Domain-Specificity versus Expertise in Face Processing

Dan O'Shea and Peter Combs

18 Feb 2008

COS 598B

Prof. Fei Fei Li

Inferotemporal Cortex and Object Vision

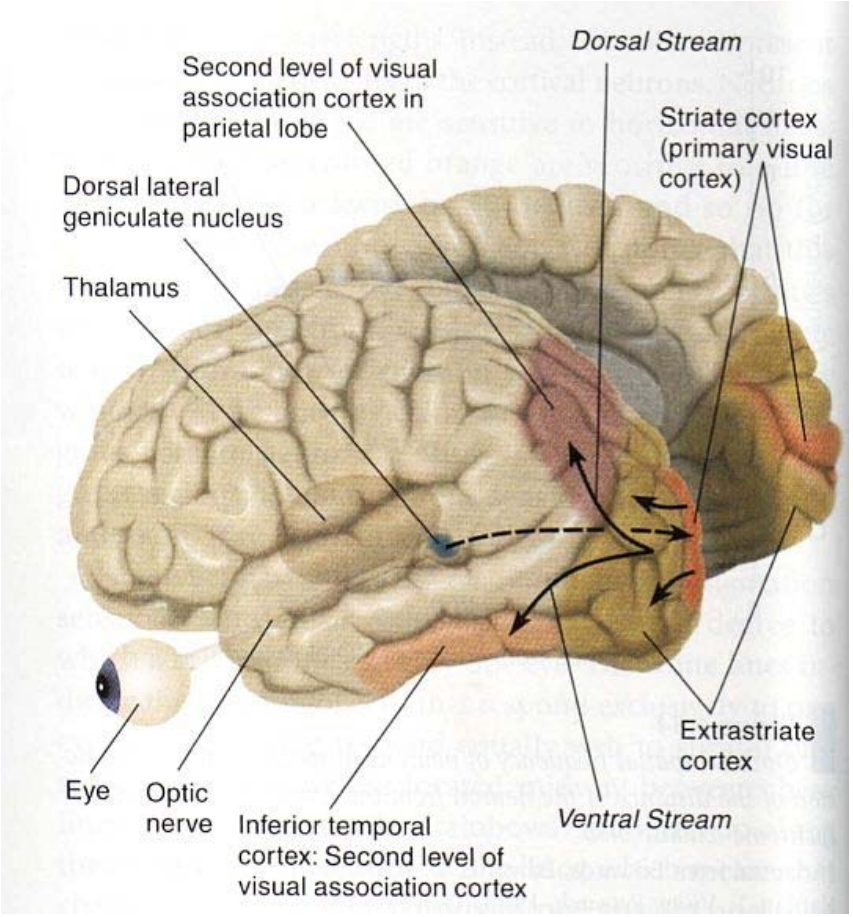
Keiji Tanaka

Annual Review of Neuroscience, 1996

Objective: Describe the properties of TE cells and the connections leading to and projecting out of TE with the goal of understanding the functional implications of TE's functional organization in object recognition

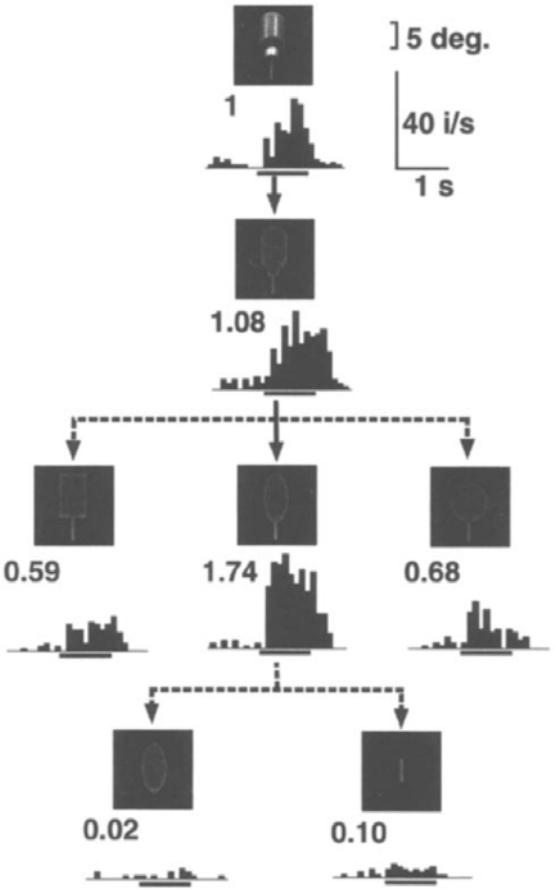
Dorsal Visual Pathway

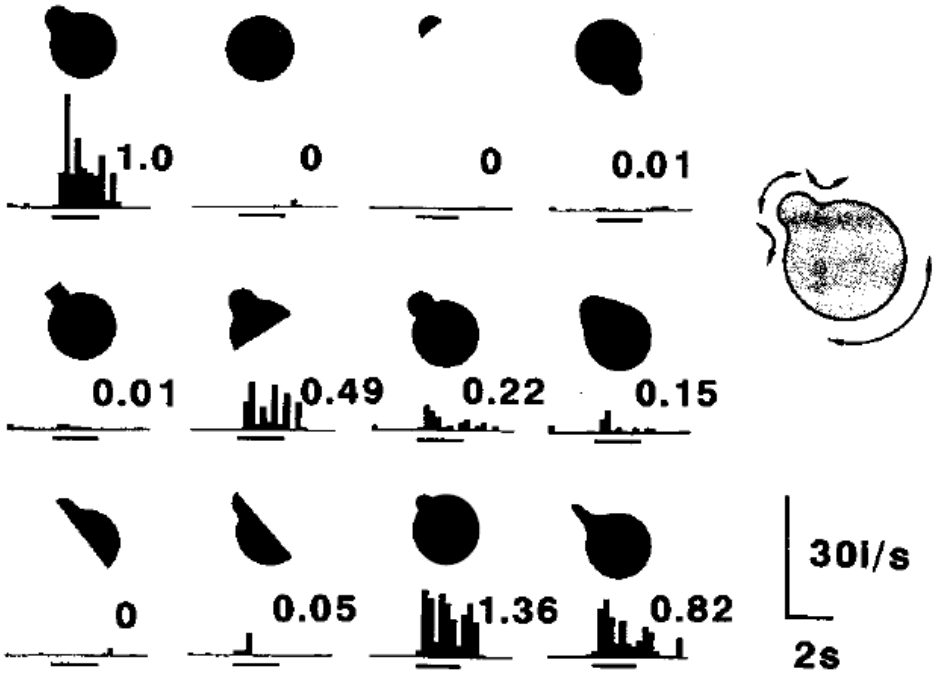
- Performs visual stimulus recognition
- “What” Pathway



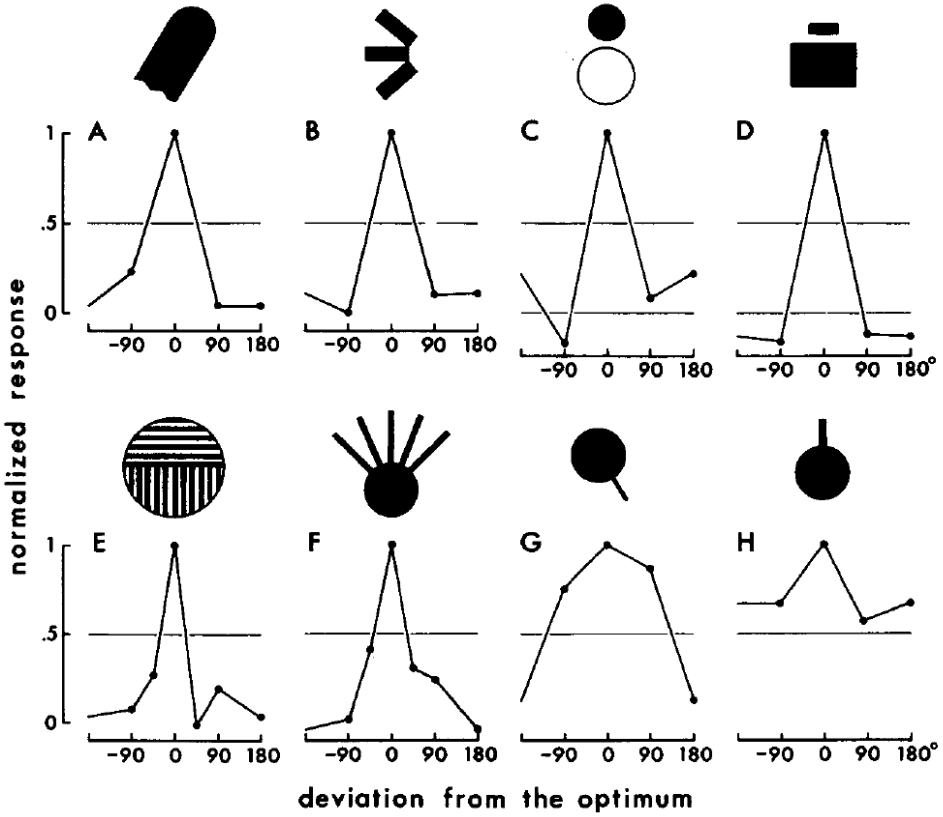
TE Cells Selective for Complex Features

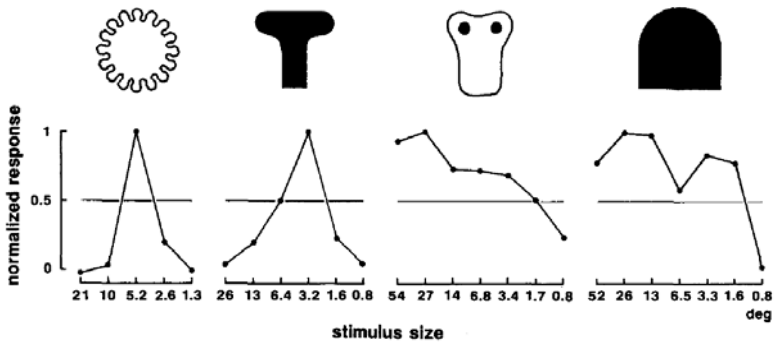
Dorsal TE cells selective for moderately complex features, some for combinations of these shapes with color or texture



