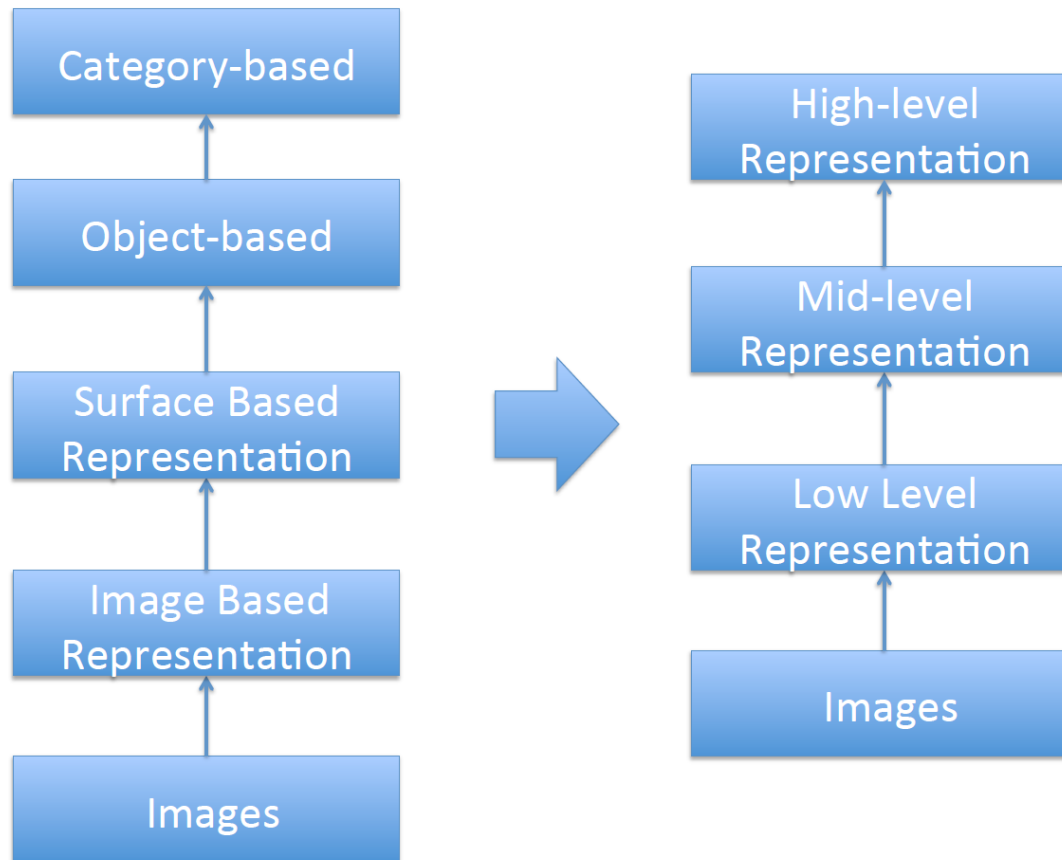


Information Processing: Top-Down vs. Bottom-Up

Ishan Misra, Wentao Liu

So far: bottom up processing



What have we seen in class

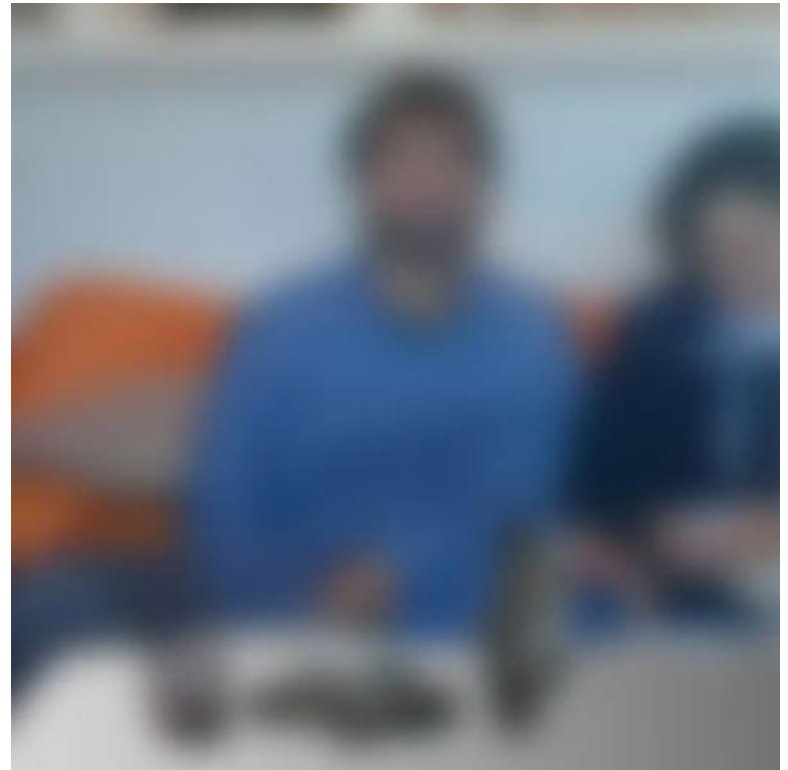
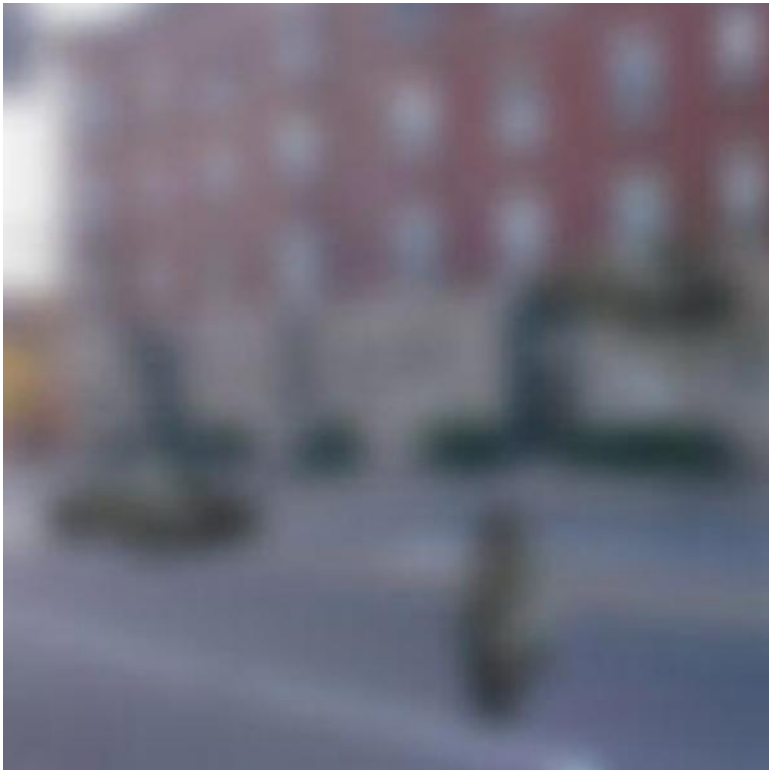
Specialized regions for tasks

- PPA for “open vs. closed” scenes
- Left/Right Medial Fusiform gyrus - “tools”
- Lateral Occipital Complex (LOC) - objects
- Retrosplenial complex (RSC) - layout

Does this mean no top-down?

- Specific regions handle specific information
- Seems to be an entirely feed-forward process?
- Dorsal and ventral streams seem to move only in one direction

But humans use top down



Multiple personalities of a blob - Antonio Torralba

But humans use top down



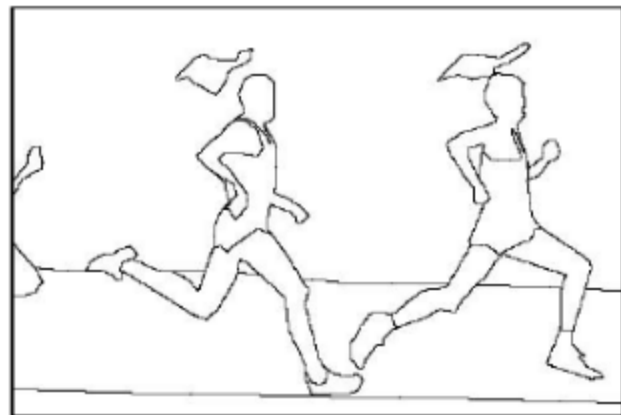
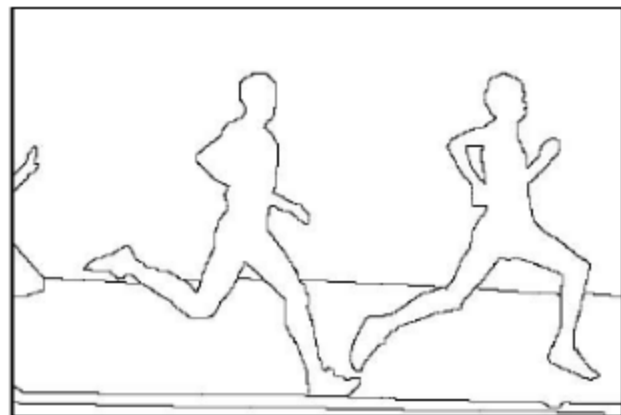
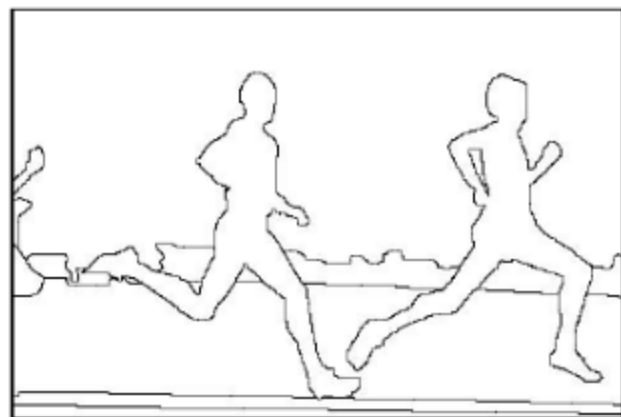
Examples from vision

