



# Mental Imagery



Geoff Cole

# What is mental imagery?

“Visual mental imagery is a set of representations that gives rise to the experience of viewing a stimulus in the absence of appropriate sensory input” (Kosslyn, 2005).

Is a picture that an observer “sees” in their head.

We can manipulate them and use them to solve problems.

Vividness of imagery differs between people with some not having any imagery at all.

Modern interest came from experiments showing that, e.g., memory for pictures and 'concrete' words is better than abstract words (Pavio & Csapo, 1969).

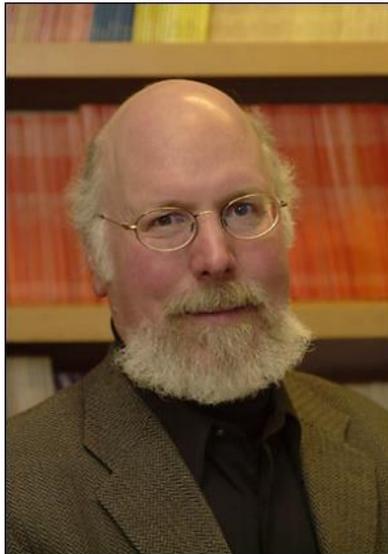
“elephant”

vs

“temptation”

# The “Great Debate”

Occurred between 1973-2003. The “Kosslyn-Pylyshyn debate”. The “mental imagery debate”.



Stephen Kosslyn  
(1948-)



Zenon Pylyshyn  
(1937-2022)

How does the brain represent information?



# The “Great Debate”

**When you generate a mental image, are you looking at it?**

Is the visual system involved? If so, to what degree? Are images represented in a different way than all other information? When you imagine a scene, do you really have an image of the scene, or is this feeling an illusion?

# Mental scanning

The crux of the issue was how we should interpret results from **mental scanning** experiments.....

# Kosslyn, Ball, & Reiser (1978)

Ps first memorized this map.

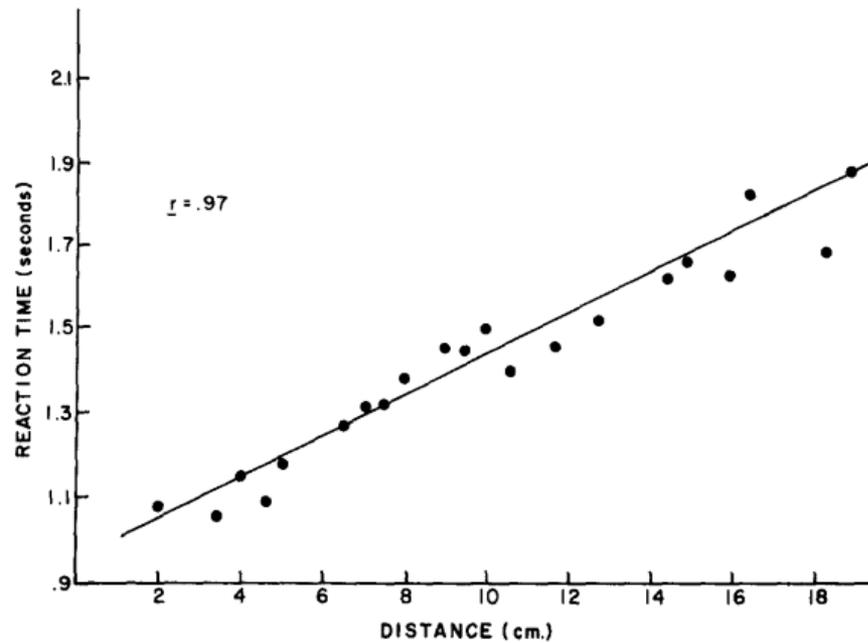
Asked to imagine the map and were given the name of an object to focus on (e.g., “Beach”).

They then heard the name of another object (e.g., “well”) and told to scan their image for that object.

Pressed a button when they found it.



# Kosslyn, Ball, & Reiser (1978)



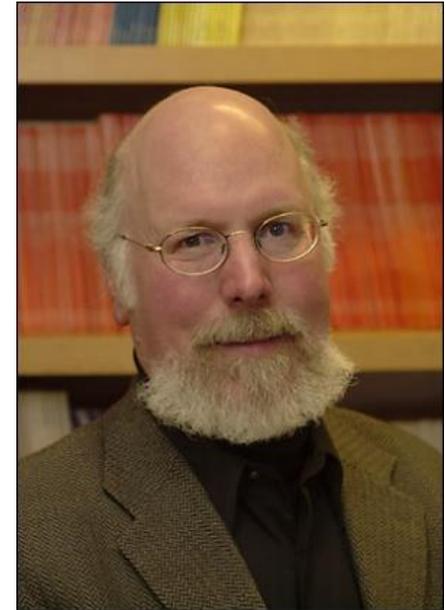
*Figure 3.* The results of Experiment 2: Time to scan between all pairs of locations on the imaged map.

# Kosslyn's view

**Images have spatial structure.**

*“parts of the surface image correspond to parts of the represented thing, and the interpoint spatial relations among the thing's parts are preserved in the image”.*

*“Images are capable of preserving relative metric distances between portions of objects”*

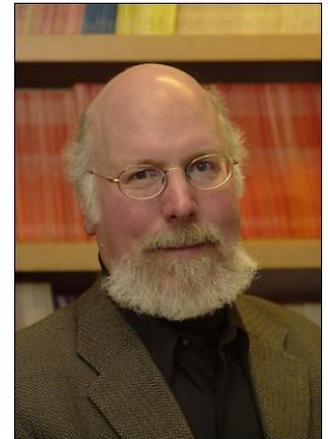


# The pictorial theory

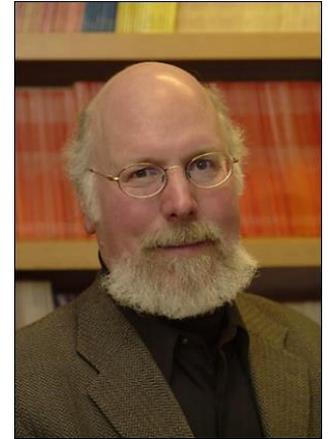
An image is retrieved from Long term memory and sits there in an objective manner. The observer then uses their visual system to “look at” the image. They can read-off information.