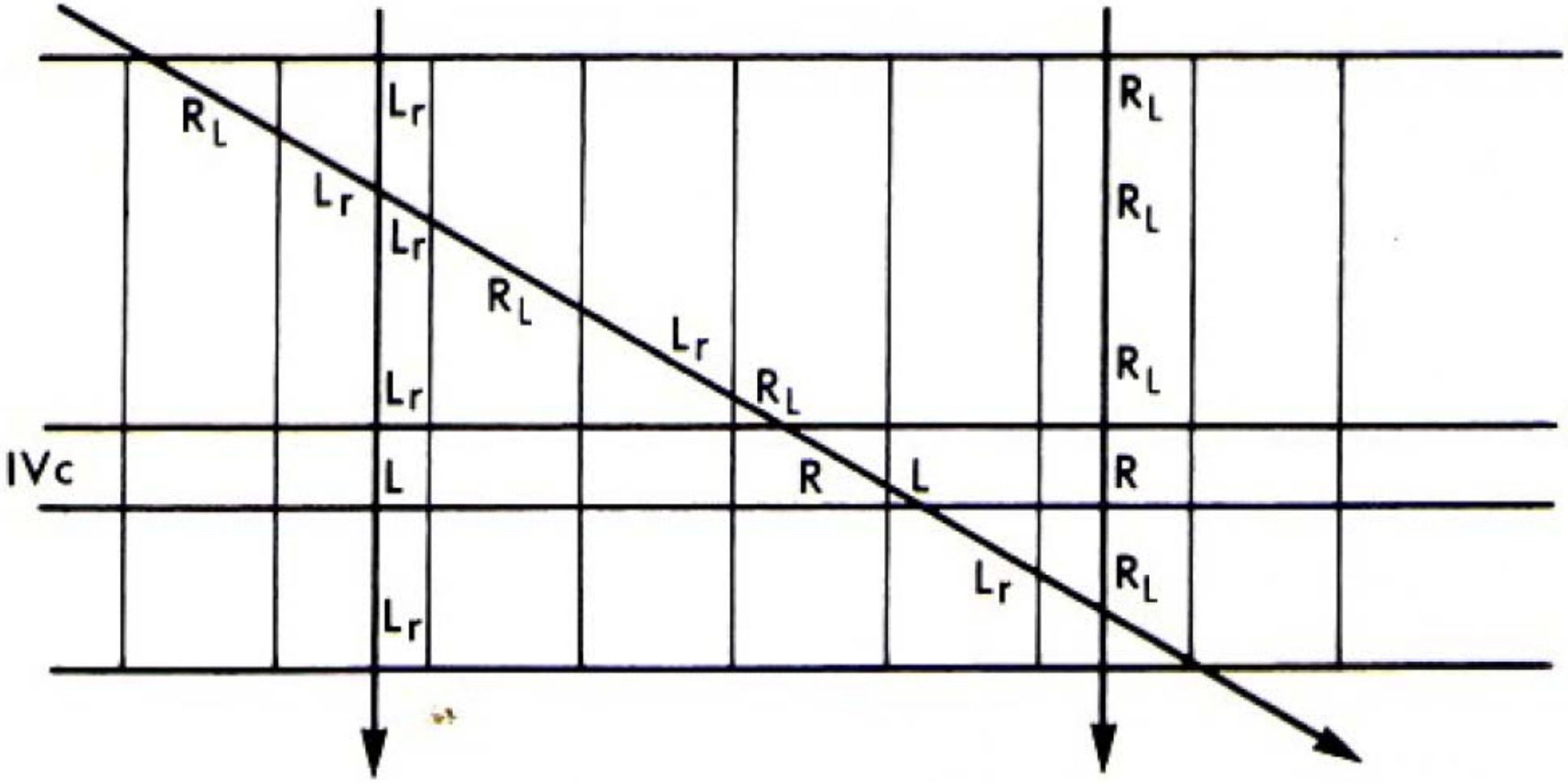


Orientation and Size Selectivity

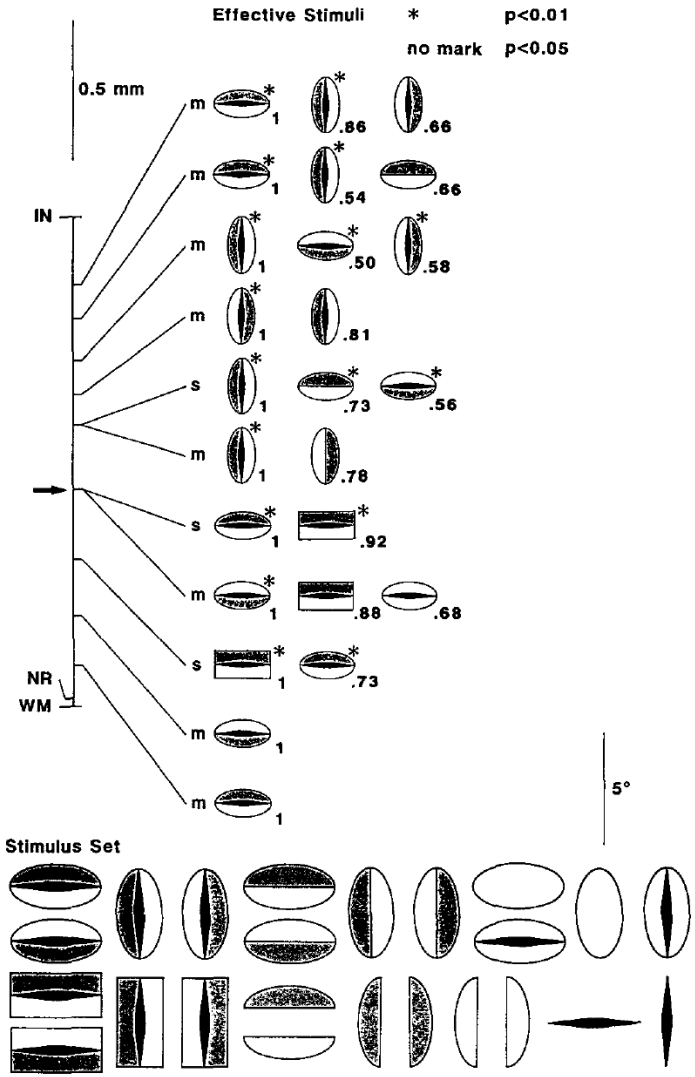


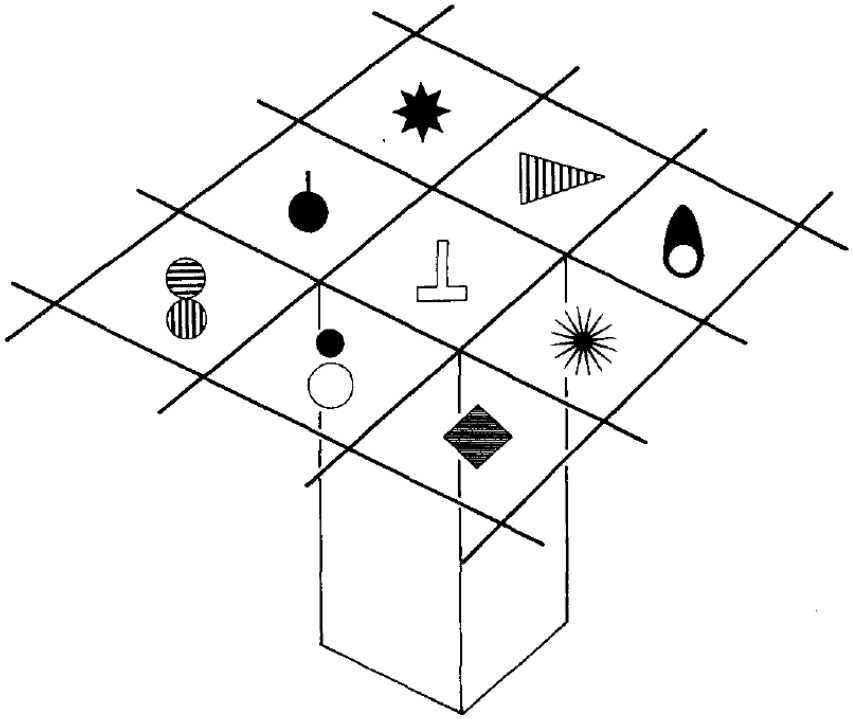


Exploring Spatial Locality



TE Columnar Organization

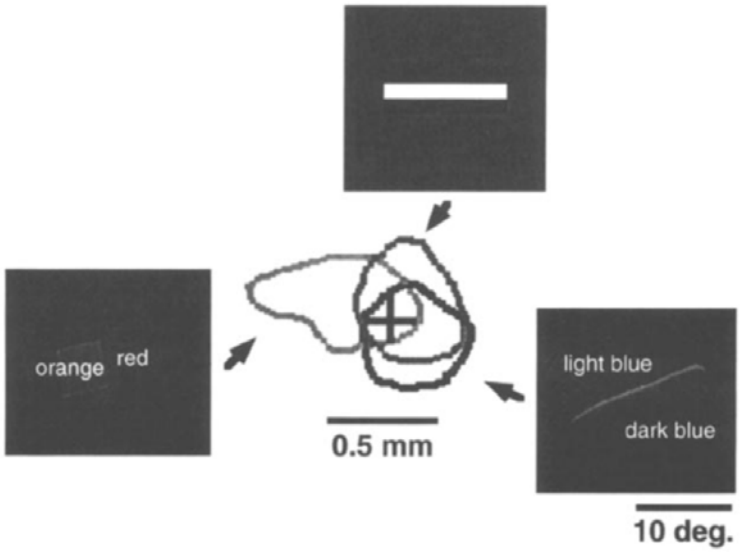


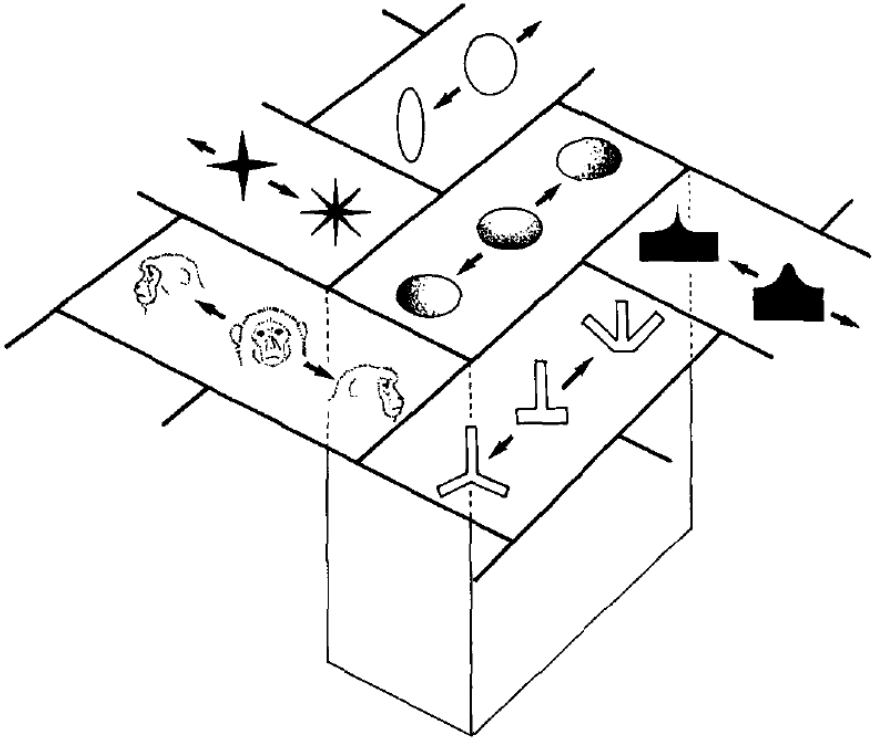


Projections to TE

- V4 and TEO selective for complex features → TEO pools project to 3-5 TE columns
- TE Pools multiple partial features and RFs → achieves position invariance

Columnar Organization Revisited

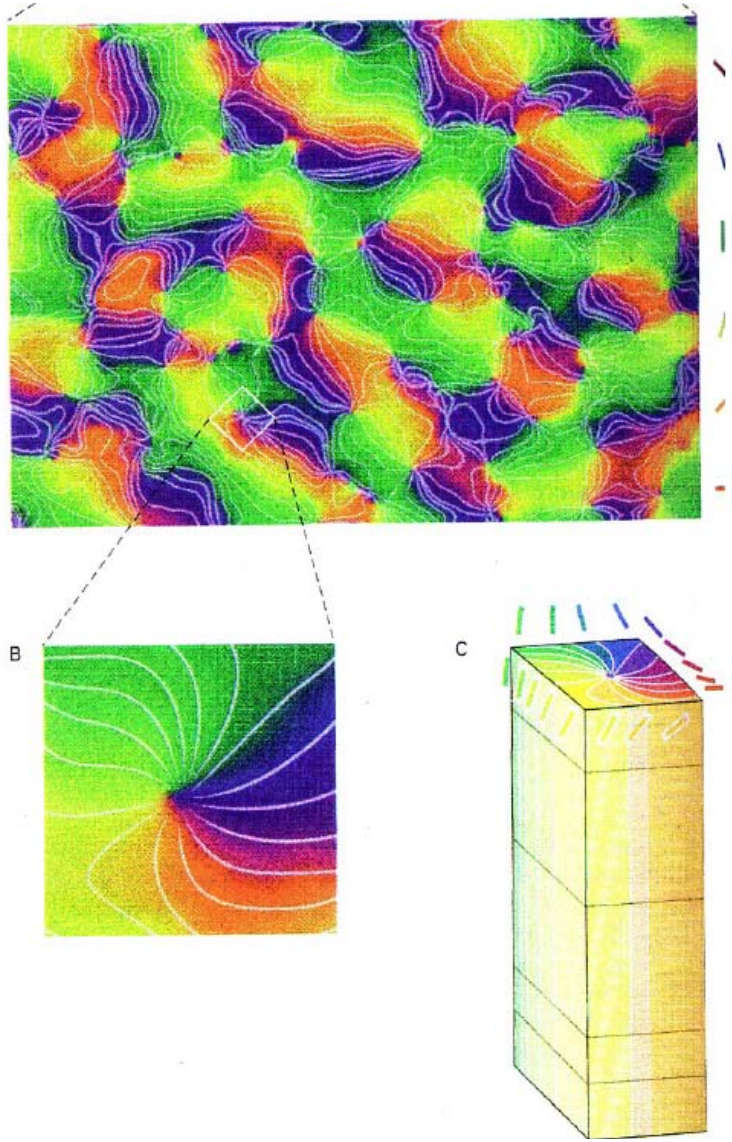




Overlapping activation spots in optical imaging

Continuous Mapping? Substrate for computations?

Alternative Pinwheel Organization



Functional Implications of TE Columns

- Distributed representation lends robustness and precision