Top Down vs. Bottom up in vision

Image Segmentation

Bottom up - pixel based

Top down - transfer mask to detections



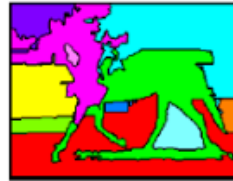
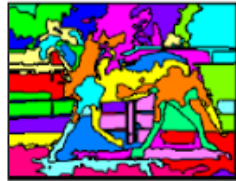


Input



(a)

Bottom-up



(b)

Top-down



(c)

From the Blog

David



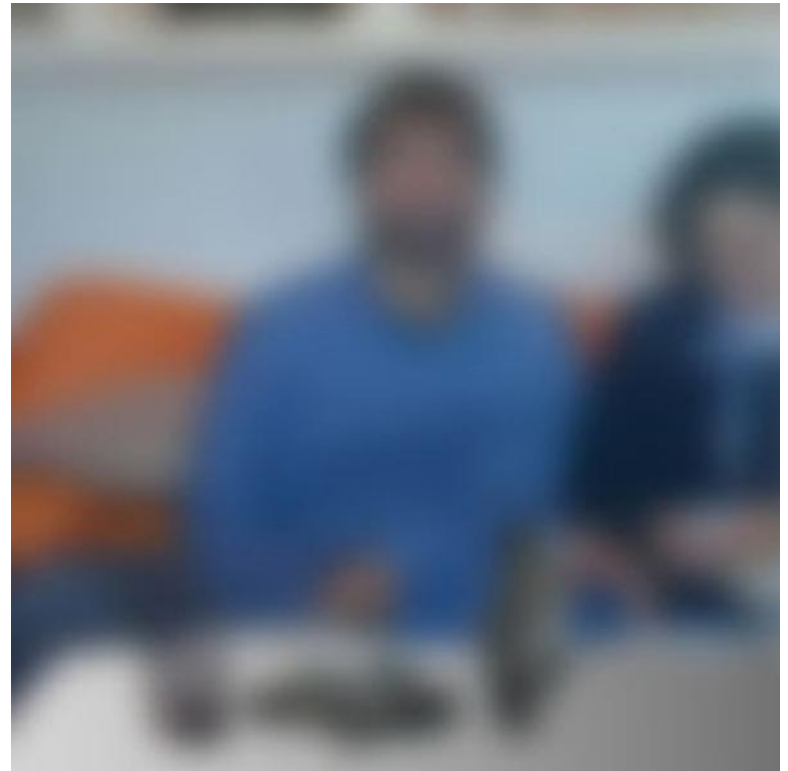
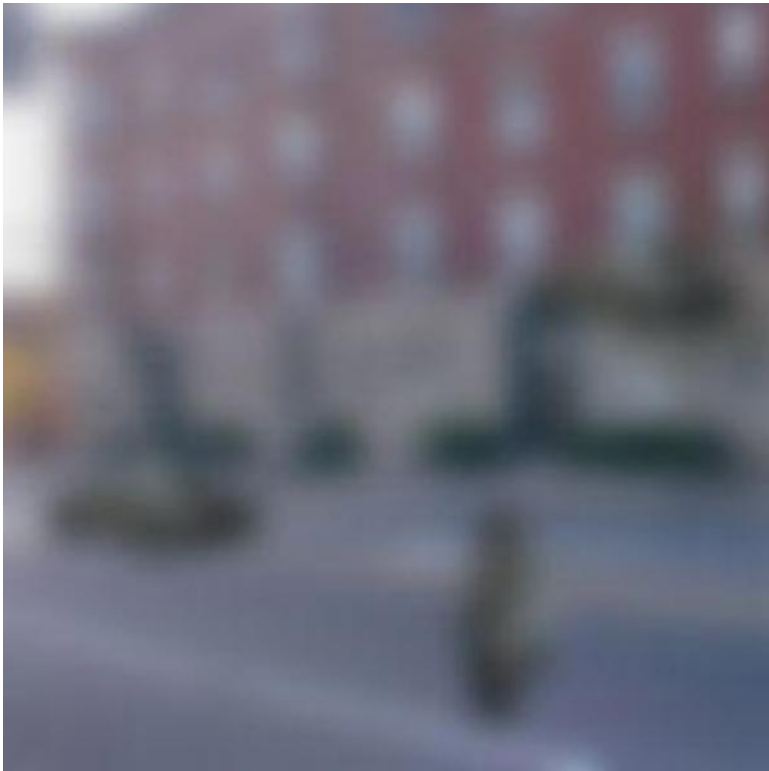
- Other examples of top-down in vision
 - single view geometry



Images from Hoiem et al., ICCV 2005; Hedau et al., ICCV 2009

How can we use top-down?

Context



Multiple personalities of a blob - Antonio Torralba

From the Blog



Aayush & Krishna

- What are some other ways of modeling context?
 - Exemplars seem too specific

How can we model contextual
associations?

Representation for context

Associate objects with

- Categories
- Prototypes
- Exemplars

What are categories?

1. Categories are defined by a list of properties shared by all elements in a category
2. Category membership is binary
3. Every member in the category is equal

Why we need categories



Associations

Ask not what it is but what it is like

- Moshe Bar

Associations

Categories make as much sense as a potato and vodka detector

- Smith hall folks quoting Alyosha Efros



Prototype theory

Proposed by Eleanor Rosch in 1978

- Single exemplar selected as prototype
 - May be real exemplar, or combination of features from different exemplars
- Membership in category determined by similarity to prototype
- Higher similarity = better member of category
- A category defined by a prototype will have graded membership and a fuzzy boundary.

Exemplar Theory

Proposed by [Medin, Schaffer '78] and [Nosofsky '86]

- Rejects notion of category - fuzzy or not
- Says that humans learn by associations to “exemplars” of a “category”
- Unknown object is compared against ALL known exemplars
- No hierarchy

Exemplars vs. Prototypes

Any thoughts?

Exemplars vs. Prototypes



Exemplars



Prototype - think visual subcategories

Images from NEIL (American Rambler)

Torralba's Context Challenge



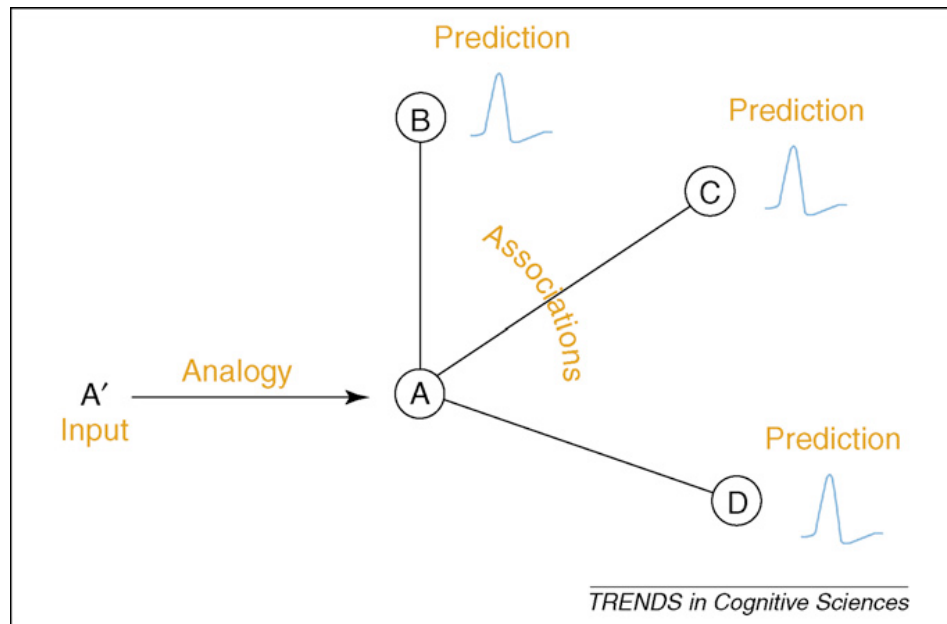
**Any neuroscience
theories?**

The proactive brain: using analogies and associations to generate predictions

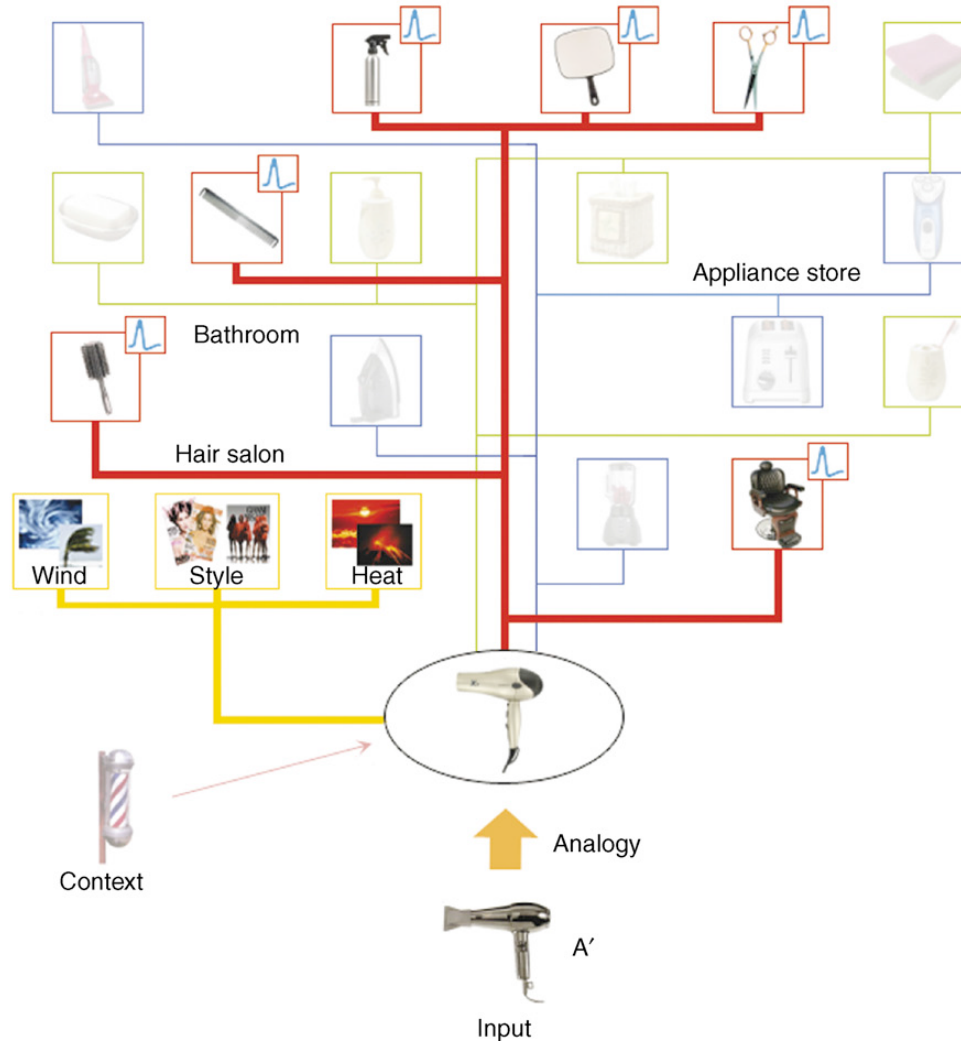
Bar, M. (2007)

