

Object Recognition – Functional Categories

By:
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Objects don't exist in a static world



Objects move sometimes on their own
Some are manipulated by humans

Living Beings - Differentiation



Motion of Living beings enable differentiation.

Visual Attributes to Functions



Used for Shearing Function!

Non-living object Functionality is known to experts



Tool Recognition - Tough Using only Attributes



Metallic?



Has Jaws ?



Tools Recognition - Functionality



Attributes and Functions for Tools

Attributes could define functions.

We need to know how tools can be manipulated by actually using them.

Formal Neuroscience Representation of Tools

How Tools are Represented

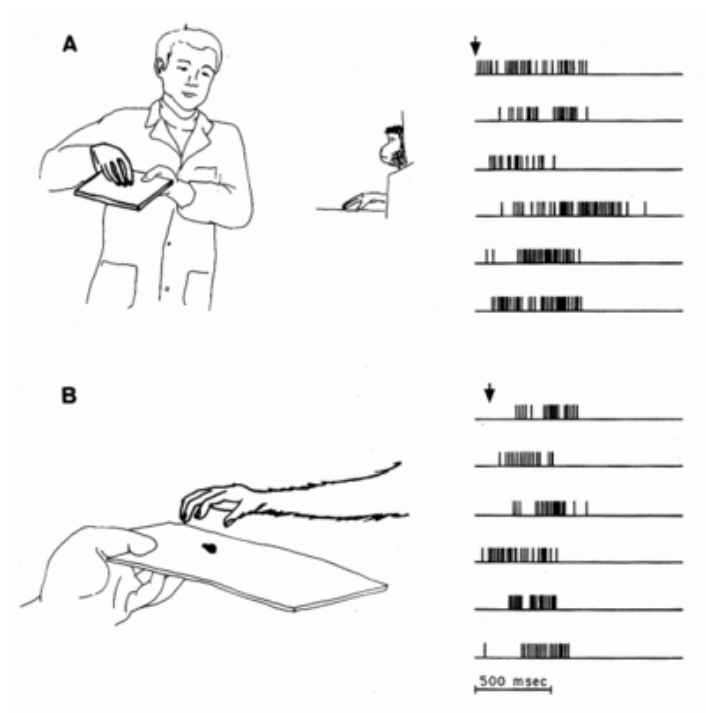


Ways we can hold it.
How/where we can use it *Dorsal*
for a task.

Visual recognition

Ventral

Mirror Neuron



Response of F5 mirror neuron in premotor cortex over 6 trials.

Embodied Cognition Hypothesis

Sensorimotor representations (in Dorsal stream) are activated in course of object analysis.

Studies found overlap between motor cortex activation for foot movements and for words describing actions.

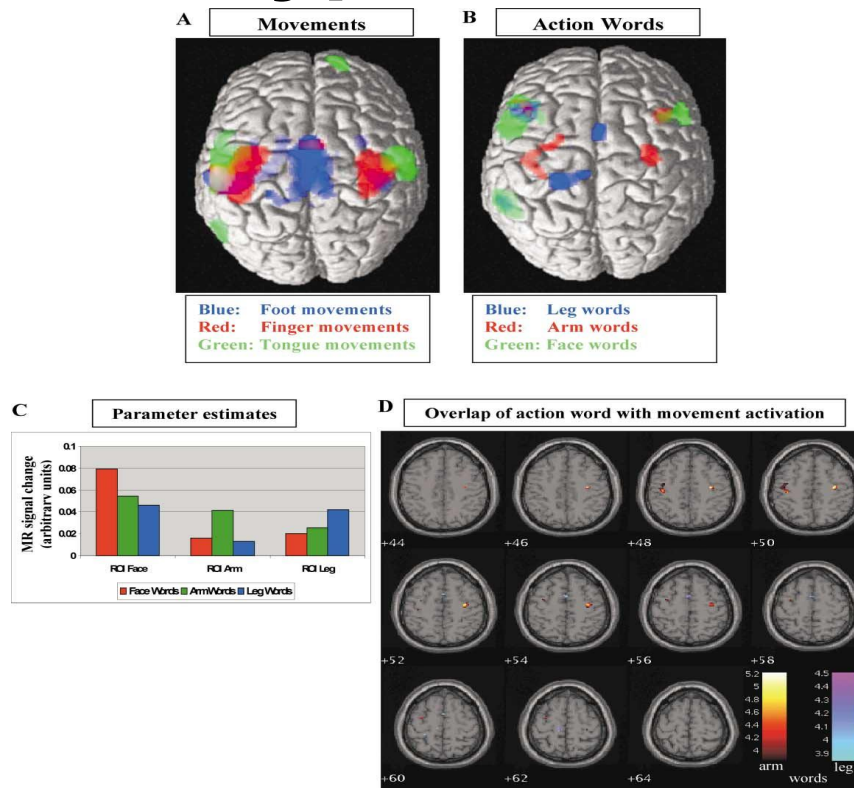


Figure from Hauk et al. (2004)

Another FOR Embodied Cognition Hypothesis

Boulenger et al. (2008) look for differences in word recognition ability



Experiment subjects:
Parkinson's patients
Motor cortices are not
functioning properly

