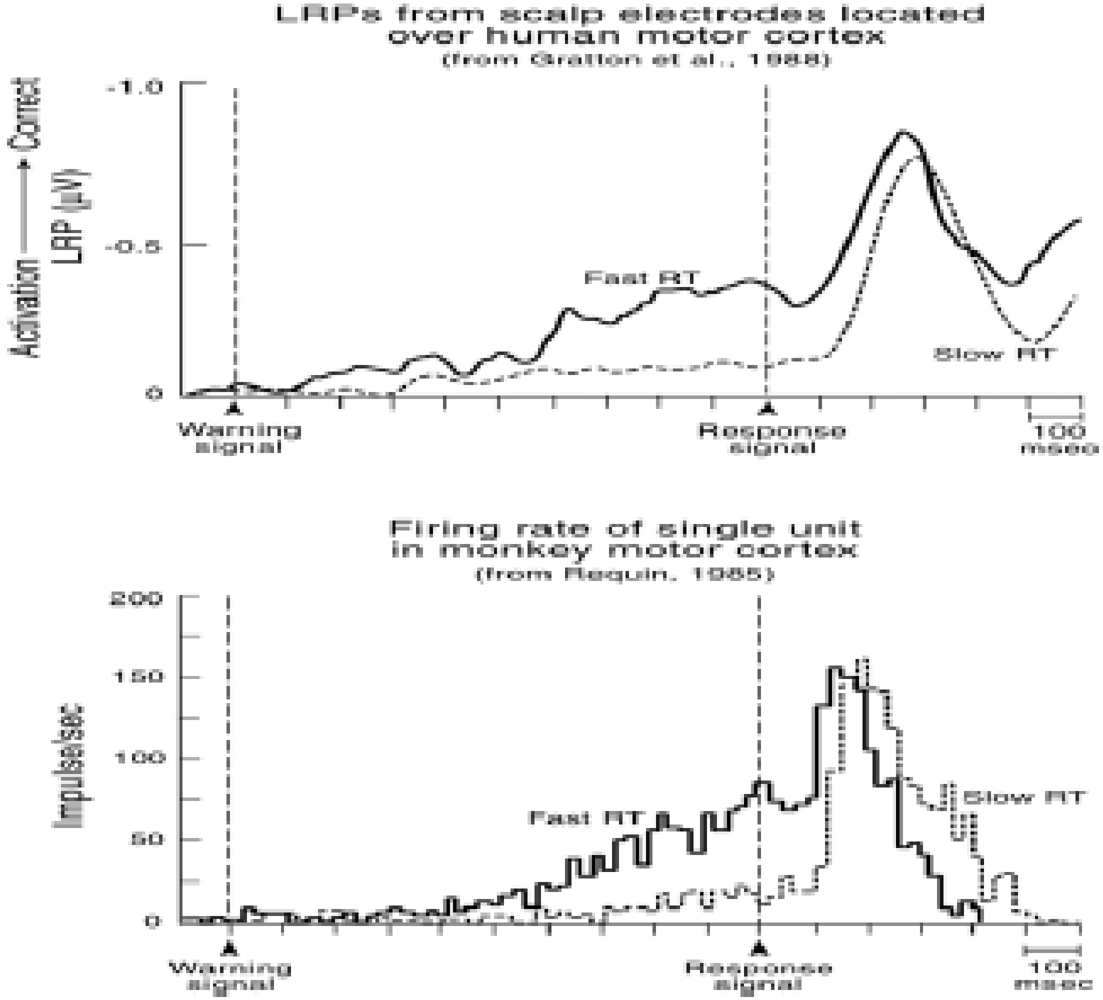


Figure 3. Upper panel: LRPs recorded from scalp electrodes located above motor cortex on trials with fast and slow reaction times. Data from Gratton et al. (1988). Lower panel: Firing rate of cell in monkey motor cortex on trials with fast and slow reaction times. Data from Requin (1985).

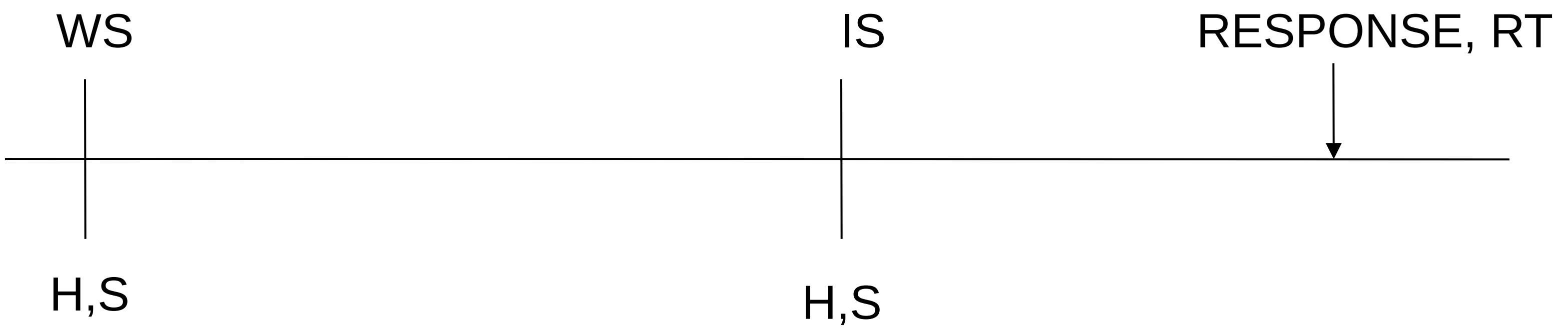
INFERENCES from LRPs

- WHETHER OR NOT: Deviation of LRP from zero indicates **whether or not a response has been *preferentially* activated**; polarity of deviation indicates which response has been activated

- DEGREE; Magnitude of LRP indicates **degree of preferential activation**

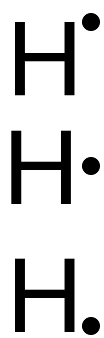
- WHEN: Latency of the LRP indicates the time at which preferential activation occurs (i.e, **when a response is preferentially activated**)