- Hyperacuity by overlapping sensitivities
- Binding of multiple coactive columns?
  - Per-object synchrony
  - Attentional selection

TE projections to other areas

- STPa – social communication
- PFC – temporal behavior, decision making
- Amygdala – emotional content
- Perirhinal cortex – association
- IPS – 3d shape for tactile processing

Tanaka Summary

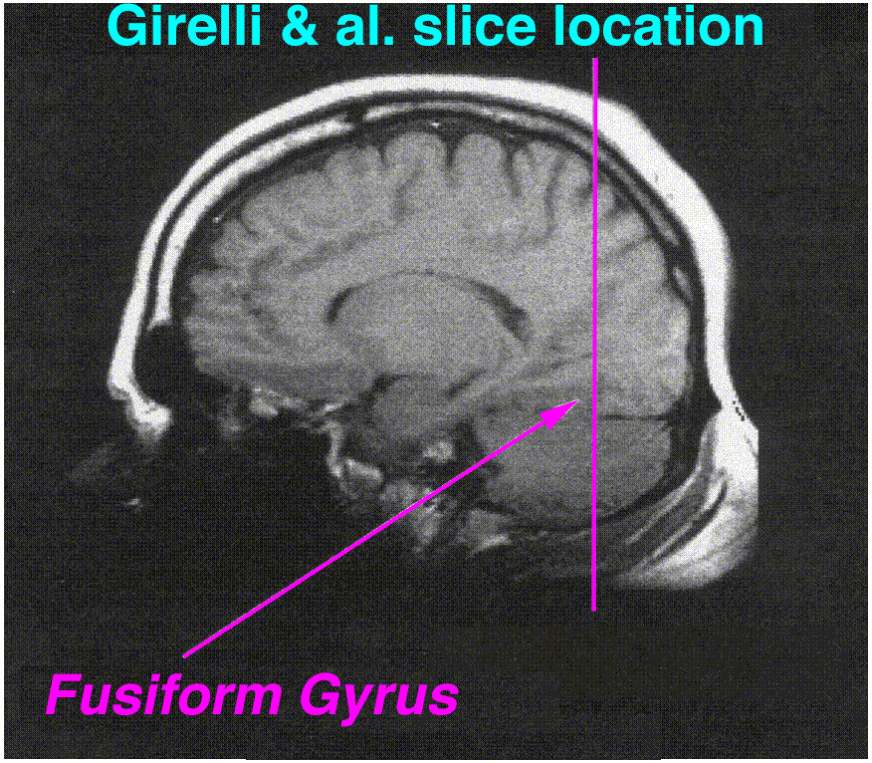
- TE achieves position invariance and columnar organization
- Two levels of population coding
  - Combinations of multiple columns
  - Multiple cells in column with overlapping sensitivity

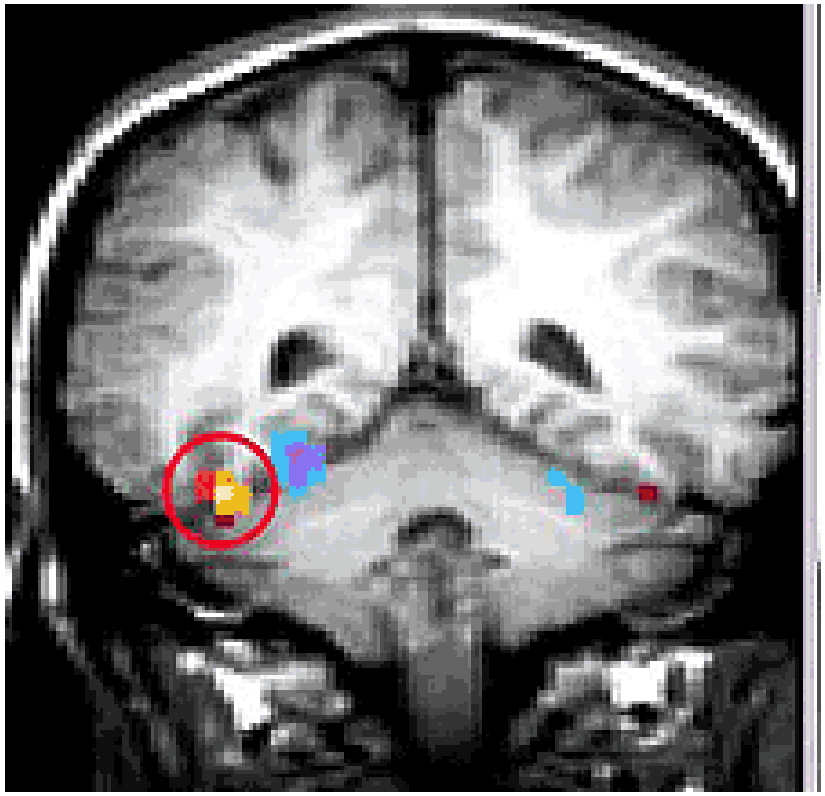
The Fusiform Face Area: A Module in Human Extrastriate Cortex Specialized for Face Perception

Nancy Kanwisher, Josh McDermott, Marvin M. Chun
Journal of Neuroscience, 1997.