Images, *“once formed, can be operated upon in various ways”*

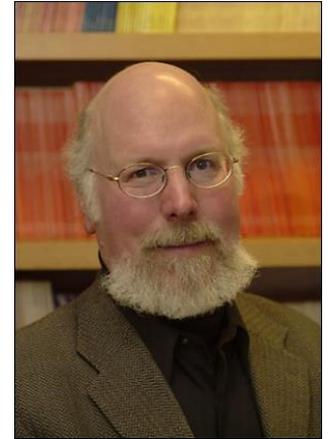
Images have **intrinsic optical and geometric properties**, i.e., have spatial structure.



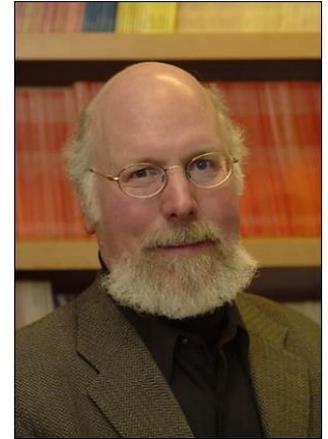
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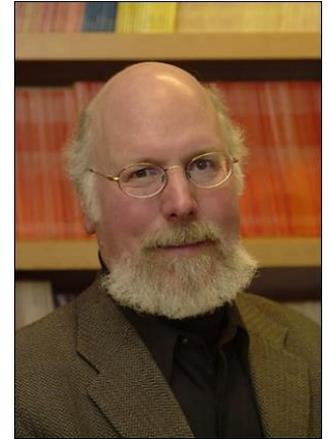
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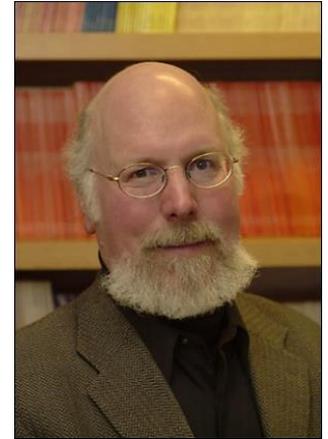
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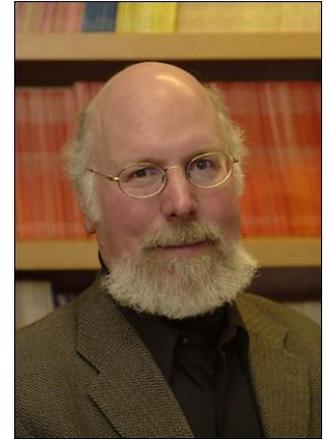
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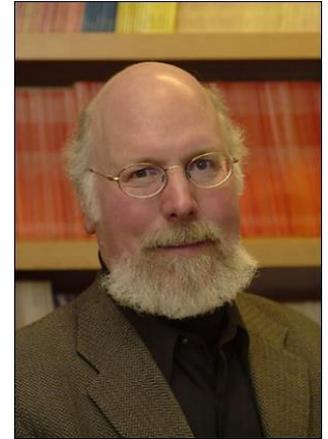
# The pictorial theory



# The pictorial theory



# The pictorial theory



# Pylyshyn's view

*Why do we find it so difficult to accept that when we “examine our mental image” we are not in fact examining an inner state?*

*[Kosslyn's view] is a strong conclusion about cognitive architecture. It says, in effect, that the symbolic code idea that forms the foundation of computational theories does not apply to mental images.*



*Are there really pictures in the brain?*

# The descriptive theory

It **looks like** images have spatial structure. They do not. It **looks like** we scan images but this is an illusion.

We know what it is like to, for instance, look at a map or look at the front of our house.

We **simulate** that experience when generating an image. Results are not due to any **intrinsic property** of the image.



# Looking or simulating?

**Imagery demo:** Imagine moving quickly from location *X* to *Y* around a couple of obstacles....

Think about your mental image when you were doing that task.

Was the **image** constraining you? i.e., was there something inherent in your image doing this? Or were you **simulating** that constraint?

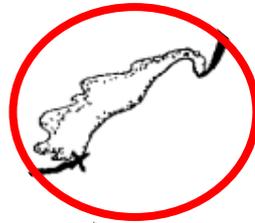
# The descriptive theory

*[Kosslyn's results] "are due to the fact that the task of "imaging" invites people to simulate what they believe would happen if they were looking at the actual situation being visualized".*



*"when subjects are asked to "imagine x," they use their knowledge of what "seeing x" would be like and they simulate as many of these effects as they can".*