LRP is an index of selective/preferential response activation



H-right hand, S-left hand or vice versa

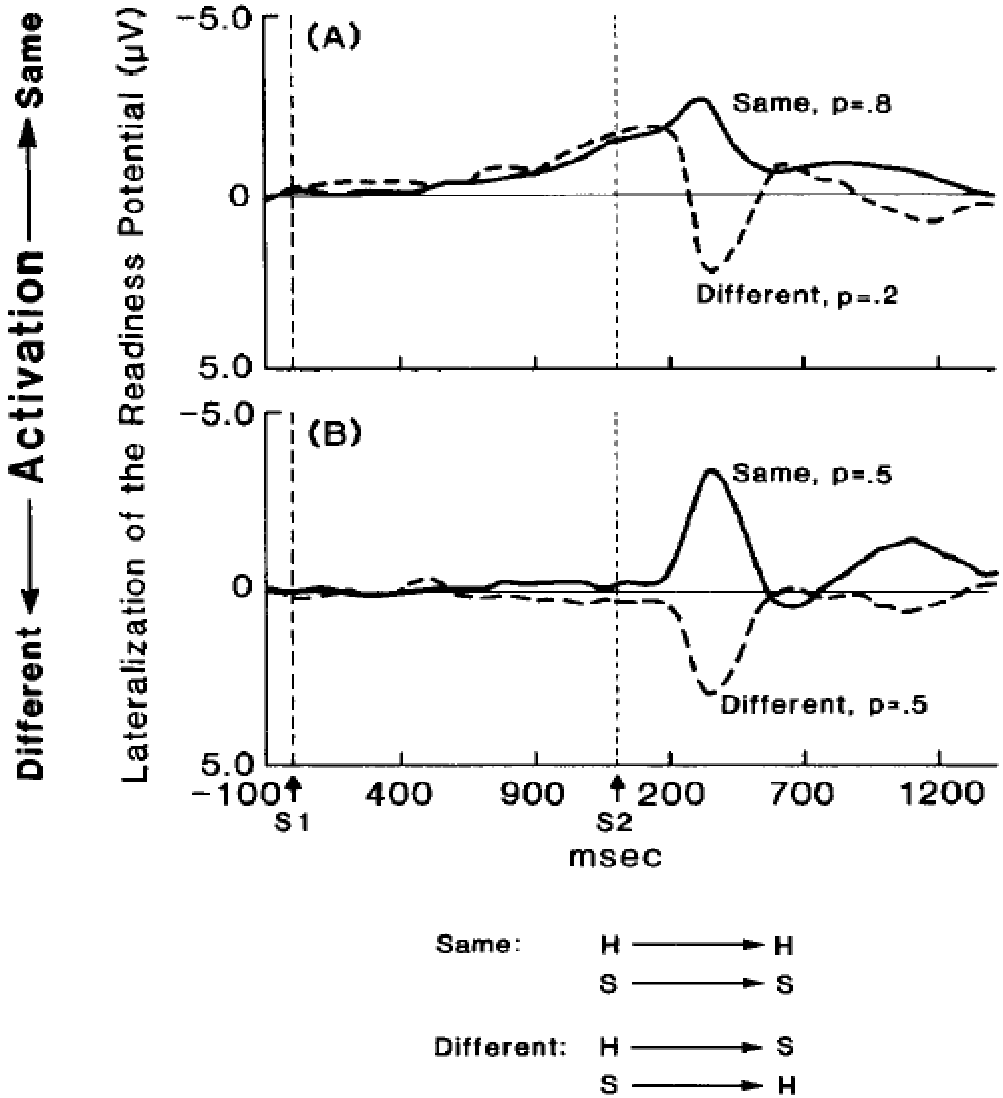
WS:



Same letter at IS with 80% probability, same

Same letter at IS with 50% probability, 50/50

Other letter at IS with 80% probability, other



Different ← Activation → Same
Lateralization of the Readiness Potential (μV)
-5.0
0
5.0
(A)
Same, p=.8
Different, p=.2
(B)
Same, p=.5
Different, p=.5
-100
400
900
200
700
1200
S1
S2
msec
Same: H → H
S → S
Different: H → S
S → H