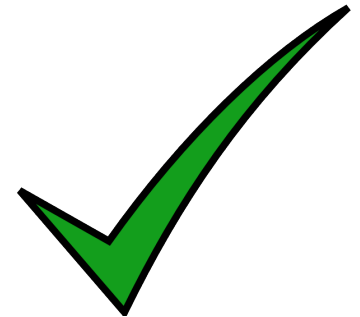


Action words

draw, kick

Noun words

mill, house



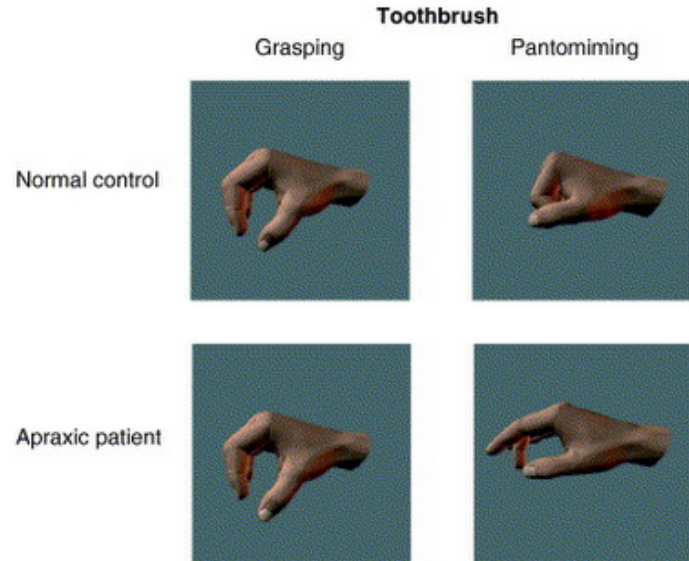
AGAINST Embodied Cognition Hypothesis

Trends in Cognitive Sciences by Elena Daprati and Angela Sirigu looks at object use and object recognition in patients with lesions in motor cortex.

Object Recognition



Actions



Action Related Properties Shape Object Representations in Ventral Stream

Hypotheses:

- Tool presentation will trigger responses in ventral stream (represented in medial fusiform gyrus) and dorsal stream areas.
- Perturbation in dorsal stream will affect ventral stream.

Object Recognition Experiments

- fMRI to:
 - Find brain areas that respond to tools.
 - study modulations in RS as function of motor relevant properties.
- Lesion study to converge with fMRI results.

Types of Stimulus



Tools

Animals



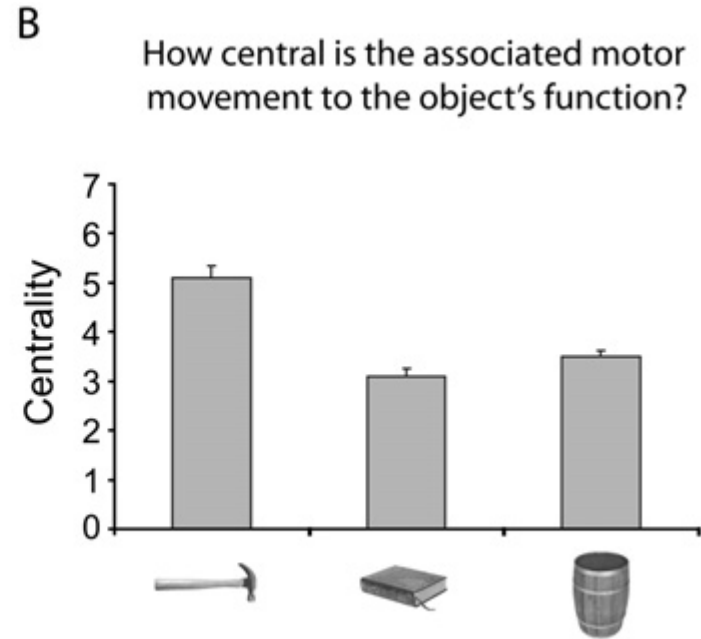
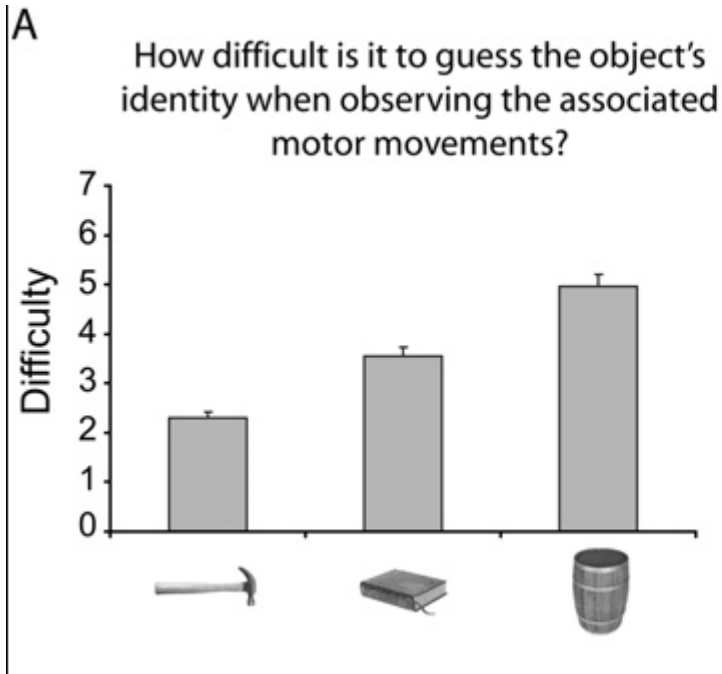
Manipulable objects