# The descriptive theory



# The descriptive theory

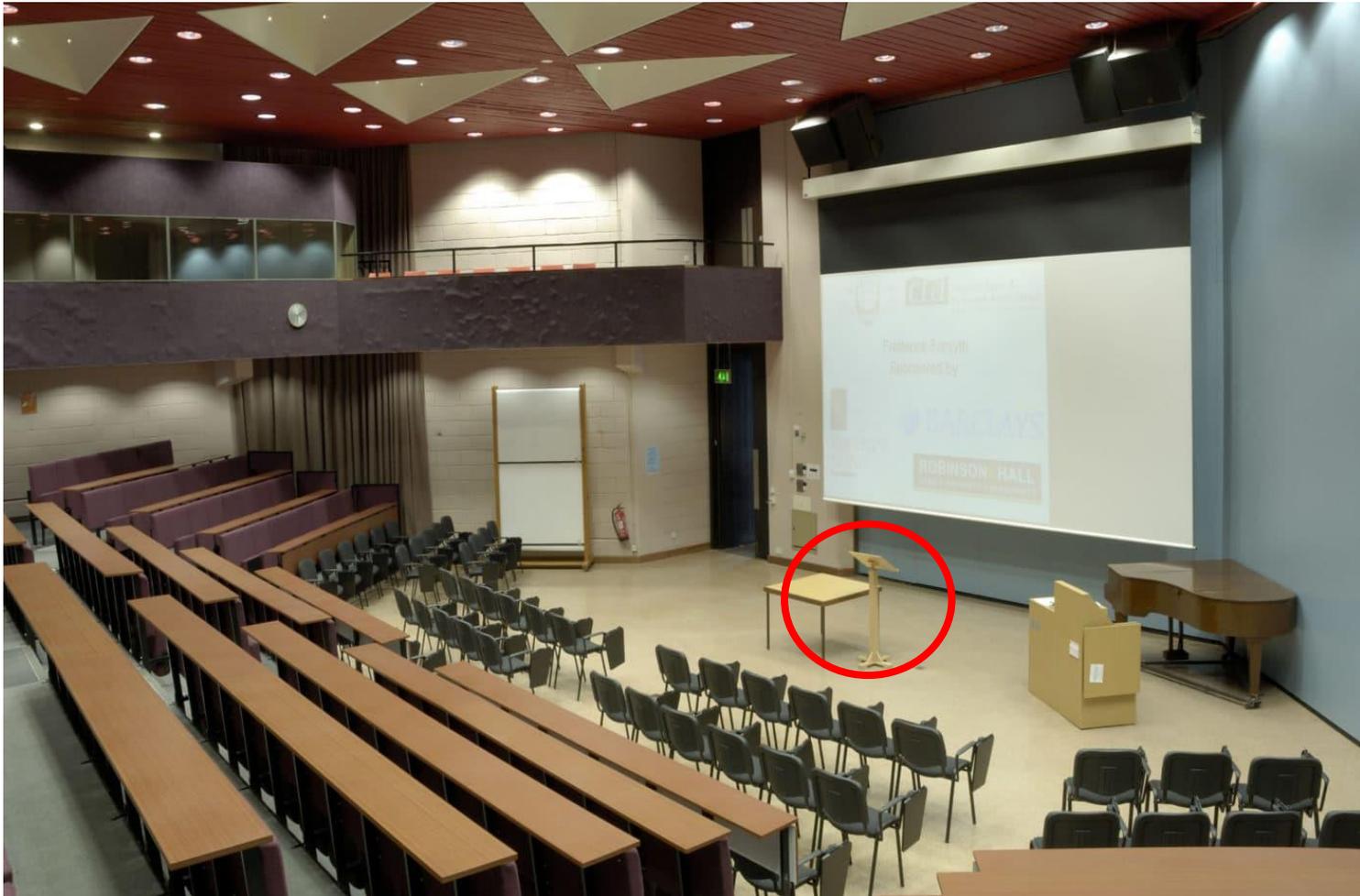












**Visual perception doesn't work  
like that.**

**This happens.....**

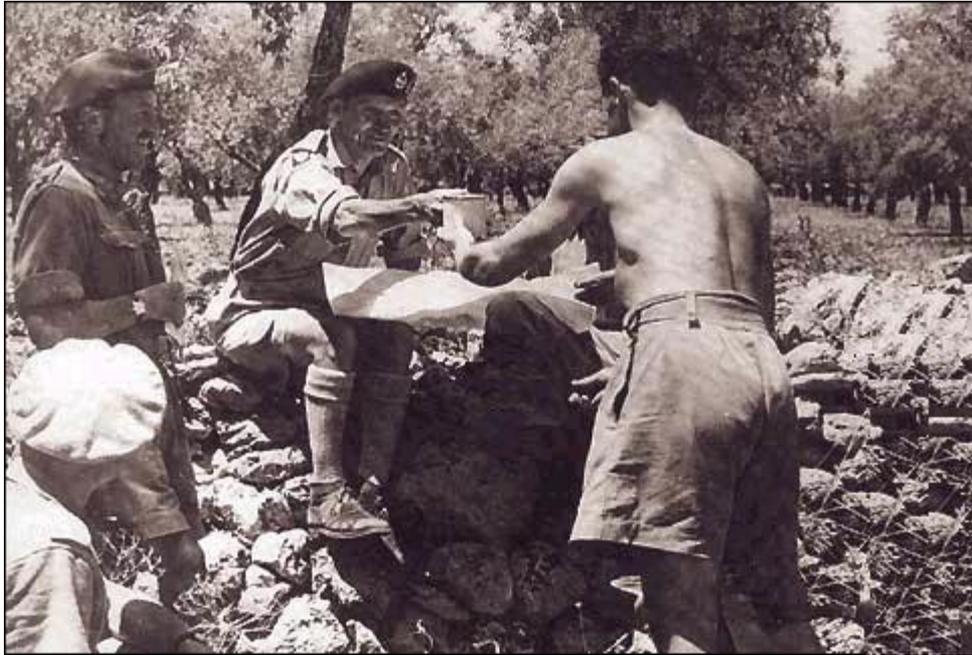




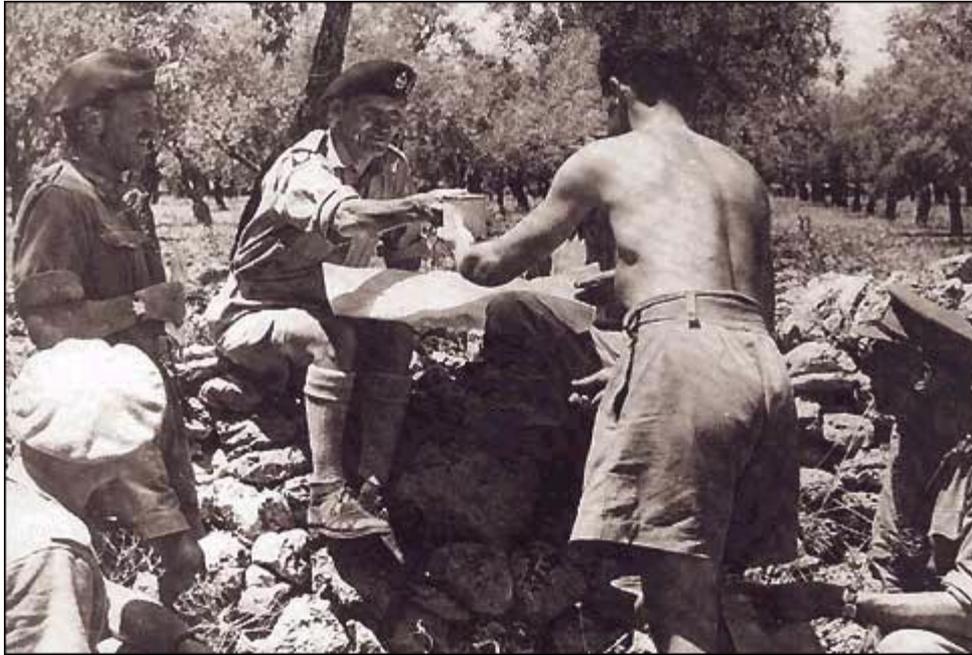




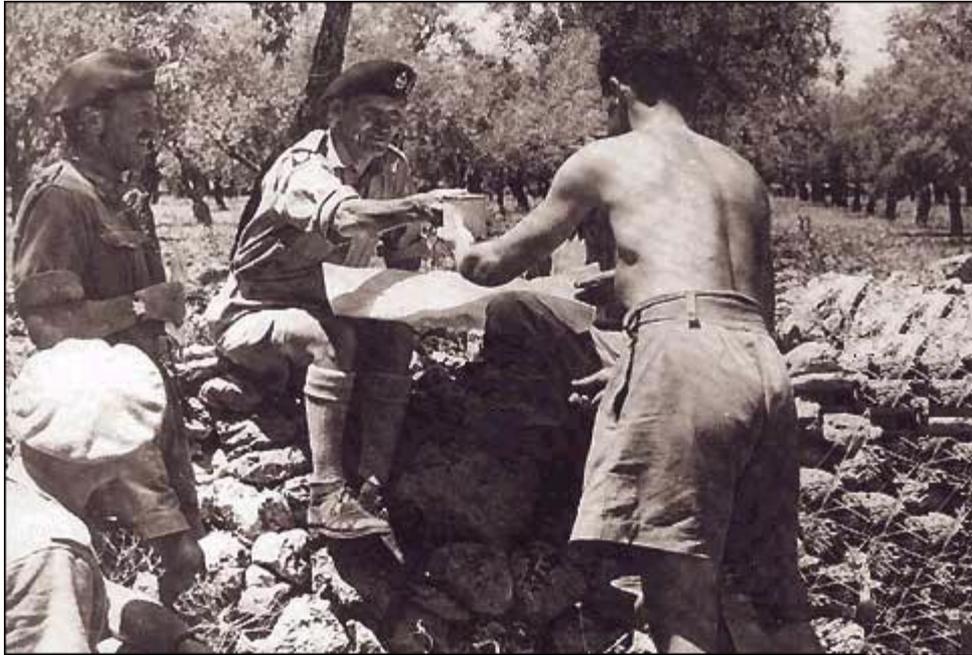




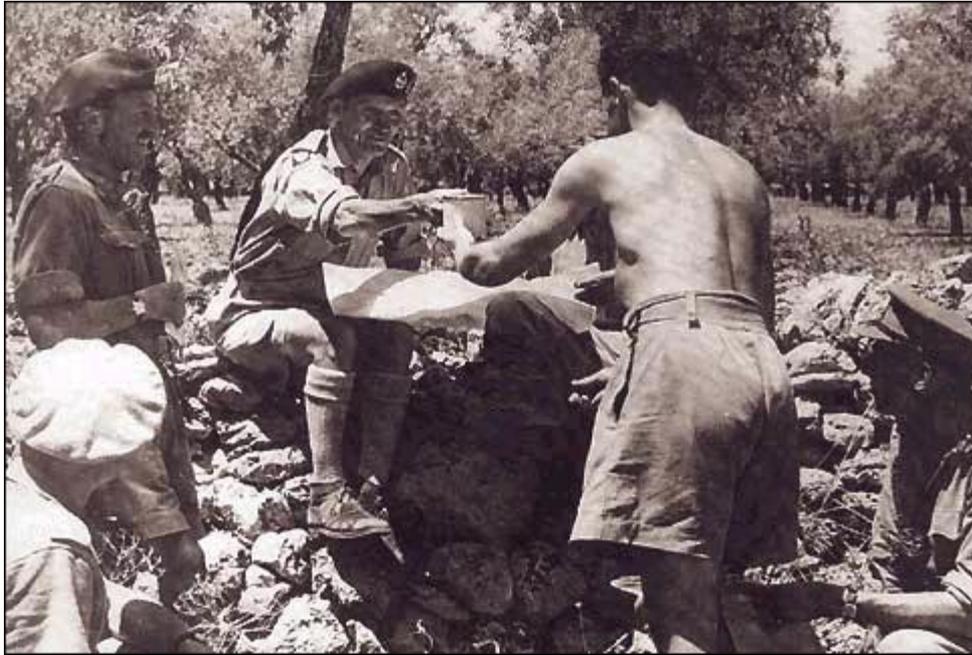










































# Pylyshyn's variant of map scanning

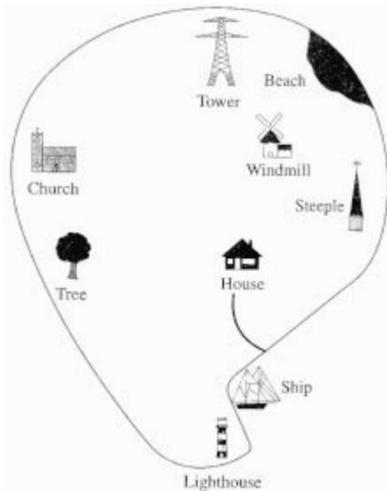
Pylyshyn (1981) noted that the Kosslyn et al. (1978) study emphasised ***scanning***, i.e., a movement of attention across the image.

From the Kosslyn et al. method....

Subjects were told that 5 sec after focusing on the named object, another word would be presented; if this word named an object depicted on the map, the subjects were to scan to it and depress one button when they arrived at the dot centered on it. The scanning was to be accomplished by imaging a little black speck zipping in the shortest straight line from the first object to the second. The speck was to move as quickly as possible, while still remaining visible.

# Pylyshyn's variant of map scanning

Pylyshyn (2002) described an experiment in which no emphasis was placed on scanning.