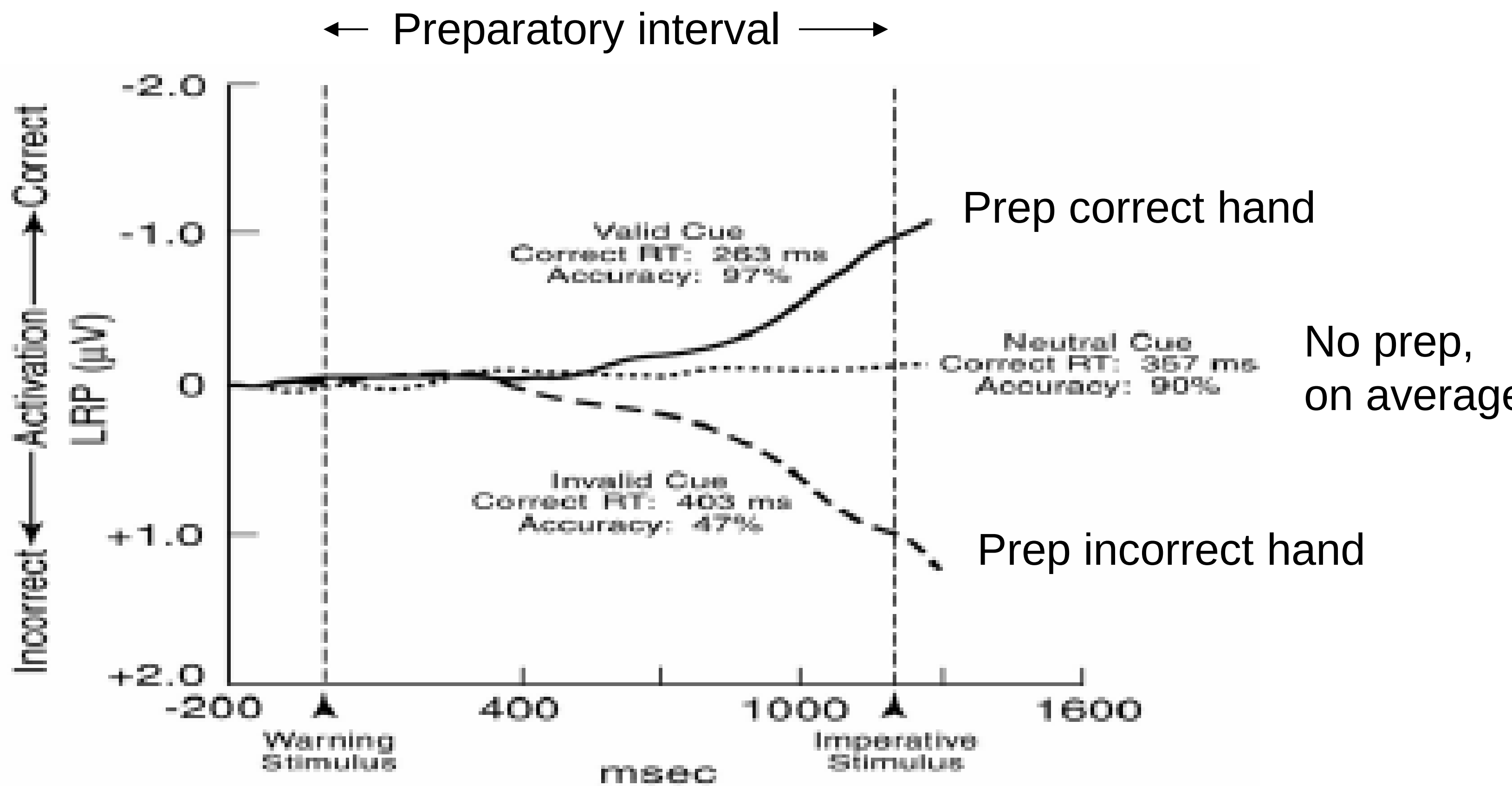


Figure 2. Effects of movement precue validity on the LRP measured in the interval between cue and target stimulus. Data from Gratton et al., 1990.

People prep response they expect to make;if that’s it they are faster, if not then slower

Response accuracy depends in part on which response is preferentially activated

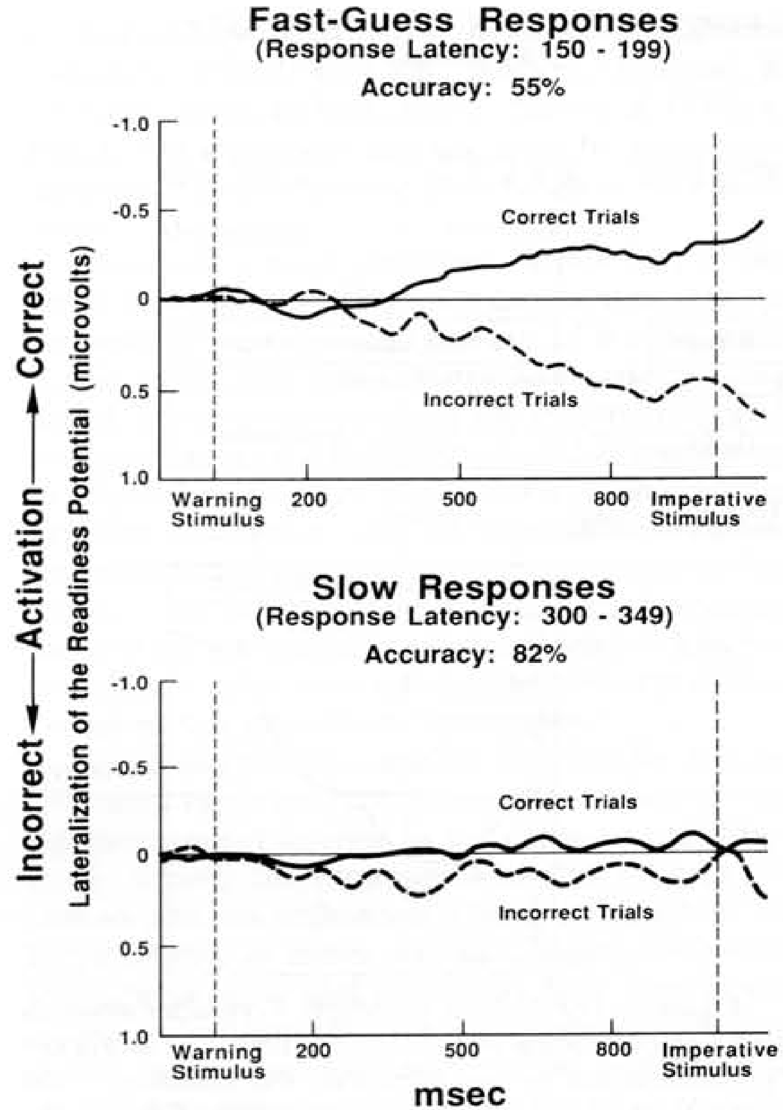


Figure 7. Lateralized readiness potential data for fast guess trials in which the subjects happened to guess correctly or incorrectly (upper panel). Data for slower response trials are also shown (lower panel). From Gratton, Coles, Sirevaag, Eriksen, and Donchin (1988). Copyright 1988 American Psychological Association. Reprinted with

INFERENCES from LRPs

- WHETHER OR NOT: Deviation of LRP from zero indicates the one or other of the two responses has been preferentially primed, i.e., **whether or not response has been preferentially activated.**

- DEGREE; Magnitude of LRP (before the response is given) indicates **degree of preferential response activation**

- WHEN: Latency of the LRP indicates the time at which preferential preparation occurs (i..e, **when a response is preferentially activated**)

