

Visual Imagery

“Imagine the Taj Majal”

t.konkle
14 March 06
9.012 Cog Core

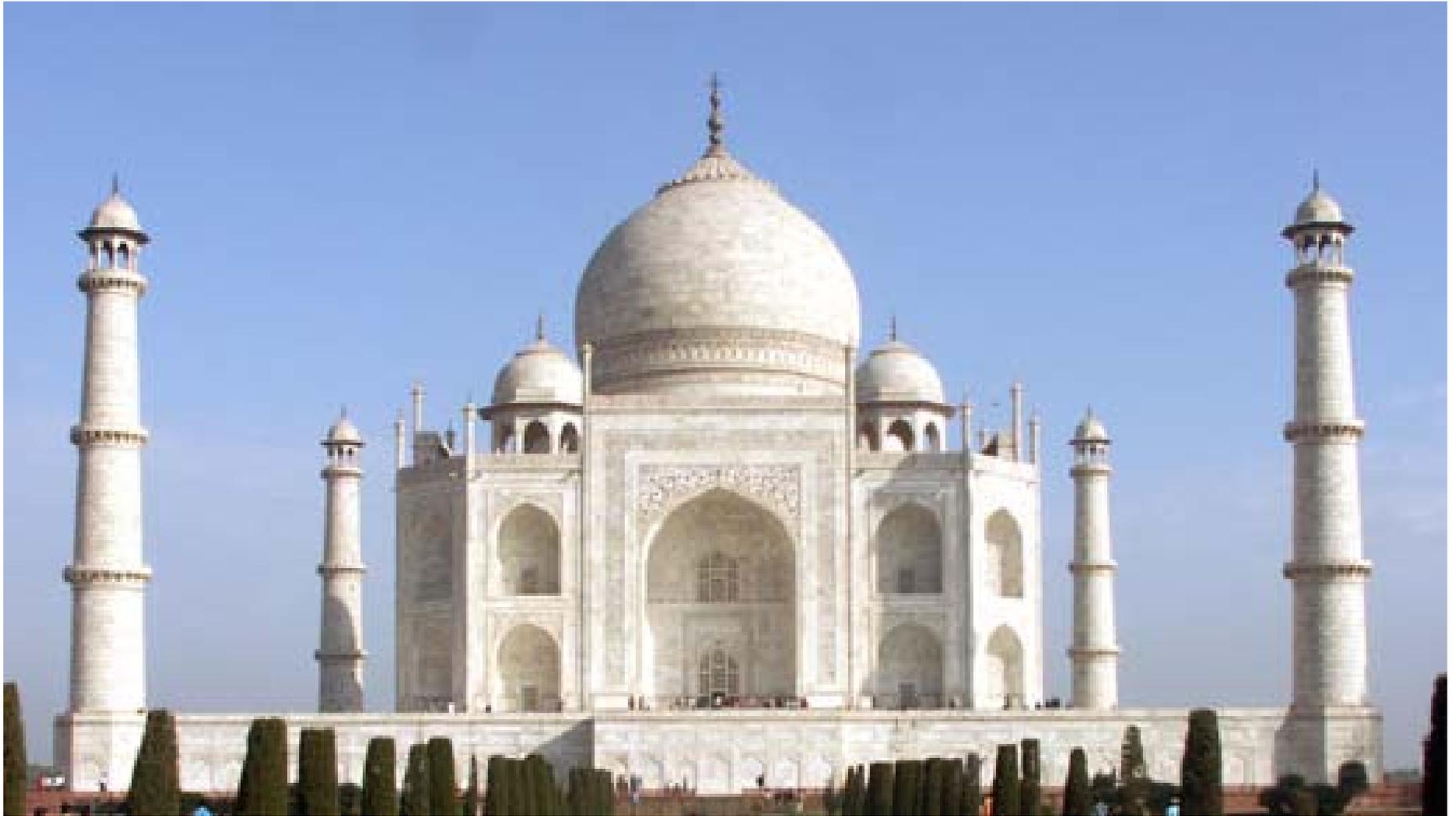


Image courtesy of [Rana Banerjee](http://ranabanerjee.org) , <http://ranabanerjee.org>
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Obligatory “Definitions”

Visual Image

what you get when you **recall** a vision-related experience from long term **memory**

Visual Imagery

the **processes** involved in generating, examining, and manipulating recalled visual images

(Palmer, Vision Science)

the **representation** of perceptual information in the **absence** of visual input

(Laeng, 2002)

resembles perceptual experience, but which occurs in the **absence of the appropriate stimuli** for the relevant perception

(Plessinger)

Your intuitions...

is it the same as daydreaming?

guided imagery = directed daydreaming

is it the same as visual memory?

process/product distinction ?

can it be concurrent with vision?

some studies show people have BETTER imagery when their eyes are open and getting light. But, now how do we define it?

Why is Visual Imagery important to study?

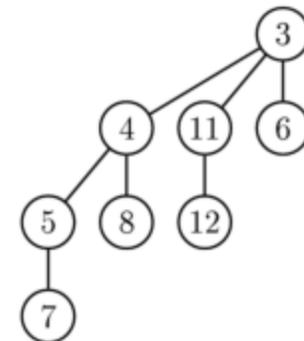
intuitive appeals:

- imagery a pervasive phenomena
- we use it to **reason** and **solve problems**, especially when things are no longer present in our visual environment



cognitive insights:

- it can tell us something about the **format** of our **representation** of the world



Intended Trajectory for this lecture:

Great Debate 1:

Descriptive vs. **Propositional**

**Cognitive
Representation**

Great Debate 2:

The Relationship between
Perception and **Imagery**

Neural Instantiation

Great Debate 3:

Imagery and the
Primary Sensory Cortical Areas

Introducing Modalities

Potpourri:

Imagery and **Beyond...**

Assorted Questions

Historic Context

Imagery's Hey Day in the 1970's

Insight:

there are ways to
objectively measure the
impact of visualization
on, e.g., memory
performance

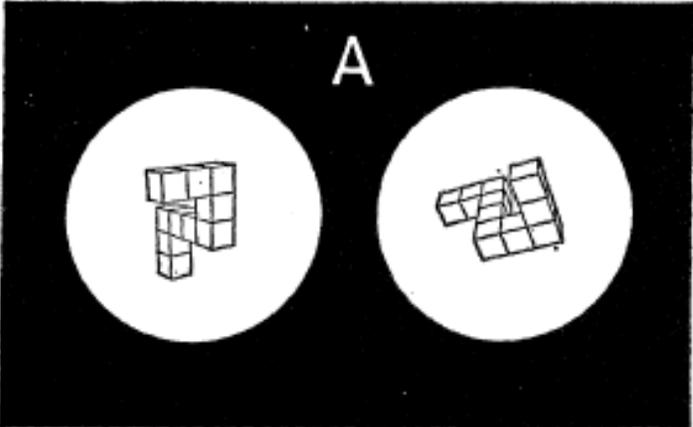
(Yuille and Paivio, 1968)