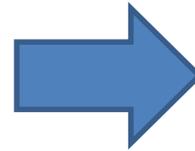
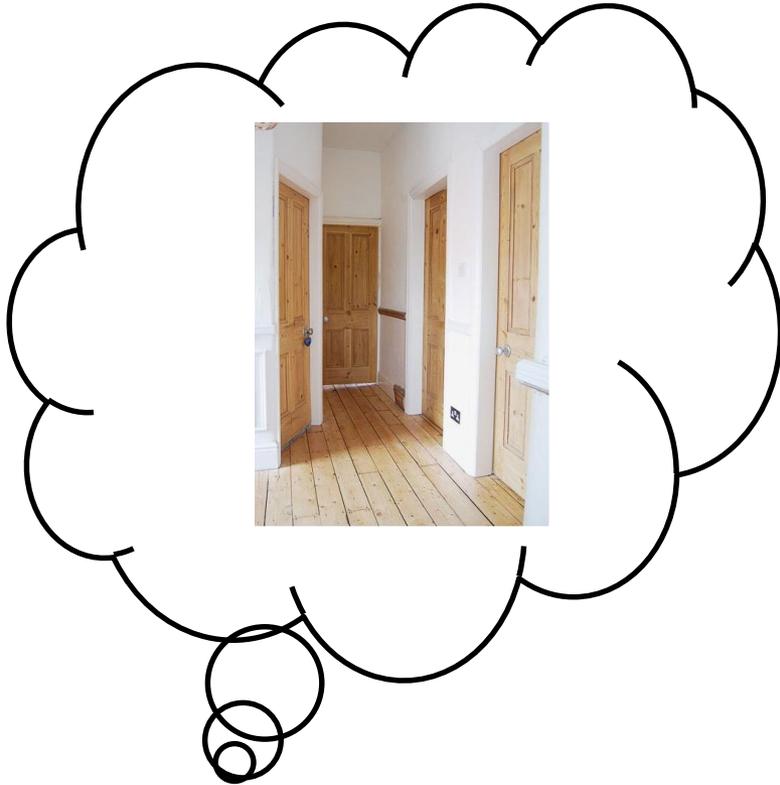


Participants asked to imagine a light turned on at the cued object (e.g., "Ship") then a light turned on at different object (e.g., "Church").

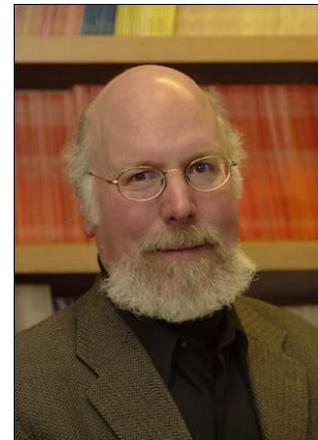
Results: No distance effect.

Concluded that the Kosslyn results are not due to the **intrinsic** nature of images.

# An issue of cause and effect

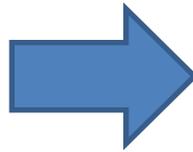


*“Ten”*



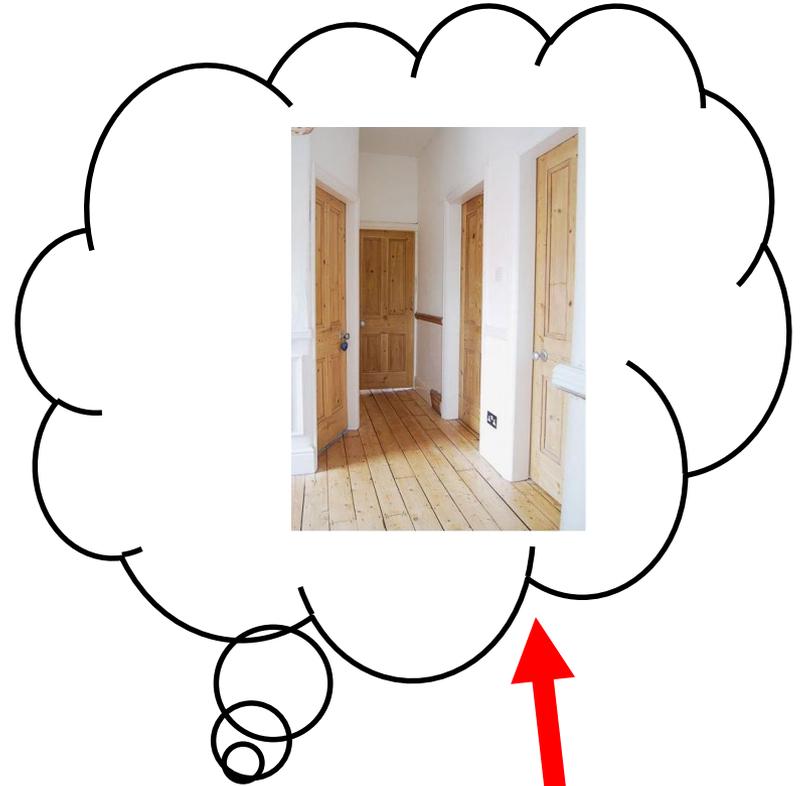
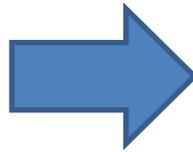
# An issue of cause and effect

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*“Ten”*



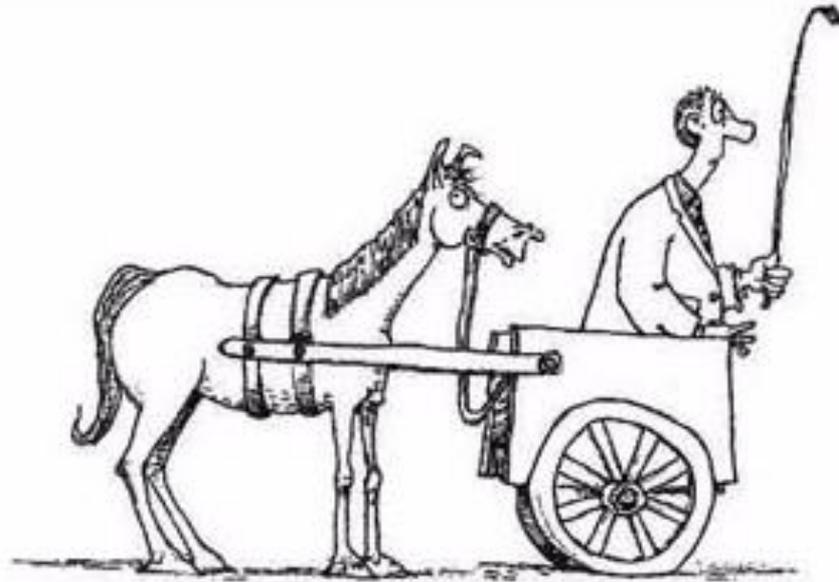
*This is epiphenomenal*

# “Epiphenomenal”

Just like this Penny Farthing in Brightlingsea.