LRP Amplitude

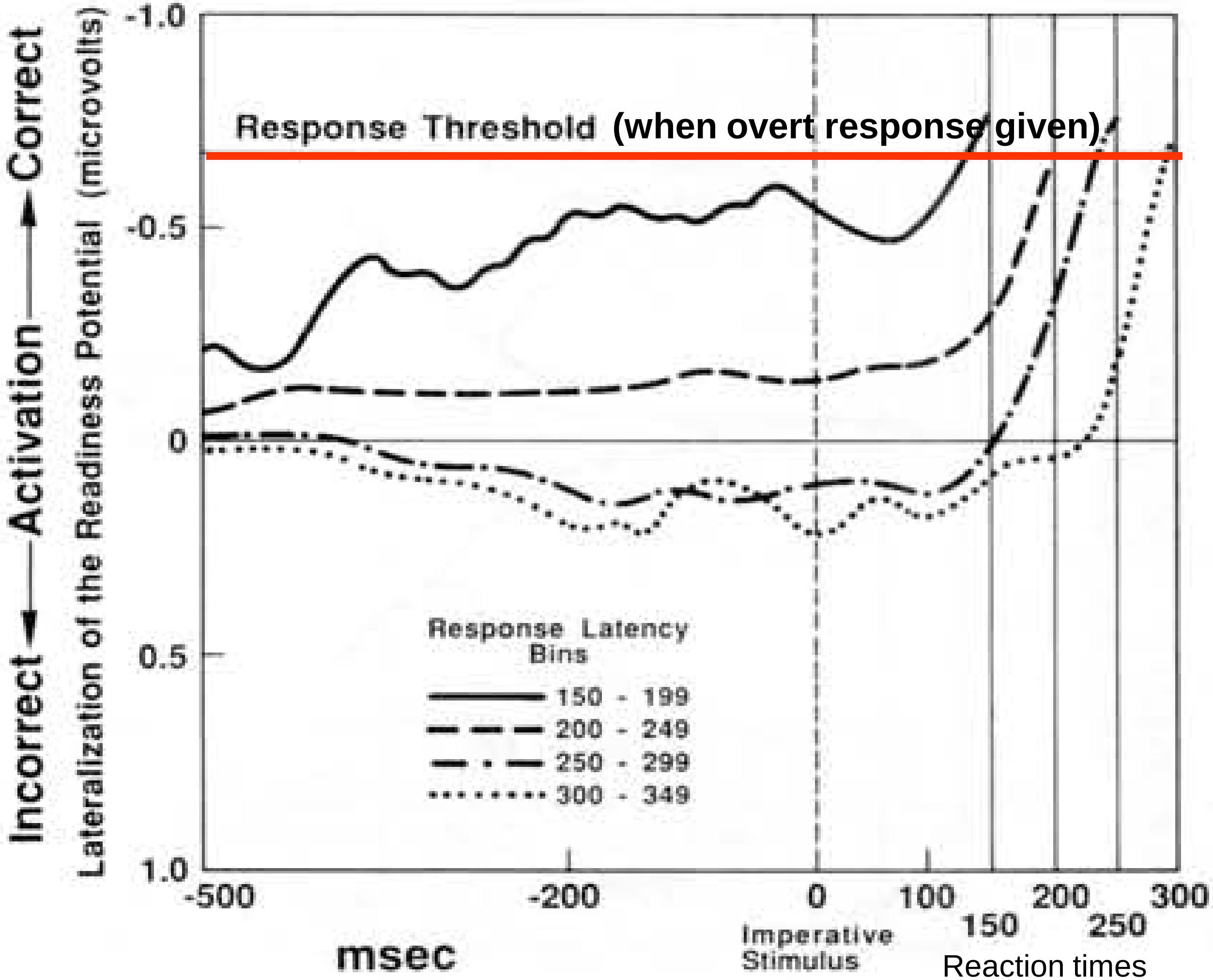


Figure 6. The lateralized readiness potential at the time of the electromyographic response for trials with different response latencies. See text for details. From Gratton, Coles, Sirevaag, Eriksen, and Donchin (1988). Copyright 1988, American Psychological Association. Reprinted with permission.

INFERENCES from LRPs

- WHETHER OR NOT: Deviation of LRP from zero indicates the one or other of the two responses has been preferentially primed, i.e., **whether or not response has been preferentially activated.**

- DEGREE; Magnitude of LRP indicates **degree of preferential activation**

- WHEN: Latency of the LRP indicates the time at which preferential preparation occurs (i.e., **when a response is preferentially activated**)

.

INFERENCES from LRPs

- WHETHER OR NOT: Deviation of LRP from zero indicates the one or other of the two responses has been preferentially primed, i.e., **whether or not response has been preferentially activated.**

- DEGREE; Magnitude of LRP indicates **degree of preferential activation**

- WHEN: Latency of the LRP indicates the time at which preferential preparation occurs (i..e, **when a response is preferentially activated**)

- LRP onset latencies computed in stimulus and response locked LRP waveforms provide different and complementary information about the timing of cognitive and response processes; it is a way to partition the reaction time interval,

Stimulus locked average: stimulus to LRP onset
Response locked average: LRP onset to response

Osman and colleagues maintain it is important to distinguish stimulus-locked averages from response-locked averages.

In ***stimulus-locked average***: can examine interval/timing between stimulus and LRP onset; activity determined by processes *prior to selective activation of response*

In ***response-locked average***: can examine interval/timing between LRP onset and the response; activity determined by duration of processes that take place between LRP onset and response execution – *after response selection.*

So one can compare two types of averages to determine which factors affect process *prior to or after start* of the selective response activation.

Main types of questions addressed in LRP research

- About **dynamics of information processing**, especially nature of transmission in the processing system. *e.g.,* Is partial information about a stimulus transmitted to the response system before stimulus is fully evaluated?

2. About **order in which information about a stimulus is extracted**, e.g., when a stimulus consists of more than one attribute, in what order is information about the different attributes extracted?

3. About **processing locus of particular experimental effects or individual differences**, e.g., Given processing is delayed in an experimental condition or group, where in processing system does the delay occur?

4. About **locus of inhibitory effects**
   e.g., at what level in processing system do inhibitory mechanisms act to stop a response?