General framework for predictions

- Experience (Input)
- Analogy with existing memories
- Associations generate predictions

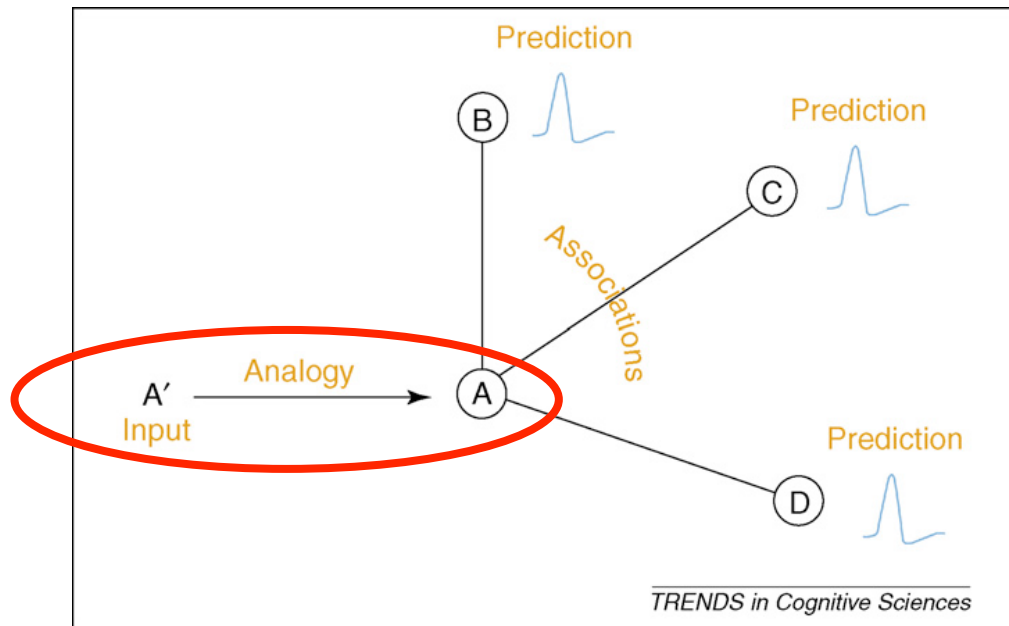


Example: Hair dryer



General framework for predictions

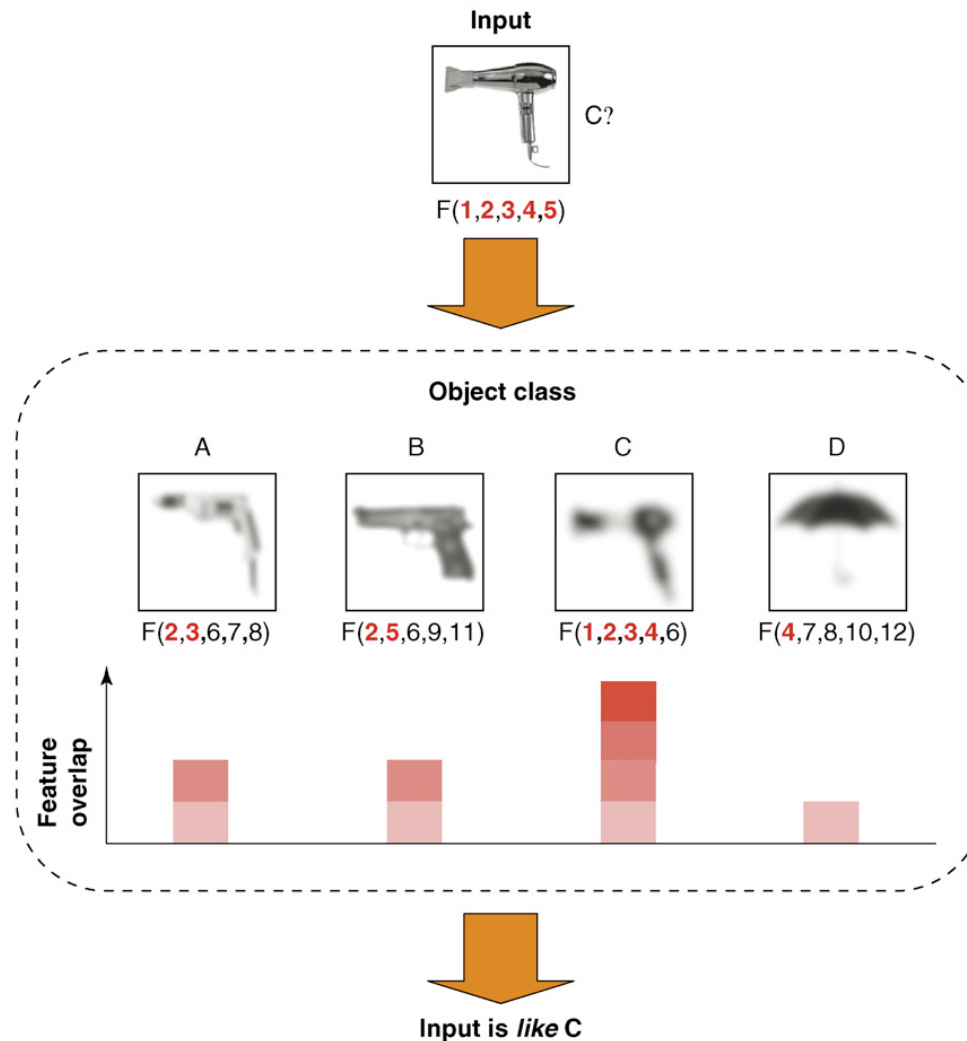
- Experience (Input)
- Analogy with existing memories
- Associations generate predictions



Analogy: not just recognition

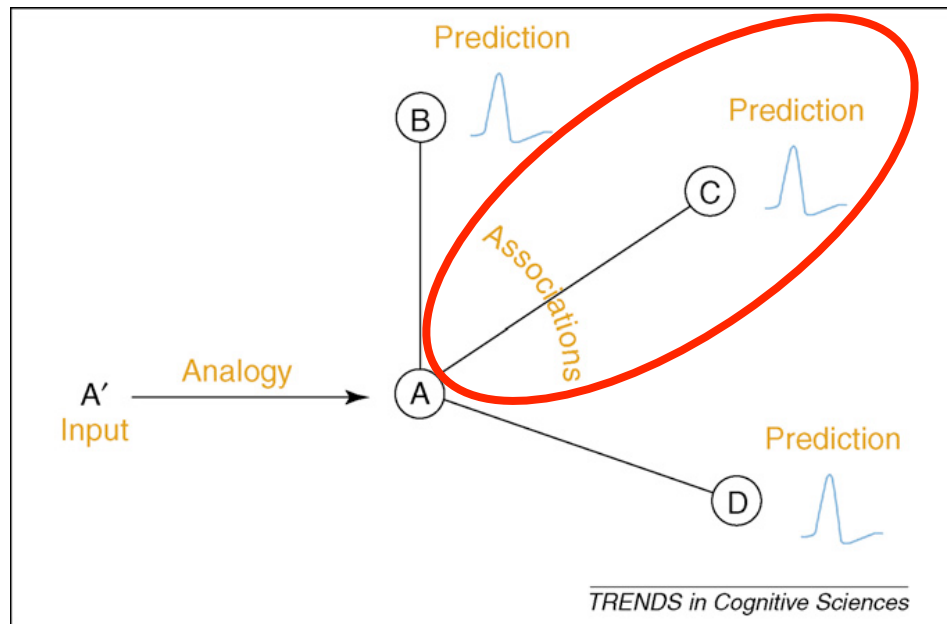
- For projecting attributes and generating predictions
- Complex mapping
- Based on context

Proposed mechanism for Analogy



General framework for predictions

- Experience (Input)
- Analogy with existing memories
- Associations generate predictions