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

Outline

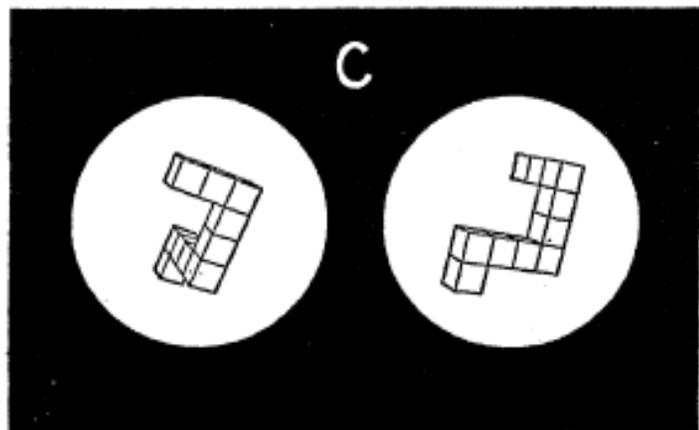
Great Debate 1:	Descriptive vs. Propositional	Cognitive Representation
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A couple of the classics....



B





Mental Rotation

Shepard and Metzler, 1971

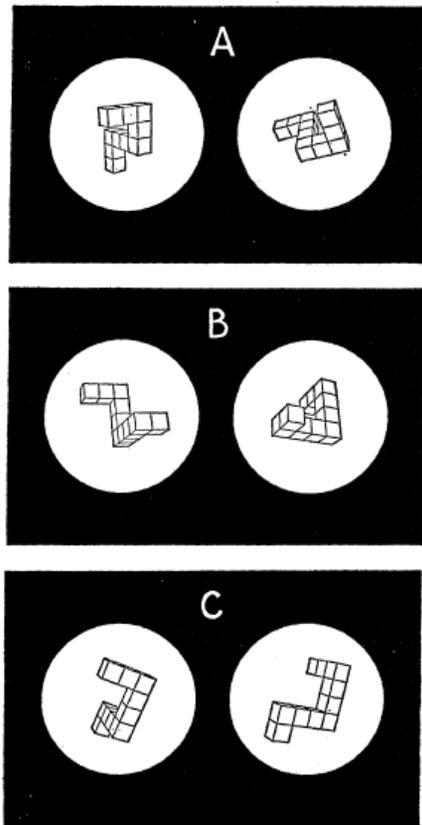
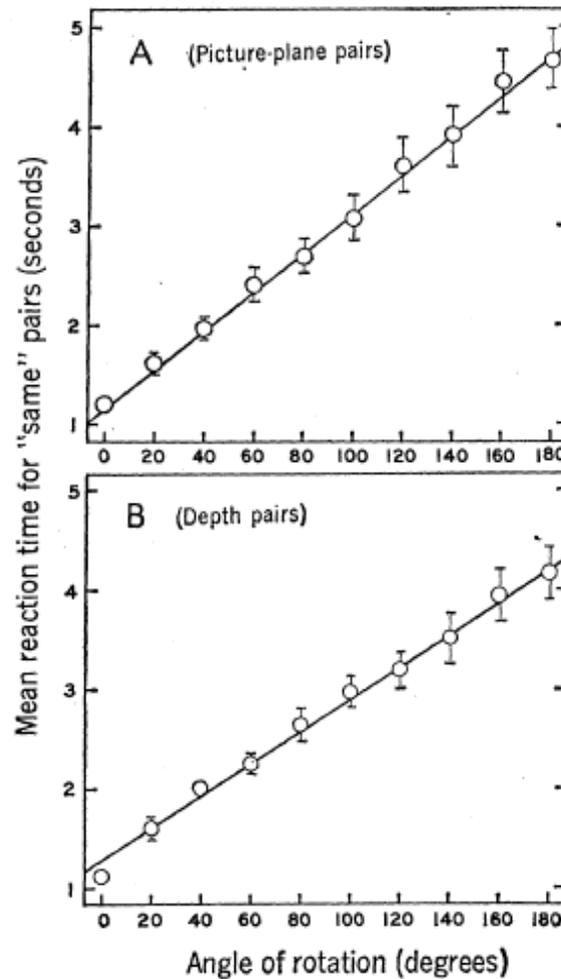


Fig. 1. Examples of pairs of perspective line drawings presented to the subjects. (A) A "same" pair, which differs by an 80° rotation in the picture plane; (B) a "same" pair, which differs by an 80° rotation in depth; and (C) a "different" pair, which cannot be brought into congruence by any rotation.



Shepherd and Cooper, 1982

- different stimuli (letters, polygons),
- continuous path of internal representations (not just a longer time to compute a larger transformations)

Bundesen and Larson (1975)

- zooming also is continuous

Fig. 2. Mean reaction times to two perspective line drawings portraying objects of the same three-dimensional shape. Times are plotted as a function of angular difference in portrayed orientation: (A) for pairs differing by a rotation in the picture plane only; and (B) for pairs differing by a rotation in depth. (The centers of the circles indicate the means and, when they extend far enough to show outside these circles, the vertical bars around each circle indicate a conservative estimate of the standard error of that mean based on the distribution of the eight component means contributed by the individual subjects.)

General Methods

Usually the tests are in the form...

Recall

something from memory with which you're already familiar
something you just saw immediately before
something you saw a previous from amongst a bunch of things

Probe

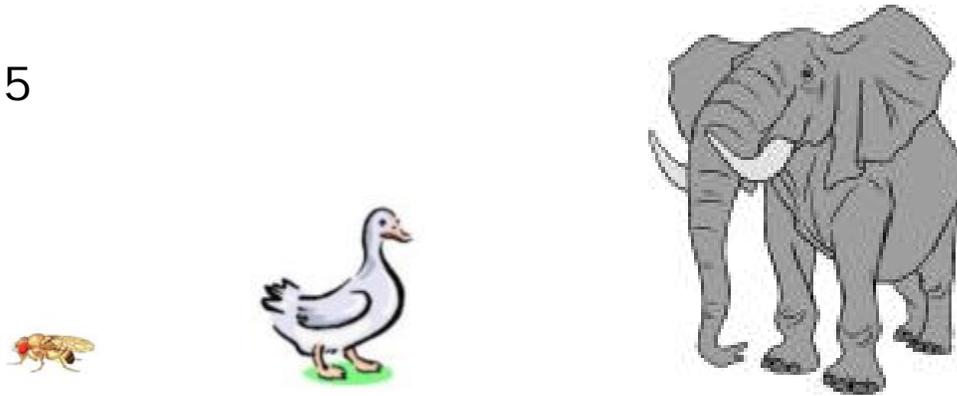
detect something in your mental image
manipulate your mental image (rotation, zoom)

Measure

speed of response
accuracy of memory

Image Size

Kosslyn, 1975



Imagine: an elephant next to a duck

Ask: "is there a beak?"

