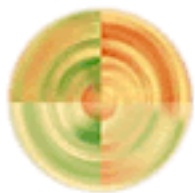


# EEG and behavioral studies of object recognition in natural images

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Theoretical Neuroscience, UC Berkeley

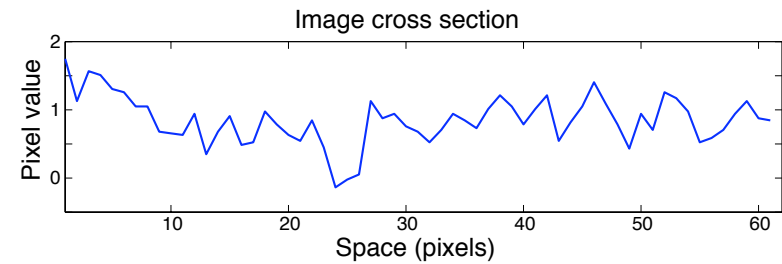
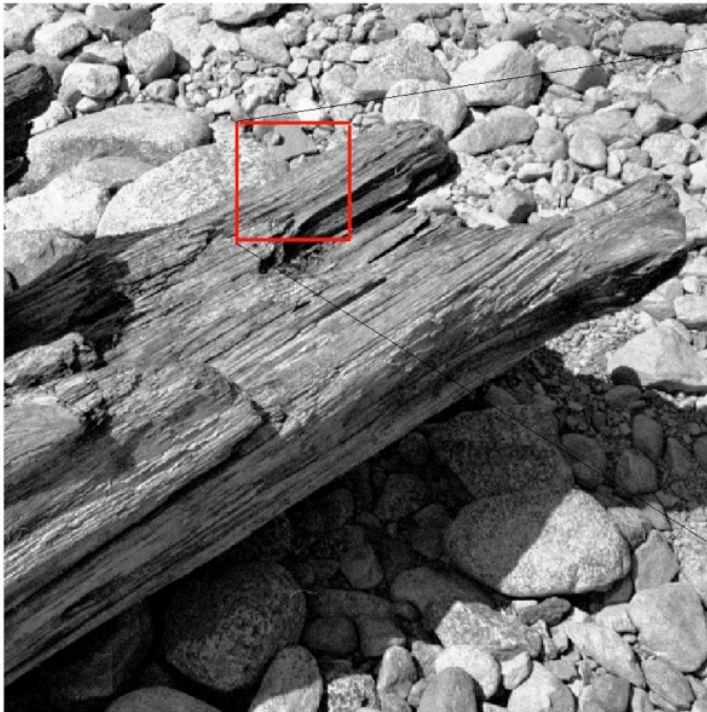
with Jeff Johnson, UC Davis



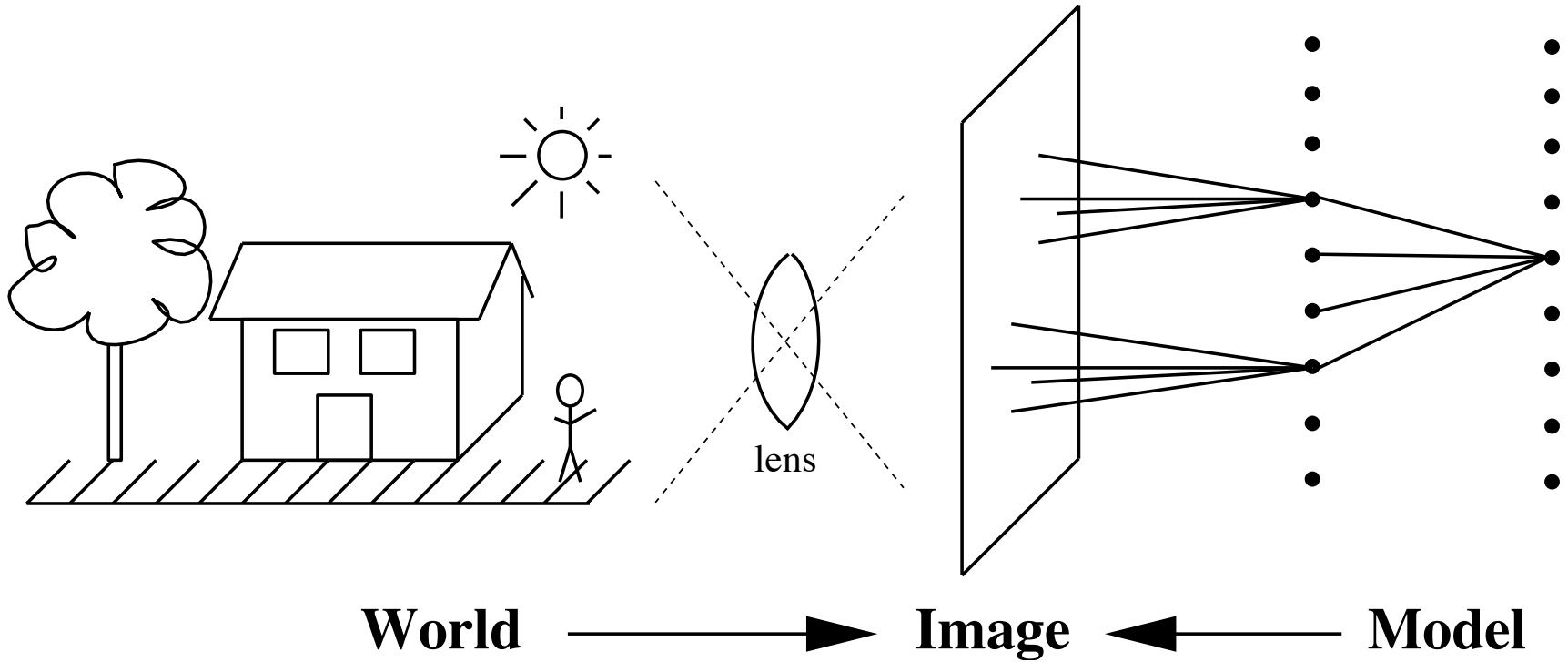
**REDWOOD CENTER**  
for Theoretical Neuroscience