Non-Manipulable objects



Tools distinction : Behavioural study

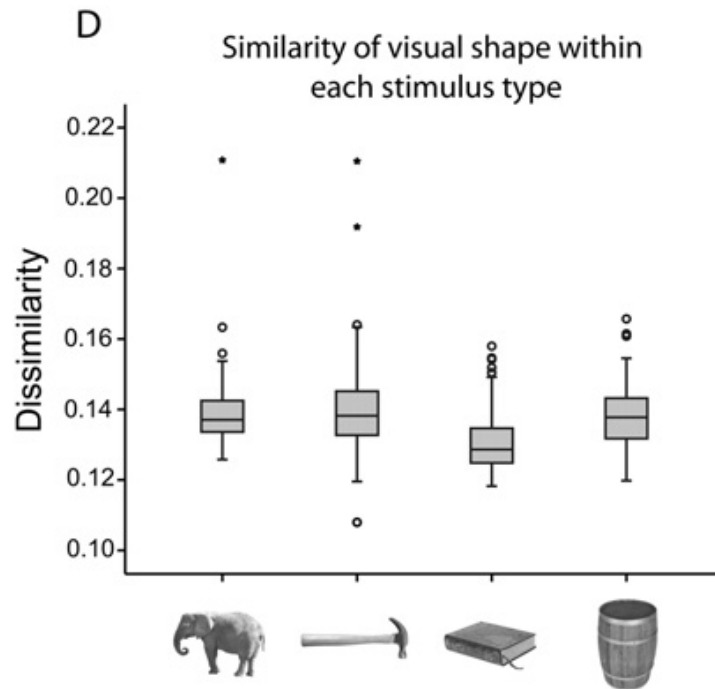
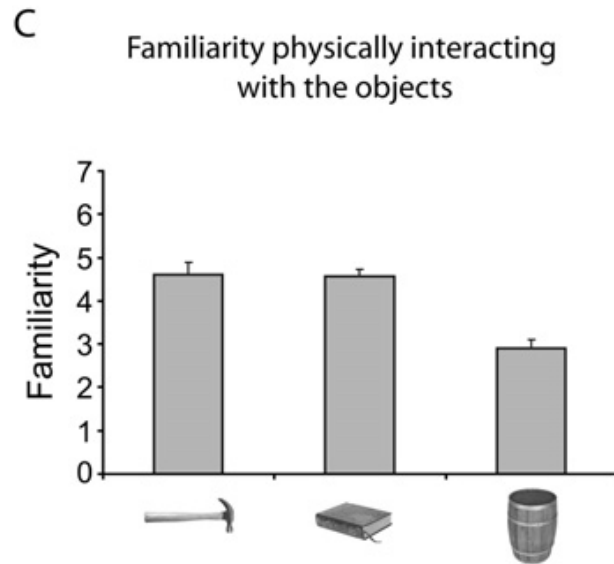


Controls for Object Recognition

Distinctions in :

- **Concept familiarity** - Maybe we are just more familiar with tools. This taints object recognition neural study.
- **Visual complexity and shape**

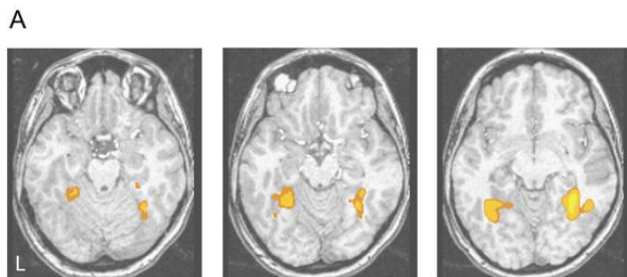
fMRI stimulus characteristics



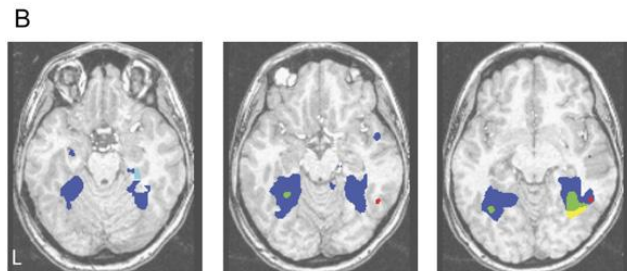
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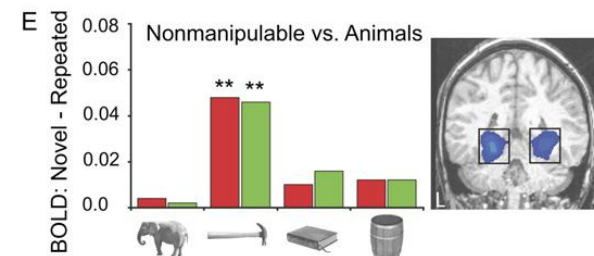
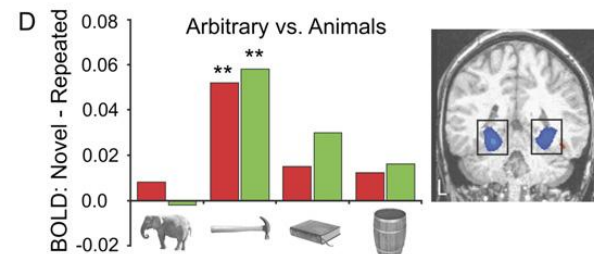
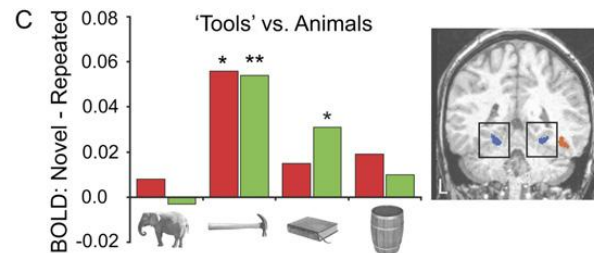
Tool areas - Ventral Stream



Voxels in the fusiform gyrus showing a main effect of RS
 $p \leq .005$ $p \geq 4.9 \times 10^{-5}$