The Logic: if there is a pictorial representation in your head and you are using the image, than it should take you longer to answer if the part is small vs if it is large.

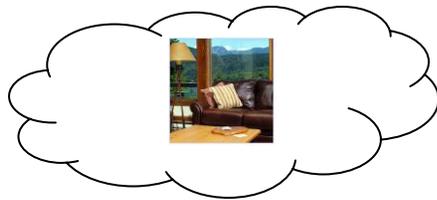
The result: Reaction times when a goose was with elephant than when goose was with a fly.

Proof of the Logic: Imagine a fly as big as an elephant. The RT effect goes away.

Great Debate 1: What is the form of the Representation?

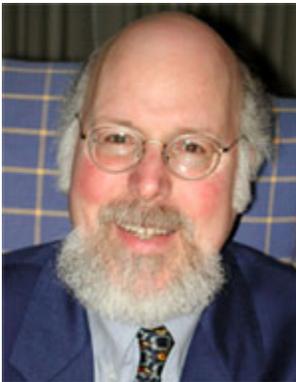
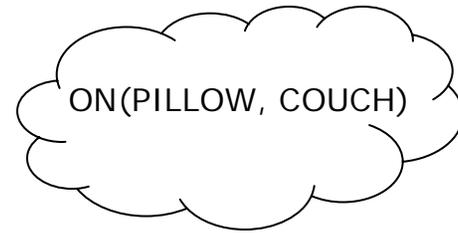
Descriptive

picture metaphor



Propositional

logical propositions



"But... Look at all the testable predictions that have come true!"



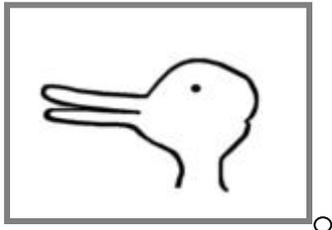
"What the mind's Eye Tells the Mind's Brain"
(1973)

- access has to be somewhat symbolic
- homunculus problem
- indeterminate information

The Fixed Interpretation of Mental images

Polyshyn, 1973

What do you see?



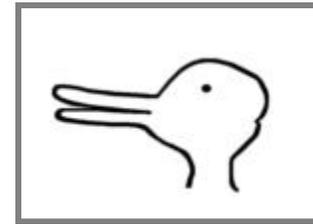
a duck.

can you "see"
it as a rabbit?

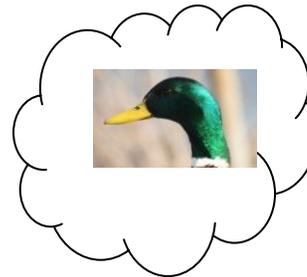


no.

can you see it
as a rabbit
now?



yup.



fails with rotating the letter N 90 degrees to the right. (Finke, Pinker, Farah 1989)

Descriptive vs. Propositional Account

The Ultimate Problem:

These hypotheses seem irreconcilable because **both** theories can account for **any** resulting data, with a few cludges.

complexity of model

fit to data

Descriptive

Predictive results

Matches intuitions

can't get around the homunculus problem

requires *some* propositional structure to solve the access problem anyway

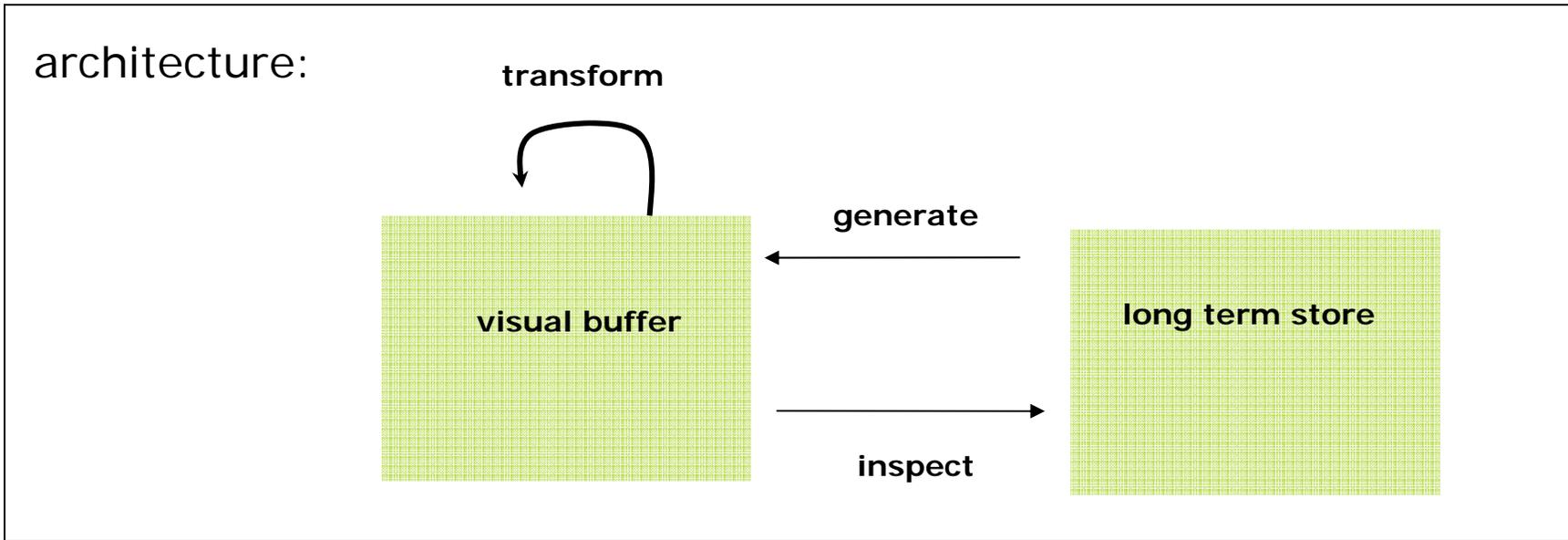
Propositional

Post-hoc structural additions

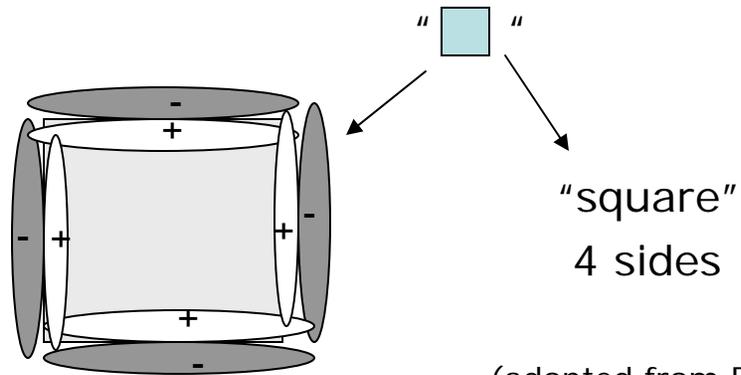
No mind's eye needed

Potential domain-general representational structure
(*Fodor*)

Kosslyn's Model of imagery



a visual image :



(adopted from Palmer)

To the Brain...