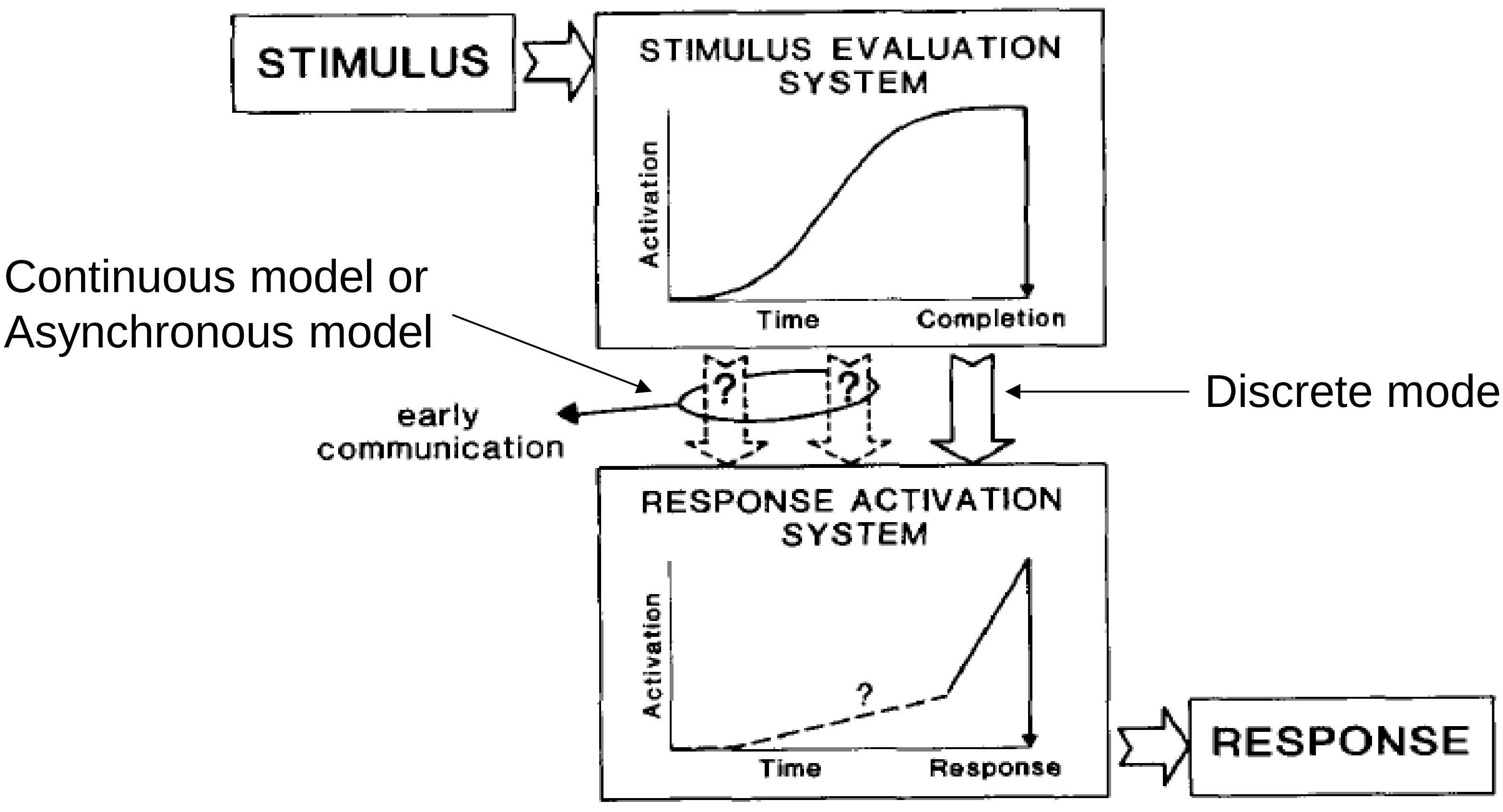
PARTIAL INFORMATION TRANSMISSION?

Is partial information about a stimulus transmitted to the response system before a stimulus has been fully evaluated?

Discrete Models: Response selection based on complete sensory analysis.

Continuous Models: During course of stimulus evaluation information is continuously sent to response selection system. Thus, response selection can ***begin*** before stimulus evaluation is complete.

Asynchronous Transmission though not continuous, etc.



STIMULUS
STIMULUS EVALUATION SYSTEM
Activation
Time
Completion
Continuous model or
Asynchronous model
?
?
early
communication
Discrete model
RESPONSE ACTIVATION SYSTEM
Activation
?
Time
Response
RESPONSE

Conflict Paradigm

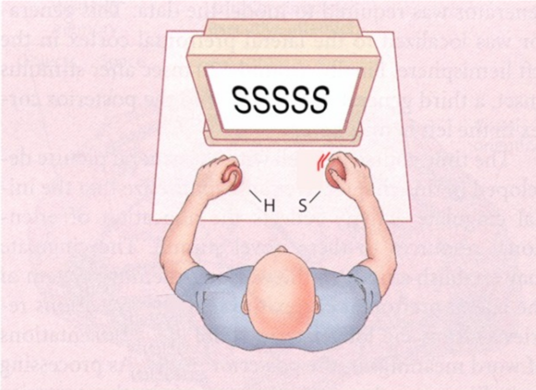
Go-NoGo Paradigm

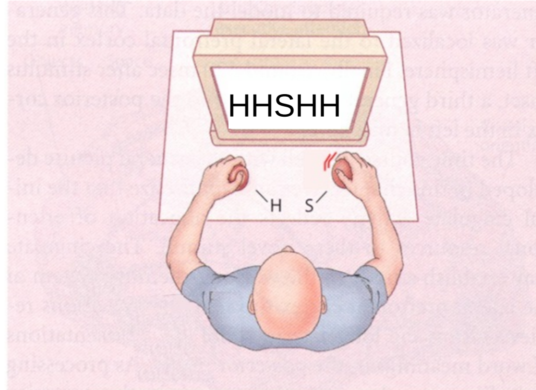
CONFLICT PARADIGM

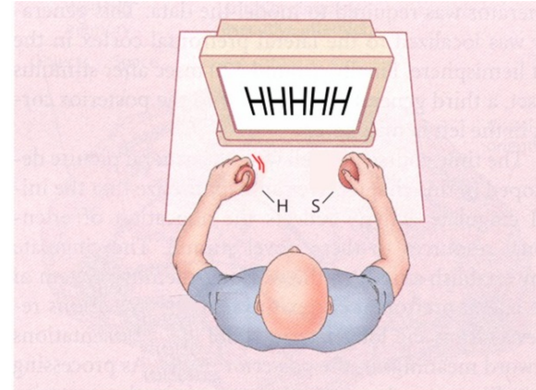
Need stimuli with multiple attributes where different attributes provide conflicting information about what response to execute.

Compare conditions where both attributes are mapped onto the same correct response versus conditions where the two attributes are mapped onto different responses (one hand for correct and other hand for incorrect responses).

Inference: If there is incorrect response activation in conflict condition, then partial information about the attribute mapped onto the incorrect response must have been transmitted to the response system.