# An issue of cause and effect



# The “null hypothesis”

Images do not sit there objectively. If they did, they would adhere better to the laws of nature. They would not be so malleable.

*“It is you alone who controls your image”.*



*“You can imagine things being pretty much any size, color, or shape that you choose..... You can imagine all sorts of physically impossible things”.*

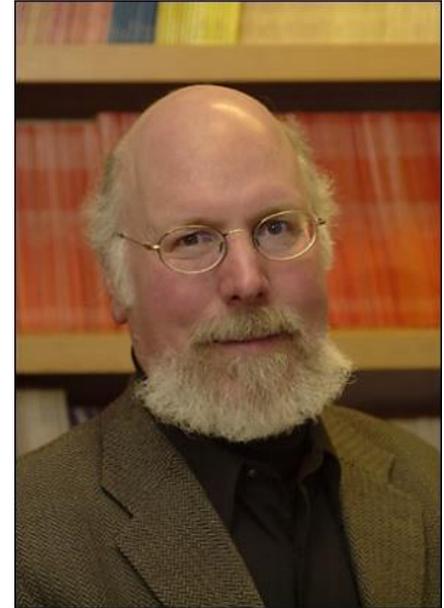
# The issue of representation

## *The Pictorial theory*

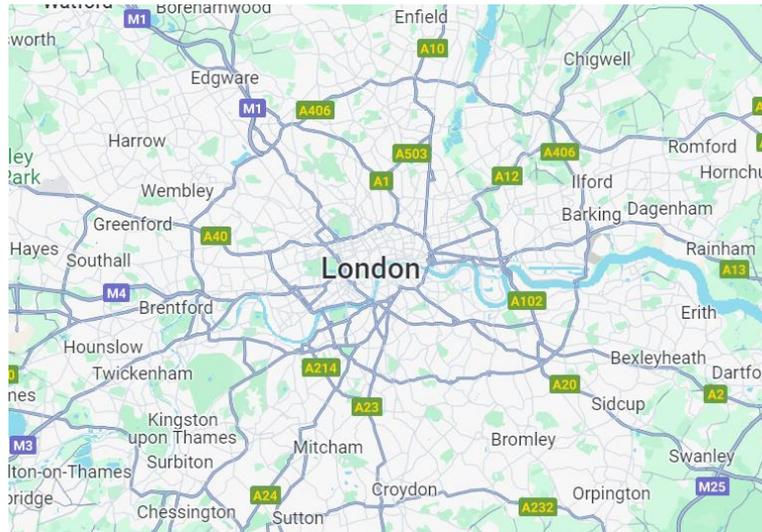
Images are a special form of representation. They are different to how the brain represents all other information.

The internal representation **itself** is 'pictorial' or 'depictive'.

The representation has distance and space.



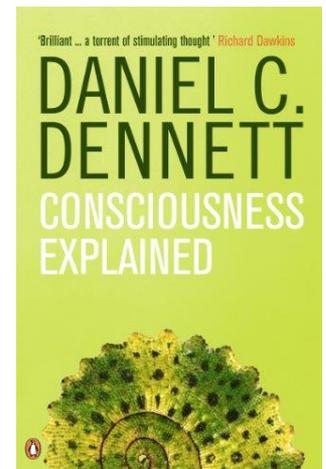
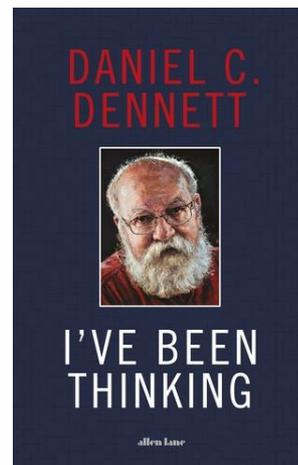
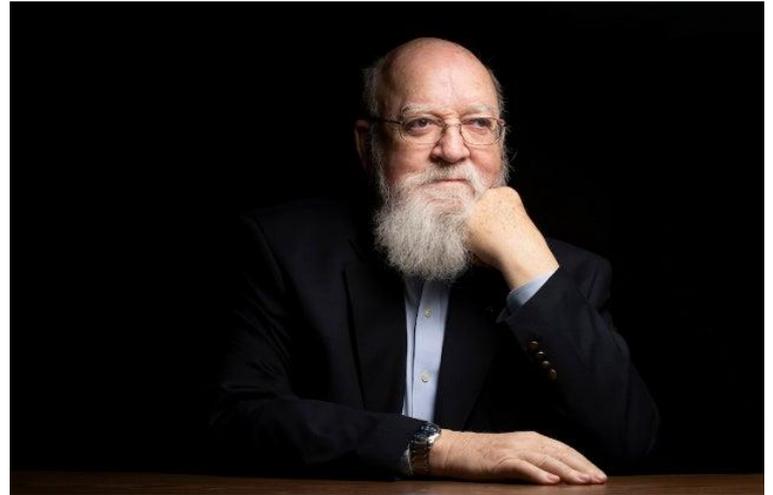
# *London is larger than Birmingham*



# Daniel Dennett

*When singing happy birthday to a relative over a landline. Information travels down the wire. But, that information does not form the words “Happy Birthday” as seen from above.*