Potential Support for Depictive Representation:

- retinotopy in visual cortex
- does this make the homunculus error Polyshyn warned against?

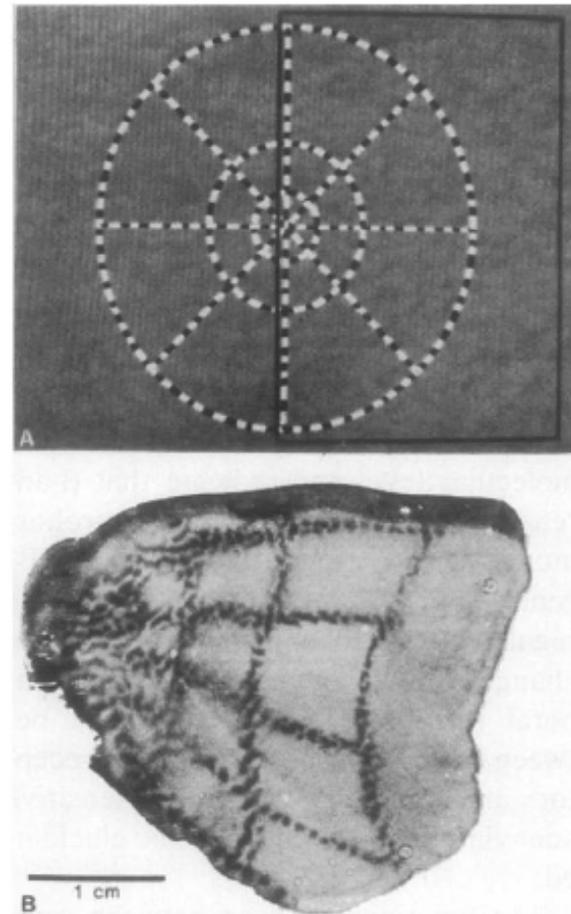
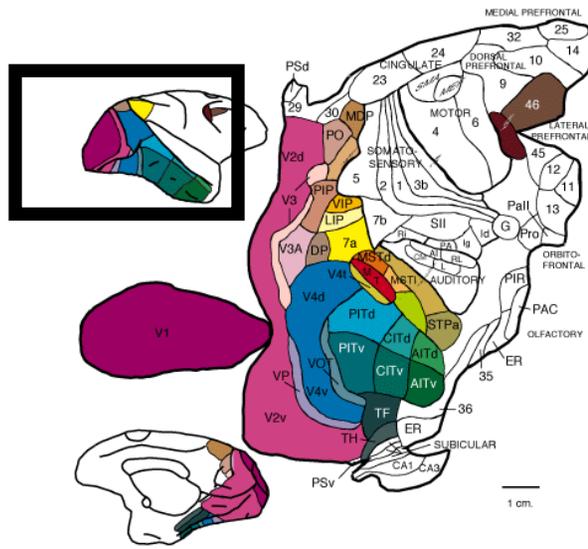


Fig. 1. (A) One of the visual stimuli used. The solid black rectangle encloses that portion of the visual stimulus that stimulated the region of striate cortex shown in (B). (B) Pattern of brain activation produced by the visual stimulus shown in (A), as revealed by 2DG. This is an autoradiograph from a single flat-mounted tissue section (mostly from layers 4B and 4C). About half of the total surface area of the macaque striate cortex can be seen.

Outline

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Great Debate 2:	The Relationship between Perception and Imagery	Neural Instantiation
Great Debate 3:	Imagery and the Primary Sensory Cortical Areas	Introducing Modalities
Potpourri:	Imagery and Beyond...	Assorted Questions

Great Debate 2:

What is the Relationship between Perception and Imagery in the Brain?

Operative Definition: What's left when you close your eyes...

But: Introspectively, it seems that we can have imagery with our eyes open...

The question:

When you imagine a scene, do you **activate the same neural circuitry** as when you regard that scene with your eyes?

The answer:
(as you expected)

Yes and No.

Some evidence that says YES...

Adaptation and Imagery

Gilden and Hurst, 1995

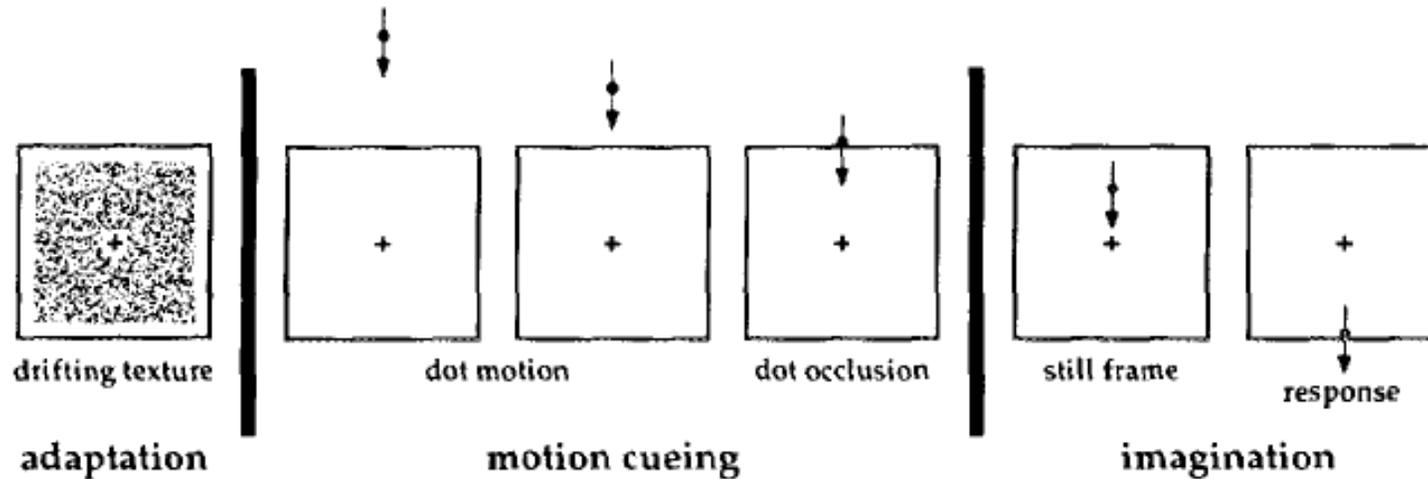
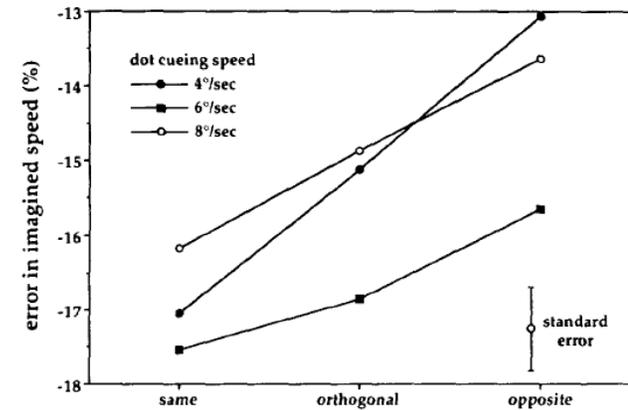