ERIKSEN'S NOISE COMPATIBILITY PARADIGM

S – right hand
H – left hand

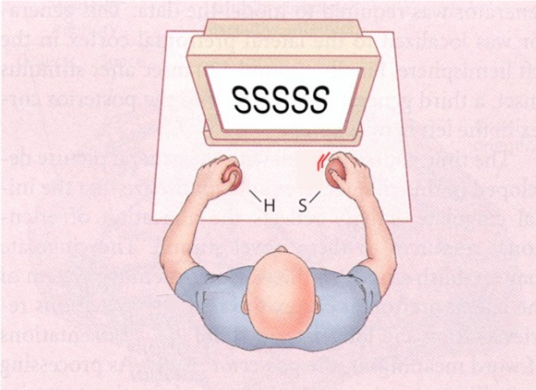
Target

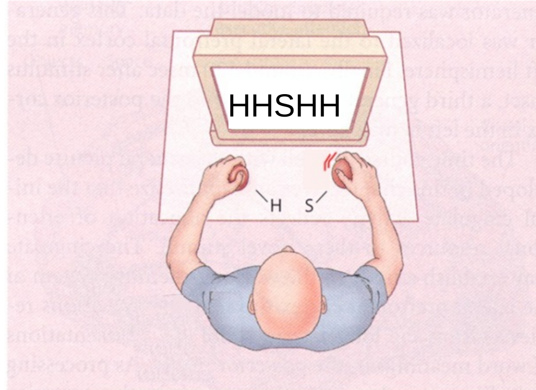
Visual Arrays:

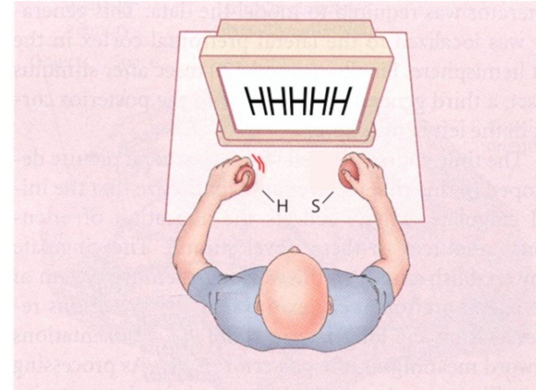
H H H H H
S S S S S
compatible

S S H S S
H H S H H
incompatible

Attribute 1: Identity of flanker letters
Attribute 2: Identity of target letter







ERIKSEN'S NOISE COMPATIBILITY PARADIGM

S – right hand
H – left hand

Target

Visual Arrays:

compatible	incompatible
H H H H H	S S H S S
S S S S S	H H S H H

Attribute 1: Identity of flanker letters
Attribute 2: Identity of target letter

Will there be evidence of incorrect activation due to the presence of incompatible flankers? If so, then info about flanking letters got into the response system before stimulus evaluation is complete.