Objective: Demonstrate that the fusiform face area is selectively activated by holistic processing of faces and thus represents a special face-processing vision pathway

Fusiform Face Area

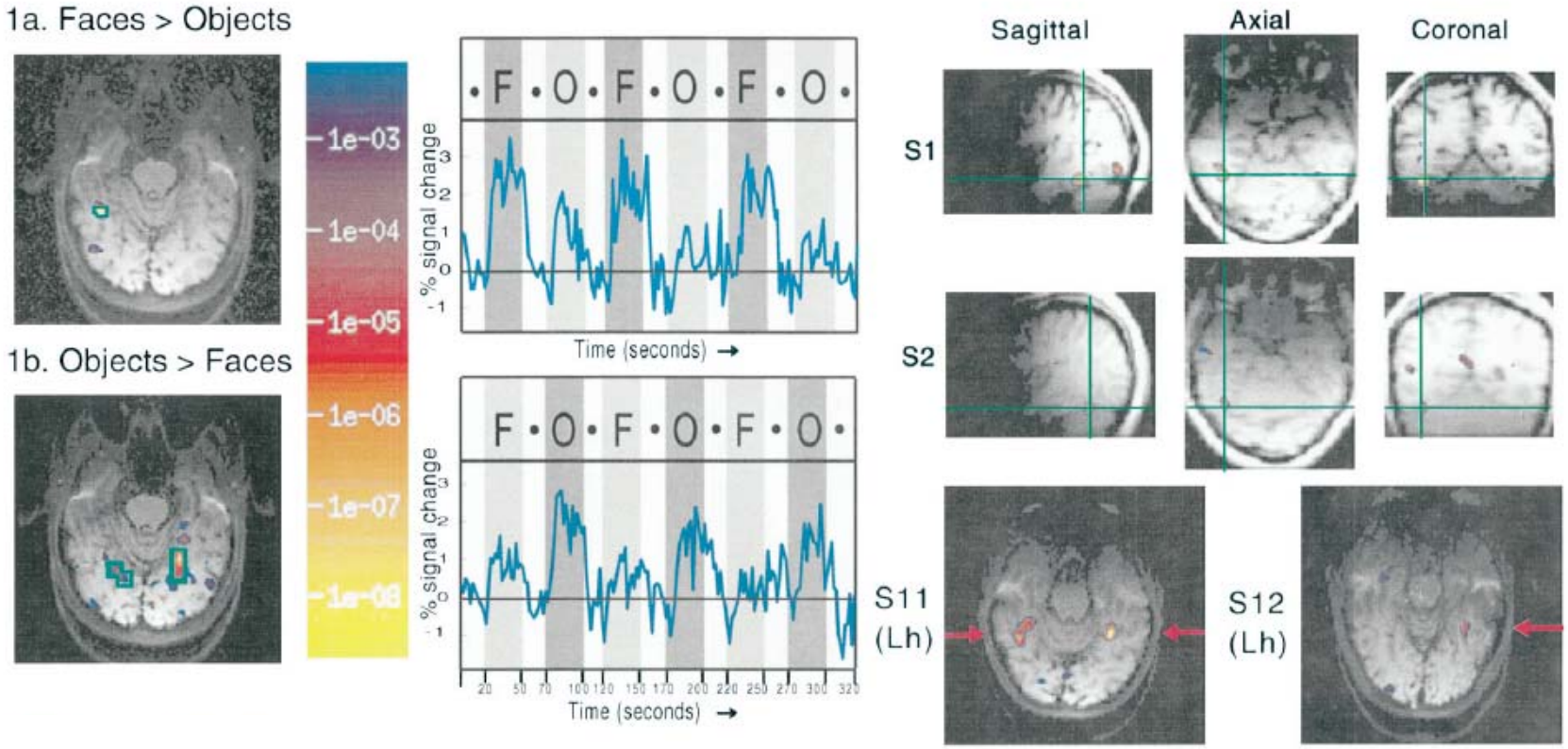




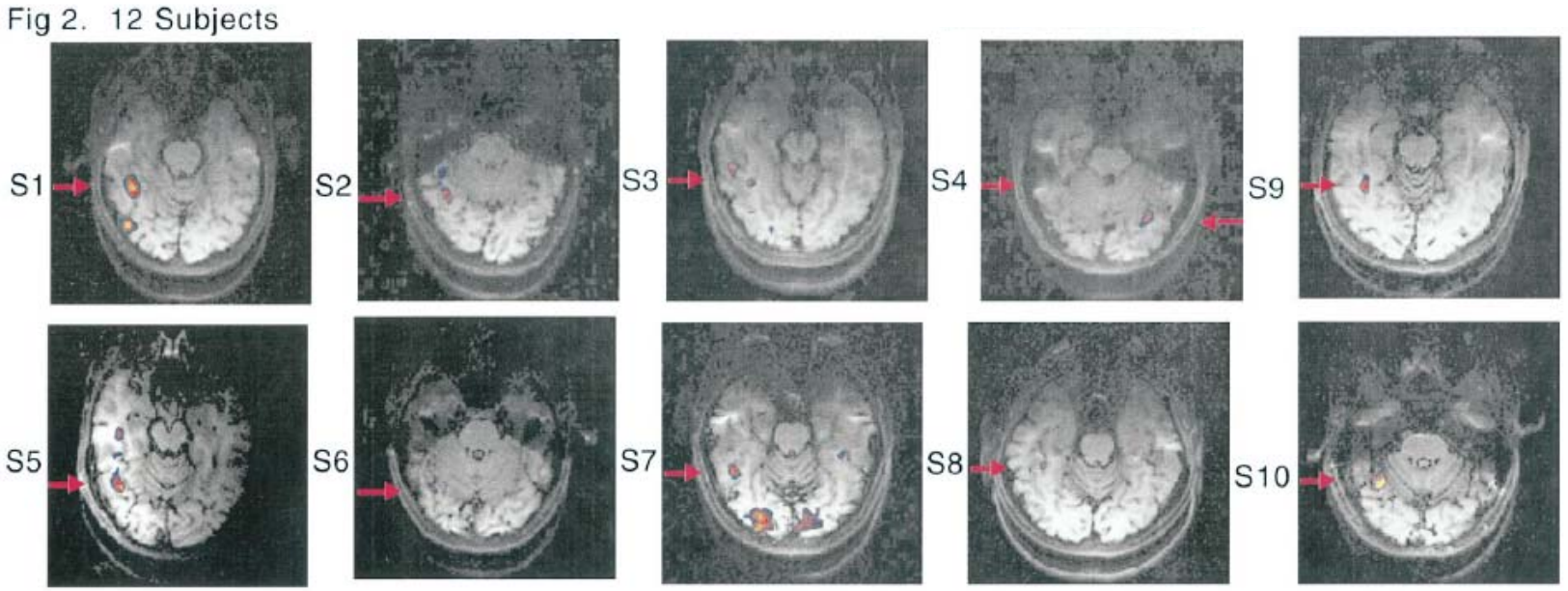
Part I

- Comparison: faces vs objects
- Purpose: find ROI that responds more strongly to faces than objects
- Results: Located FFA in right fusiform gyrus

Faces vs. Objects



Cross-Subject Consistency



Part IIa

- Comparison: B&W vs. Scrambled
- Purpose: Responding to low-level visual features present only in face stimuli

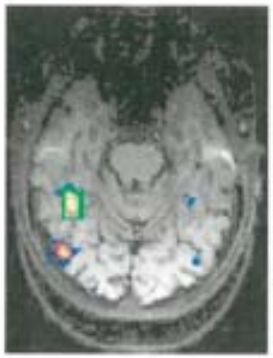
- Results: ROI from Part I responds more strongly to intact faces than scrambled faces (ratio = 3.2)

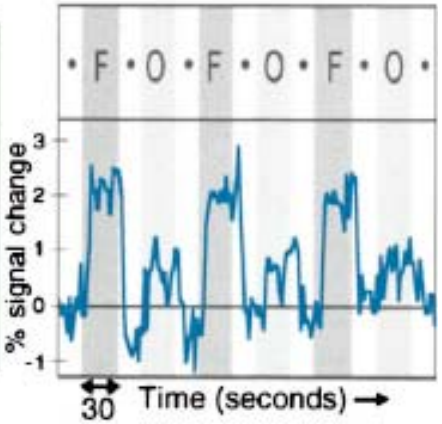
Part IIb

- Comparison: Faces vs. Houses
- Purpose: Distinguising between exemplars of single object category?

