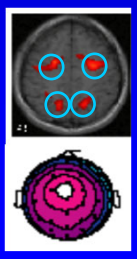
SSNAP *May 2021*

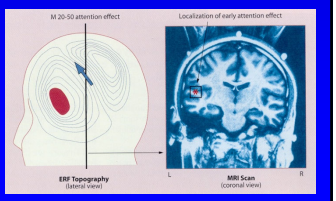
Workshop

ERPs/EEG/MEG in cognitive neuroscience

Marty G. Woldorff, Ph.D.

Center for Cognitive Neuroscience
Duke University





1

ERPs are particularly effective for questions of timing and sequence of cognitive processes

Attention: When does attention affect stimulus processing (early vs. late selection)
During attentional control, what is the cascade of frontal and parietal involvement?

Language: When does semantic processing of a word begin?
At what point in processing do we pick up different grammatical errors?

Perception: What facets or phases of perceptual processing are associated with conscious awareness?
How does early sensory processing covary with perceptual detection or discrimination?

Decision Making: How does neural set immediately prestimulus influence a decision?
How does the rapid accumulation of neural processing lead to or influence a decision?

Memory: What phases of neural encoding lead to better or worse later memory?
What is the neural cascade of explicit recall versus familiarity responses?

Generally: What is the temporal cascade of neural processes underlying a cognitive function?
What facets / phases of processing are modified by training?
What is the role of reentrance / recurrence of neural processing in a cognitive function?
(e.g., conscious awareness?)

2

ATTENTION

"Everyone knows what attention is. It is the taking possession of the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought.

Focalization, concentration of consciousness are of its essence. It implies withdrawal from somethings in order to deal effectively with others…."

William James (1890)

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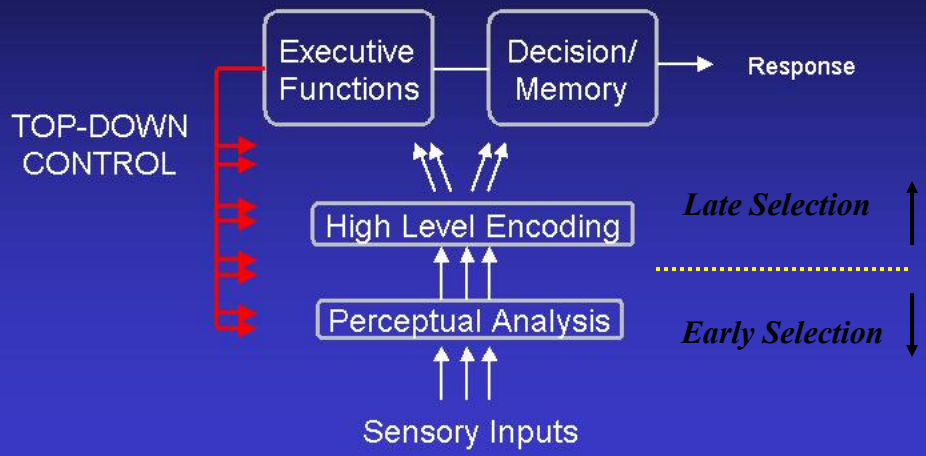
Information Processing Models of Selective Visual Attention



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Auditory Selective Attention:The Cocktail Party Effect

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Cherry (1953): Can not attend well to 2 simultaneous auditory channels.

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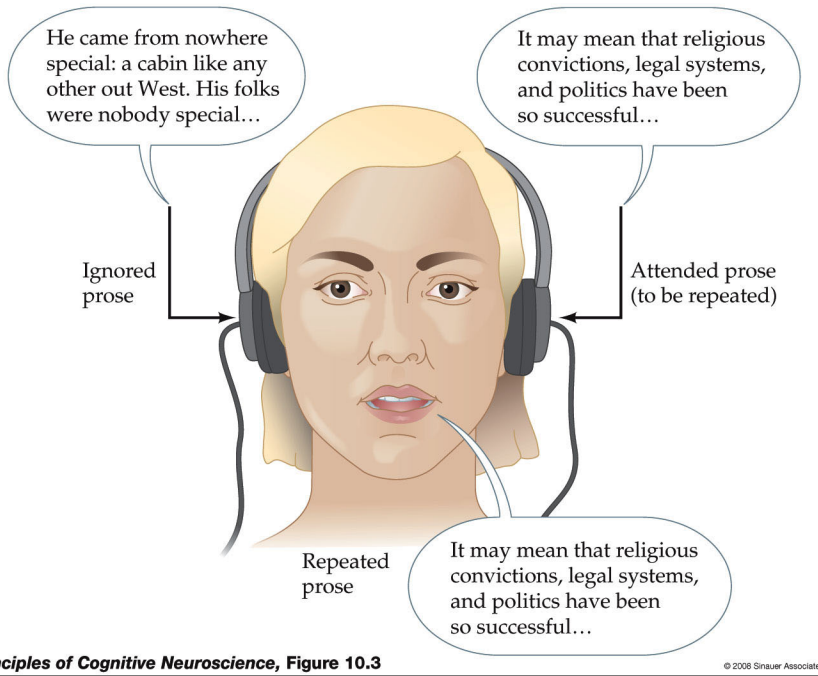
Figure 10.3 Auditory shadowing study of selective attention



Principles of Cognitive Neuroscience, Figure 10.3

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Cherry (1953): Can not attend well to 2 simultaneous auditory channels.
→ Limited attentional resources

Moray (1959): But your name in an unattended channel could "break through"

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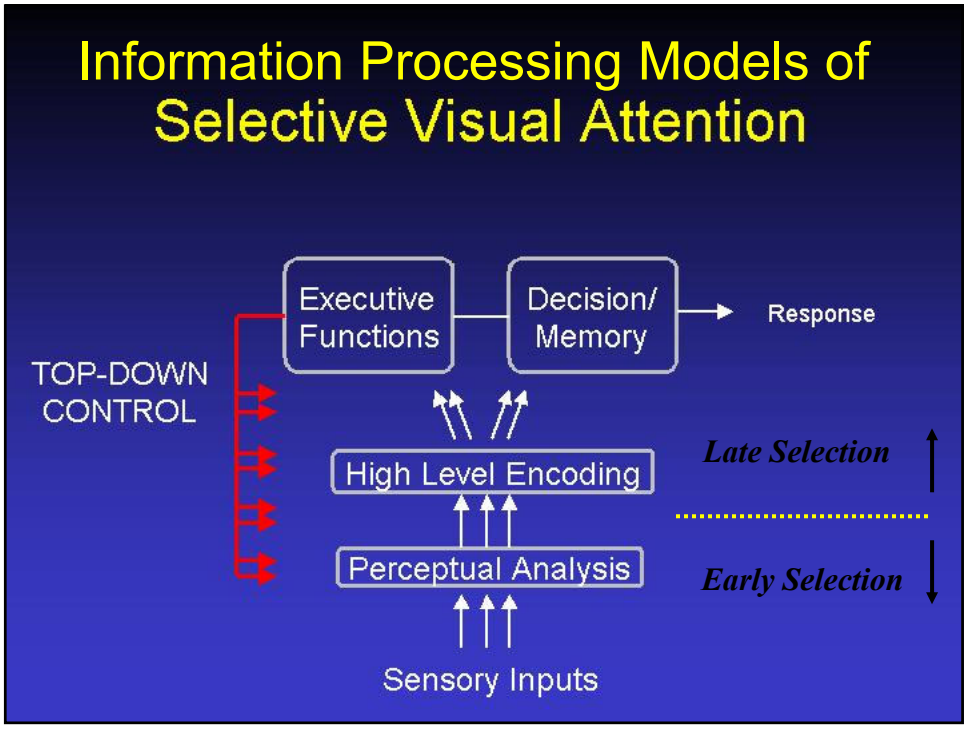