Outcome that would favor partial info transmission

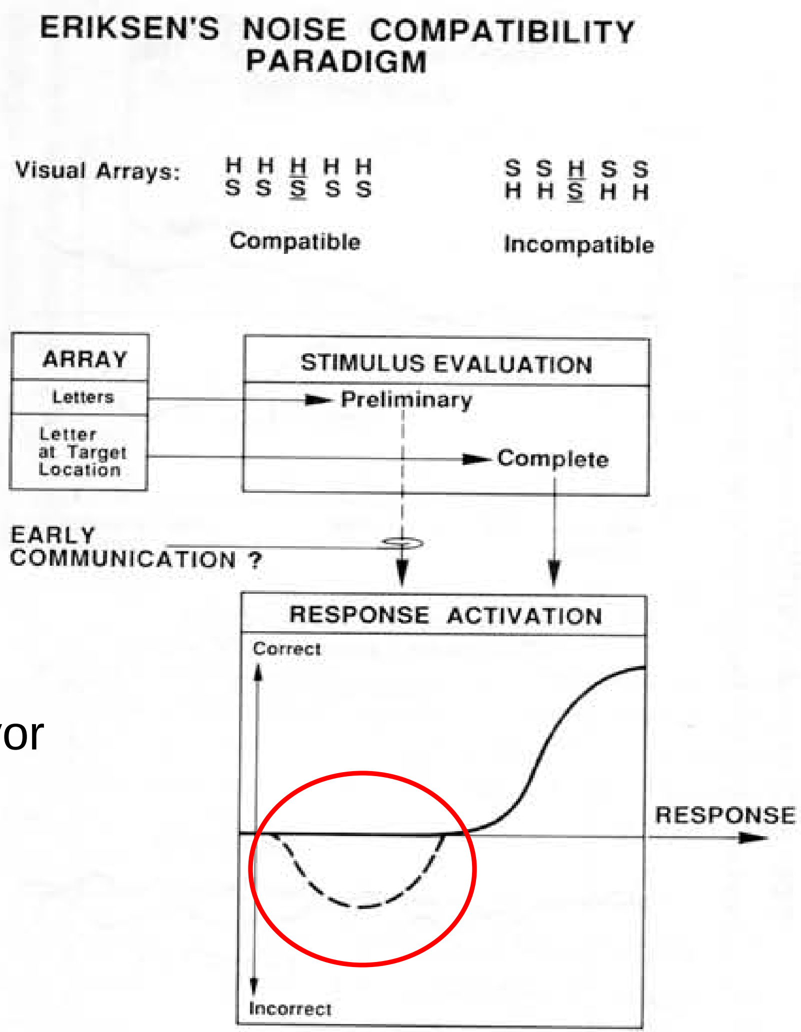
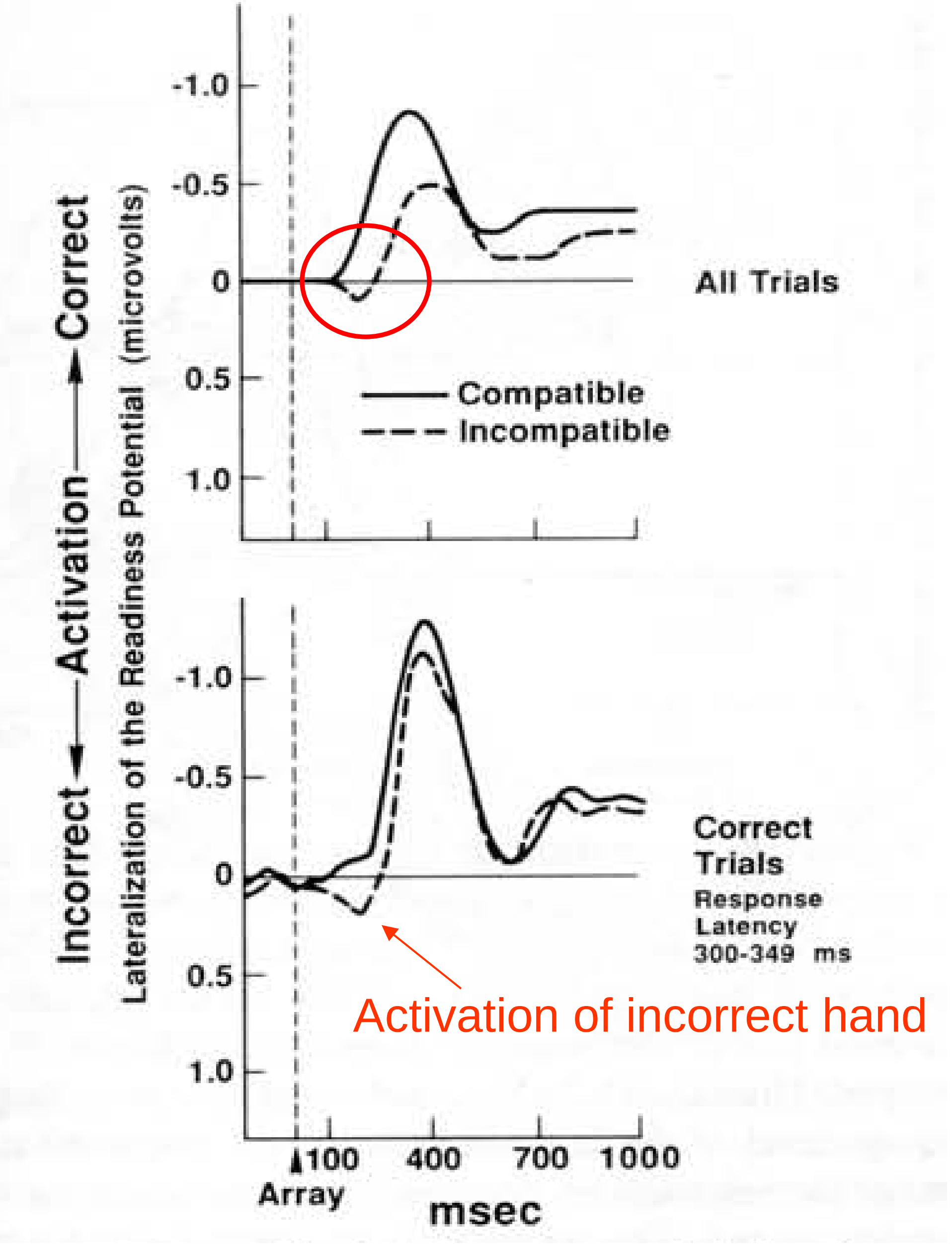
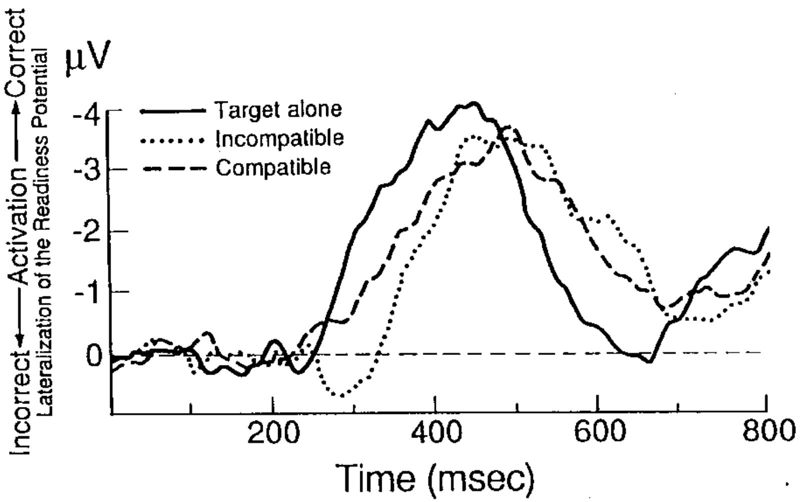


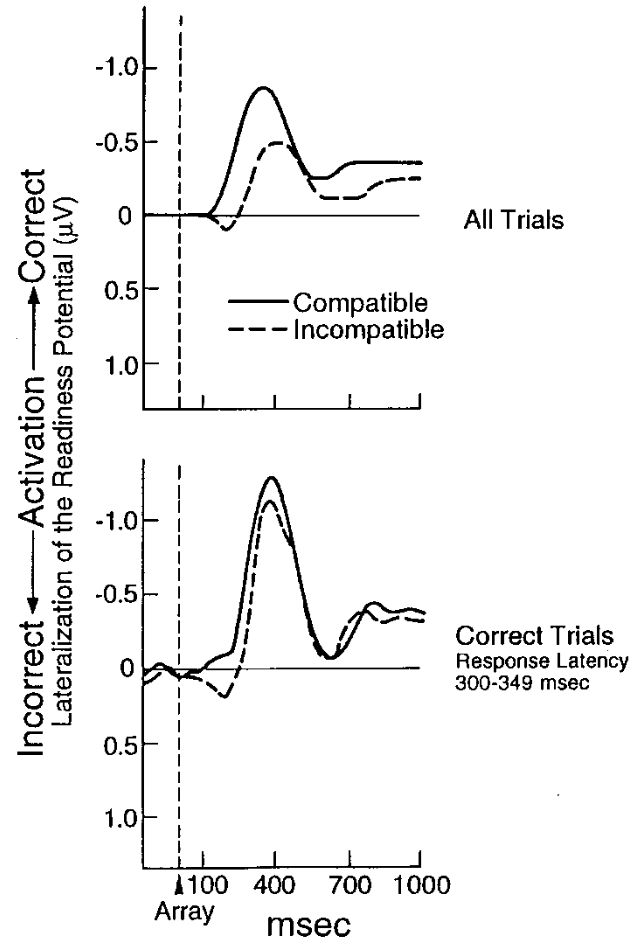
Figure 8. The Eriksen paradigm. Five-letter stimulus arrays can be compatible or incompatible. The arrays can be characterized by two attributes: the identities of the letters in the array, and the identity of the letter at the central target location. If there is early communication between stimulus evaluation and response activation systems, then there should be a dip in the activation function (see lower panel, dashed line) on incompatible trials.