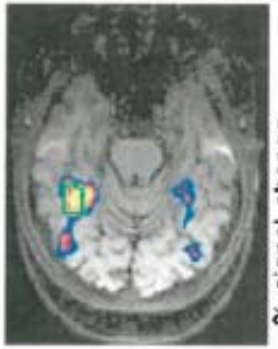
- Results: ROI from Part I responds more strongly to faces than houses (ratio = 6.6)

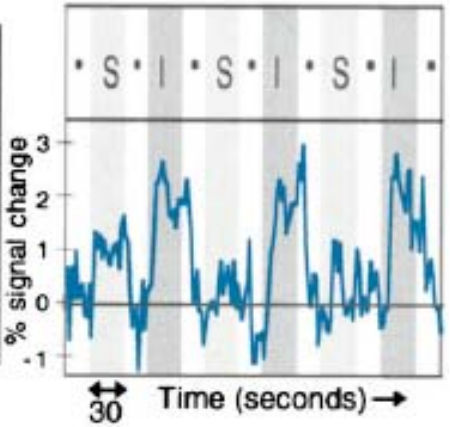
3a. Faces > Objects



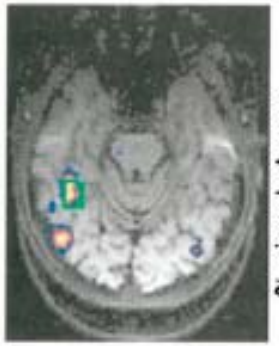


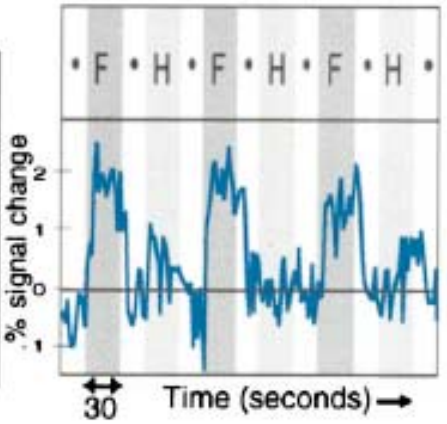
3b. Intact Faces > Scrambled Faces





3c. Faces > Houses

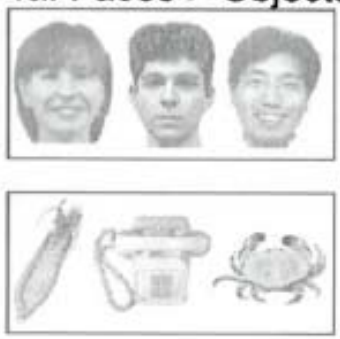


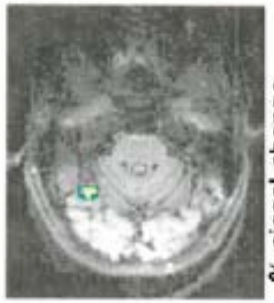


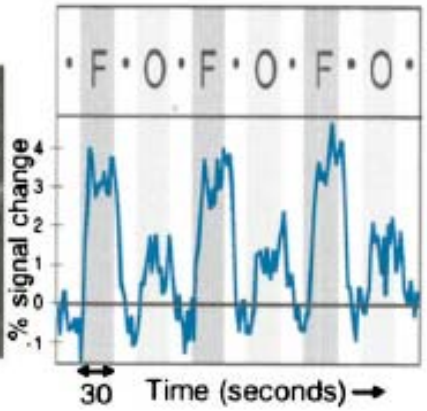
Part III

- Comparison: ¾ faces vs. hands
- Purpose:
  - Do responses generalize to different viewpoints?
  - Recognition on the basis of internal (versus external) features?
  - Faces versus body parts?
  - Effect of attentional load?
- Results: Stronger response to faces during passive viewing and 1-back memory task

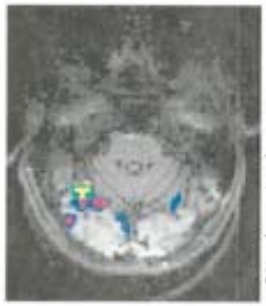
4a. Faces > Objects

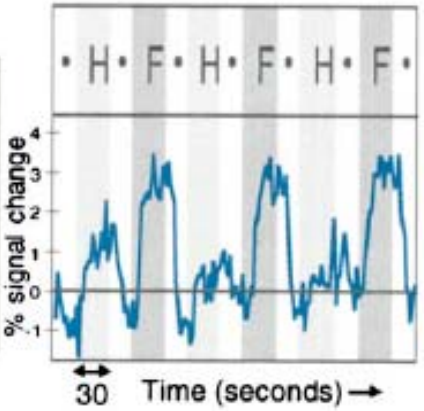




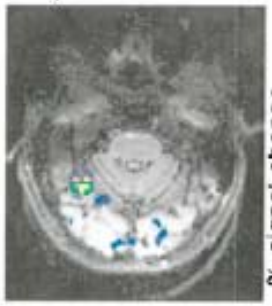


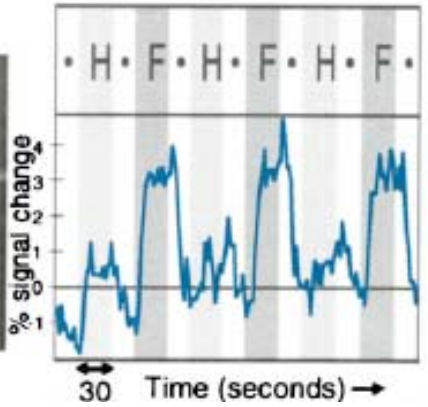
4b. 3/4 Faces > Hands





4c. 3/4 F > H (1-back)





Kanwisher Conclusion

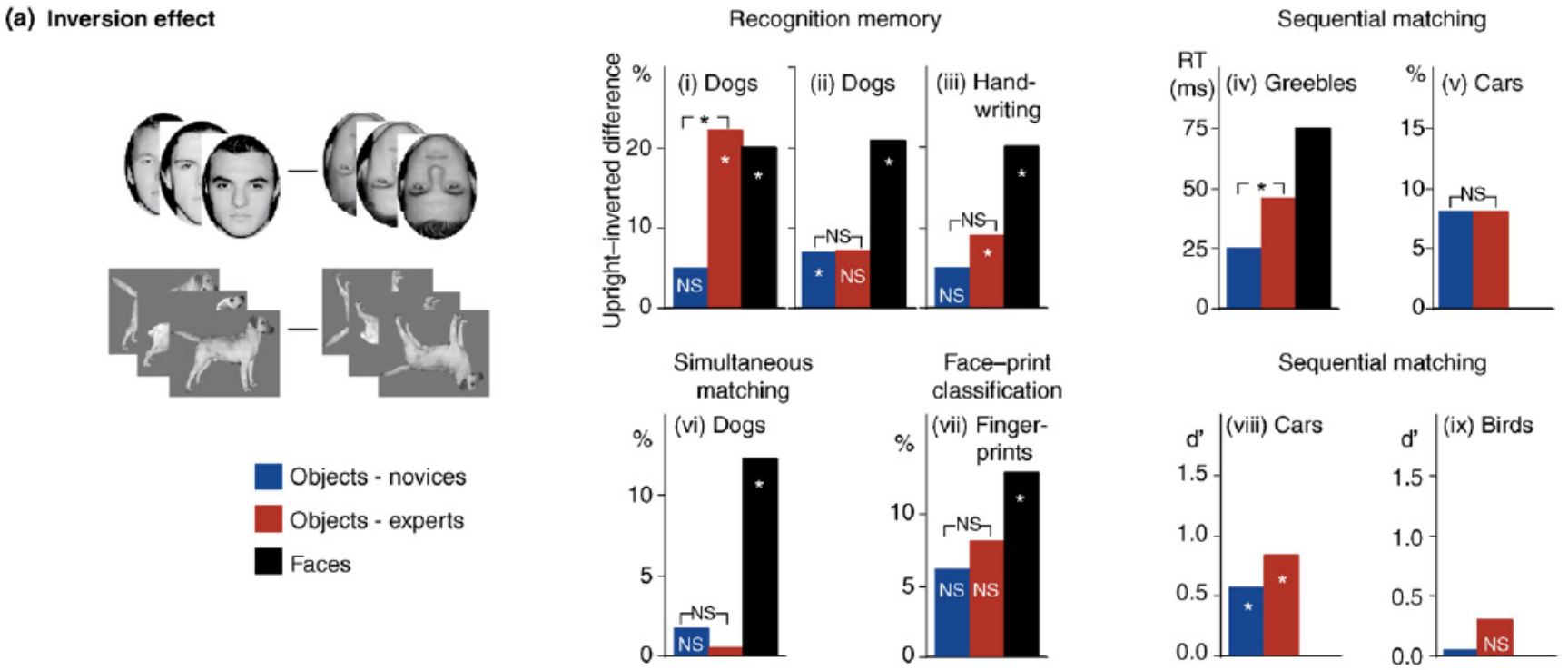
- FFA activation is reliably selective for faces within and across subjects
- FFA activation reflects a special processing pathway for holistic face processing
- No unified, overarching visual recognition processing scheme

Can generic expertise explain special processing for faces?