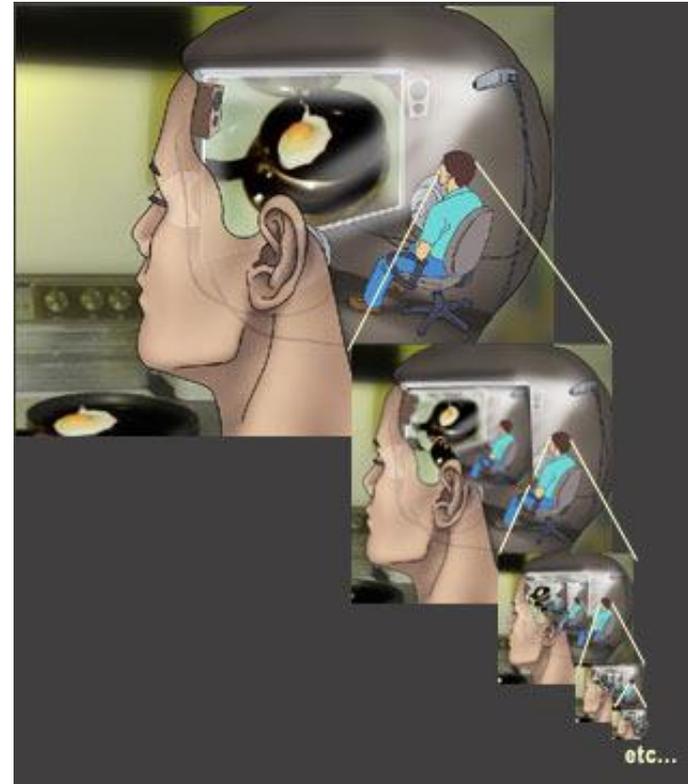
(Paraphrased from Dennett, 2002).



# The homunculus requirement

In cognitive science the notion of a homunculus is used to illustrate how the brain does not operate.

e.g., visual perception.



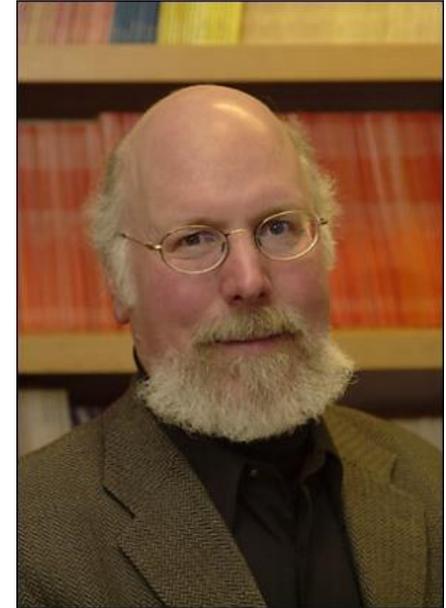
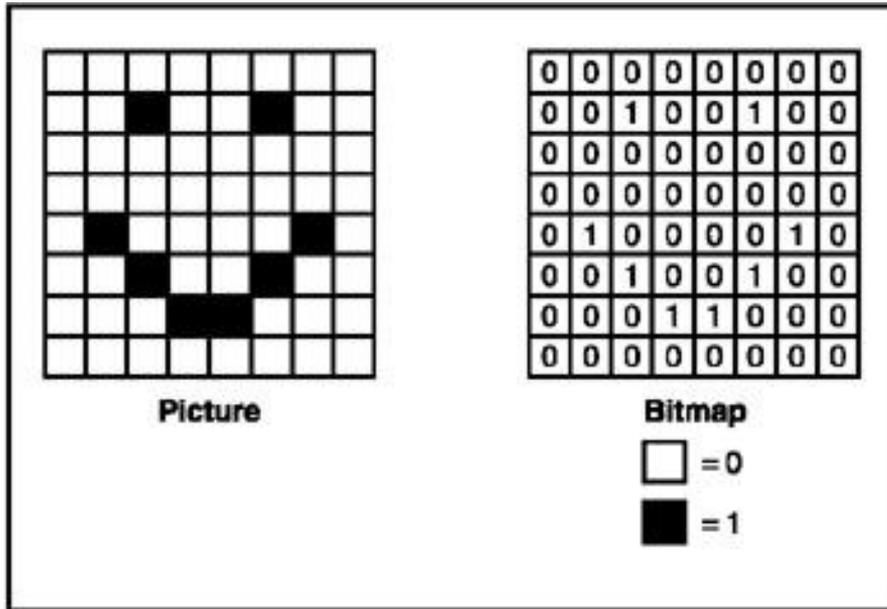
# Rene Descartes (1596-1650)

What is in our head when we perceive an object “bears some resemblance to the objects from which it proceeds”.

*“we must not think that it is by means of this resemblance that the picture causes our sensory perception of these objects – as if there were yet other eyes within our brain with which we could perceive it”.*



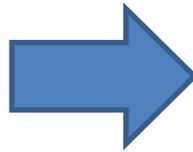
# Pictures in the brain?



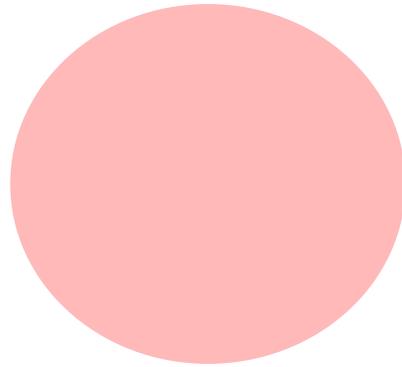
Would often state that he didn't mean there are literally pictures in the brain.

# Reasoning is based on your knowledge not imagery

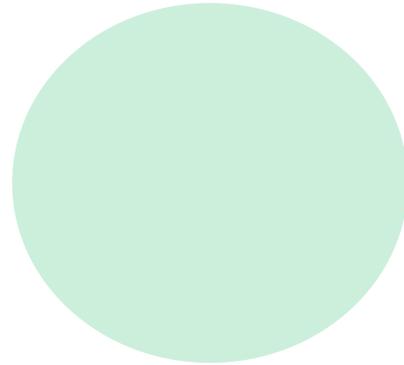
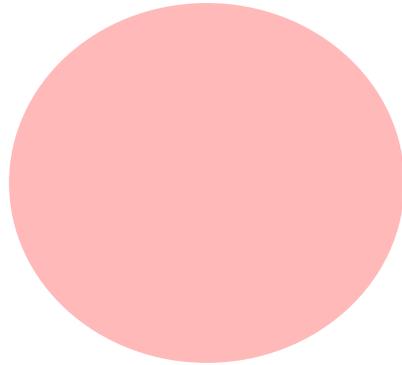
*“Ten”*