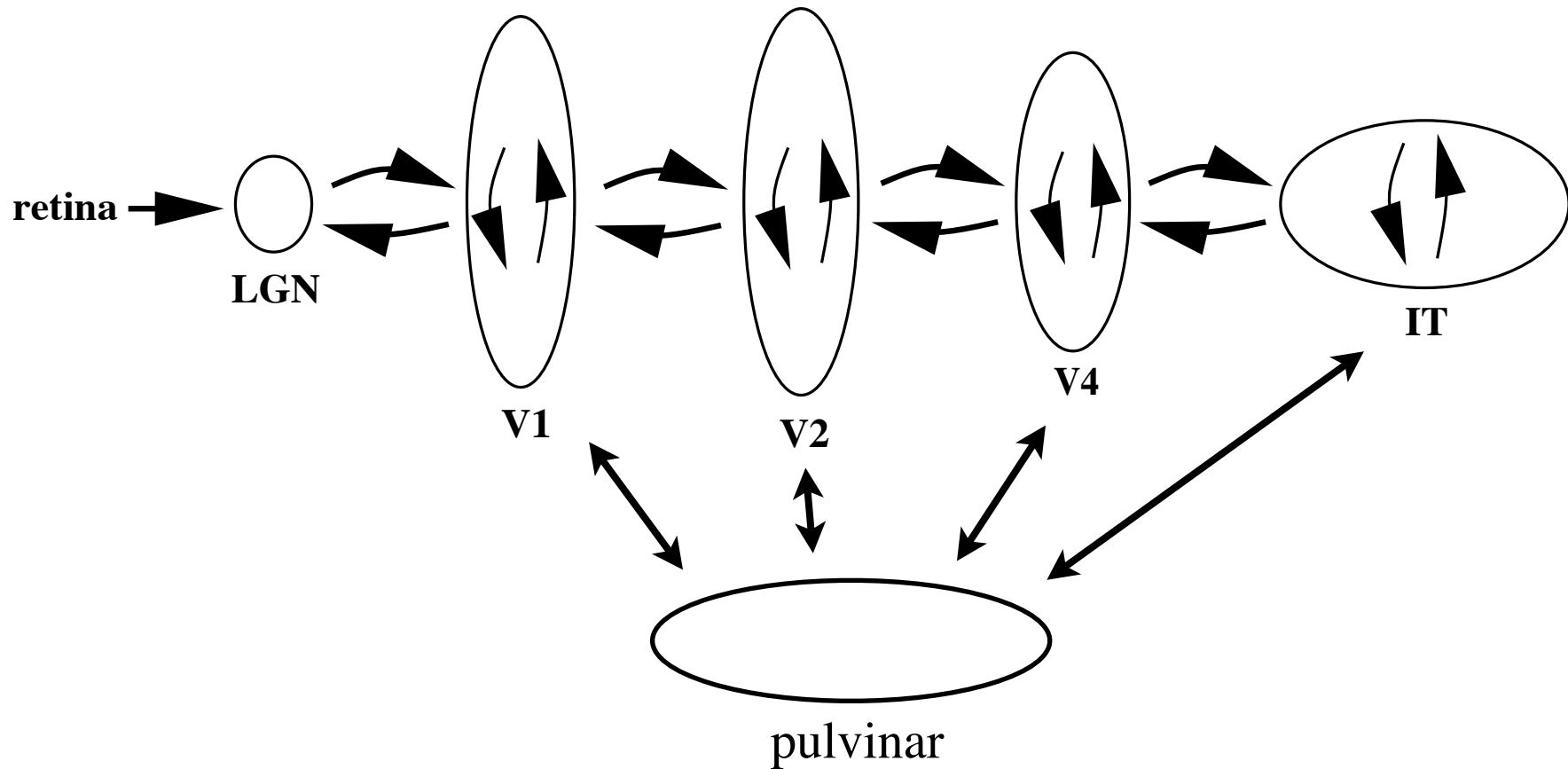
# Scene analysis is a difficult problem



# Vision as inference

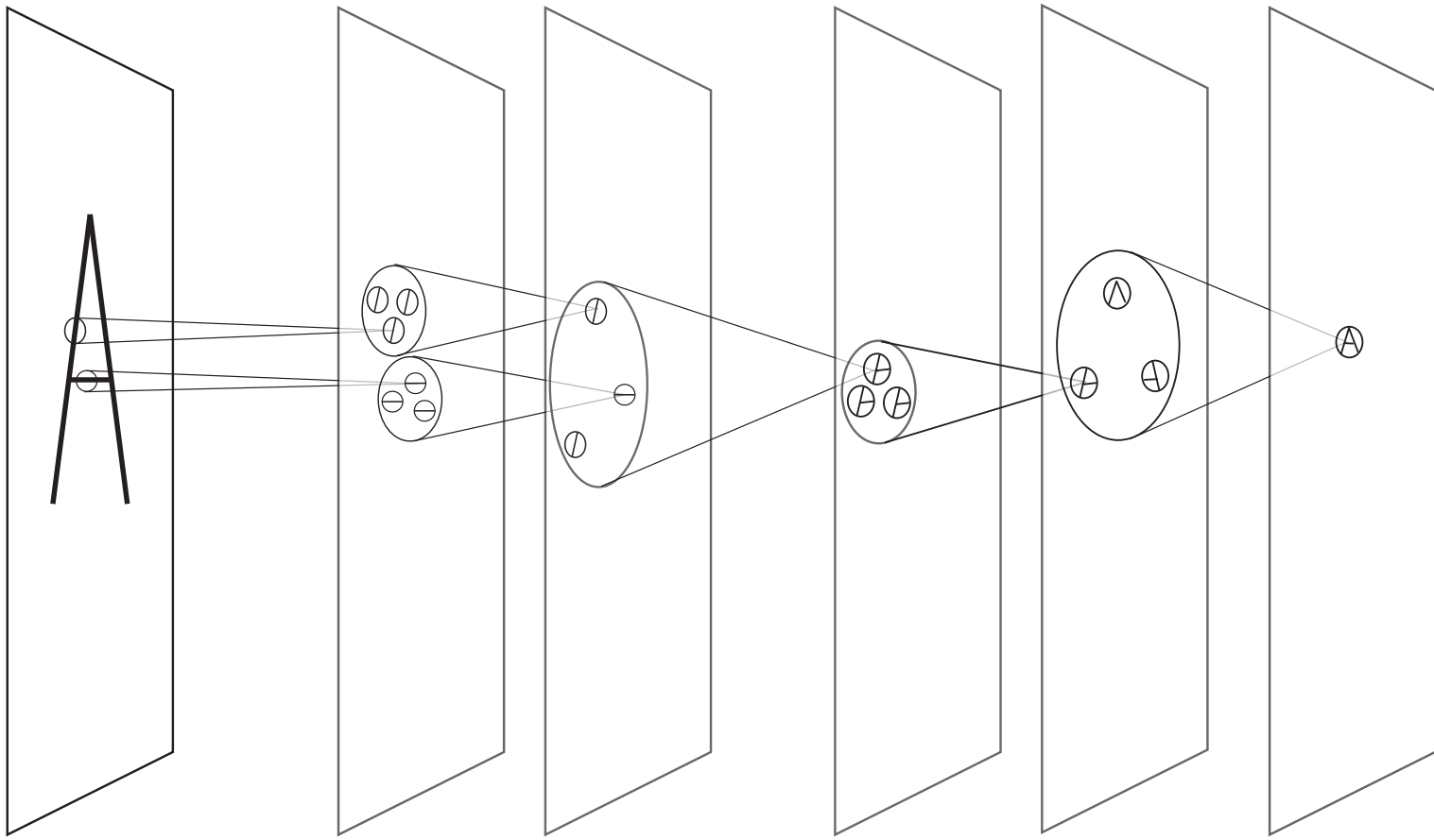


Feedback connections may carry predictions of higher-levels to lower-levels to help resolve ambiguity

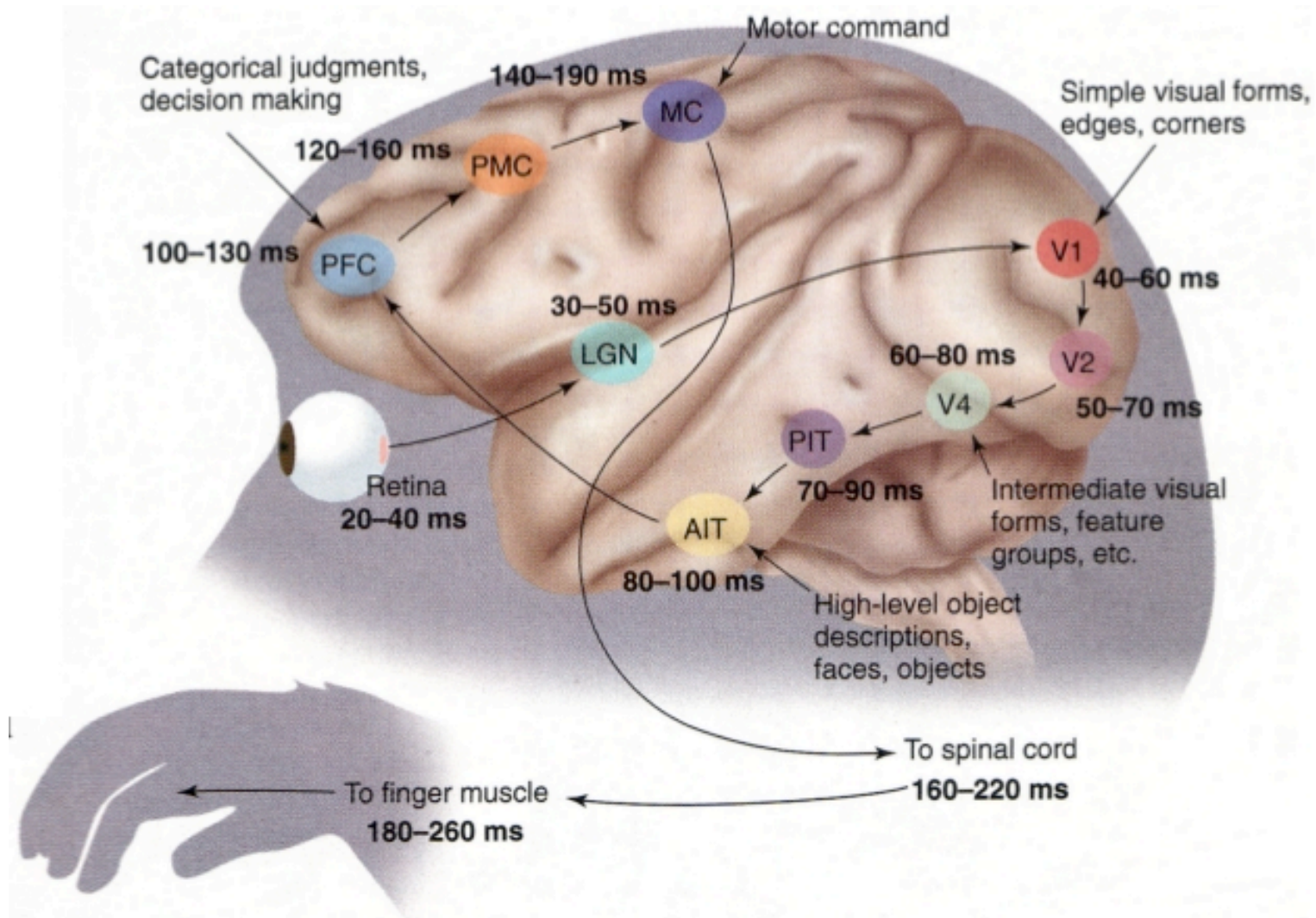


# Feedforward models

Pandemonium (Selfridge, 1959); Neocognitron (Fukushima, 1980);  
H-max (Riesenhuber & Poggio, 1998)