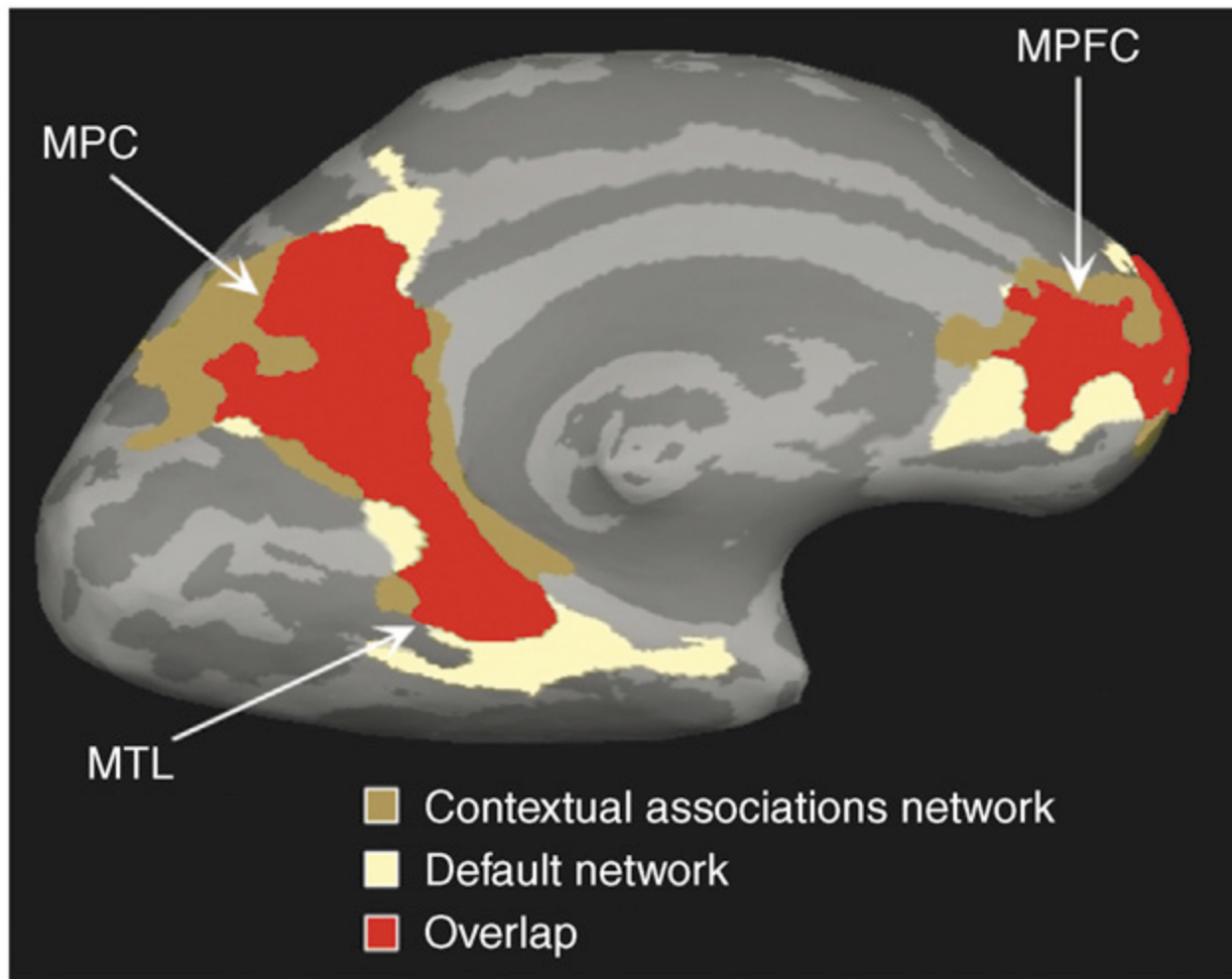


Associations and Predictions

- We are doing this all the time!

Evidence:

- Activations when not engaged in task
(‘default network’)
overlaps with:
- Activations when performing associative task



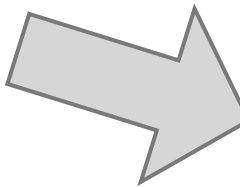
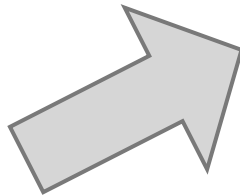
More evidence

- Bidirectional cortical communication
 - Feedback projections might exceed feedforward connections
- Associations: in various regions
- Analogies: in lateral and medial PFC
- Predictions: preparatory activation

Detecting Errors in predictions

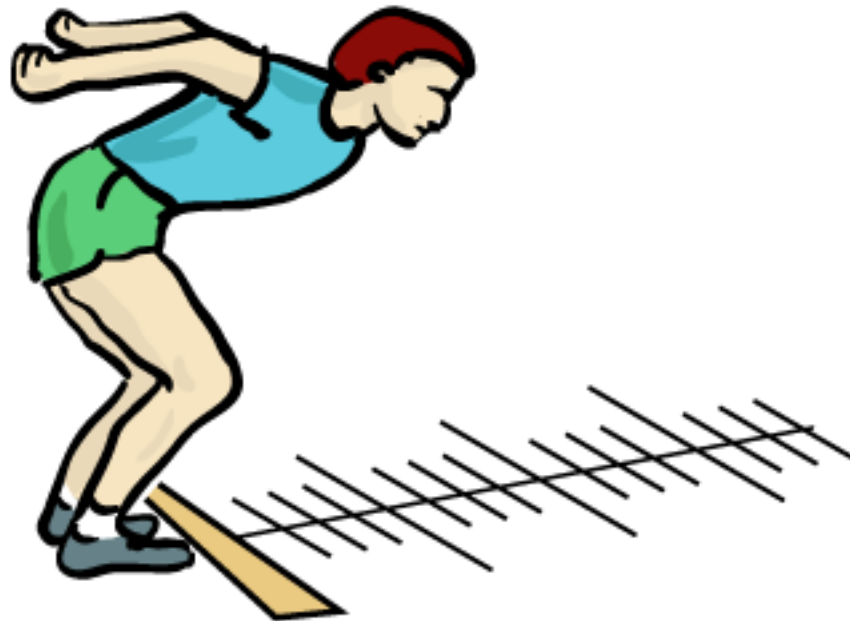
- Detect and learn from regularities in the environment
- Internal generalizations are updated to improve future predictions

Changing predictions



Applying predictions

- Static photographs that implies motion cause motion processing areas to be activated



Neural mechanisms

- For vision: low spatial frequency top-down feedback (in assigned paper)
- Bayesian analysis

Break time

Break time

- David, Allie, Anirudh, Aaron, Yuxiong, Aravindh
 - If time were not an issue, where is top-down useful?

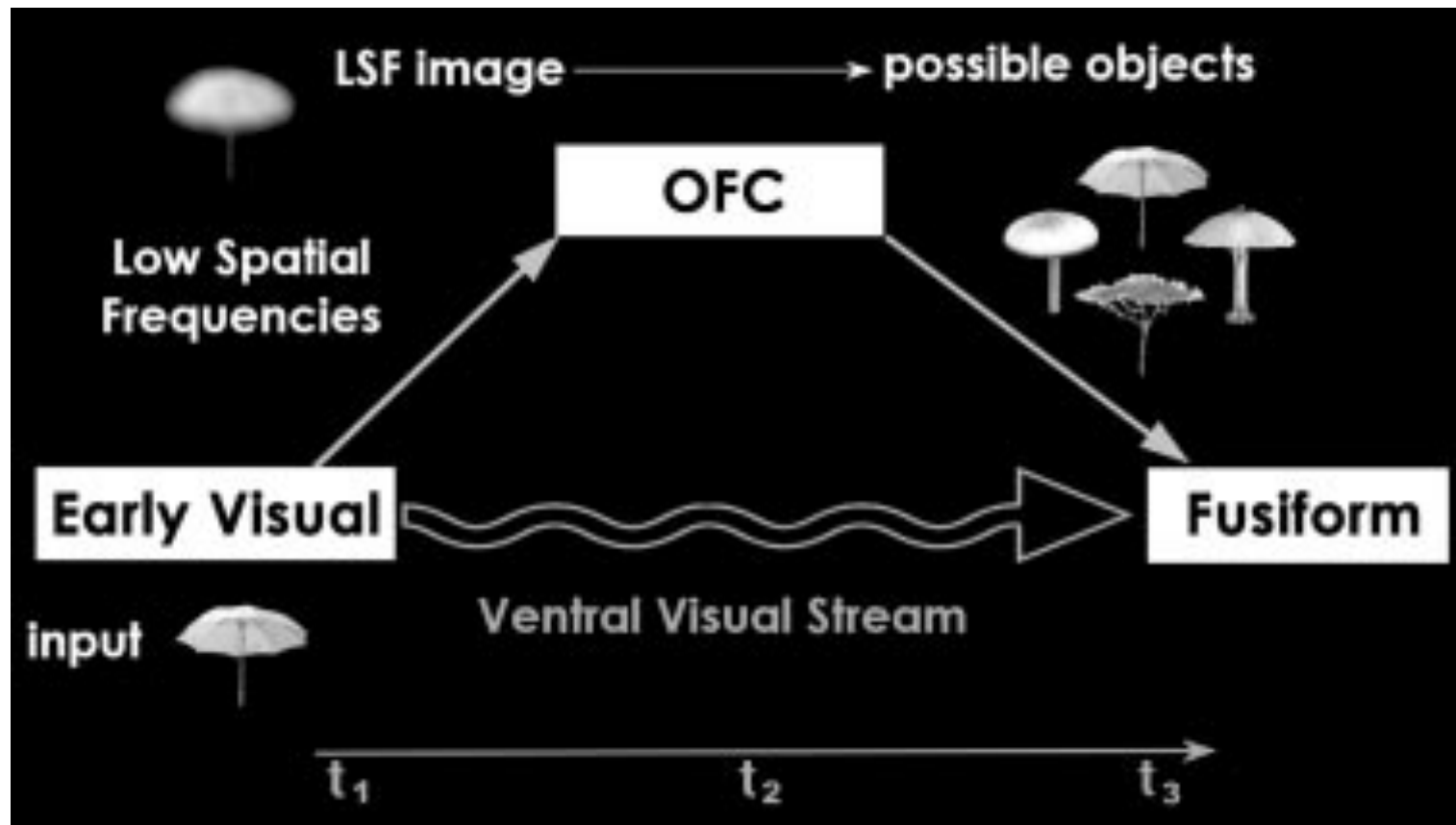


**Any neuroscience
evidence?**

Top-down facilitation of visual recognition

Bar, M et al. (2006)

Bar's proposed model



If this model is correct, then...