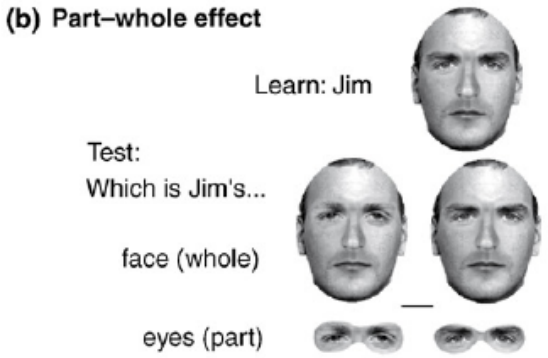
McKone, Kanwisher, and Duchaine
Trends in Cognitive Sciences, 2007.

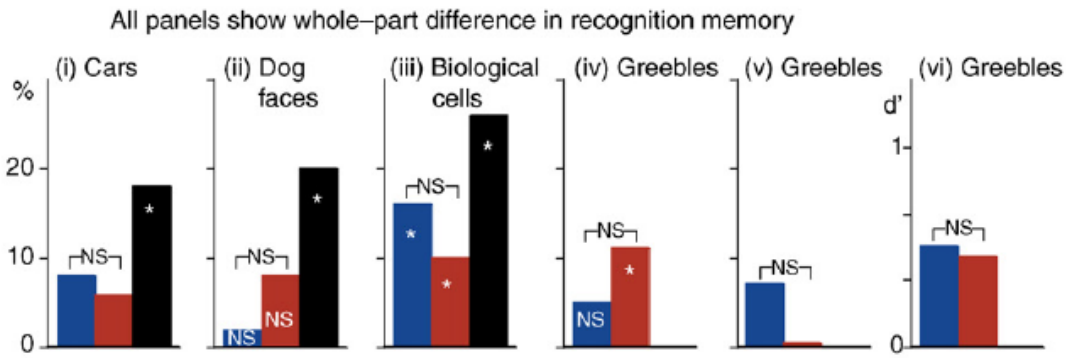
Objective: Address the claims of the expertise hypothesis, show that objects of expertise do not show the same holistic face-like processing patterns, and present a specialized model of face-processing

Inversion Effect

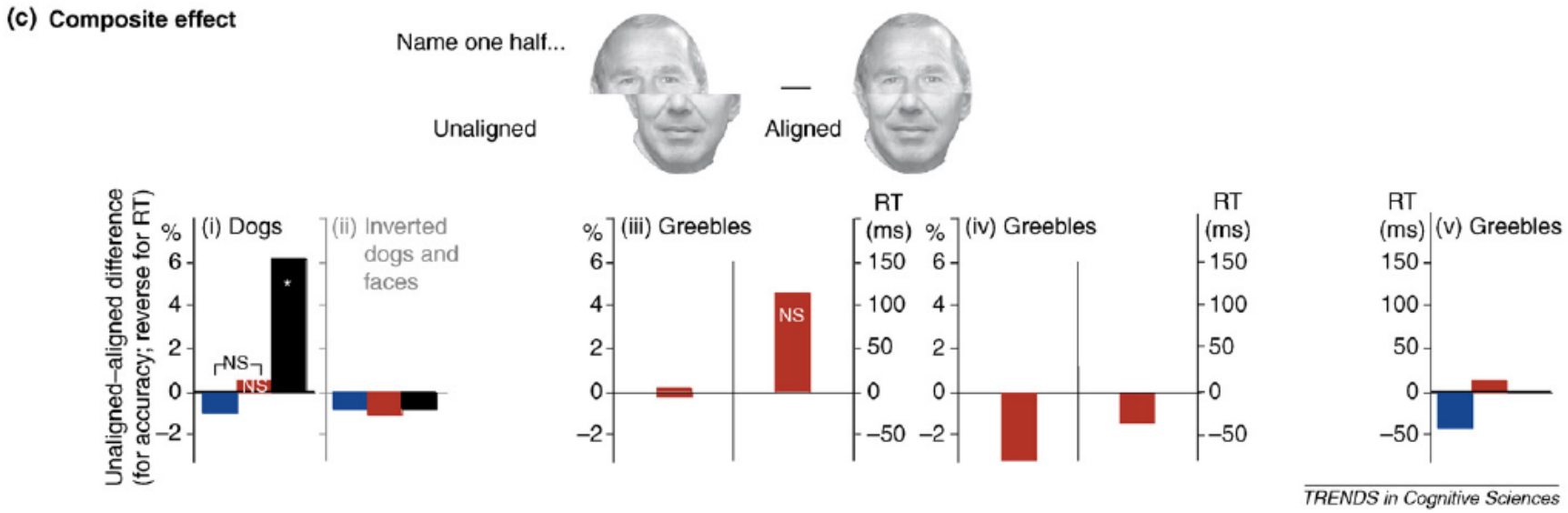


Part-whole Effect



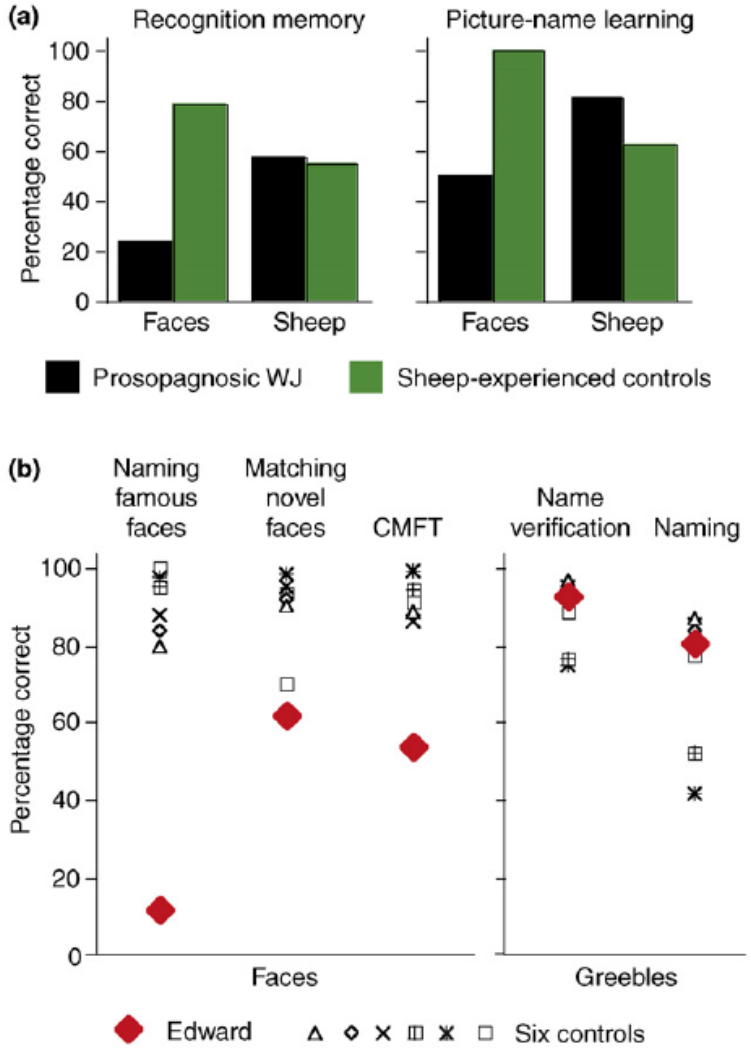


Composite Effect



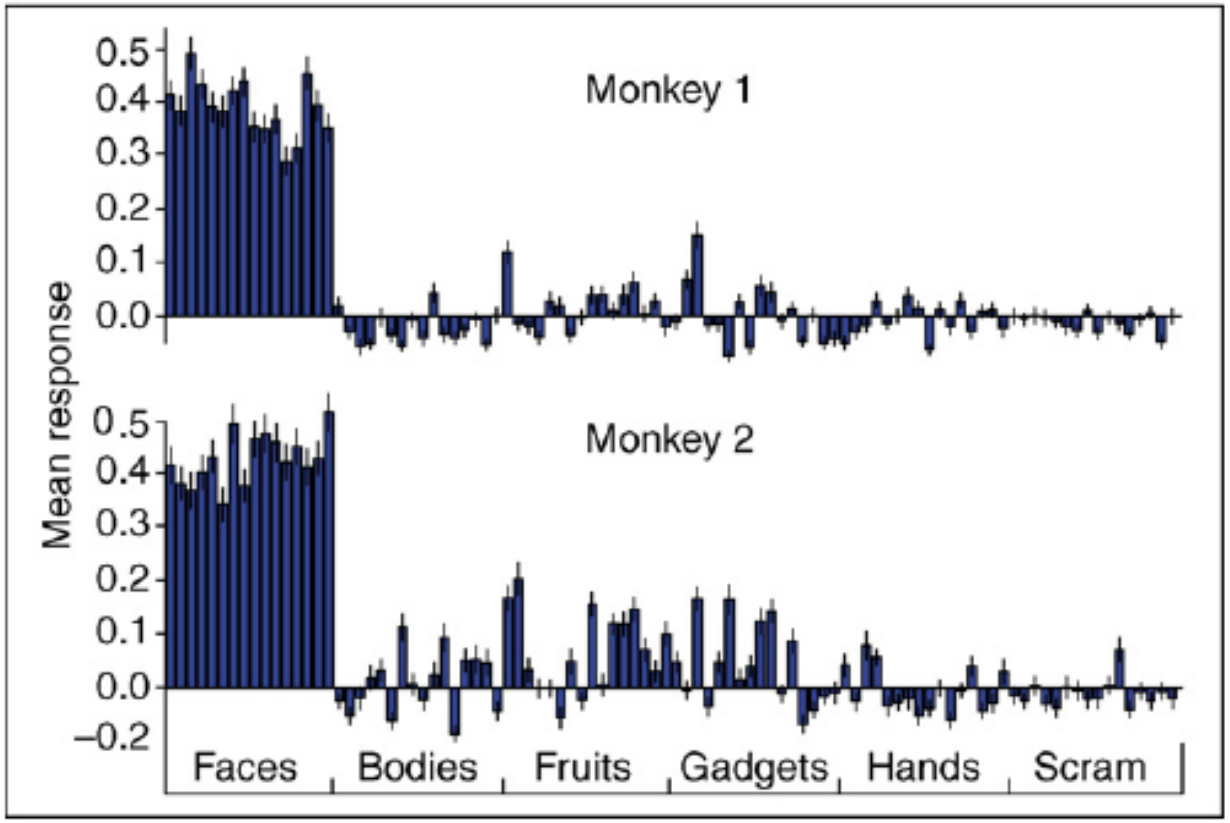
Prosopagnosia

- Prospagnosia and object agnosia are often dissociated
- Objects of expertise recognition performance dissociates from face performance as well