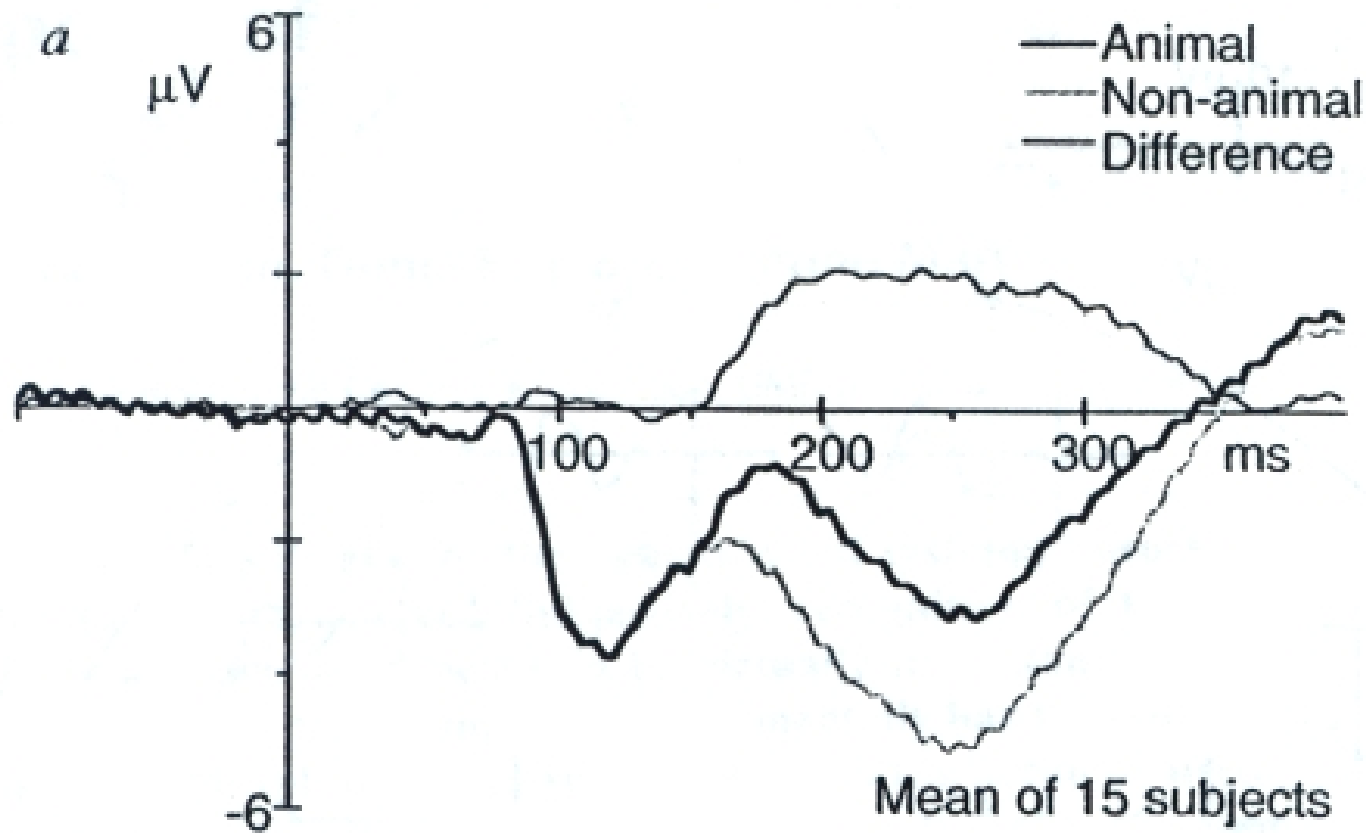


# Is there enough time for feedback?



from Thorpe & Fabre-Thorpe, 2001

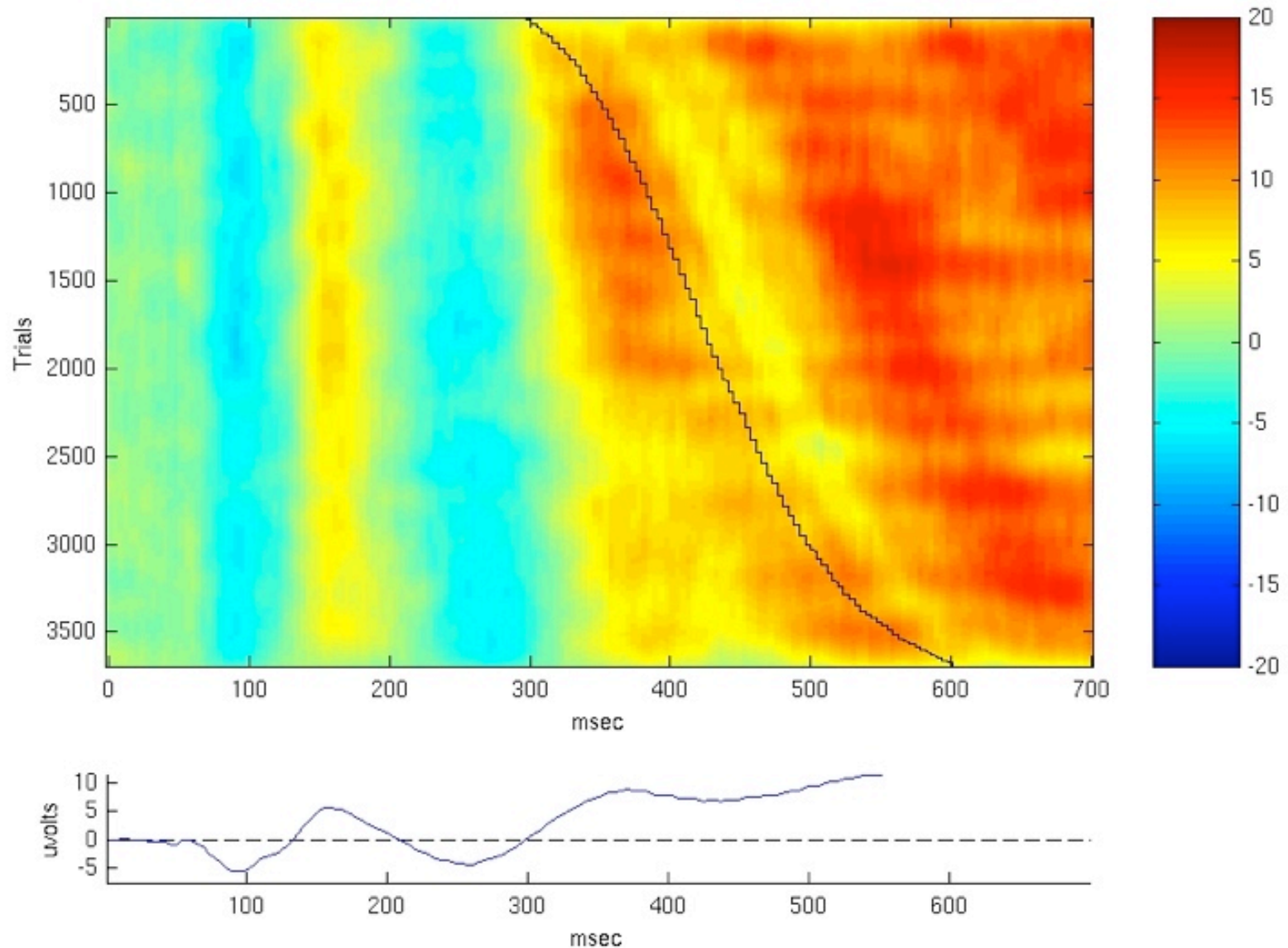
# EEG correlates of object recognition in humans arise at 150 ms after stimulus onset