FIG. 2. We illustrate here the three epochs that define a trial; adaptation, motion cueing, and imagined motion. Dots depicted as open circles were not presented but are shown to clarify the task logic. The dot did not reappear following occlusion and the outline square was not displayed during adaptation - we show it here simply to emphasize that the adapting field was centered within the area of imagined motion. The spatial region within which elements were displayed during the cueing epoch was set to ensure that neither the dot motion nor the boundaries of the square fell within adapted portions of the visual field.

FIG. 4. Raw speed errors averaged over adaptation direction are shown for the three cueing dot speeds. For all cueing speeds, the imagined speed is smallest in the direction of adaptation, intermediate in orthogonal directions, and greatest in the direction opposite to adaptation.



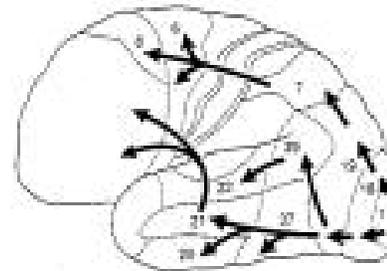
Insights from the Clinical Neuropsychology

Color:

Patient has selective deficits to perceiving AND imagining color.

Farah (1988) Interestingly, she can sort objects according to color but cannot name colors or point to a named color. She also cannot answer questions about the colors of objects (she knew that a banana was a fruit but not that it was yellow).

Mr. I – an artist who suffered achromatopsia after a stroke. After 1 year his memory for colors started to “slip away”



What-Where

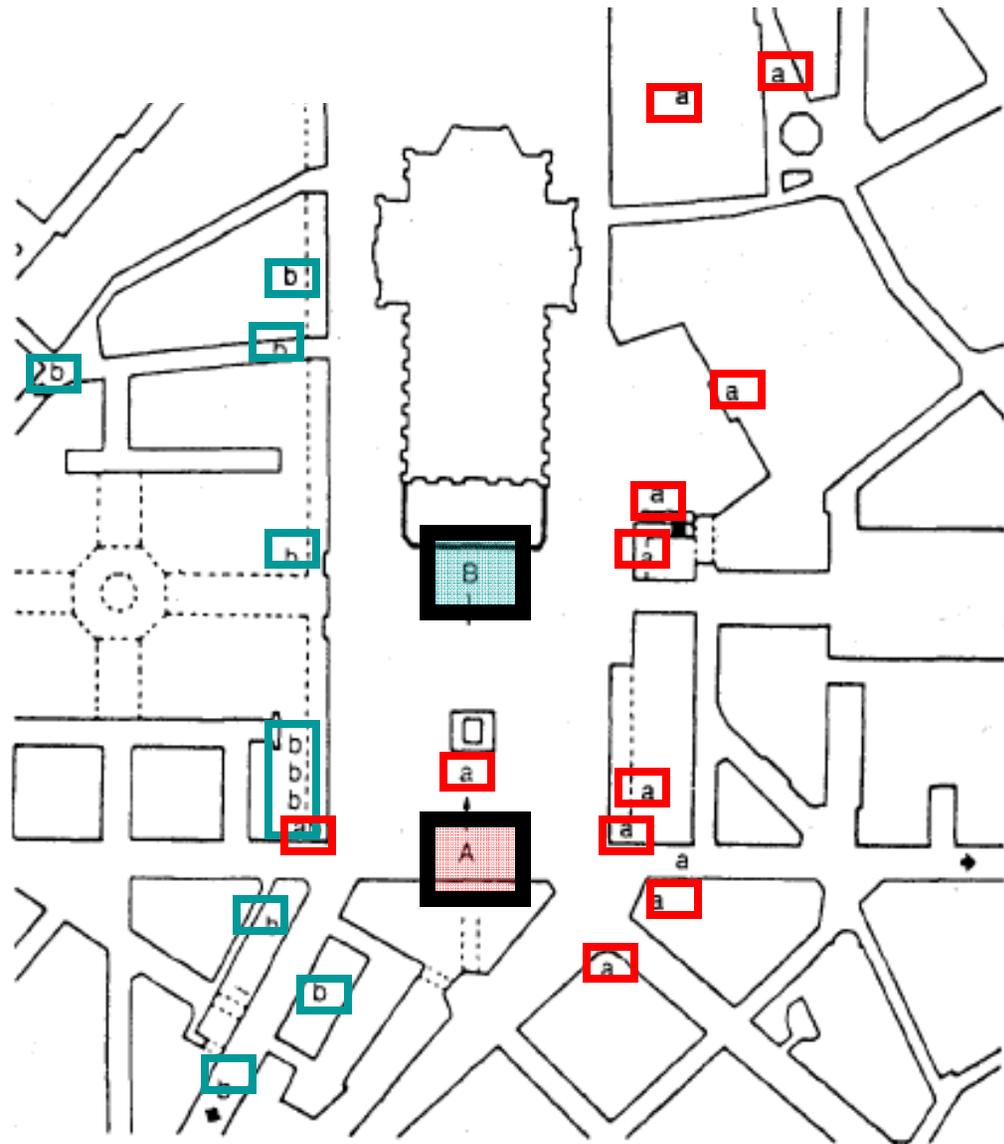
Deficits parallel the perceptual streams:

	what	where
bilateral temporal lobe and left-occipital lesions	elephant has a long neck	can draw a floor plan of his house
bilateral parietal-occipital lesions	can describe an elephant	can't describe how to navigate through his neighborhood

Insights from the Clinical Neuropsychology

Hemispatial neglect extends to mental imagery

Bisiach and Luzzati (1978)



Some evidence that says NO...