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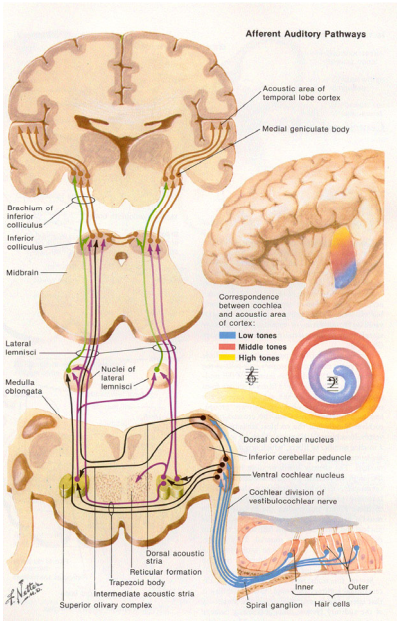
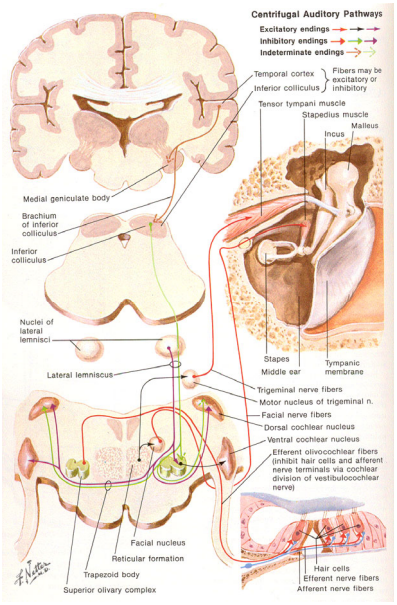
Ascending (afferent) auditory pathways



Descending (efferent) auditory pathways



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Auditory selective attention:

Can be studied non-invasively in humans by recording ERPs and ERFs from the scalp.

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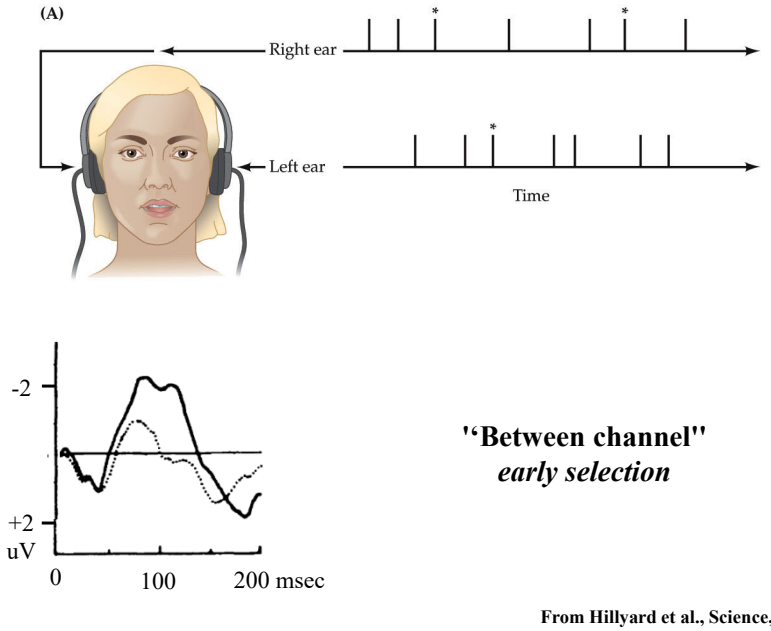
Figure 11.2 Early and late selection during auditory attention



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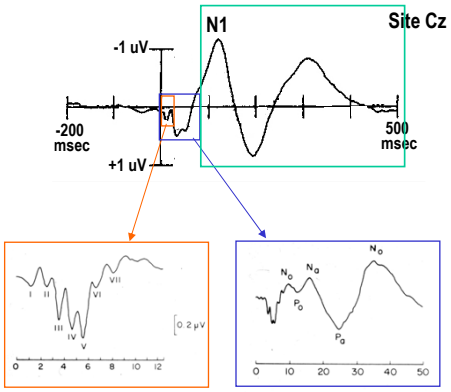
ERP to left-ear sounds



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AUDITORY SELECTIVE ATTENTION
Further Questions

- Is the processing before 70 msec all hardwired, strongly automatic?
- [Do the effects of attention include an amplitude modulation of sensory evoked activity (e.g. N100?)]
- Where in the brain are the attention effects occurring?

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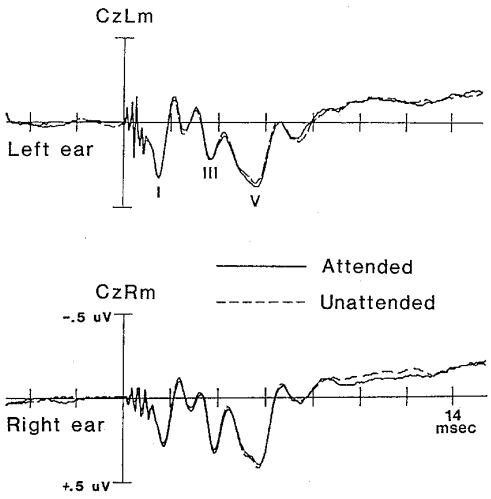
BERs



Woldorff et al., EEGJ, 1987

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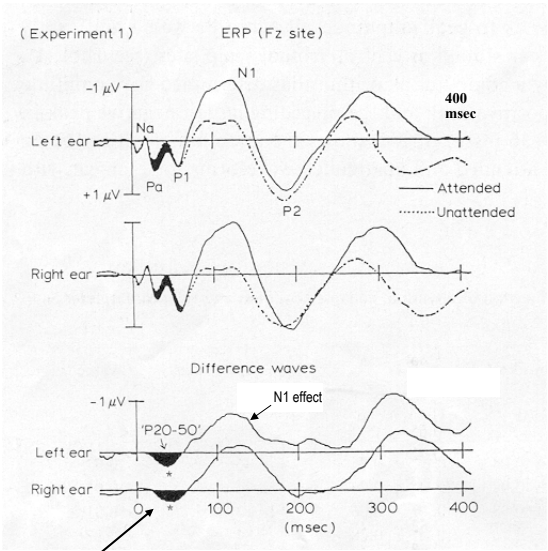
Overlay of ERPs to same stimulus under different attention conditions.