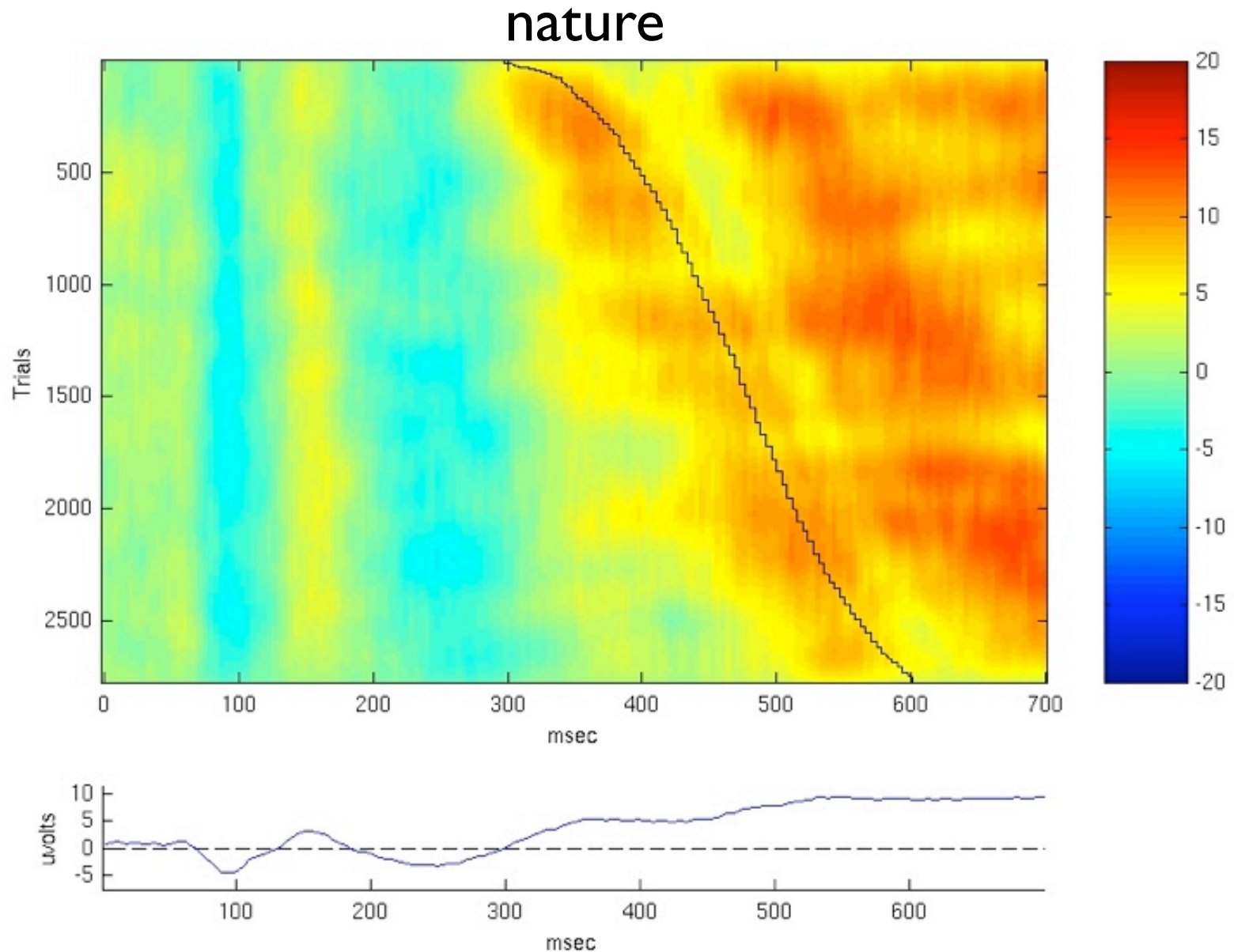
from Thorpe et al., 1996

# ERPimage reveals stimulus-locked vs. reaction-time locked components

animal

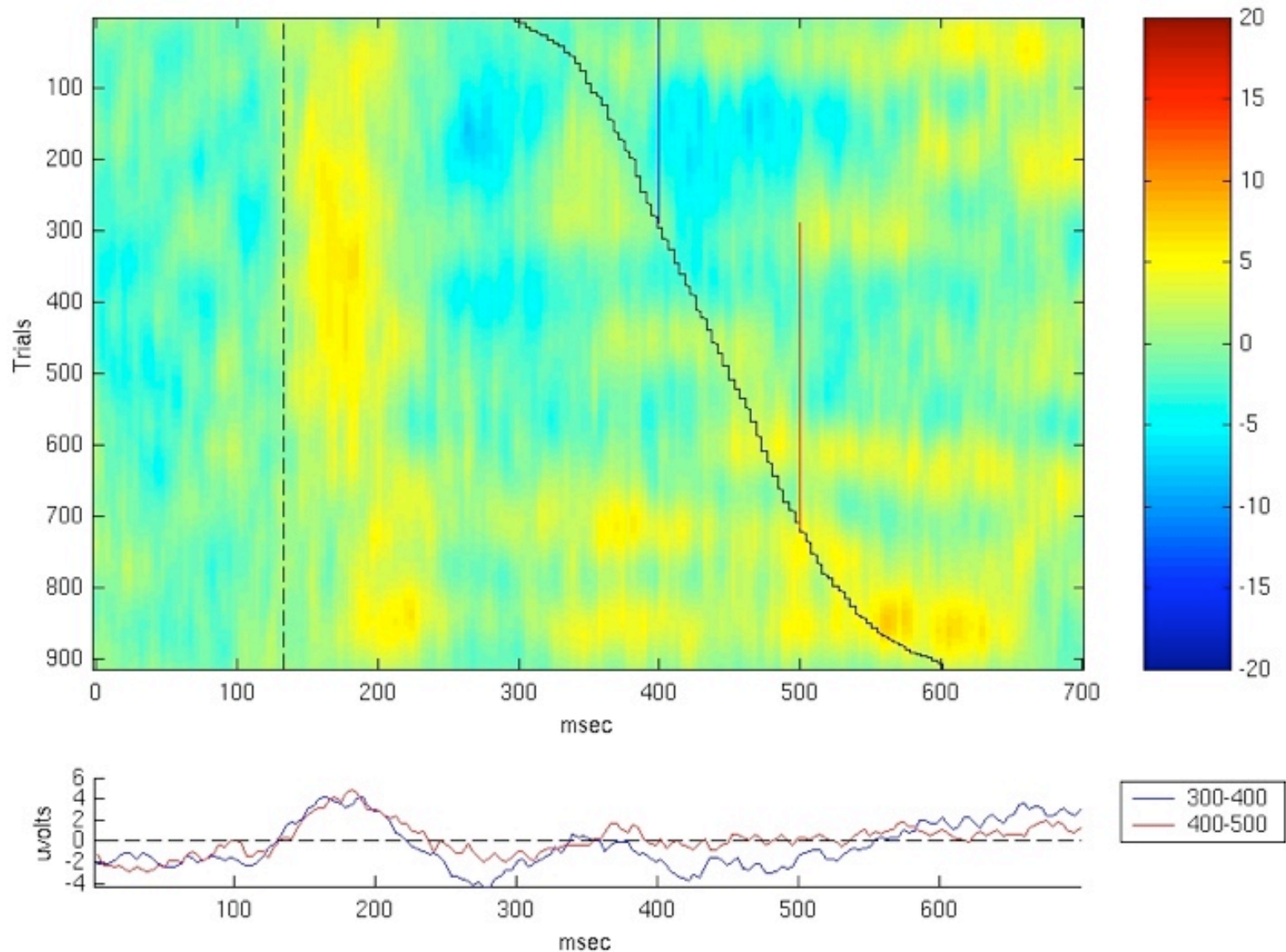


# ERPimage reveals stimulus-locked vs. reaction-time locked components

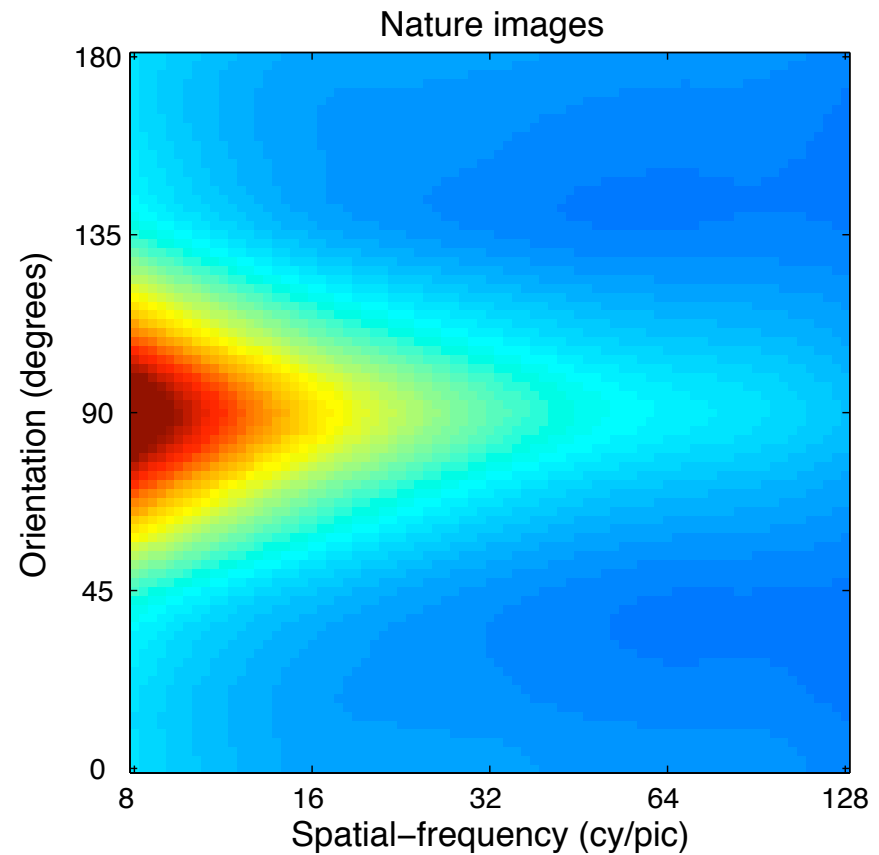
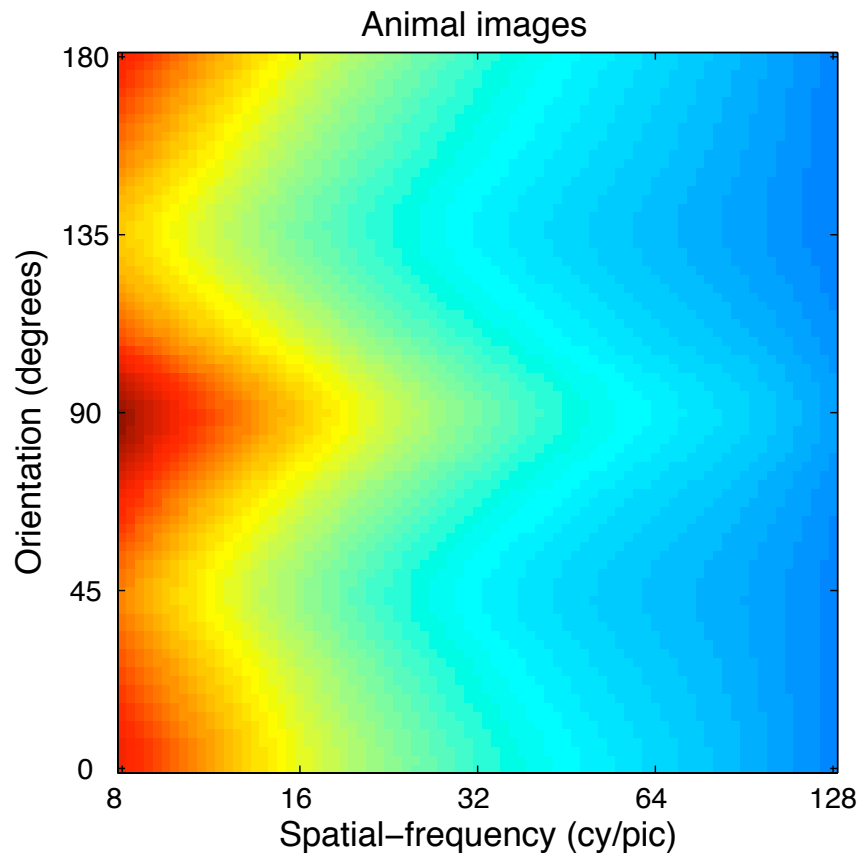