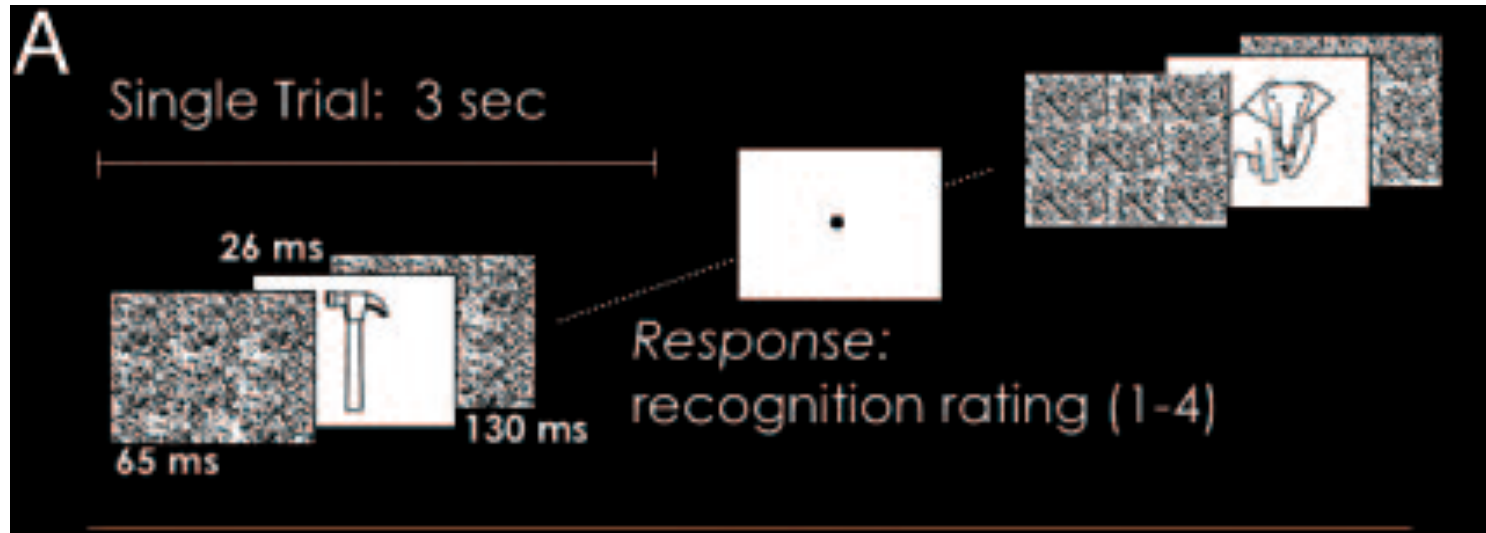
1. Then there must be activation in OFC when visual stimuli is viewed
2. This activation in OFC must occur before the object is recognized
3. LSF information in image is necessary for top-down

If this model is correct, then...

1. There must be activation in OFC when visual stimuli is viewed
2. This activation in OFC must occur before the object is recognized
3. LSF information in image is necessary for top-down

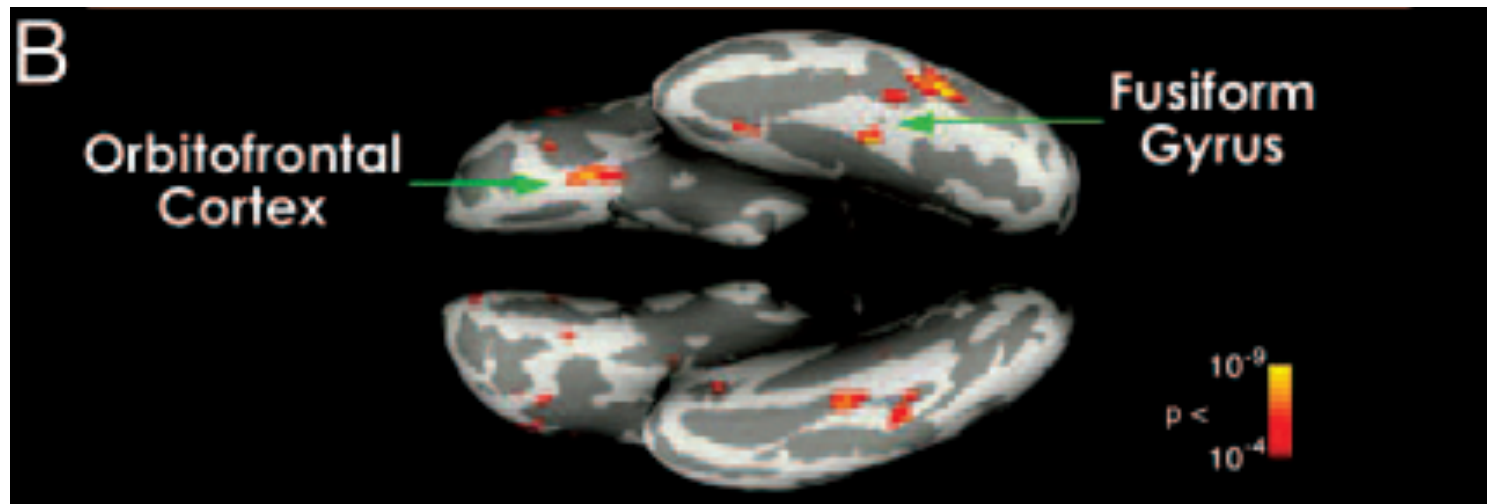
Experiment 1

- Mask → Object → Mask

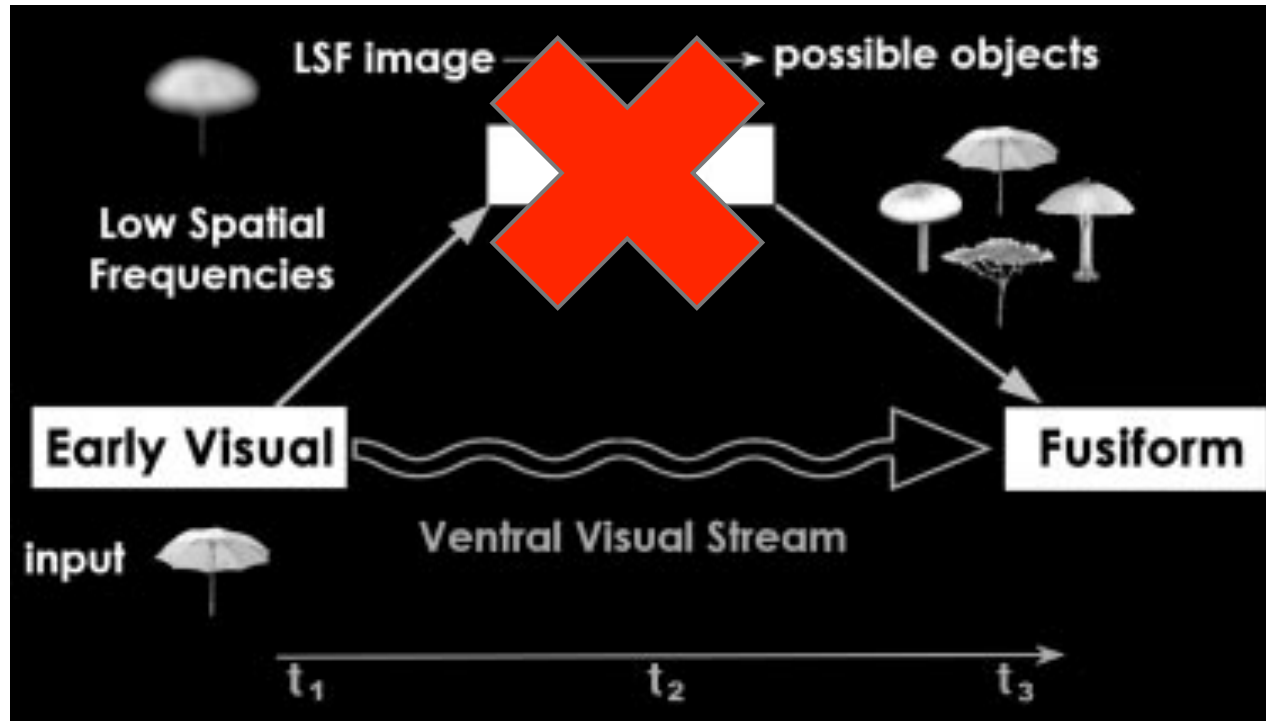


Experiment 1

- Differential activation in orbitofrontal cortex(OFC)



But what if OFC activation is just post processing?



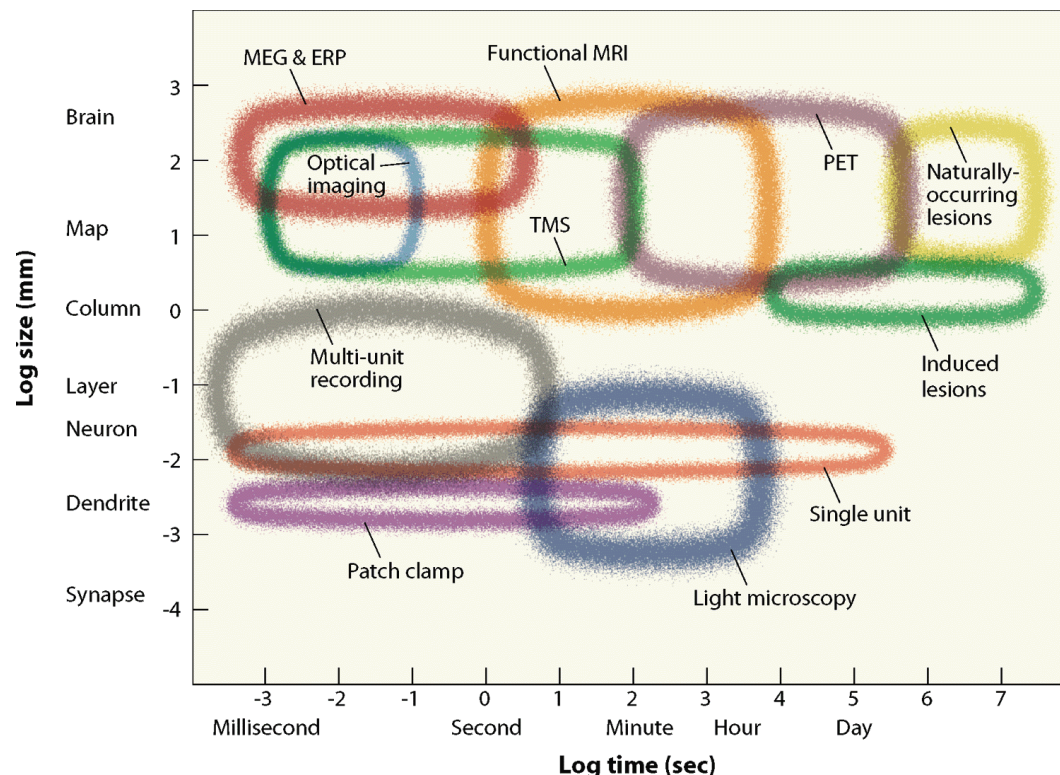
→ OFC

If this model is correct, then...