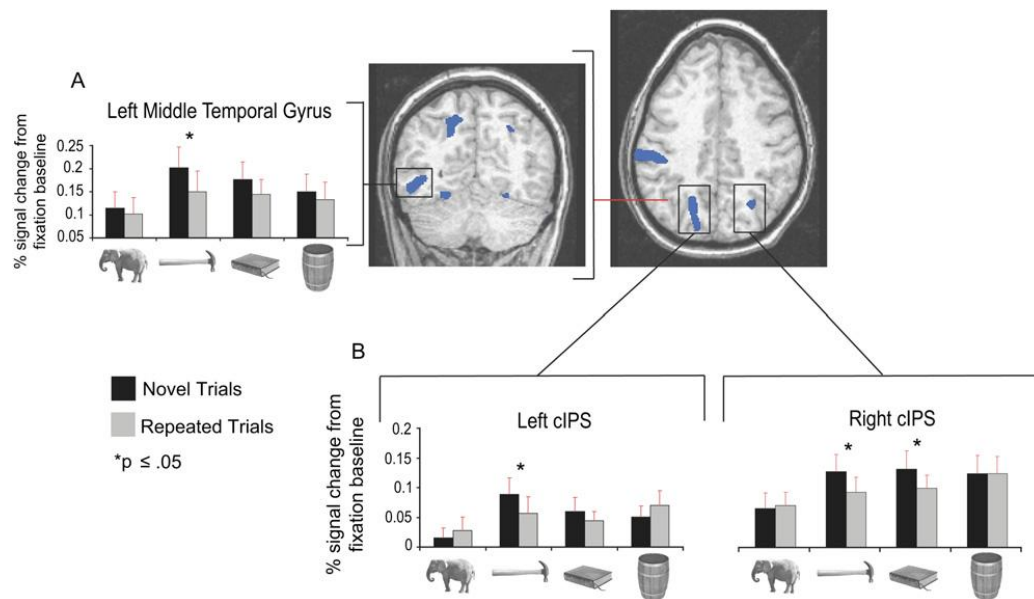


■ 'Tool' RS only
■ Arbitrary RS only
■ 'Tool' and arbitrary RS only
■ Animal RS only
■ Nonmanipulable RS only



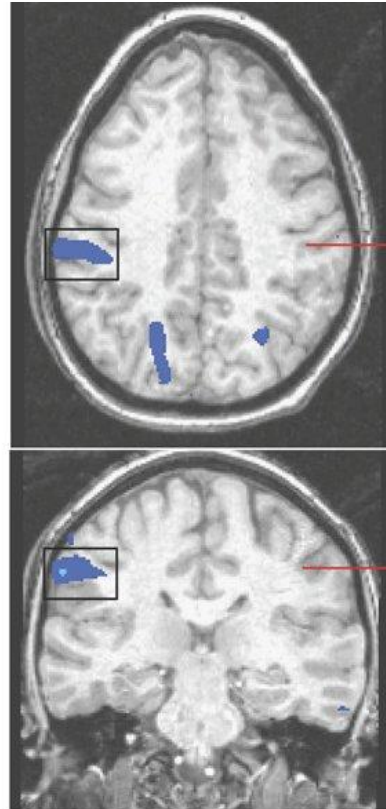
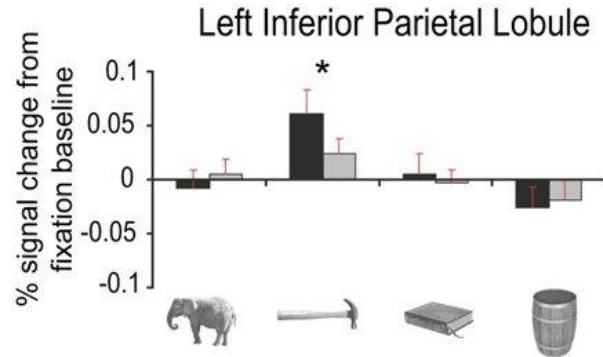
■ RS in left fusiform gyrus
■ RS in right fusiform gyrus
 * $p \leq .05$ ** $p \leq .001$

Dorsal Stream I



Dorsal Stream II

A



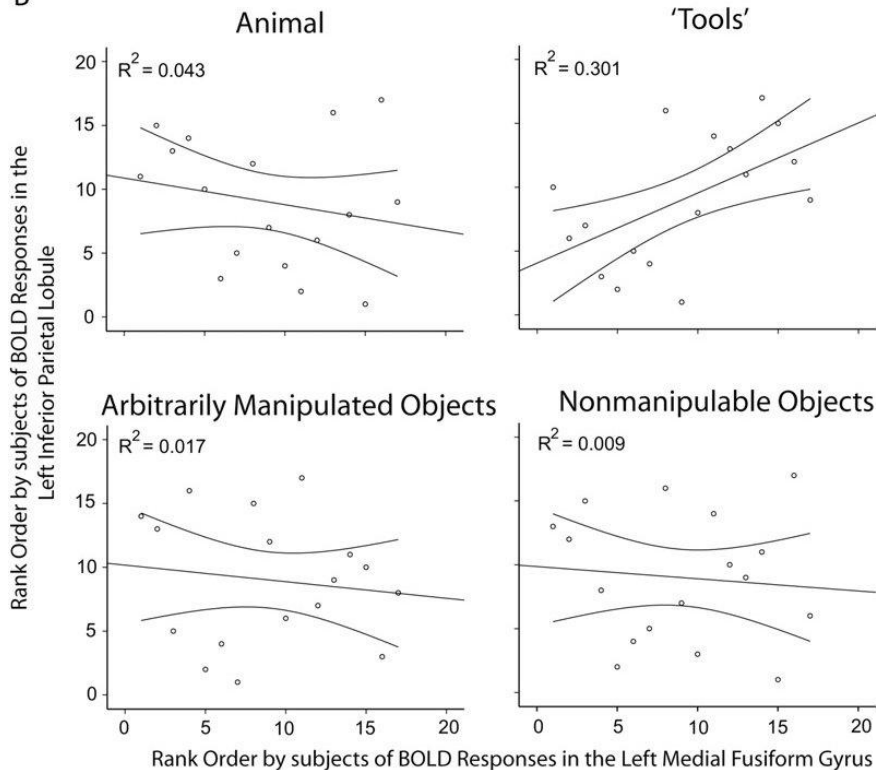
Object Recognition Experiments

- fMRI to:
 - Find brain areas that respond to tools.
 - study correlation of dorsal and ventral stream when exposed to tools.
- Lesion study to confirm fMRI results.