# ERPimage reveals stimulus-locked vs. reaction-time locked components

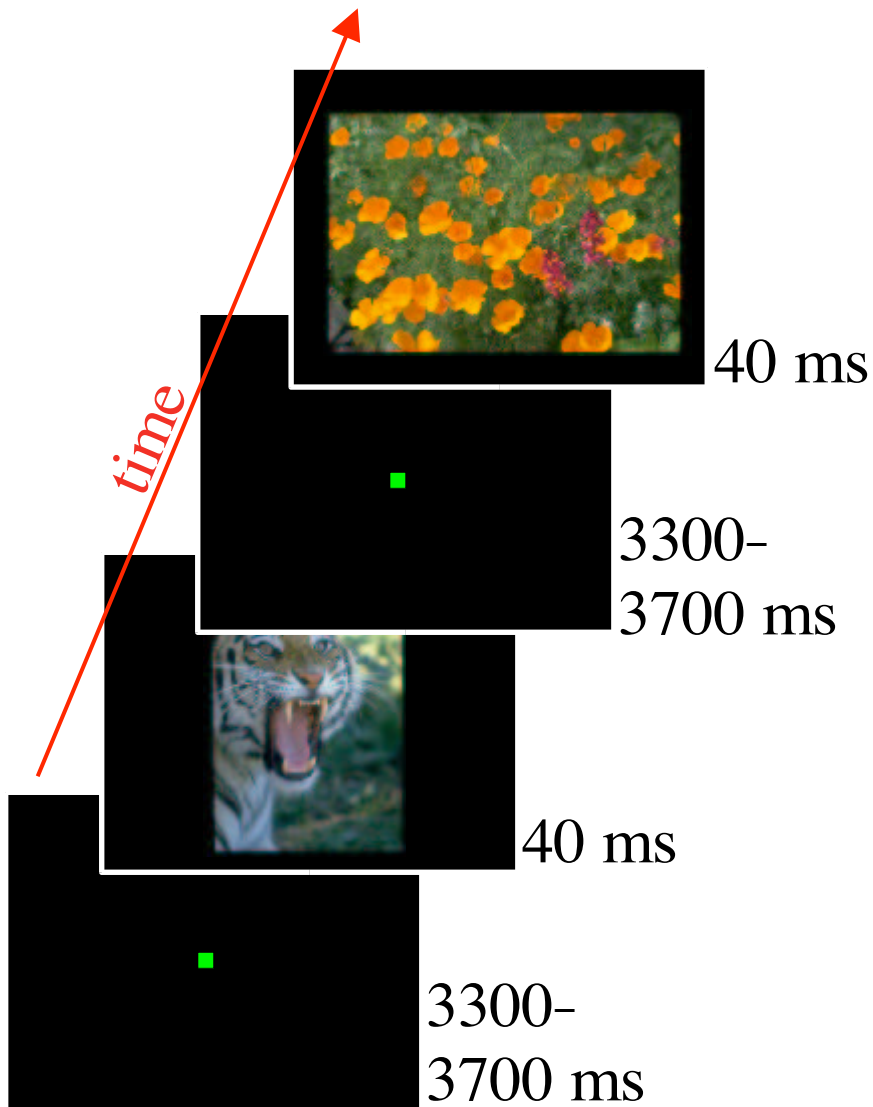
animal - nature



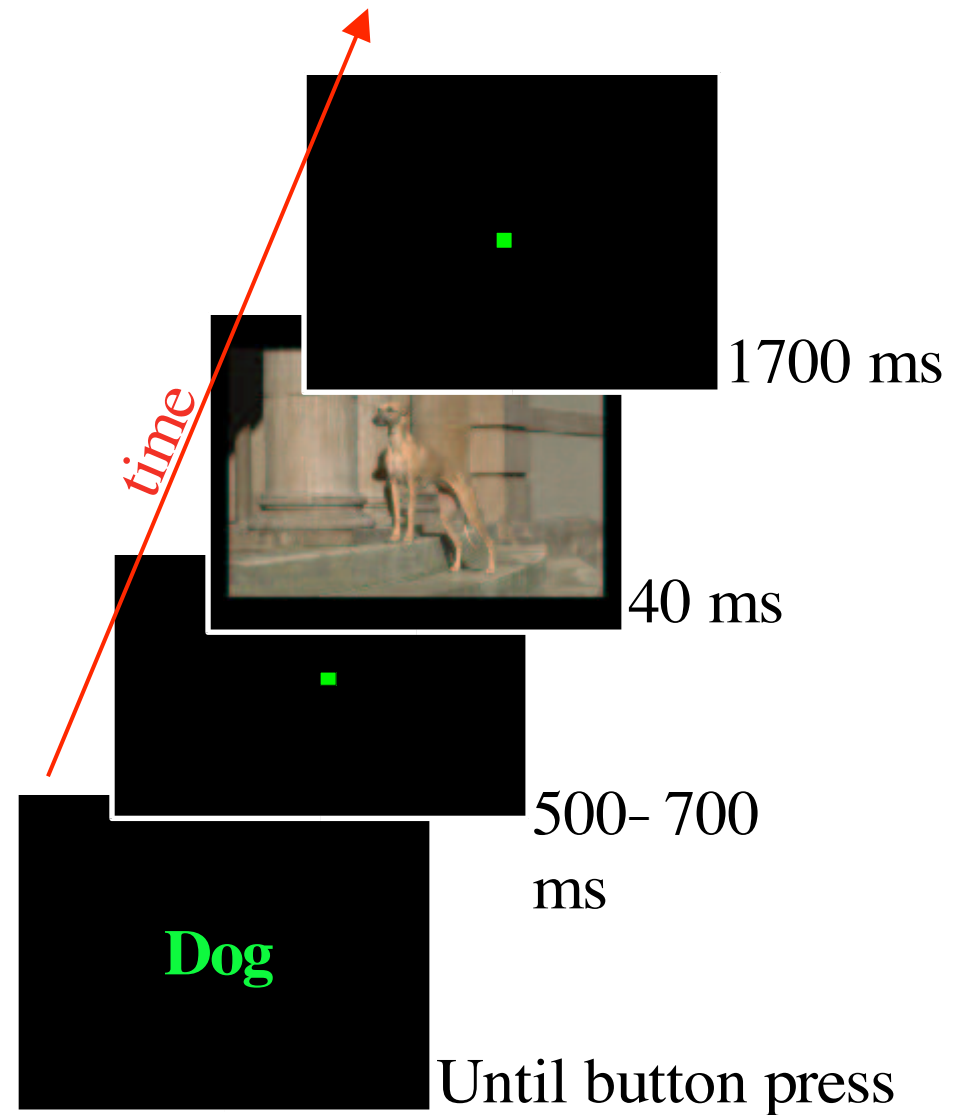
# Power spectra are different