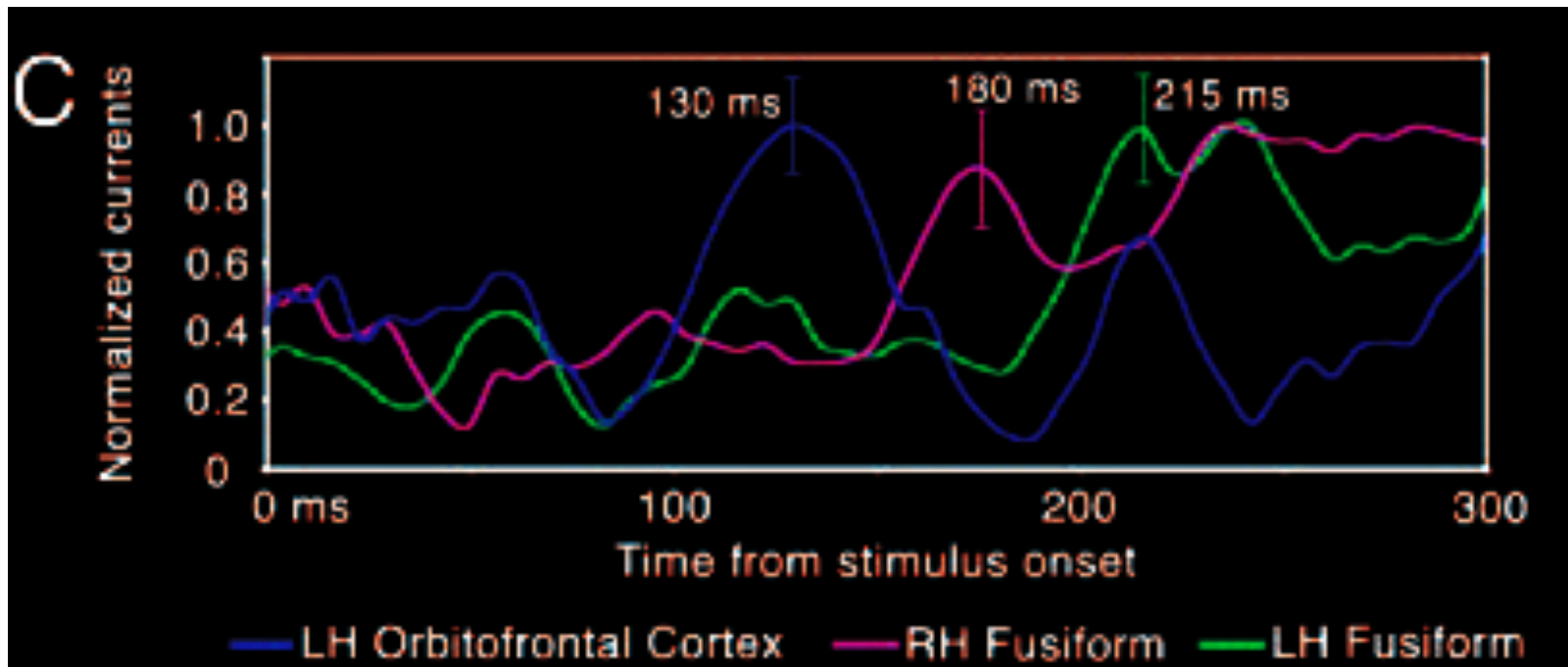
1. Then there must be activation in OFC when visual stimuli is viewed
2. This activation in OFC must occur before the object is recognized
3. LSF information in image is necessary for top-down

Need to find out the temporal order

- But fMRI has bad temporal resolution, so use MEG

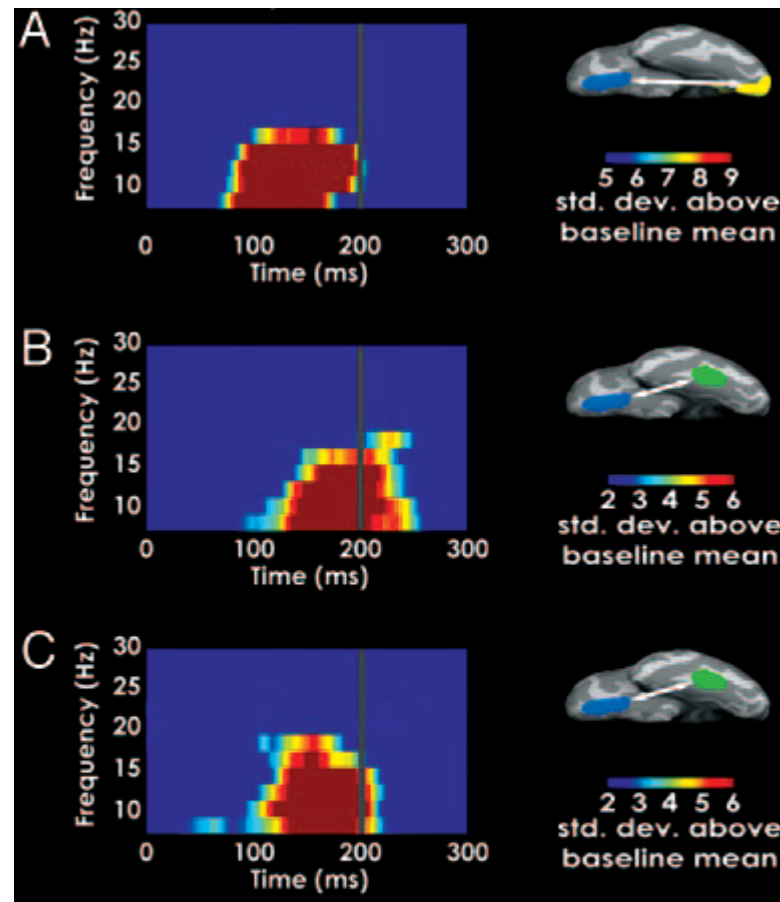


Activation in OFC before Fusiform

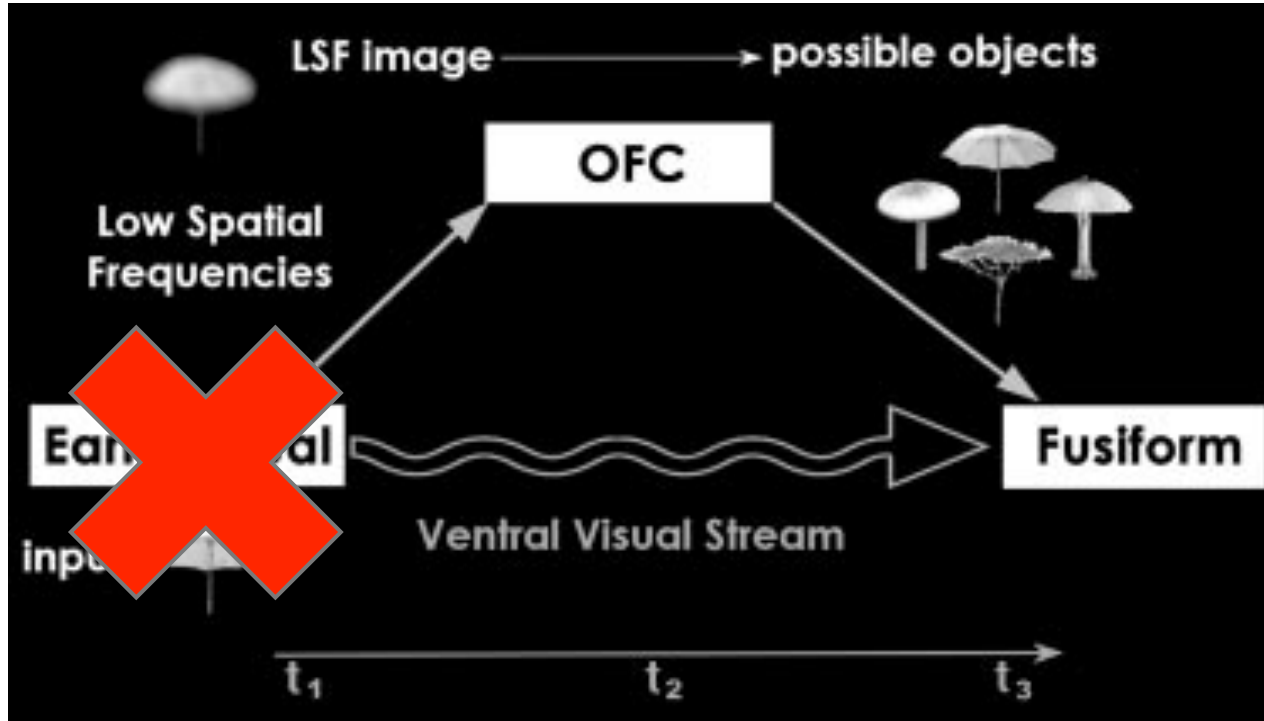


Activation in OFC before Fusiform

- Supported by phase-locking analysis



Where does input to OFC come from?