Difference Waves

ERPs show very early onset (20 msec) of attention-related modulation of sensory processing activity.

Woldorff et al., EEGJ, 1987

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Where are the early auditory attention effects coming from?

→ **Use MEG**

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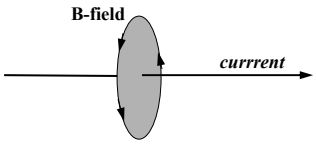
Magnetic fields of the Brain→ MEG



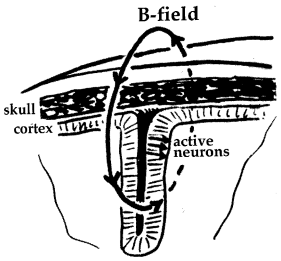


Fig. 14. Production of magnetic (B) field by activated neuronal tissue in a cortical sulcus, such as the auditory cortex on the STP. (See text for discussion.)

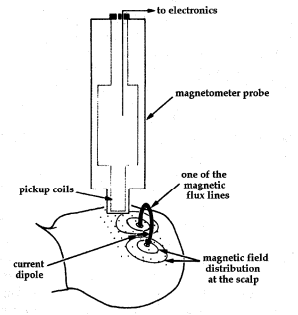


Fig. 15. Production of magnetic field distribution at the scalp by a focal current dipole, and the detection of these fields by a magnetometer.

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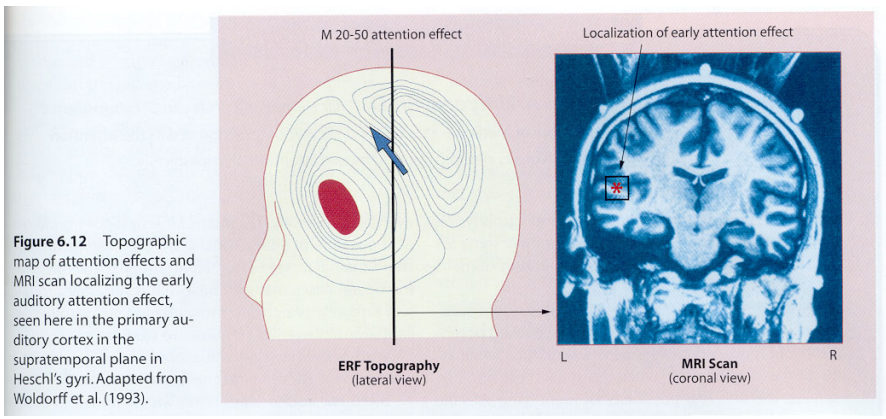

Figure 6.12 Topographic map of attention effects and MRI scan localizing the early auditory attention effect, seen here in the primary auditory cortex in the supratemporal plane in Heschl's gyri. Adapted from Woldorff et al. (1993).

From Woldorff et al., *PNAS*, 1993

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AUDITORY SELECTIVE ATTENTION: Early Effects Conclusions

- Can affect stimulus processing of sounds very early (by 20 msec).
- These early effects include an amplitude modulation of sensory evoked activity in auditory cortex on the sup. temp. plane
- Involves a preset biasing of the sensory input.

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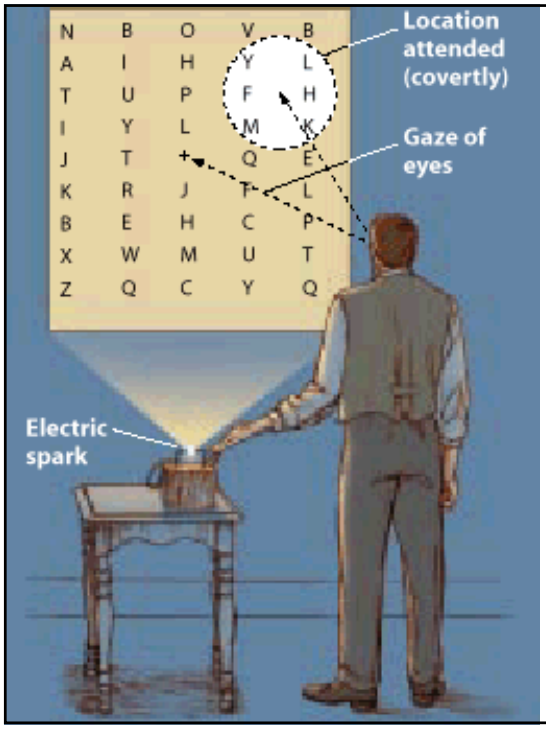

Herman Von Helmholtz (Late 1800's)

-Limits of Perception

-Covert Attention

-Spatial Attention

"These experiments demonstrated, so it seems to me, that by a voluntary kind of intention, even without eye movements, and without changes of accommodation, one can concentrate attention on the sensation from a particular part of our peripheral nervous system and at the same time exclude attention from all other parts."

Helmholtz (1896)

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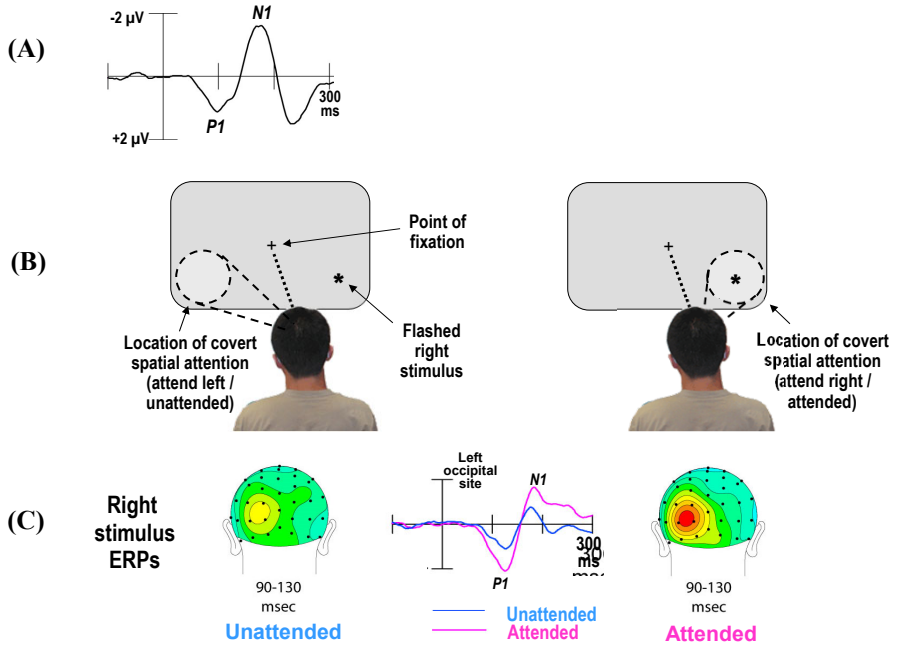
Visual spatial attention and ERPs