Correlation in response to Tools in Dorsal and Ventral streams

Dorsal stream

B



Ventral stream

Object Recognition Experiments

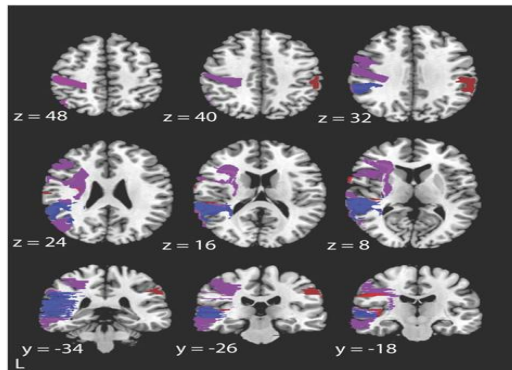
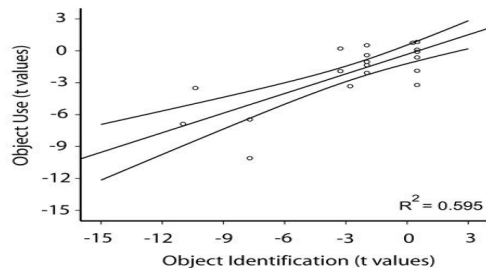
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Aim of Lesion Overlap Study

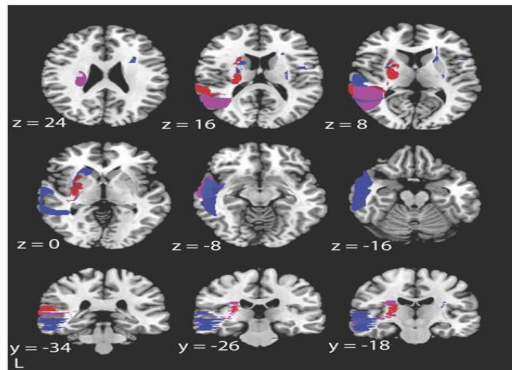
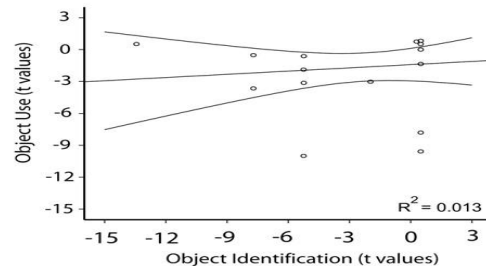
Whether lesions in Dorsal stream affect Object Recognition

Parietal Cortex Lesions affect Object Identifications

A



B



- Lesions associated with impairments for identifying objects
- Lesions associated with impairments for using objects
- Overlap between lesions associated with impairments for using object and identifying objects

Discussion

Human hallucinate actions when looking at tools?

Actions help identify tools ?

Discussion

Other Brain regions' specificity (FFA, PPA) driven by connectivity ?

eg. Emotions with FFA

CV Application

Actions as a clue for Objects in scene.

Occluded object recognition through Action recognition.

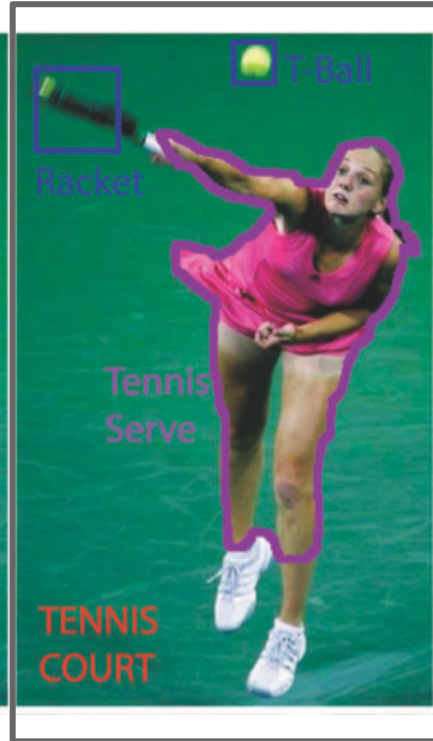
Human-Object Interactions Leveraged



First order predictors



After applying constraints



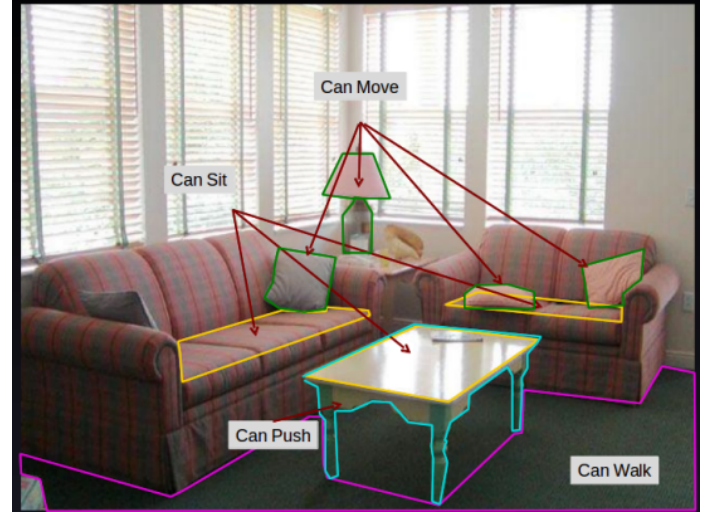
From:
*Observing
Human-Object
Interactions:
Using Spatial
and Functional
Compatibility for
Recognition*
Abhinav Gupta
et al.