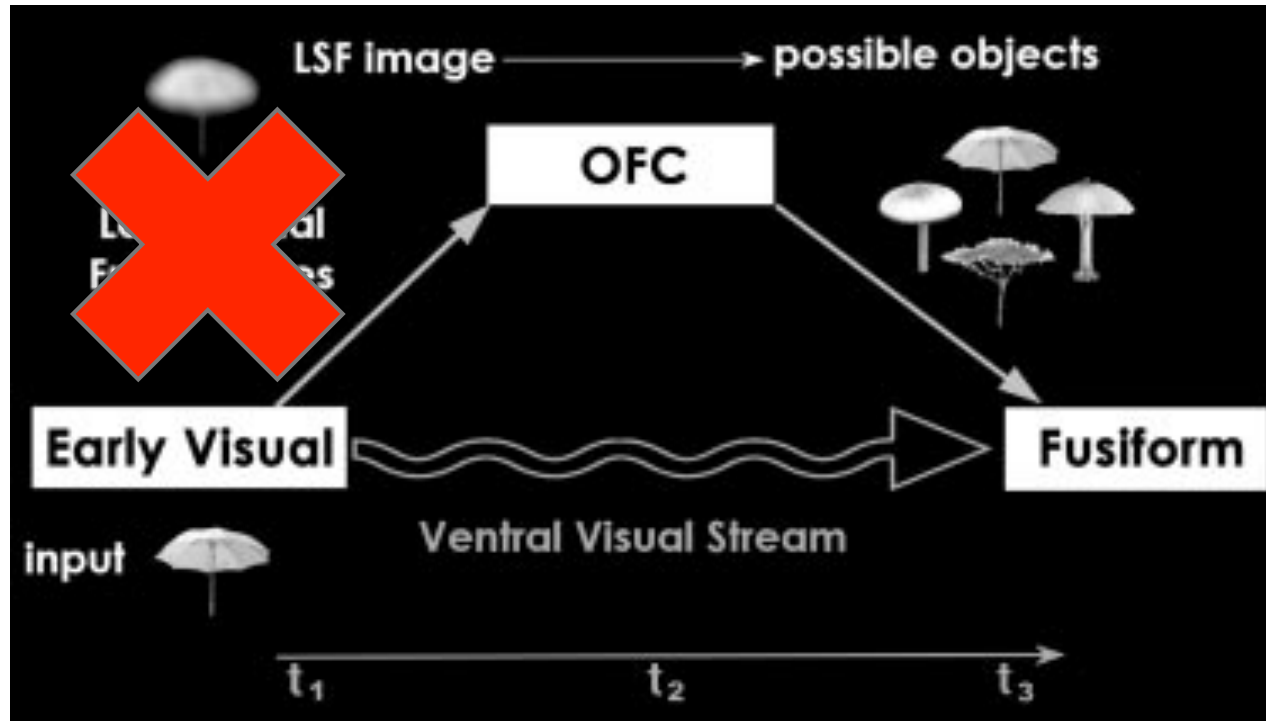


→ OFC

Input to OFC is from early visual areas

- Early activation in occipital cortex (early visual areas)
 - unrecognized > recognized
- Strong covariance between occipital visual areas and OFC, then later between OFC and fusiform gyrus

But what if OFC is not processing LSF information?



→ OFC

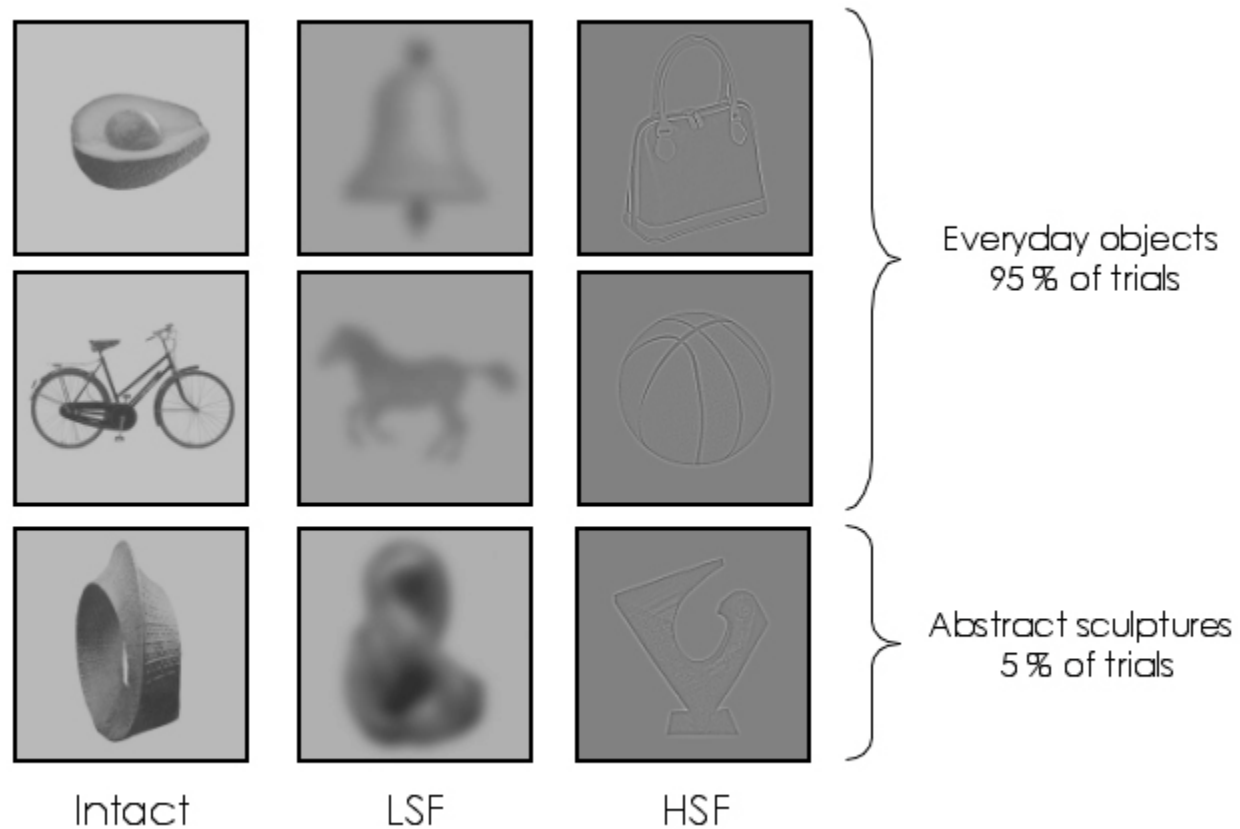
If this model is correct, then...

1. Then there must be activation in OFC when visual stimuli is viewed
2. This activation in OFC must occur before the object is recognized
3. LSF information in image is necessary for top-down

Experiment 2

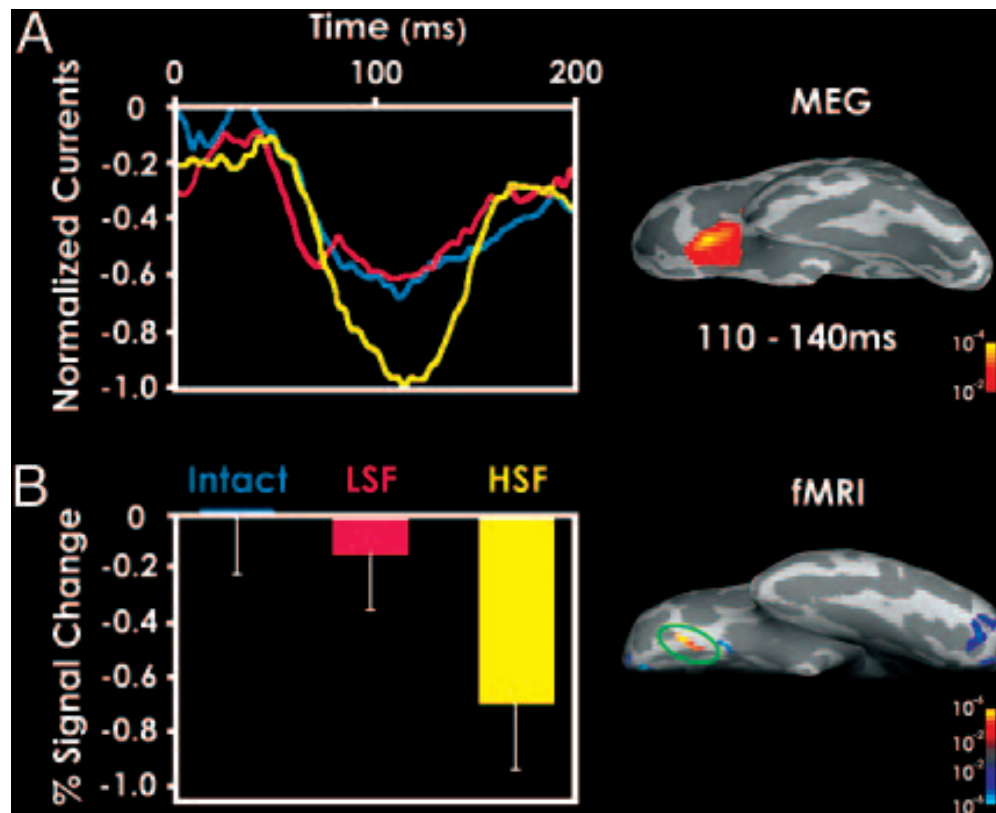
- Find out if low spatial frequencies of the image are sent to OFC
- Prediction: LSF and HSF filtered images have different effects on activity in OFC

Experiment 2: Stimuli



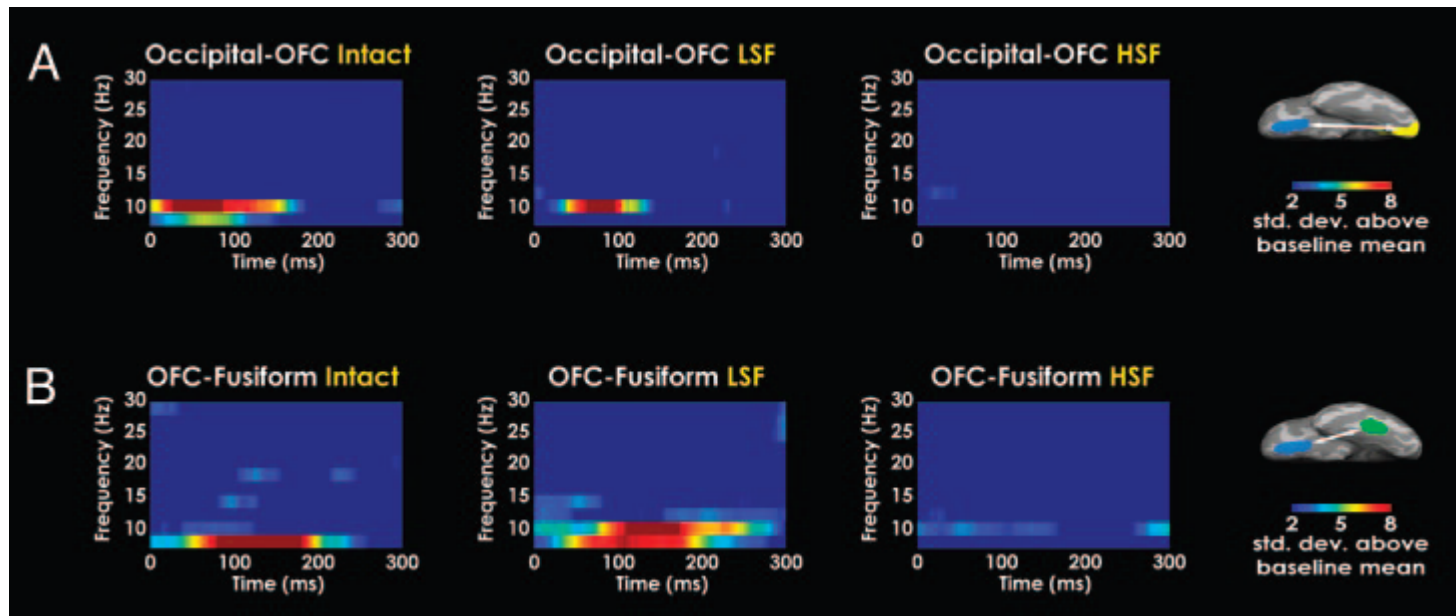
Experiment 2

- LSF object images have higher fMRI signal in OFC



Experiment 2

- Feedforward-feedback projection more synchronized for LSF images



Experiment 2

- LSF only and HSF only images have longer recognition times → both LSF and HSF needed for optimal recognition

Discussion

- Possibility of other types of information used for top-down?
 - Context?
 - Other types of prior knowledge?
 - High frequency features?
- What is the correct model of computation?
- Similar ideas in computer vision?