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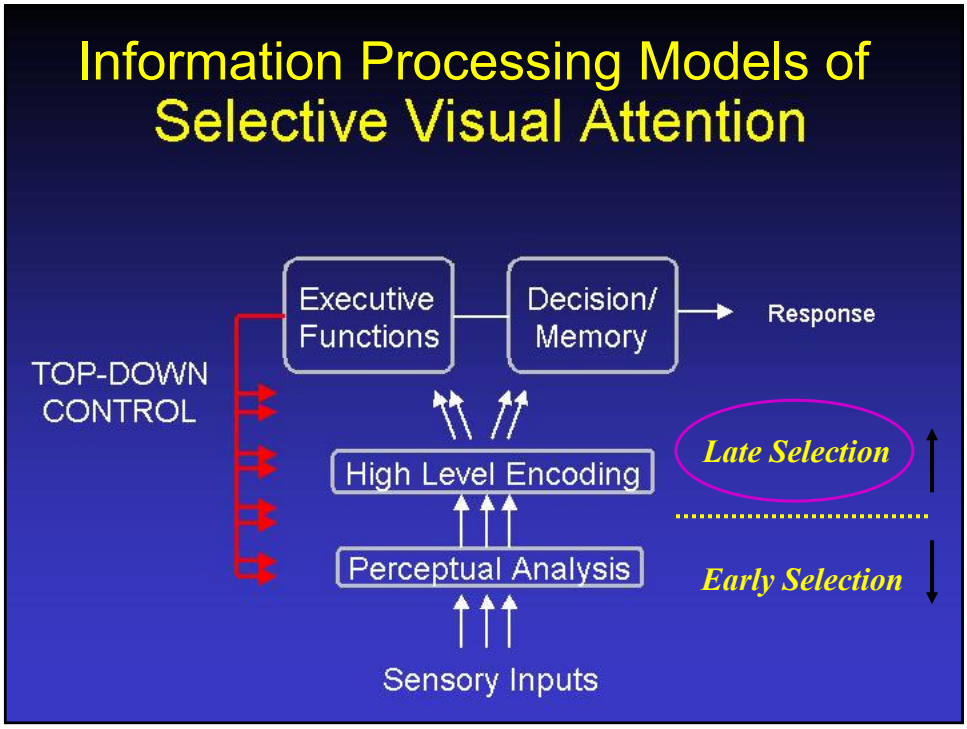

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Figure 11.2 Early and late selection during auditory attention

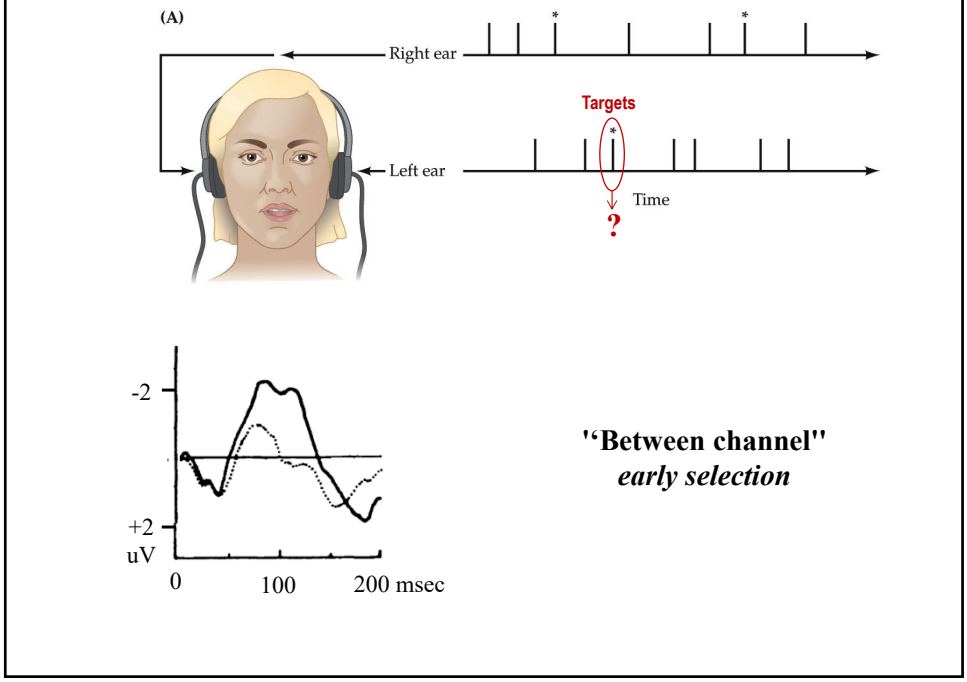

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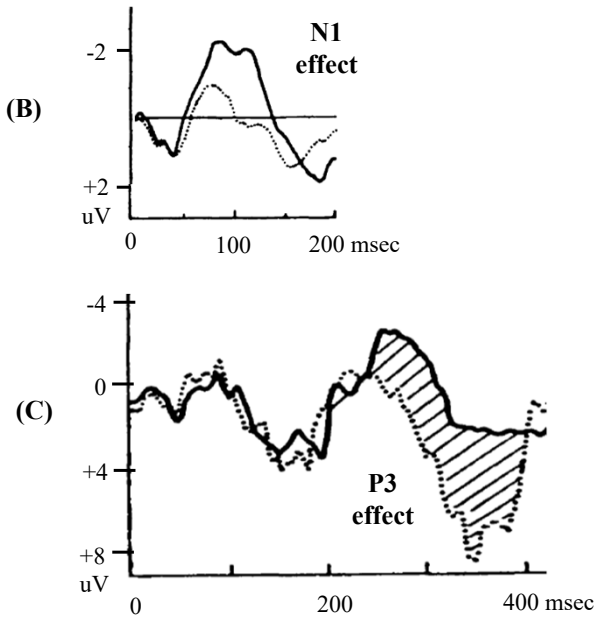
Figure 12.2 (B, C)