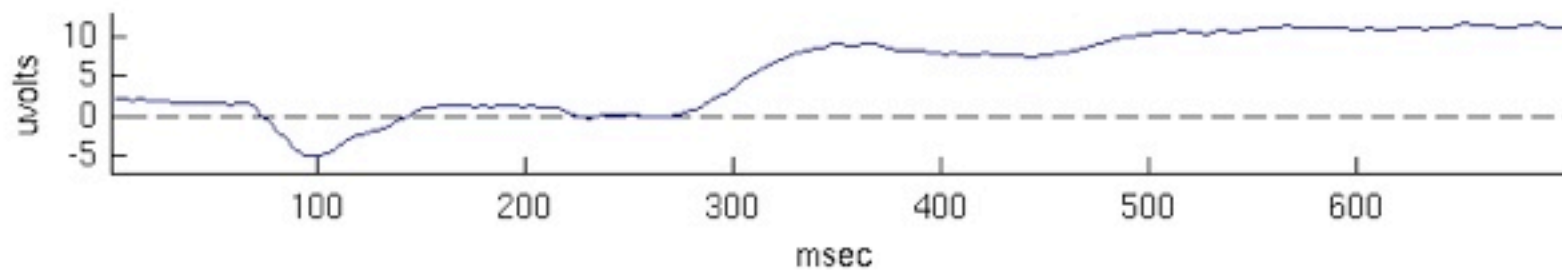
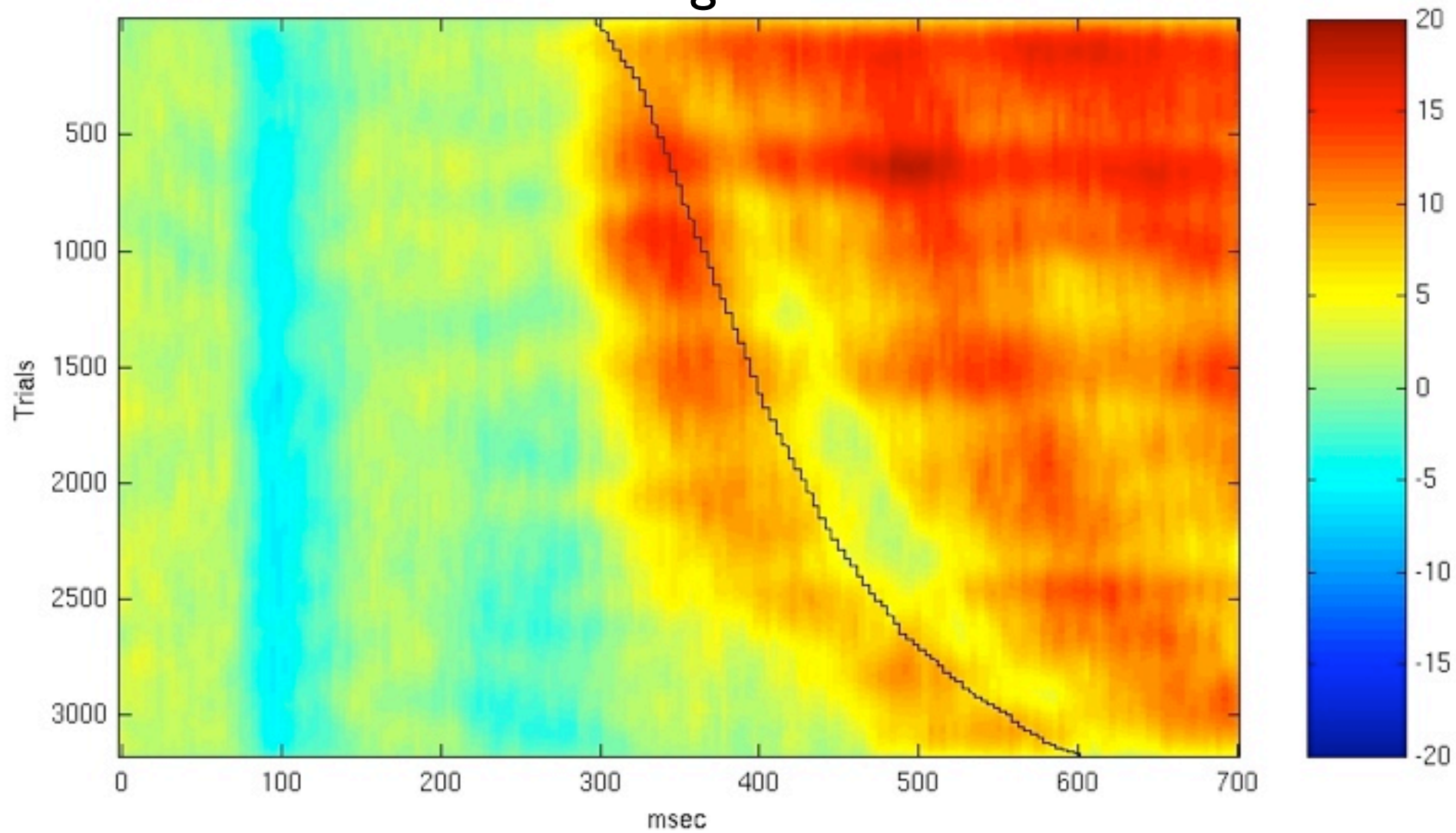
# Single category



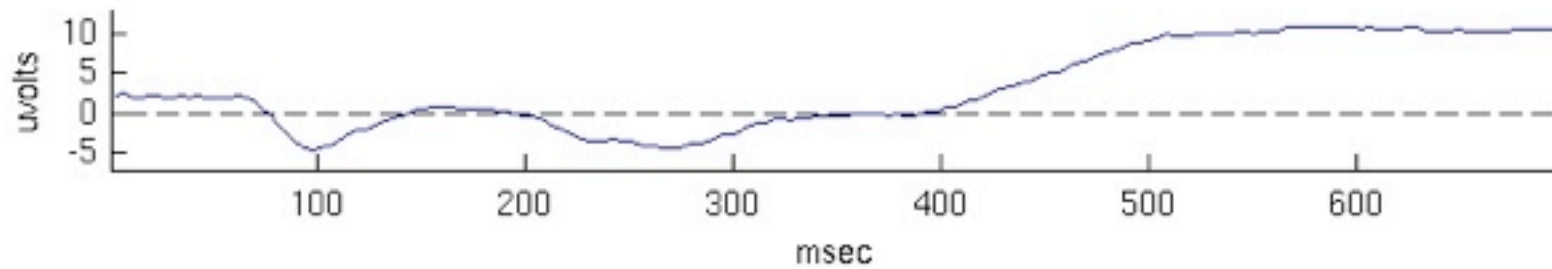
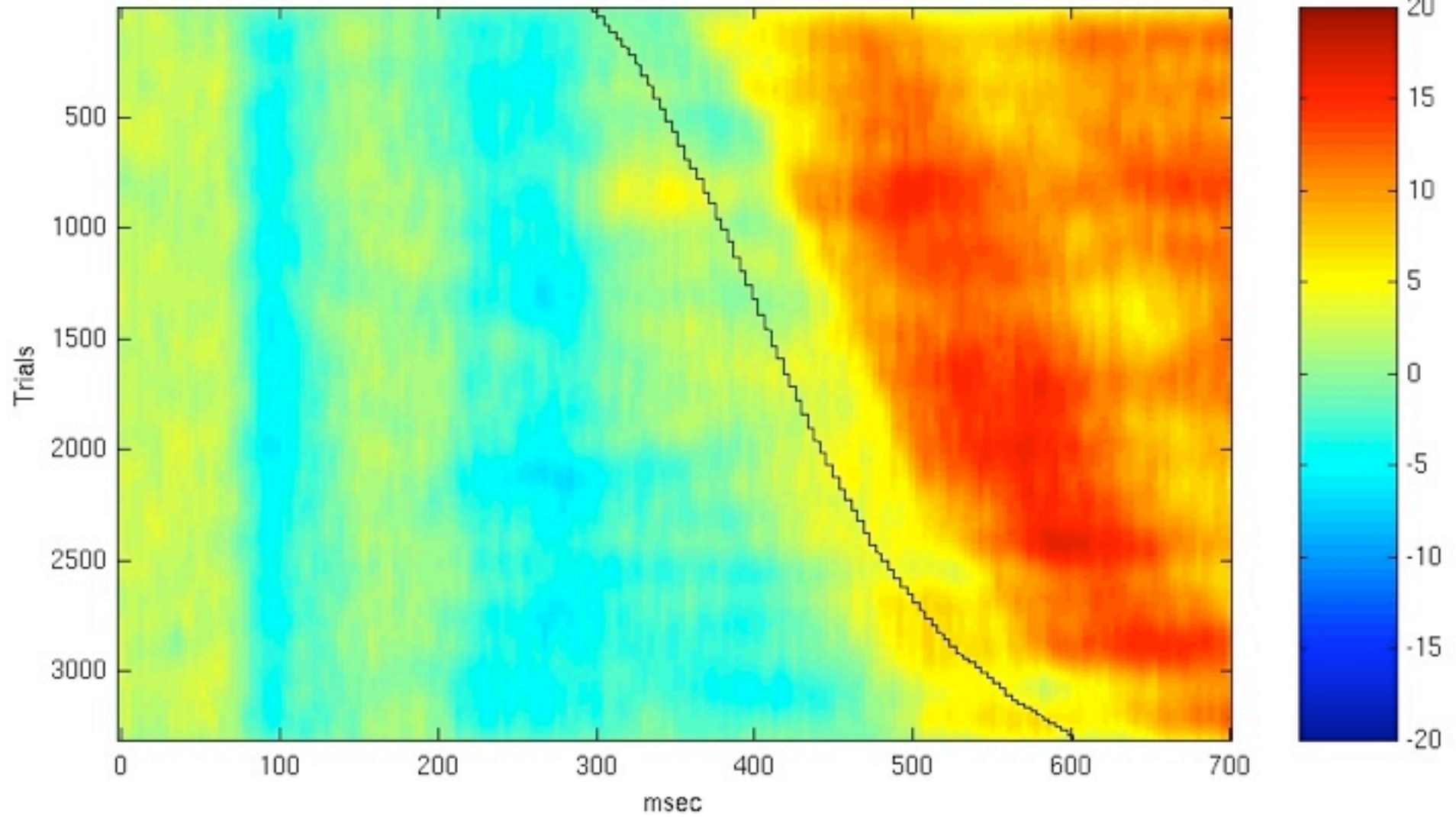
# Cued-target