Dissociations between Perception and Imagery

Usually these patients have specific deficits to the kind of visual entity being probed:



Shapes: can't answer: "does the letter P have a curved segment?", but can see letters just fine. no agnosia.



Color: achromatopsia, but can say which is redder, plum or eggplant



Faces: prosopagnosic Bri can evoke from memory the faces of his family members; M.X. can not imagine faces, colors, forms, letters, and topographical relationships, but could recognize his wife and sons



Spatial Imagery: visual neglect in the absence of imaginal neglect
(Anderson, 1993; Coslett, 1997),



imaginal neglect without visual neglect
(Beschin et al., 1997; Coslett, 1997; Guariglia et al., 1993).

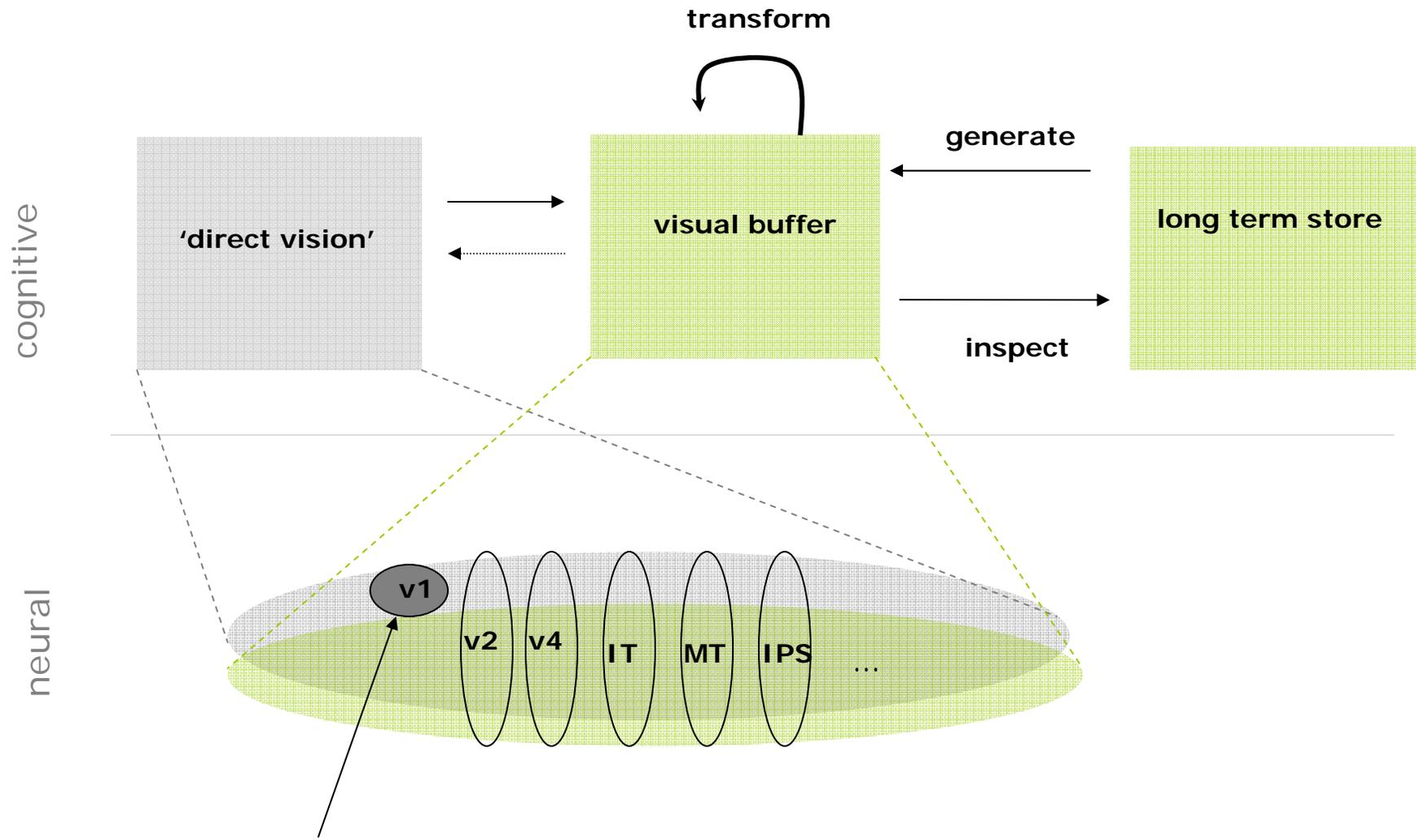
Reconciling the Perception/Imagery Debate:

- some of the neural implementation for imagery is the same as perception (**adaptation** nicely shows this in a neuron specific way, assuming you buy adaptation paradigms.)
- some of the neural implementation for imagery is different than for perception (clinical dissociation of someone with **representational neglect** and normal perception)

some implications:

- imagery is at least **constructed** through perceptual experience, and **requires perceptual experience to remain intact** (Mr. I.)
- memory for perceptual information is NOT independent of perceptual processing, because some of the hardware is shared (*Spivey 2000*)

Kosslyn's Model, revisited.



is the primary visual cortex 'protected'?

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Great Debate 3: Imagery in the Primary Sensory Areas?

Why is this question important?

If imagery can alter activation in early visual cortex, this indicates that our beliefs and expectations can modulate what we actually see during perception. (Kosslyn, 2000)

Kosslyn's Meta-Analysis

DOES VISUAL IMAGERY ACTIVATE V1?

Yes:	21 fmri, 11 pet, 2 SPECT	34
No:	3 fmri, 13 pet, 7 SPECT	23

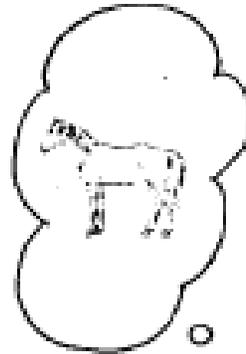
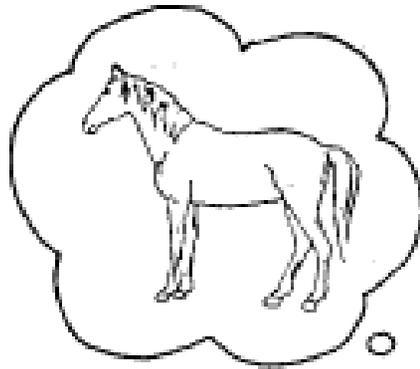
But...