From Hillyard et al., 1973



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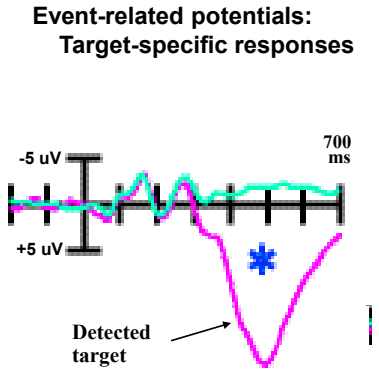

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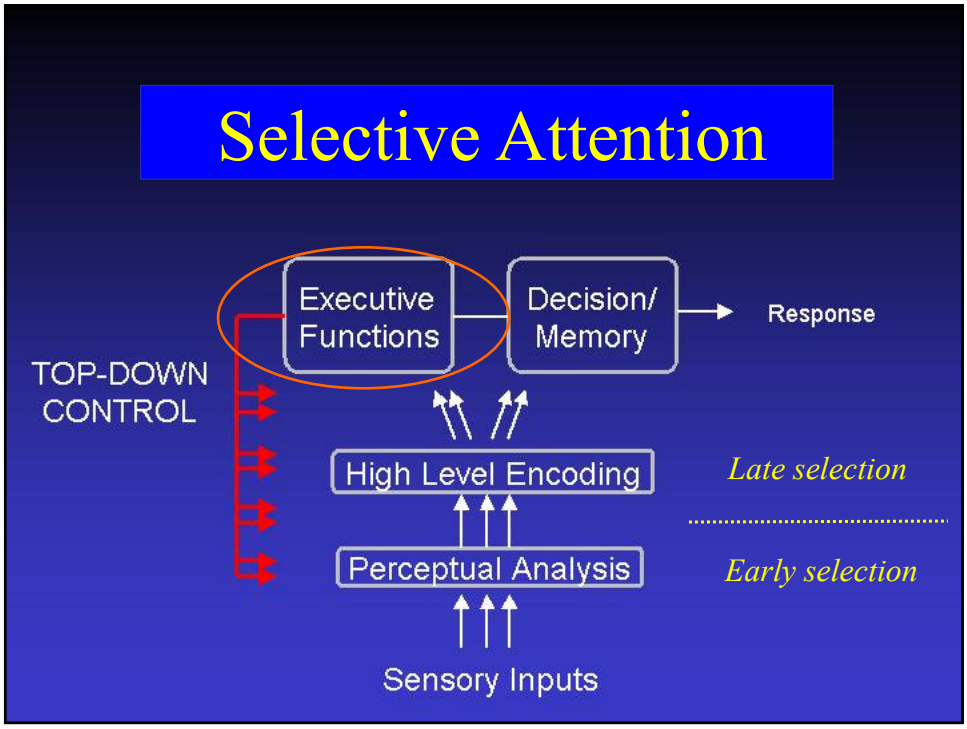
Selective Attention
Executive Functions
Decision/ Memory
Response
TOP-DOWN CONTROL
High Level Encoding
Late selection
Perceptual Analysis
Early selection
Sensory Inputs

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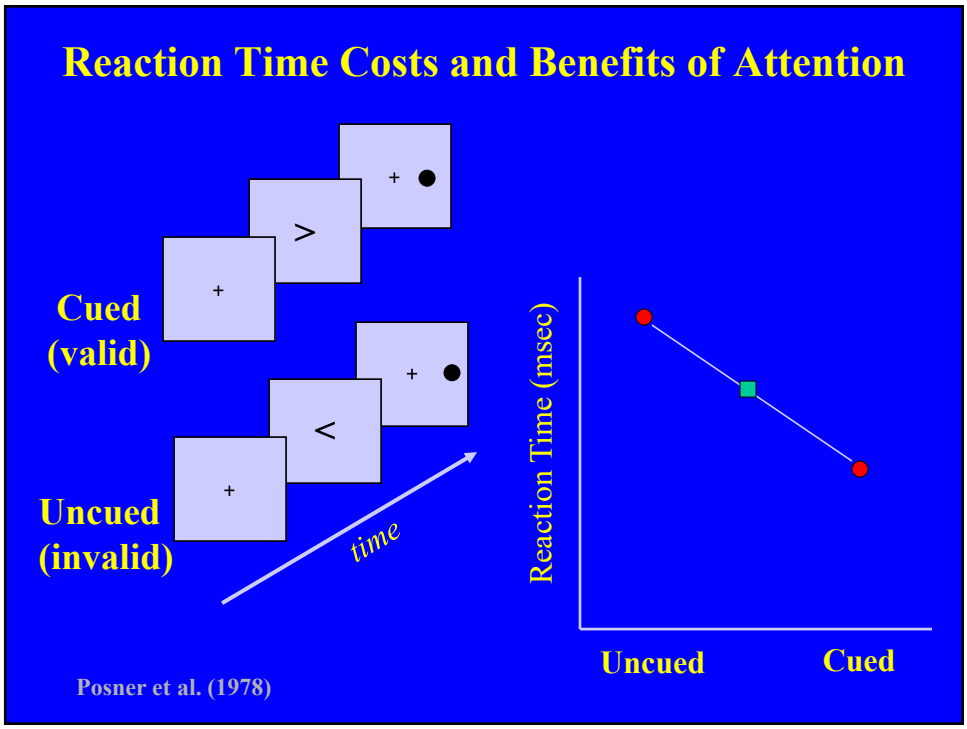
Reaction Time Costs and Benefits of Attention
Cued (valid)
Uncued (invalid)
time
Reaction Time (msec)
Uncued
Cued
Posner et al. (1978)

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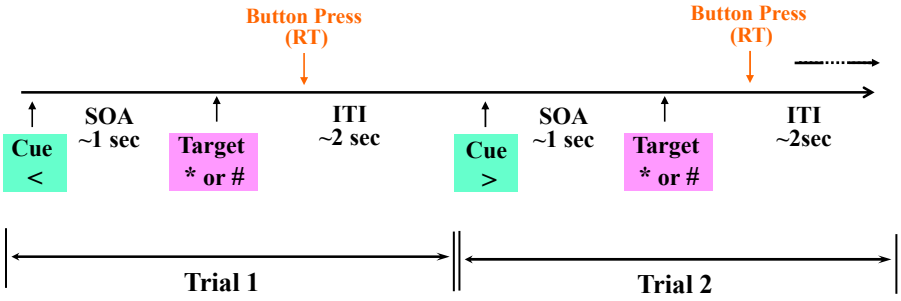
Cued attention -- Behavior