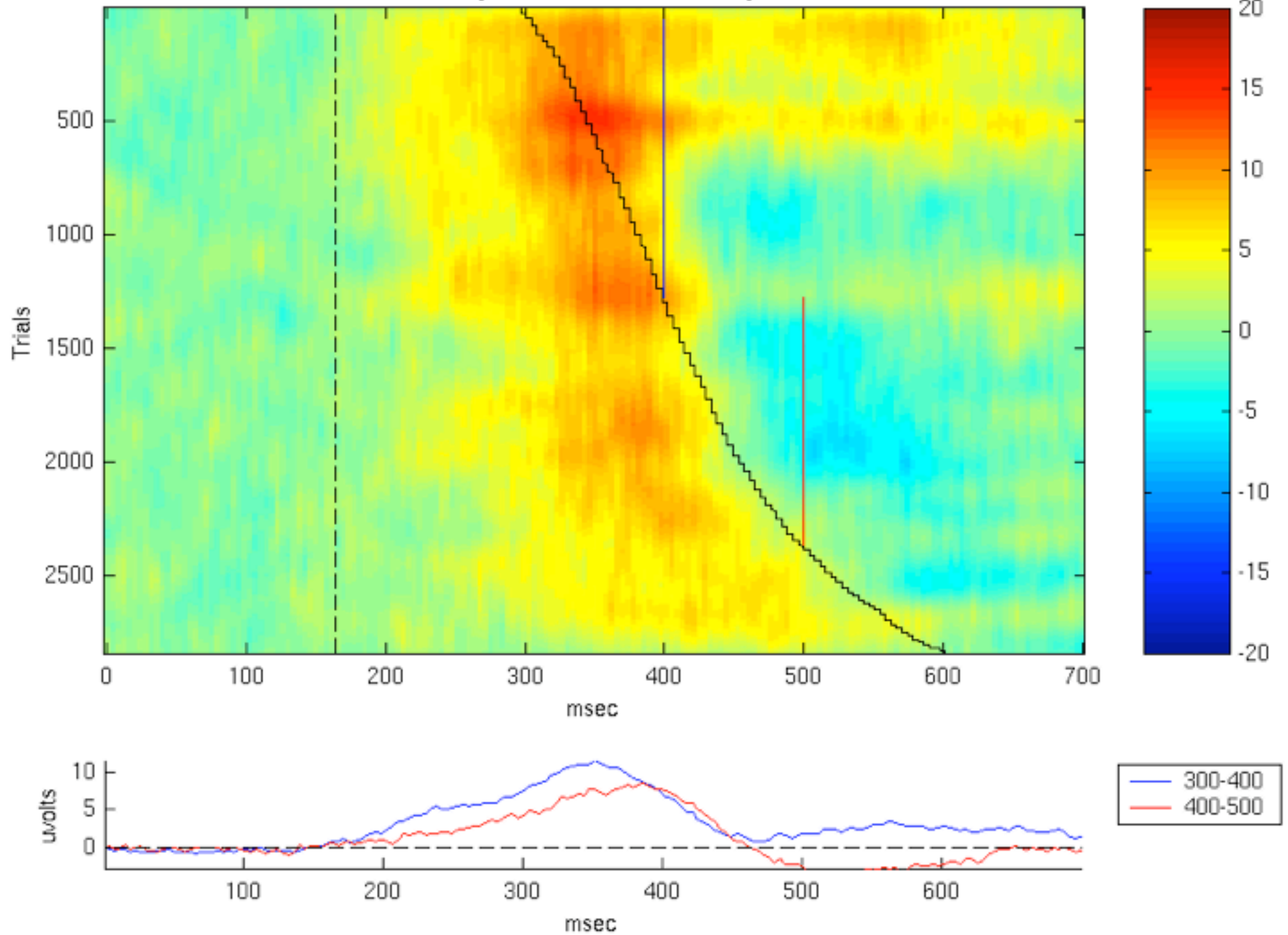
# target



# non-target



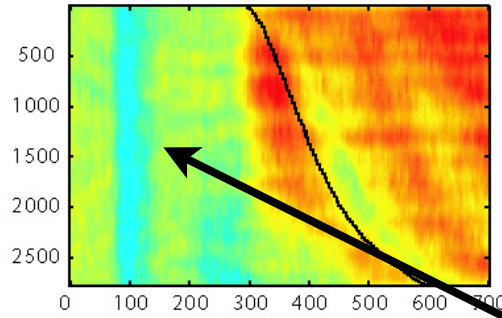
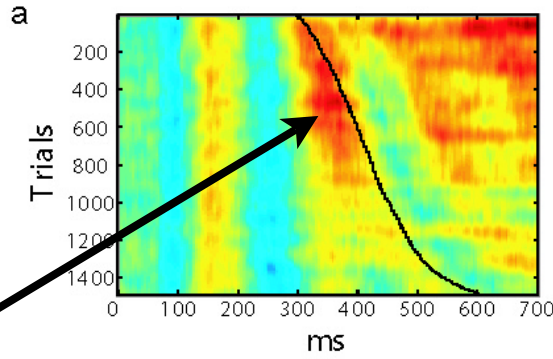
# target - non-target



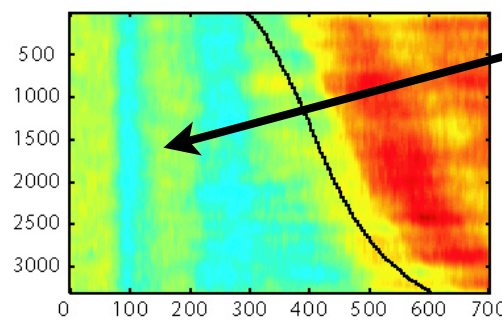
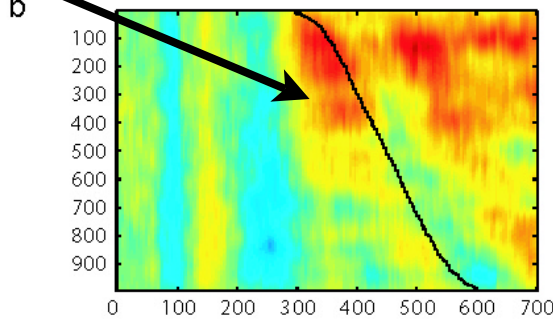
Single Category

Cued Target

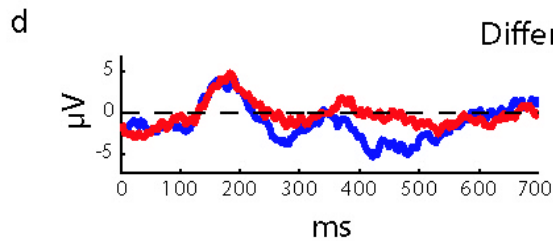
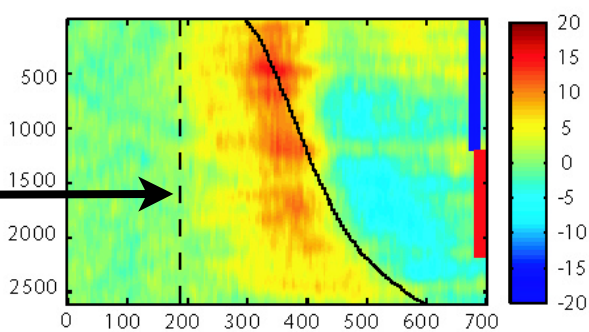
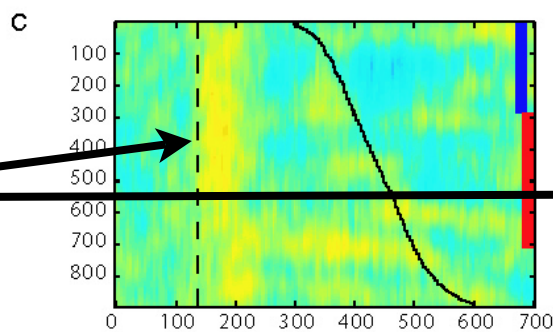
Targets



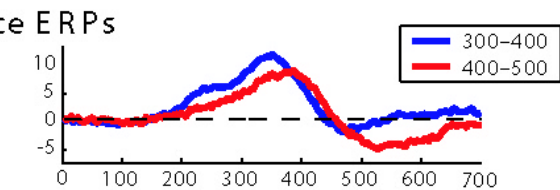
Nontargets



Difference



Difference ERPs



late positivity  
present for  
targets and  
non-targets

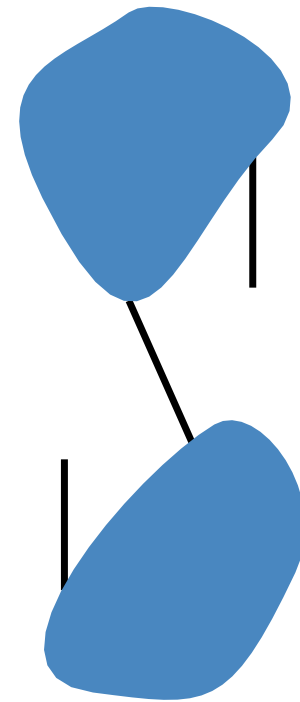
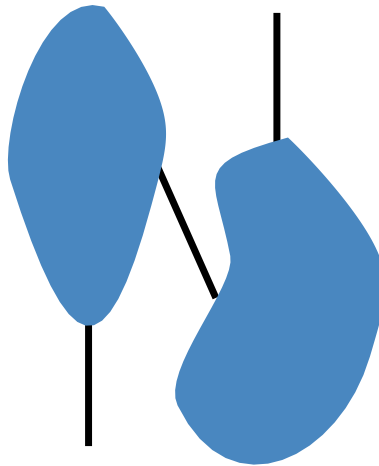
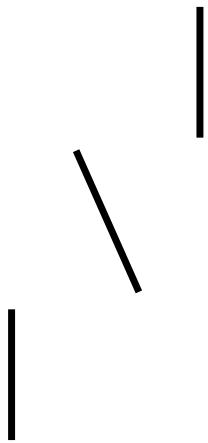
early  
positivity  
is absent