CV Application

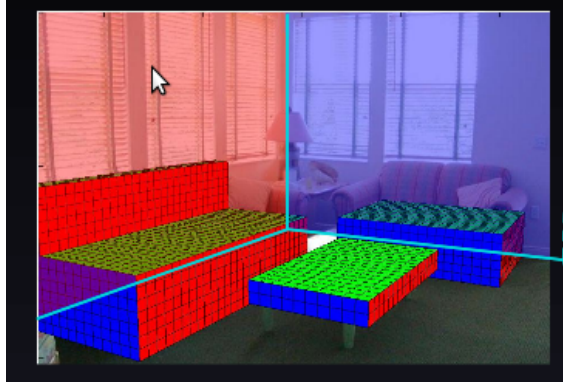
Human Centric Scene Understanding

Gibsonian View of Affordances

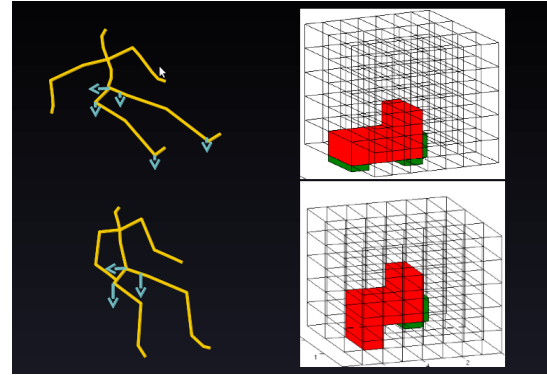
Human Centric Interpretation of Scenes



From 3D Scene Geometry to Human Workspace

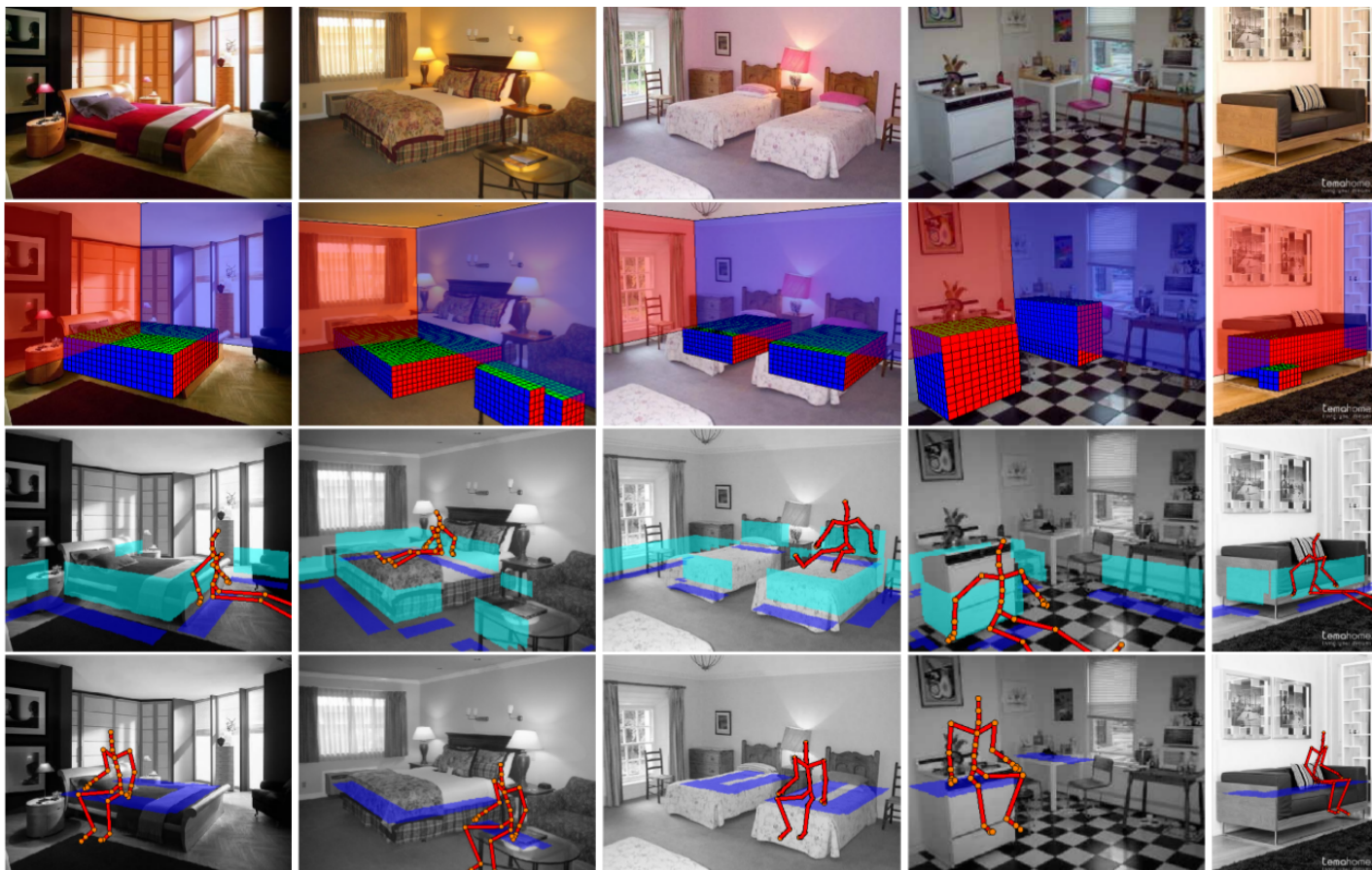


Representation of scene

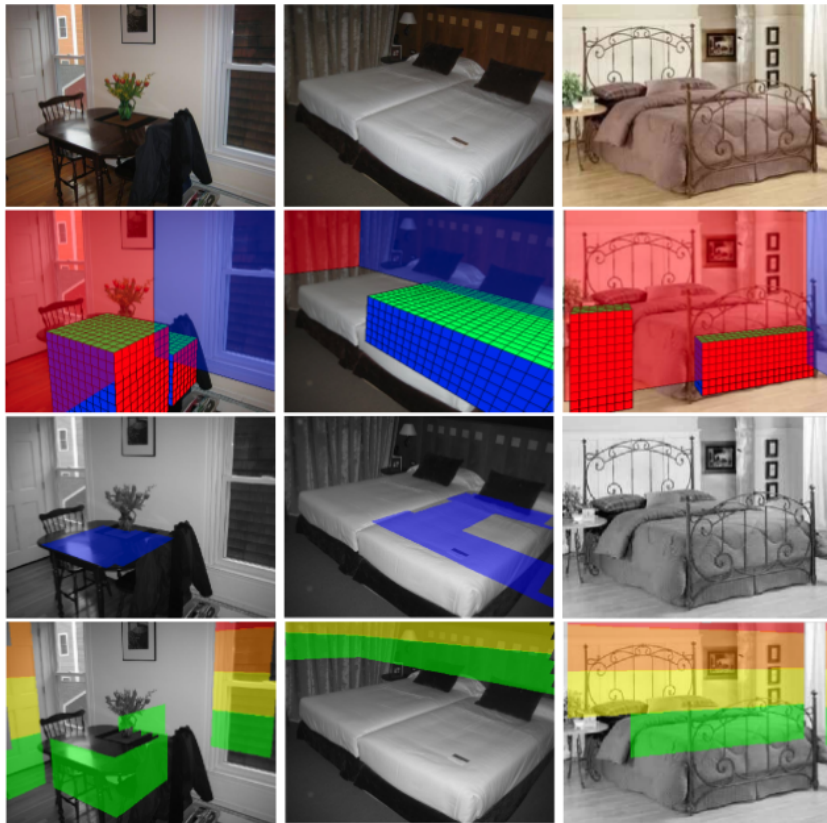


Representation of
ourselves in 3D world

Results



Challenges



Actions to determine 3D



People Watching..
by David Fouhey et al.

Another Challenge



In Summary

Object functionality is a useful clue for object recognition.

Neural studies show we simulate tool use when viewing them.

CV looks to explore object functionality and actions.

Twins Study

Innate component to face recognition.

Brain areas in twins with similar responses to faces and places.

Genes matter !

Blind Subject study

Congenitally blind patients show activation in ventral stream for objects in same areas as sighted individuals.

Lesson: Some basic scaffolding holds how information is organized.

What Humans Learn?



Humans learn appearances and the actions of tools but does knowledge of appearance and knowledge of action interact ?

Eliminativist - theory

Semantic deficits explained because items varied in

- lexical frequency