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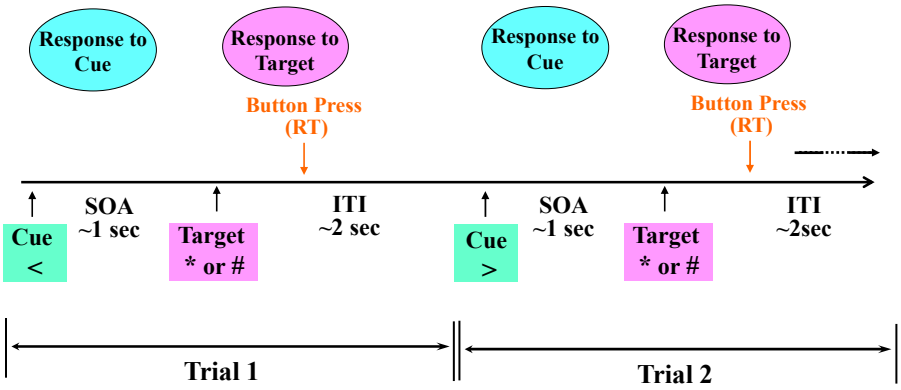
Cued attention – ERPs or fMRI



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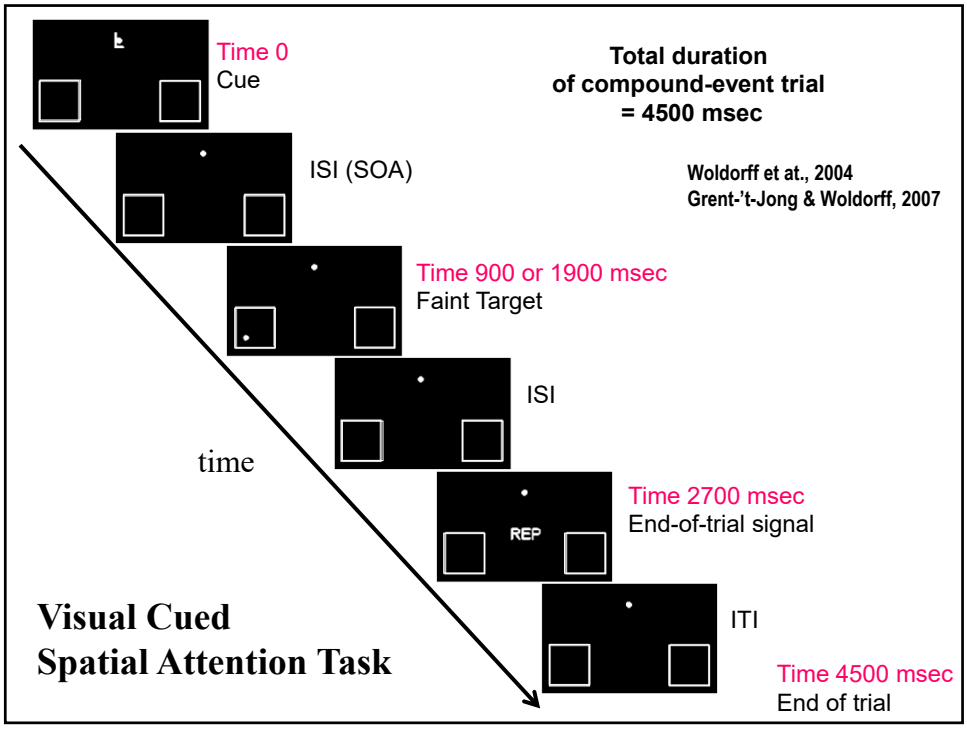
Time 0
Cue
Total duration
of compound-event trial
= 4500 msec
ISI (SOA)
Woldorff et at., 2004
Grent-'t-Jong & Woldorff, 2007
Time 900 or 1900 msec
Faint Target
ISI
time
REP
Time 2700 msec
End-of-trial signal
Visual Cued
Spatial Attention Task
ITI
Time 4500 msec
End of trial

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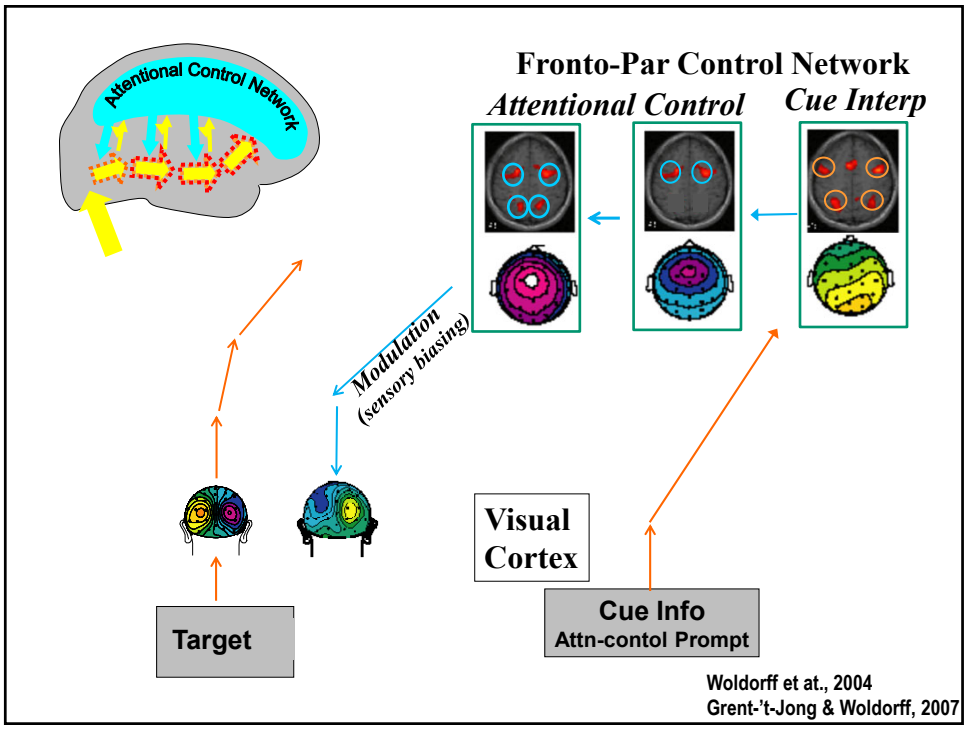
Attentional Control Network
Fronto-Par Control Network
Attentional Control
Cue Interp
Modulation
(sensory biasing)
Visual
Cortex
Target
Cue Info
Attn-contol Prompt
Woldorff et at., 2004
Grent-'t-Jong & Woldorff, 2007

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Language and ERPs

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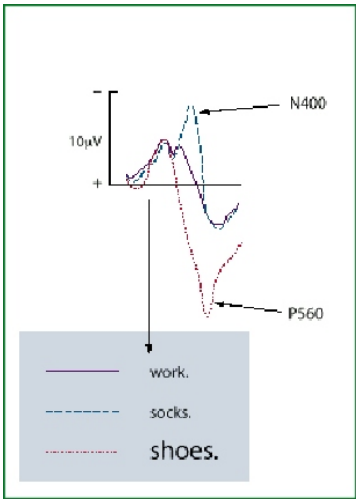
Semantics / Language
N400



Kutas & Hillyard, 1980

———	xxxxx	It	was	his	first	day	at	work.
- - - - - - - -	xxxxx	He	spread	the	warm	bread	with	socks.
-·-·-·-·-	xxxxx	She	put	on	her	high	heeled	shoes.