latency shift

# Time-course of object recognition - summary

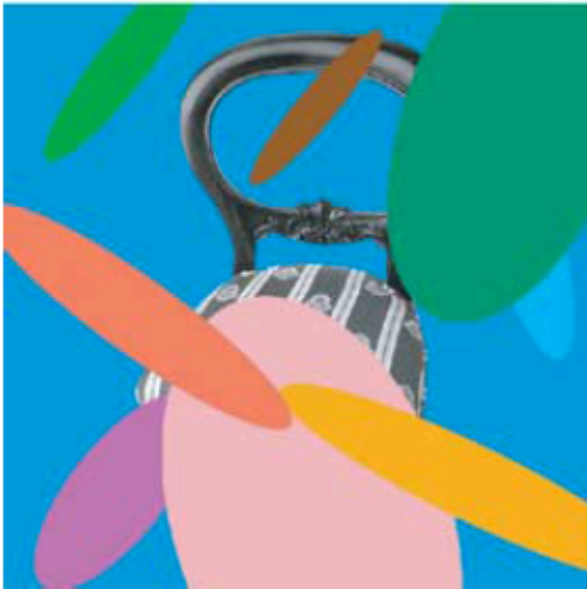
- Early (150 ms) **stimulus-locked** differences in the EEG may be due to systematic feature differences between targets and non-targets.
- Earliest EEG signals related to **object categorization** have **variable latency**, between 150-300 ms, depending on task difficulty (basically, the P300).
- But... object labeling may be a relatively **simple problem** that doesn't require solving the scene analysis problem.

# Occlusion



# Occlusion vs. deletion

Occluded



Deleted

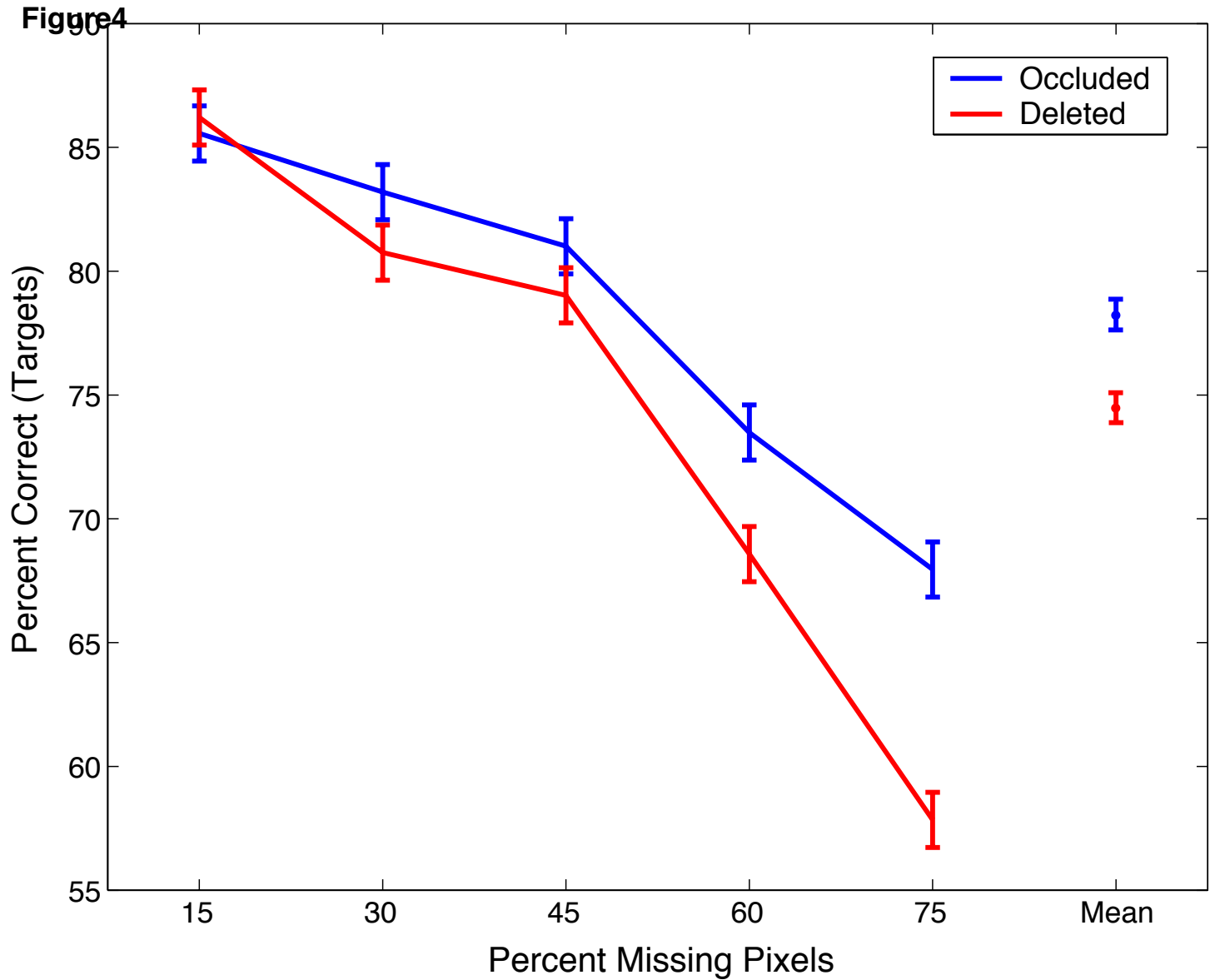


Intact

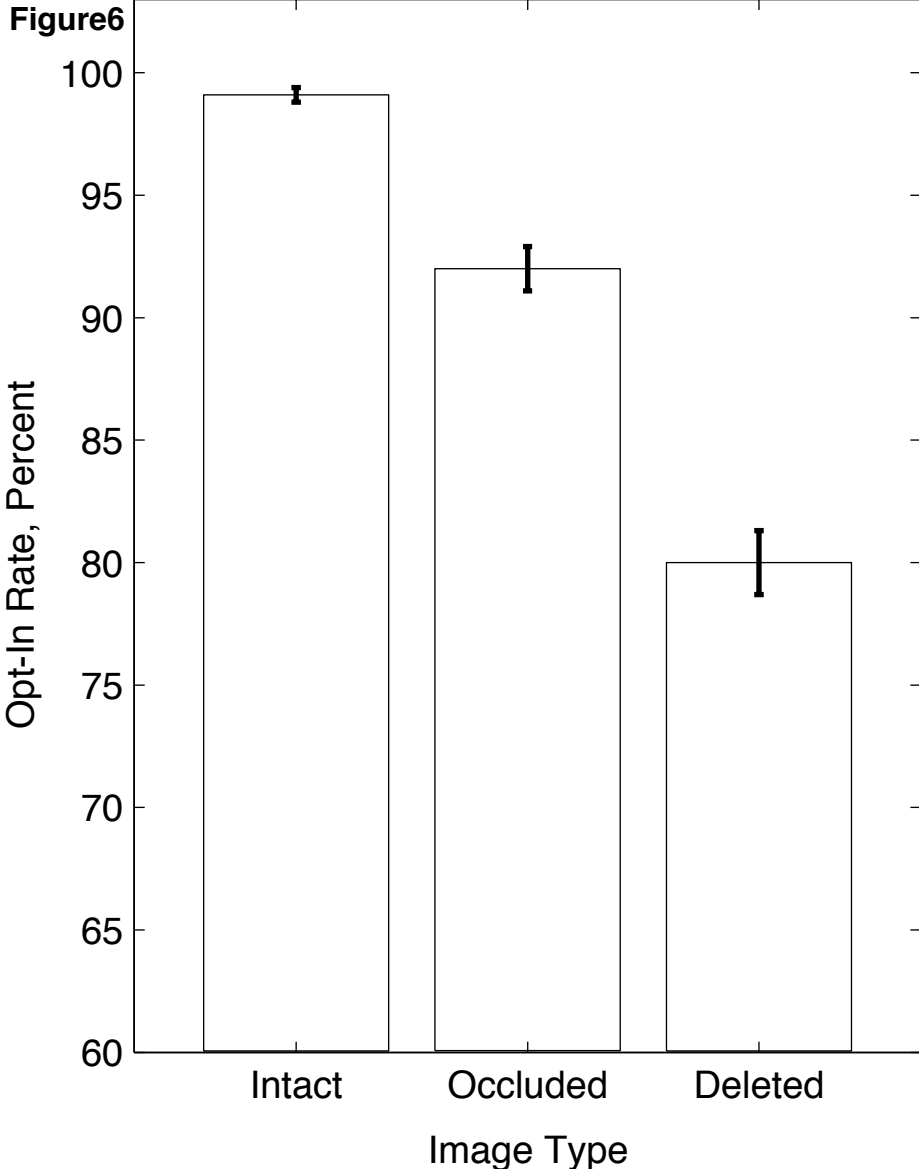


Johnson & Olshausen (2005) *Vision Research*, 45, 3262-3276

# Occluded objects are easier to recognize



# Occluded objects are easier to recognize



# Summary

- Neurophysiological correlates and reaction-time measures indicate that **object recognition happens extremely rapidly** (100-200 ms).
- Computational models also show that purely **feedforward mechanisms can often suffice for labeling objects**.
- However, **scene analysis involves much more than object labeling**. Proper figure-ground segmentation, surface description are difficult, unsolved problems.
- These latter problems may draw upon **cortical feedback mechanisms**.