A Problem for any fmri study: it's unclear whether v1 activity is necessary for visual imagery, or mental images are represented in extra-striate areas and back-activate v1.

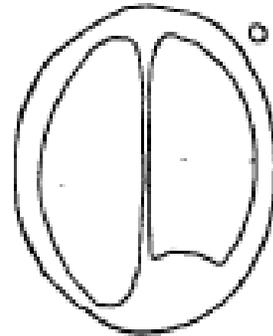
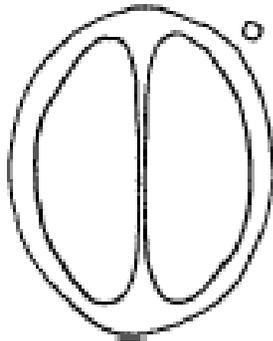
Direct V1 manipulations suggest...

rTMS over v1 slows imagery judgments compared to sham stimulation. The magnitude of this effect was similar when making perceptual judgements. (kosslyn 2001)

Removal of Primary Visual Cortex leads to...



Reduced visual angle
of mental imagery
workspace



*"I can get to within 15 feet
of the horse in my imagination
before it starts to overflow"*

*"The horse starts to overflow
at an imagined distance of
about 35 feet"*

FIGURE 62.4 Representation of the effects of occipital lobectomy on the maximal mental image size of case M. G. S.

(Farah 2000)

Kosslyn's Meta-Analysis.

Observation:

Mostly find activation if the task involved a high-resolution detail (shape of animal's ears, comparing two stripe lengths).

The Insight:

The activations caused by imagery goes **down** the stream as far as the **task** demands (based on, e.g. receptive field sizes).

My summary:

When people say 'visual imagery', the *kind* of imagery, not just the sensory modality but the kind of information being queried, *really matters*.

No clear answer about lesions to v1 and capacity for minute detail in visual imagery in that part of the field.

Neural basis of lesions is so overlapped that it's difficult to predict or isolate when you'll have a dissociation between perceptual and imagery deficits or not.

Other Types of Imagery...

auditory imagery:

Temporal Lobe Lesions can impair perception and imagery of melody.

(Zatorre and Halpern) Test: hear song and read lyrics and judge which pitch is higher for word a or word b. Or, imagine song and make same judgement. The patients who were impaired with perceptual pitch discrimination were also impaired in the imagined pitch discrimination condition.

Maintained Auditory Imagery activates auditory areas...

Listen to notes of a familiar song and then keep it going in your head. compare 'keep it going' to 'listen' and find similar activation in superior and inferior temporal cortex). Auditory imagery recruited STS and frontal lobe and SMA above and beyond.

Imaging during Auditory Hallucinations

(Griffiths) Auditory hallucinations also activate these same auditory cortex, plus basal ganglia cerebellum and inferior frontal. No evidence that A1 itself is activated during auditory imagery

Other Types of Imagery...

motor imagery:

Imagined movement activates same areas as actual movement:

You can compare activation from imagining that you are using your hand to rotate a shepard shape, or just rotating it 'externally', and see activation in contralateral M1.

The primary motor cortex is functionally involved in imagery:

TMS over M1 650 ms after presentation of hand stimulus (to be rotated) delays the response. This doesn't happen at other SOAs (temporally specific) and doesn't happen with stimulus of feet (object –representation specific). (*Ganis et al.*)

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Imagery and Skill Learning

Feltz and Landers, 1983

Meta-analysis of imagery studies in performance benefit

**Generally accepted that visualization helps performance,
(but not as much as actual practice)**

though...

Putting Imagery: (Tayler and Shaw, 2002)

- golfers imagine made or missed puts
- missed-putt imagers did worse than no imagery at all!

Since then there's been a hunt for the underlying neural mechanisms ...

Motor Skill Learning with Mental and Real Practice

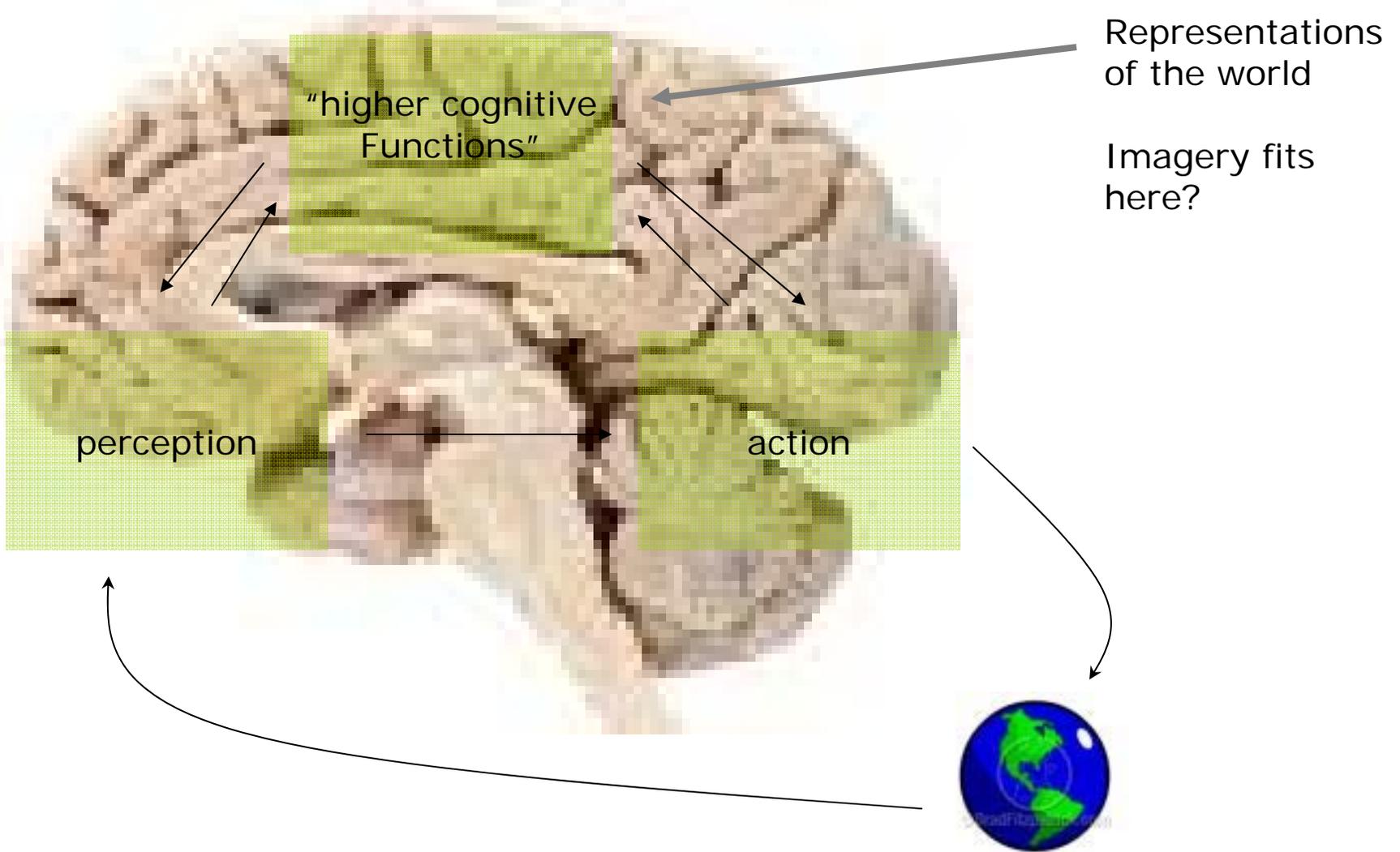
Task:
left-handed visually cued finger
sequence



QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

Larger (bilateral) network for pre-
training compared to post training

Situating imagery in the big picture...



Imagery, Perception, and Action



view



imagine

Group 1:

Free viewing

Spontaneous eye-movements
Highly correlated

Group 2:

Fixation required

Spontaneously kept
eyes at fixation

Group 3:

Free viewing

Fixation Required

Impaired recall

Conclusion:

Commands to the eyes are **stored** with the visual representation and **assist** image generation

(Bruno Laeng, 2002)

Imagery, Perception, and Action

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

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TIFF (LZW) decompressor
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TIFF (LZW) decompressor
are needed to see this picture.

(Spivey 2000)

Imagery, Perception, and Action

The last two studies demonstrate that:

Mental Images (Visual Representations) *include* motor information from eye movements. These are not 'additional' or 'supplemental' information but rather play a *functional* role in recall.

Motor commands are *spontaneously* generated even in the absence of explicitly requested imagery or required responses.

Some Conclusions ...

1. Cognitive Architecture

Imagery experiments allows us to probe the forms of underlying mental representation.

(e.g. are objects represented as a collection of 2d images or as a 3d representation?)

Do you believe that the experiments of this kind can be conclusive?

2. Neural Representation

There is a challenge to reconcile the existing data:

Much evidence shows the neural circuitry is largely shared, but there are many clinical cases where the perception-imagery equivalence fails.

Lesions are usually too crude and confounded to understand *when* and *how* imagery has selective deficits from perception and visa versa. Another method is needed.

3. Applications

Imagery can **improve memory**

Imagery can **improve performance**

Thus, exploring the capacities and limitations of imagery will be helpful for educational purposes

There is much to be researched regarding the effects of of non-visual imagery modalities and especially cross-modal imagery

4. Embodied Cognition

Imagery is nicely situated in the perception-action dynamic and, when taken within this framework, has the potential to illuminate new ways of thinking about visual perception (eye movements matter!)

(imagine a picture of
someone in the act of imagining
here)

THANKS!

Image Scanning



Image Scanning

How far apart (in TK Units) are:

British Columbia and Alberta?

British Columbia and Quebec?

Visual Imagery and Dreaming

Visual Imagery during Dreaming in Congenitally blind!

(Bertolo et al. 2003)

Visual dream content, graphical representation and EEG alpha activity in congenitally blind subjects.

- had people draw their dreams afterwards
- found same degree of EEG activity from occipital areas
- poorer performance of dreams

Imagery in Children

Kosslyn et al 1990

-mental rotation ability improves with age

- visual image maintenance shows no difference across ages.

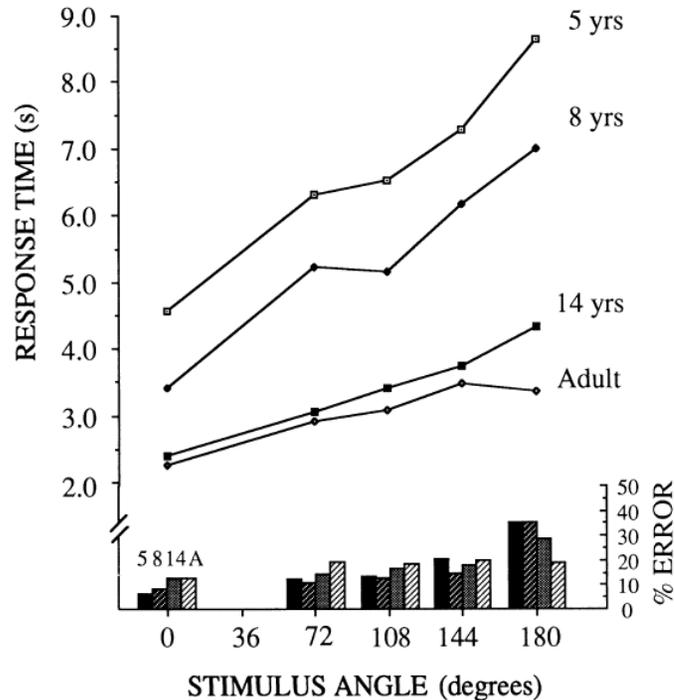


FIG. 4.—Results from the mental rotation task. The mean response times and error rates are illustrated for the different angular disparities for each age.

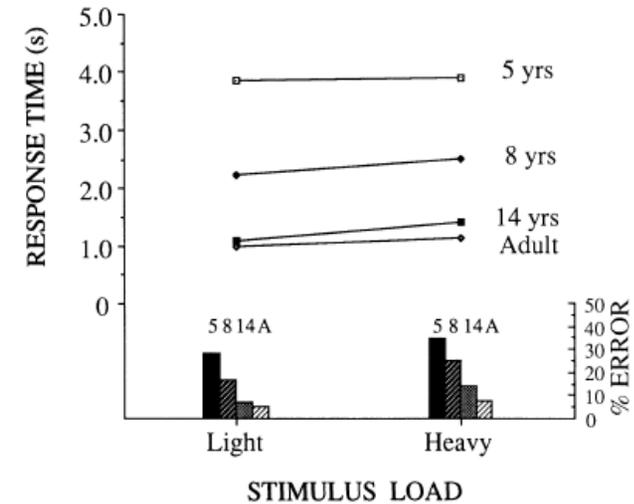


FIG. 2.—Results from the image maintenance task. The mean response times and error rates are illustrated for the light-load and heavy-load conditions for each age.

X			
	X		X
		X	

X	X	X	X
X	X	X	X
X	X	X	X
X	X	X	X
X	X	X	X

	?		

			?