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N400

- Negative wave peaking between 300-500 ms after the onset of a written, spoken, or signed word
- Largest over central-parietal sites
- Its amplitude can be modulated by a single word, sentence, or discourse context

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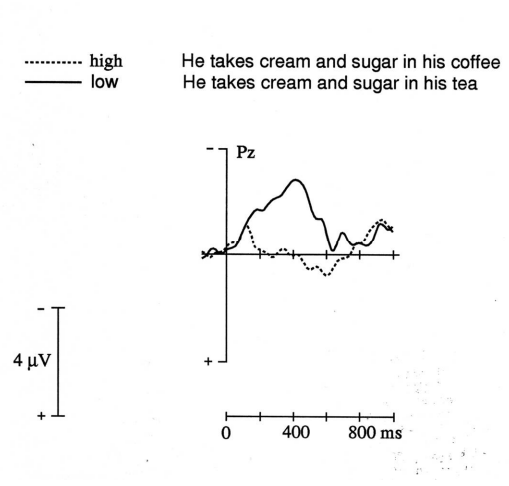
N400 and expectancy



- **Increased N400 for unexpected words, as well.**

Kutas & Hillyard, 1984

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Attentional blink and language processing

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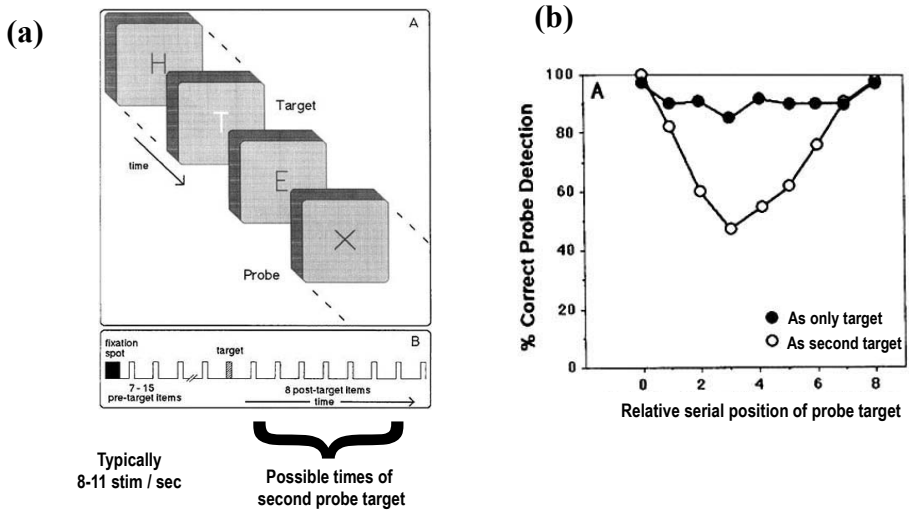
Figure 11.6 **Attentional blink**



Adapted from: Raymond, JE, Shapiro, KL, Arnell, KM. (1992). Temporary Suppression of Visual Processing in an RSVP Task: An Attentional Blink? Journ. Exp Psychol. 18:849-860

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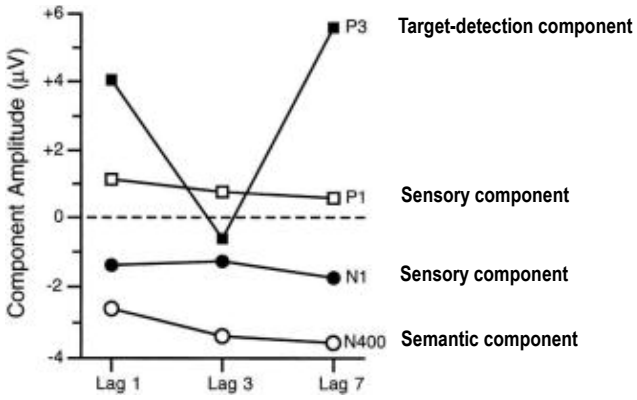
Box A Figure

Summary of ERP effects during the attentional blink



Attentional Blink ERP Studies
Luck et al., 1996
Vogel, Luck, and Shapiro, 1998

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Memory and ERPs

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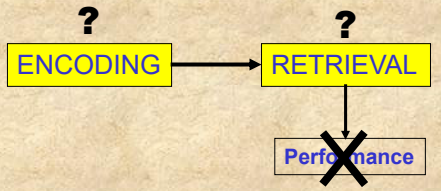
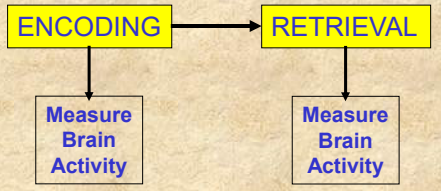
Distinguishing the Neural Correlates of Encoding and Retrieval

- Difficult or impossible using lesion approach
  - In behavioral experiments, encoding and retrieval are always confounded



- Possible with functional ERPs and neuroimaging
  - Encoding and retrieval activity can be measured independently



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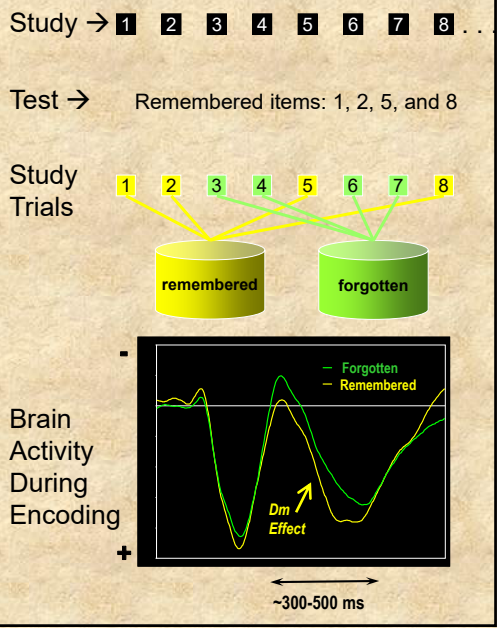
Subsequent Memory Paradigm (Dm Effect)