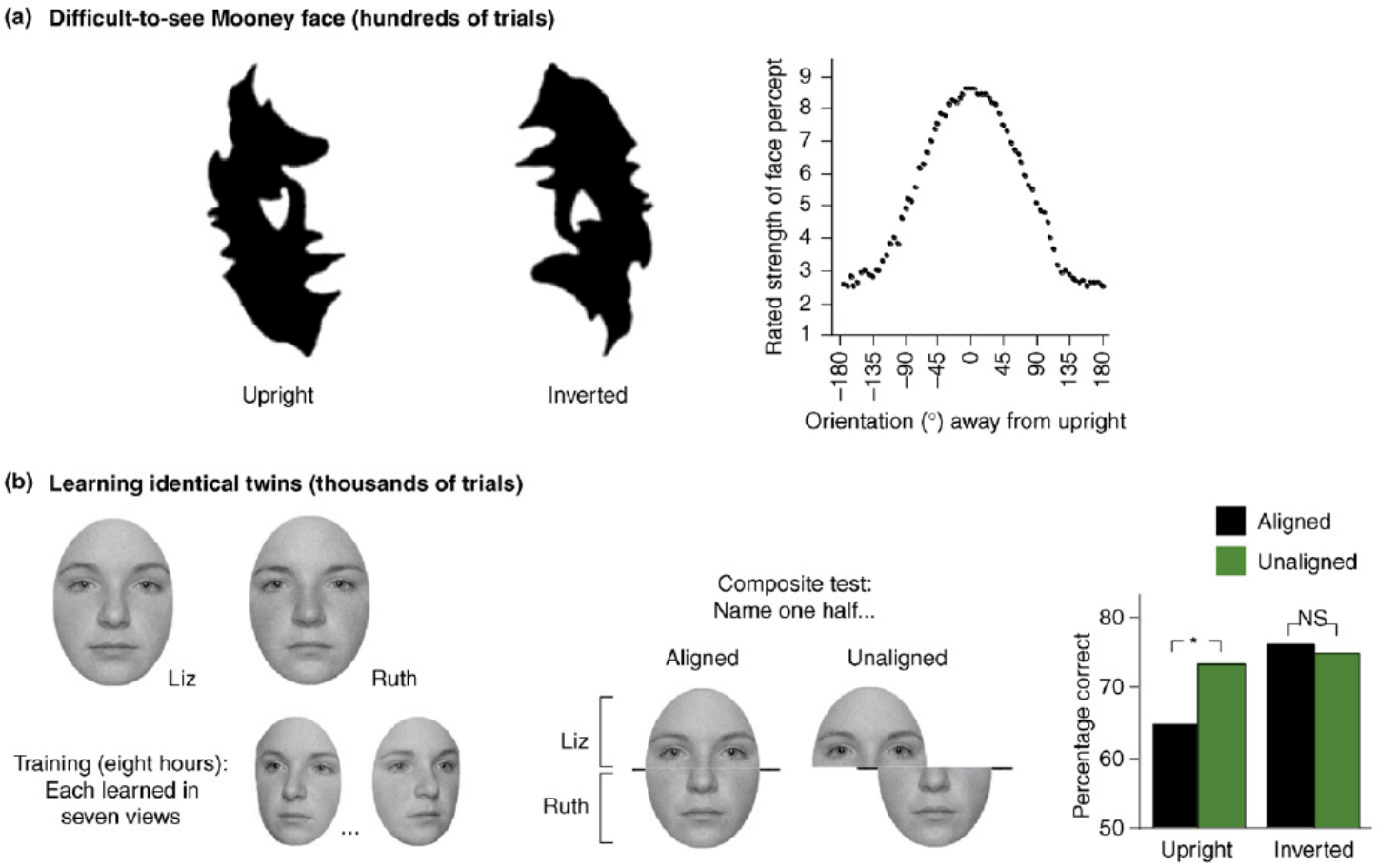
Single Unit Recording in Monkeys

97% of cells in middle face patch of macaque monkeys are highly selective for faces



Inverted Faces

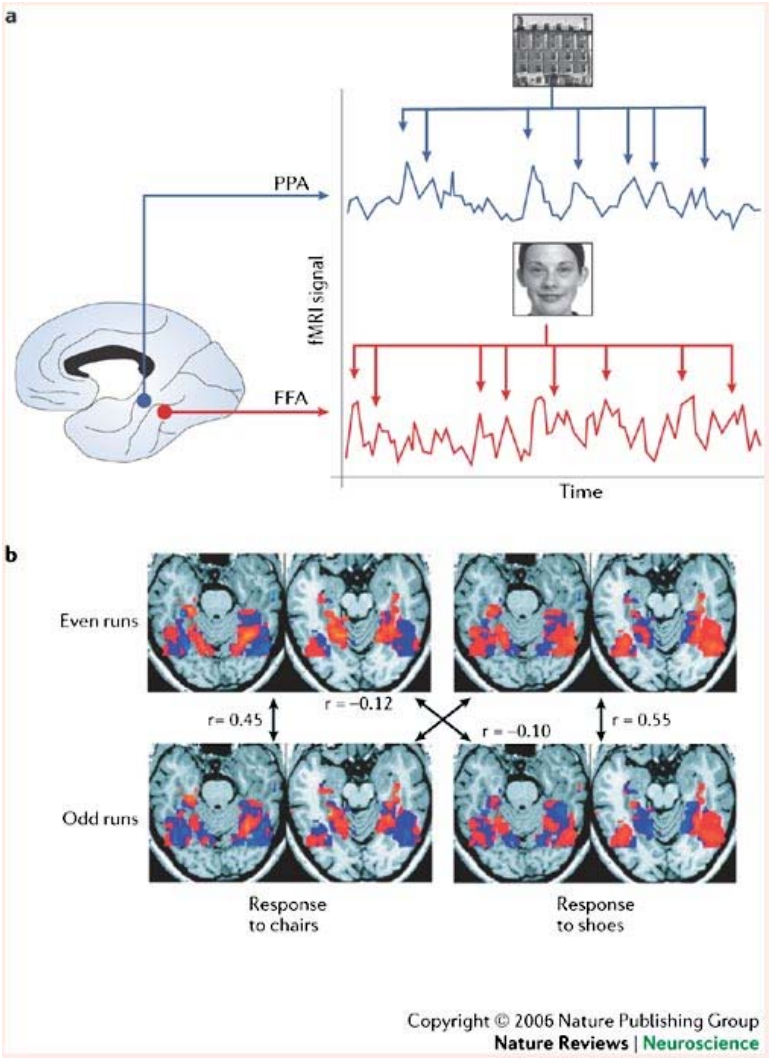
No holistic processing develops despite training



Parahippocampal Place Area

Decoding mental states from brain activity in humans

John-Dylan Haynes and Geraint Rees
Nature Reviews Neuroscience, 2006.



McKone Conclusion

- Many studies have found that objects of expertise do not invoke the same pathways or display the same behaviors as faces
- Face processing reflects either an innate template which guides recognition or a different type of expertise with an early critical period