- concept familiarity
- or visual complexity.

Some categories might be easier !

Eliminativist theory - experiments

Experiment 1

Do dissociations remain when objects are matched across lexical frequency, image complexity etc.

Experiment 2

Double dissociations can be observed over same material in different patients.

Answer is YES. Category specific semantic deficits are not spurious.

Non eliminativist

Sensory Functional Theory

Semantic system organized by modality of information.

- Visual/perceptual knowledge (Animals) and Functional knowledge (tools, man-made objects)
- Features like color, form, surface properties.

Non eliminativist

Why it fails?

Patients with impairments for animals do not have a impairment for visual/perception knowledge.

Non-reductionist theory

Brain areas divided by semantic domains.

Evidence:

1. Category specific semantic deficits doubly dissociate across patients.
2. Affect all types of knowledge that have been tested.

Non-reductionist

Semantic domain constrains object knowledge organization.

Connectivity determines domain-specificity. eg.
Dorsal and Ventral.

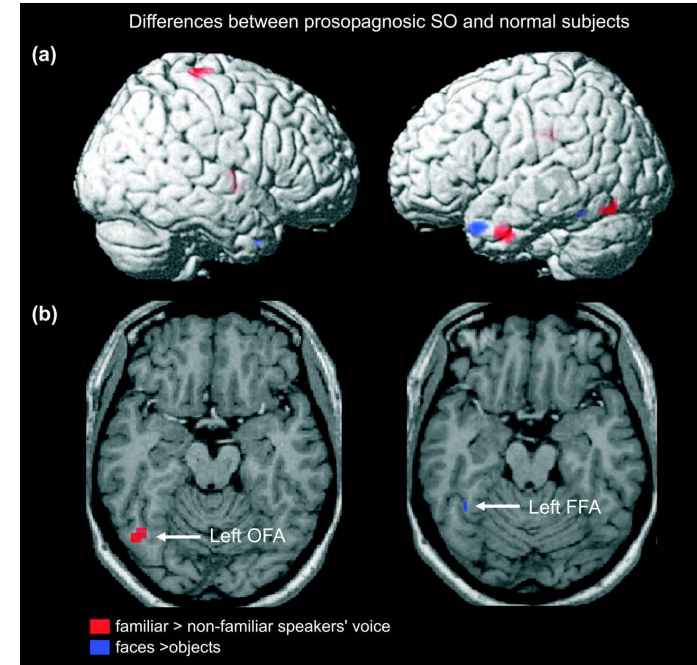
Evidence ?

Category Specific Semantic Deficits

Some categories of object conception impaired.

Prosopagnosia - Can't distinguish faces.