1. Measure brain activity while subjects study items (e.g., words)
2. Test memory for studied items
3. Sort and selectively average trials during Study according to subseq. memory performance
4. Compare brain activity for items subsequently remembered vs. items subsequently forgotten



Paller, Kutas, & Mayes,1987

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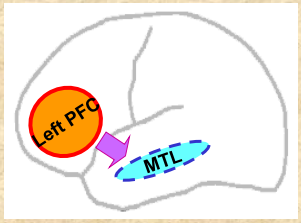
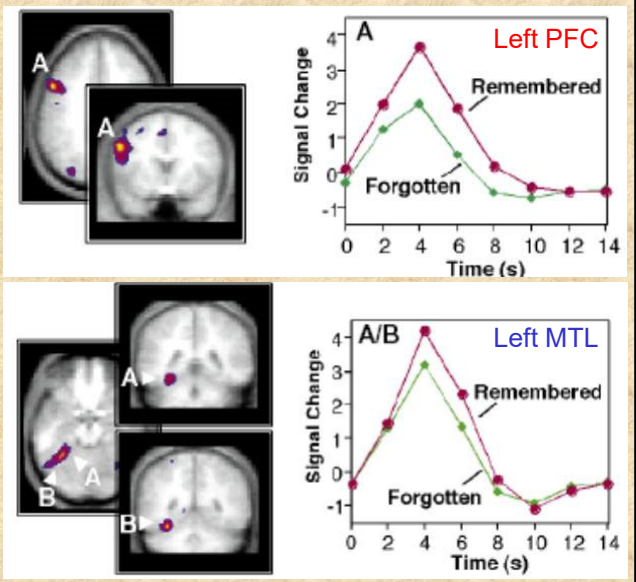
fMRI: Subsequent Memory Effect in PFC and MTL
(fMRI version of Dm Effect)





Wagner et al. (1998, Science)

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Perception and ERPs

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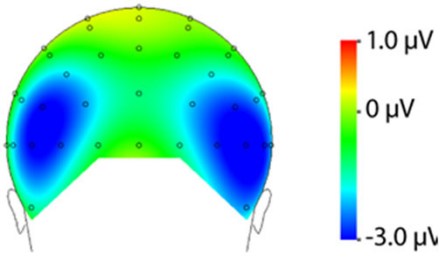
N170 face-minus-house difference



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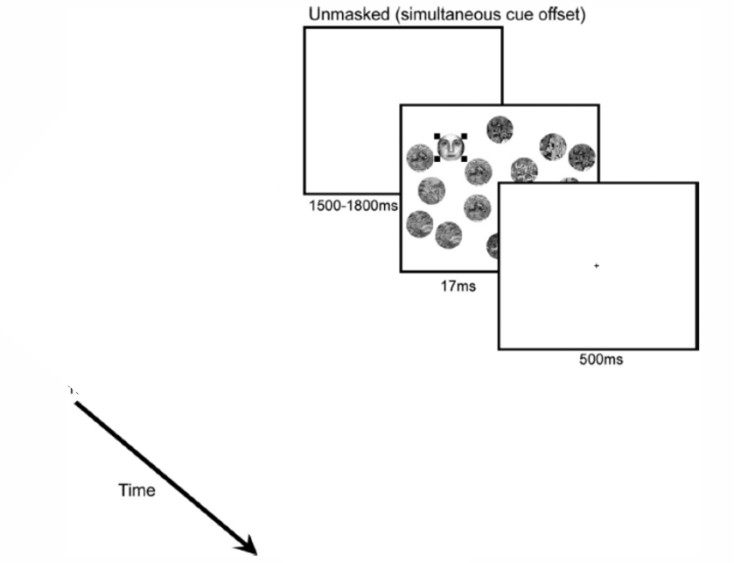
Object Substitution Masking



Harris, Ku, Woldorff, *Neuropsychogia,* 2013

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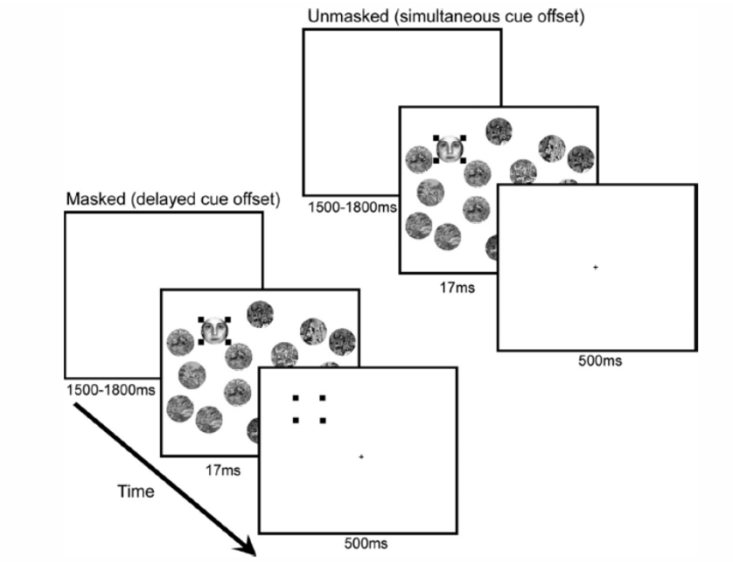
Object Substitution Masking



Harris, Ku, Woldorff, *Neuropsychogia,* 2013

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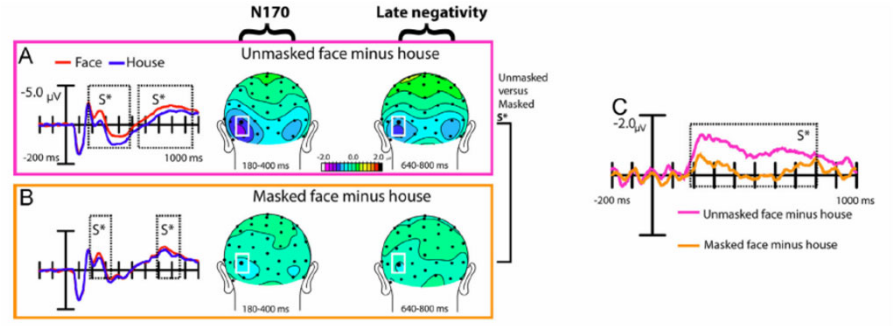
Effects of Object Substitution Masking on perceptual processing activity



Harris, Ku, Woldorff, *Neuropsychogia,* 2013

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