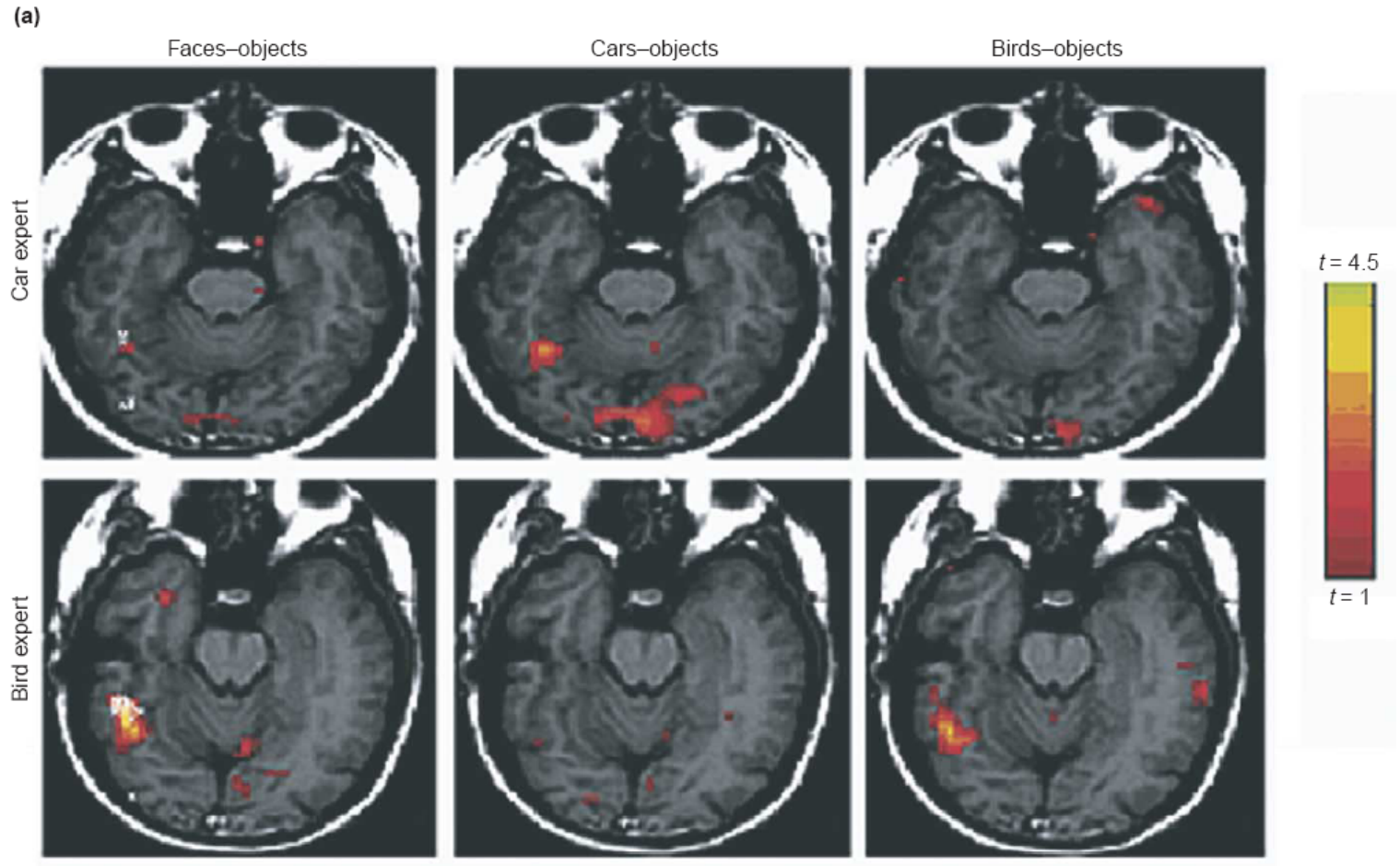
Beyond faces and modularity: the power of an expertise framework

Bukach, Gauthier, and Tarr

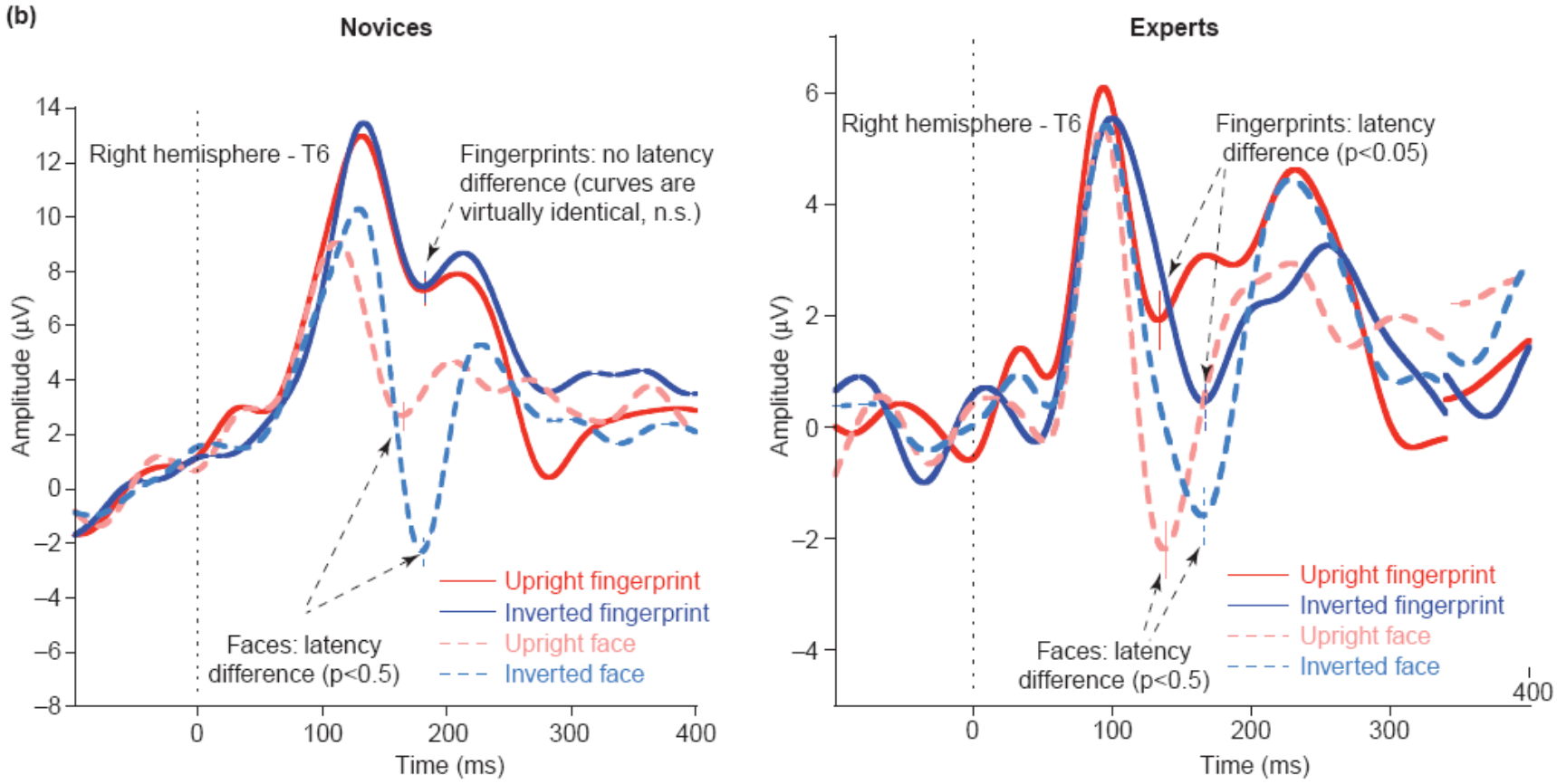
Trends in Cognitive Sciences, 2006.

Objective: Discuss the value of an expertise framework independently of the domain-specific vs. domain-general debate concerning face recognition.

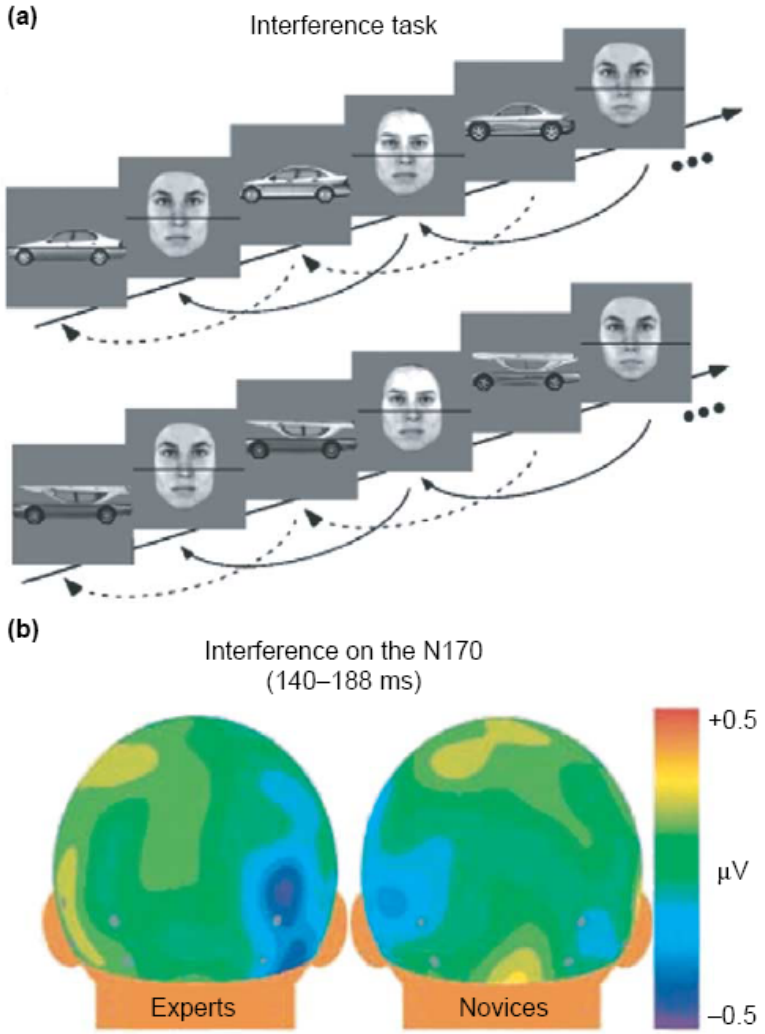
Expertise effects outside FFA



Event related potentials: N170



Dual-task Interference



Bukach Conclusion

- Expertise framework has implications outside of the FFA debate
- Properties and interactions of expertise worth studying

Box 3. Questions for future research

- How long-lasting are the effects of expertise training?
- What is the role of decisional processes in expertise?
- What is the role of attention in expertise?
- How does feature saliency change with expertise?
- Can we create feature-based expertise, and how will it differ from holistic expertise?
- What role do semantic features play in perceptual expertise?
- How does expertise for different modalities (visual, auditory, tactile) differ? In what ways are they the same?
- How does expertise affect working memory capacity?
- Can we dissociate FFA activity related to detection from FFA activity related to identification?
- How do interactions between the amygdala and the FFA influence the acquisition of expertise?
- Are there special populations that can benefit from face training?
- How does the age at which expertise is acquired influence its development and potential neural instantiation?
- What neural mechanisms are at work during the acquisition and preservation of expertise? Are there changes in connectivity? If so, at what scale?