Correct
Activation
Incorrect
Lateralization of the Readiness Potential (microvolts)
-1.0
-0.5
0
0.5
1.0
All Trials
Compatible
Incompatible
Correct Trials
Response Latency 300-349 ms
Activation of incorrect hand
100
400
700
1000
Array
msec



from Smid et al. (1991)



from Gratton et al. (1988)

Partial information about stimulus is transmitted to response system!

GO-NOGO PARADIGM

Need stimulus with multiple attributes. Map one stimulus attribute to responding hand (right, hand) and other stimulus attribute to response decision (go or no go).

Examine nogo trials

Inference: If response is activated even when no response is required (i.e., on no go trials), then partial information about attribute associated with responding hand must have been transmitted.

Two Attributes:

- **Size**: large or small T T S S
- **Identity**: S or T

Two Decisions

- **Responding Hand**: response hand determined by letter identity
- **GO/NO-GO**: go-nogo determined by letter size

e.g., respond with left hand to large S, right hand to large T, but make no response to any small letter

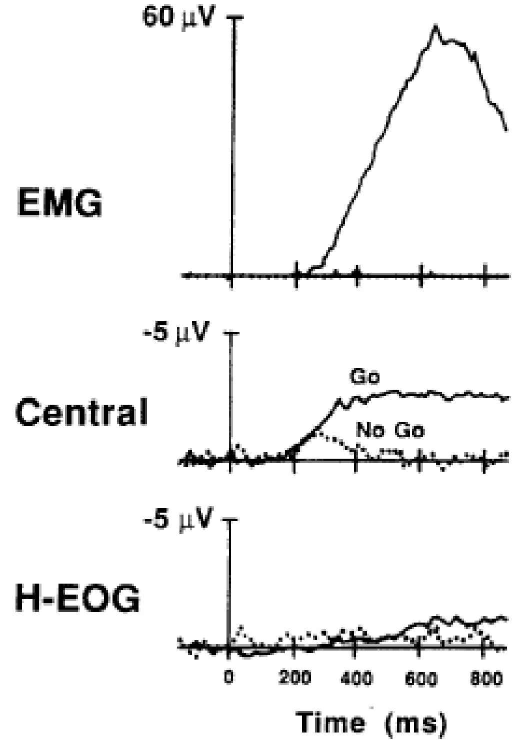


Figure 4. Grand average (N = 12) lateralized readiness potentials (Central), lateralized electromyograms (EMGs) and lateralized electro-oculograms (H-EOGs) on go and no-go trials of Experiment 2. (Lateralization of activity was calculated by subtracting, ms by ms, the waveform for trials on which the hand ipsilateral to the noninverting electrode was cued by letter shape from the waveform for trials on which the contralateral hand was cued. Note that significant lateralization of the motor readiness potential was obtained on no-go trials [dotted lines], and this lateralization was similar in onset latency to that observed on go trials [solid lines]. Each curve in this figure represents an average of roughly 2,600 responses for go trials or 660 responses for no-go trials.)

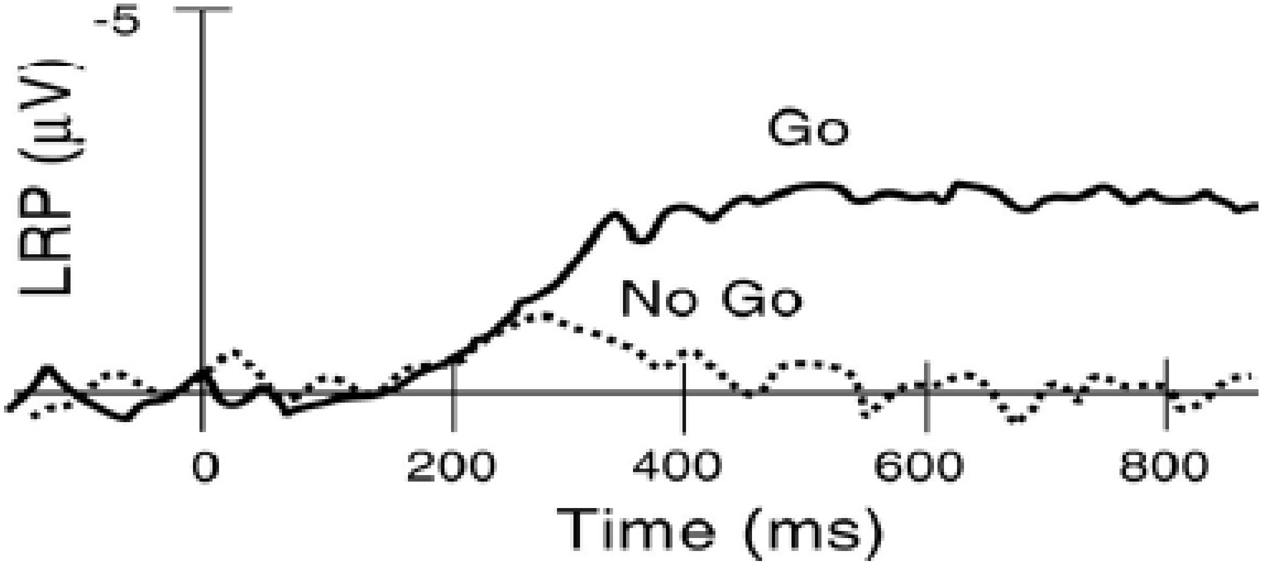


Figure 6. Lateralized readiness potentials elicited on go and no-go trials. Data from Miller & Hackley (1992).

Note LRP on NO-GO trials --- no actual response executed!

Summary: Early Information Transmission

- Some early communication does occur
- There is more than one moment where stimulus evaluation “talks” to the response system
- More generally, data are inconsistent with discrete model of information transmission, support some form of asynchronous transmission, sometimes continuous but not always

LRP can be used to visualize process of information extraction (time course of information extraction)