**Any computer vision
techniques?**

Beyond Categories: The Visual Memex Model for Reasoning About Object Relationships

T. Malisiewicz, A. A. Efros

Associations ... again

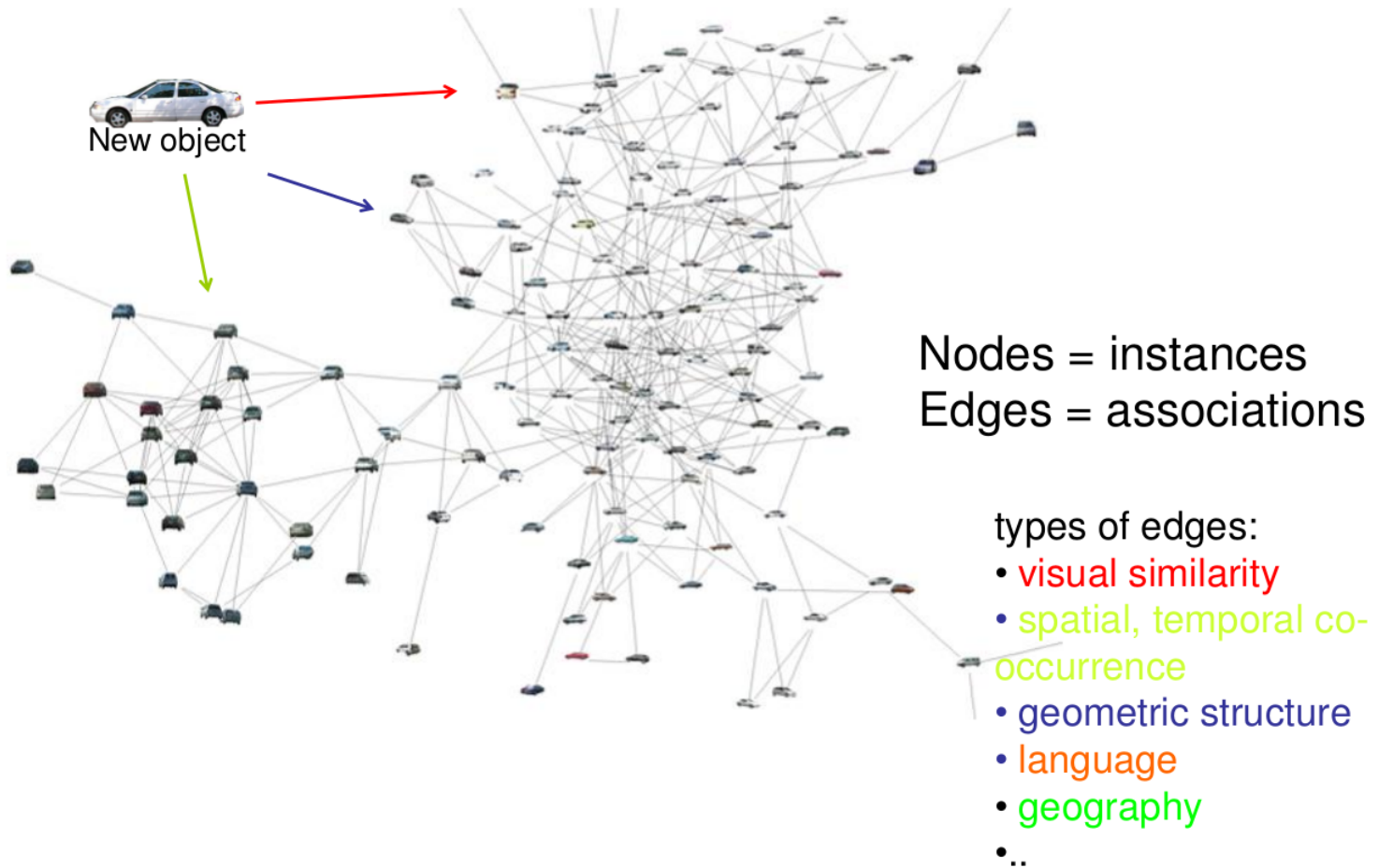
Vannevar Bush's memex (1945)

Store publications, correspondence, personal work, on microfilm

- Items retrieved rapidly using index codes
- Can annotate text with margin notes, comments
- Can construct a trail through the material and save it
- Acts as an external memory

Inspiration for hypertext

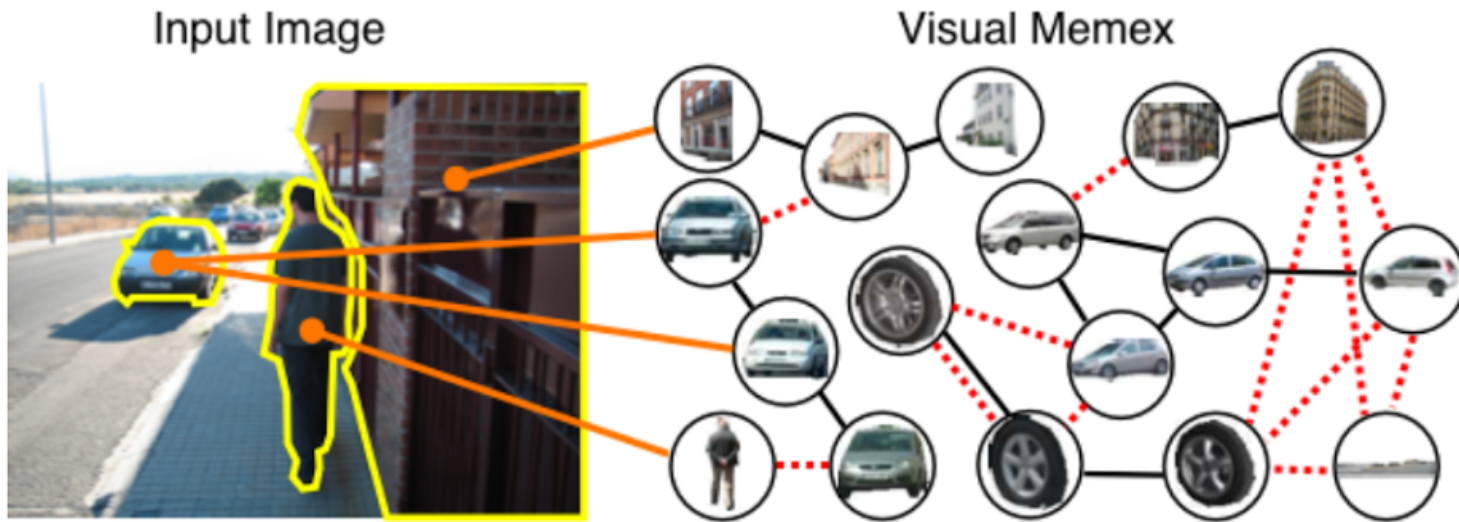
The “Visual Memex”



Torralba's Context Challenge



Inference in the memex



Qualitative Results

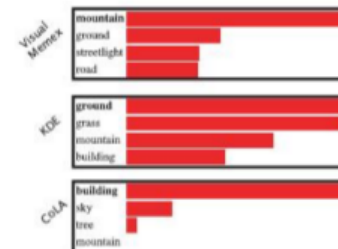
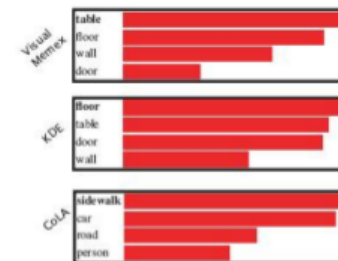
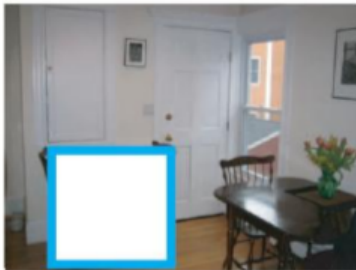
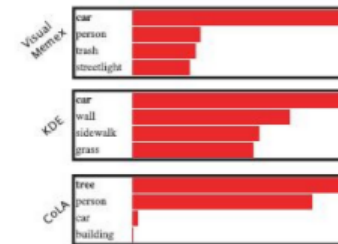
Input Image + Hidden Region



Visual Memex Exemplar Predictions



Categorization Results



From the Blog

Wentao & Tina



- Logically, is LSF the best way to handle top-down? How about HSF?

Thanks!

Exemplar vs. Prototype

- Prototype does not have to a “real” object
 - Prototype has to be “one object”
-
- Exemplars are a list of “real” objects
 - Preserve correlation between these objects for a category

Problems with categories

- People don't rely on abstract definitions / lists of shared properties (Wittgenstein 1953, Rosch 1973)
 - e.g. define the properties shared by all “games”
 - e.g. are curtains furniture? Are olives fruit?
- Typicality
 - e.g. Chicken -> bird, but bird -> eagle, pigeon, etc.

Categories - ideal world



Categories in practice