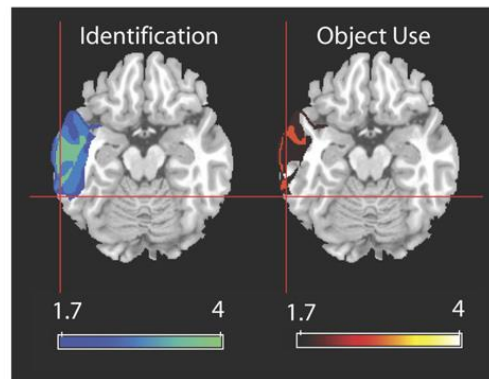
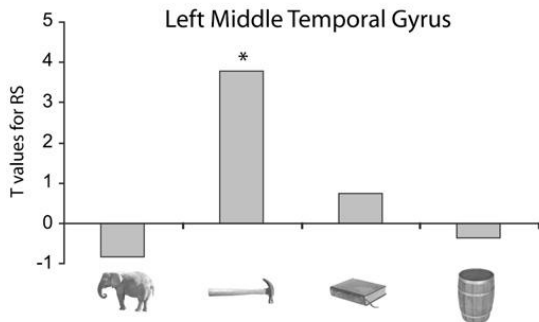
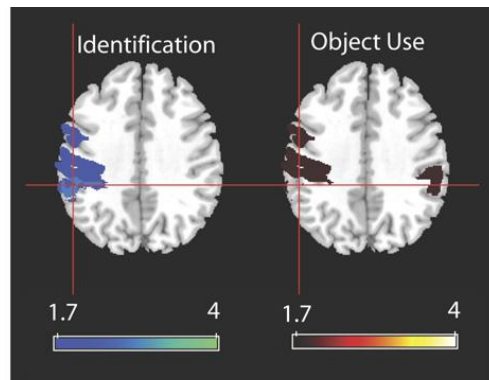
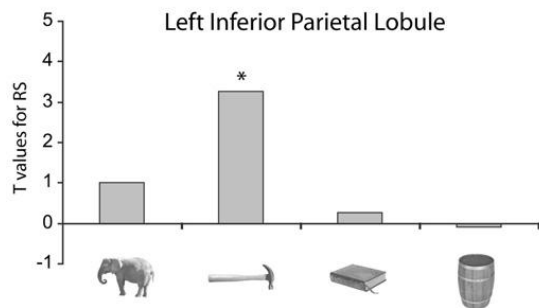
Theories to explain how knowledge is organized in brains to explain such impairments.



Monkey and Human study

Face preferring voxels comparable in monkeys and humans.

Overlay of Lesion Overlap and fMRI



* = .001 < p < .01

Computer Vision Perspective

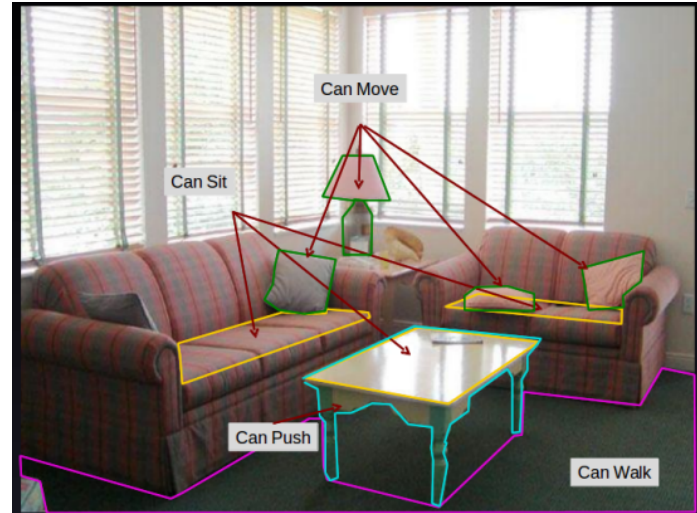
Some tools have many functions.



VS.



Interactive scenes

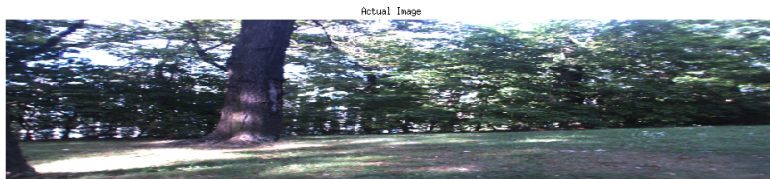


A scene is a collection of objects.

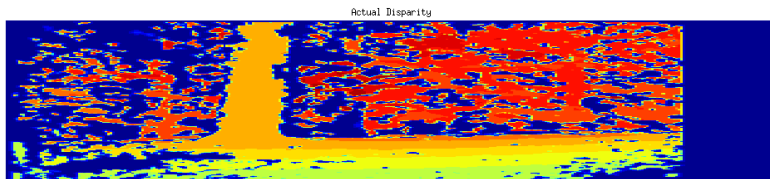
A scene is interactive and represents a 3-D space with many possibilities for manipulation and use.

Application dependent functionality

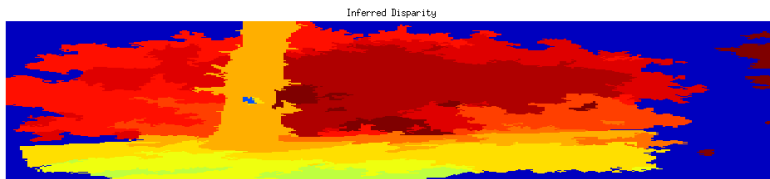
Computer vision assisted driving



Camera Image



Stereo disparity



Monocular depth prediction

Where the tree lies is important.

In the end we care about driving

Non-living Objects - Tools



Could be just pieces of metal

But they have a specific functionality depending on how we manipulate them