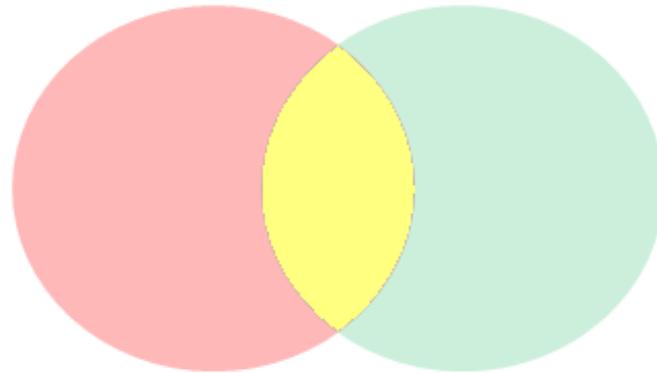
**Reasoning is based on your knowledge  
not imagery**



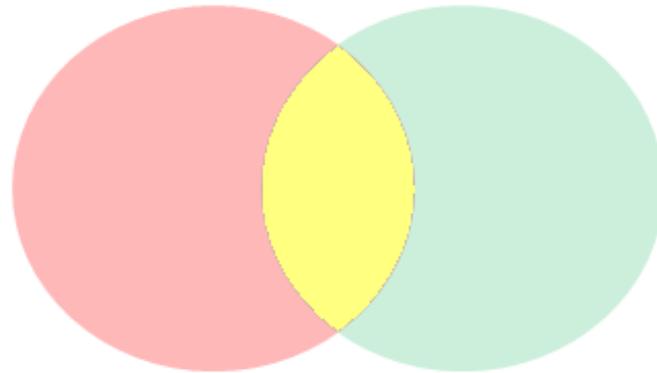
**Reasoning is based on your knowledge  
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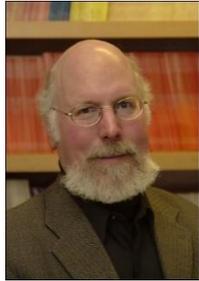


# Reasoning is based on your knowledge not imagery



Pylyshyn: If you don't have the  
knowledge you don't have the  
(correct) image.

Through the 1970s.....



# Analogue vs Descriptions



VS



# Mental rotation

## **Mental Rotation of Three-Dimensional Objects**

*Abstract. The time required to recognize that two perspective drawings portray objects of the same three-dimensional shape is found to be (i) a linearly increasing function of the angular difference in the portrayed orientations of the two objects and (ii) no shorter for differences corresponding simply to a rigid rotation of one of the two-dimensional drawings in its own picture plane than for differences corresponding to a rotation of the three-dimensional object in depth.*

*Department of Psychology,  
Stanford University,  
Stanford, California 94305*

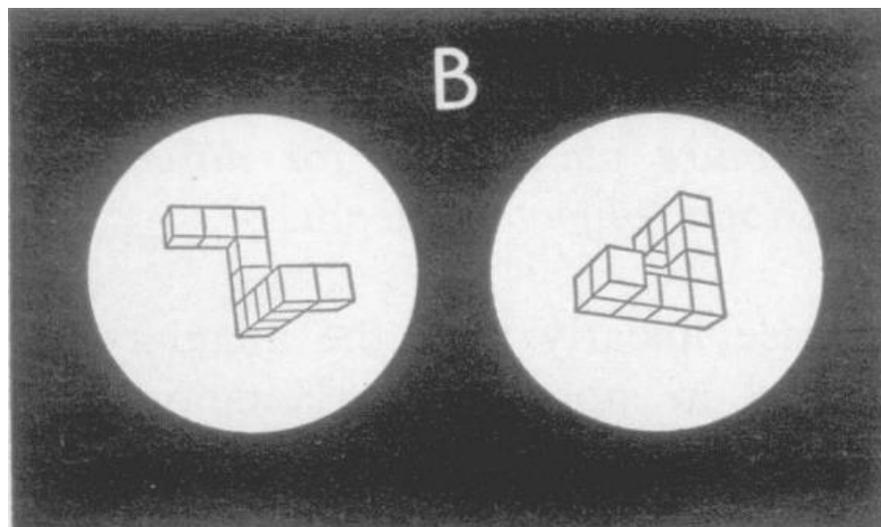
ROGER N. SHEPARD  
JACQUELINE METZLER

19 FEBRUARY 1971

SCIENCE, VOL. 171

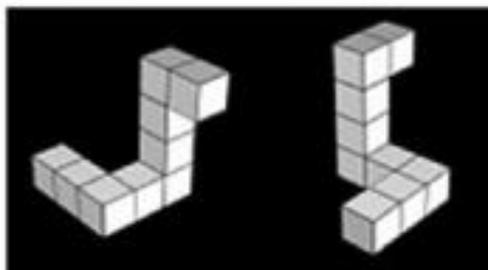
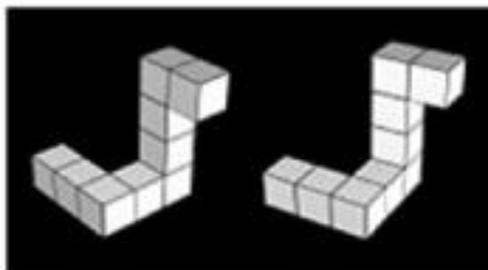
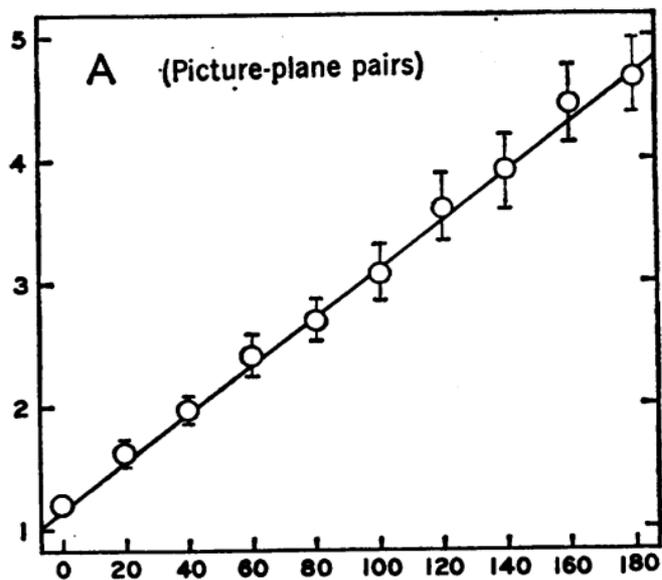
# Mental rotation

RT task to indicate whether a test object (right) matched a sample object (left).



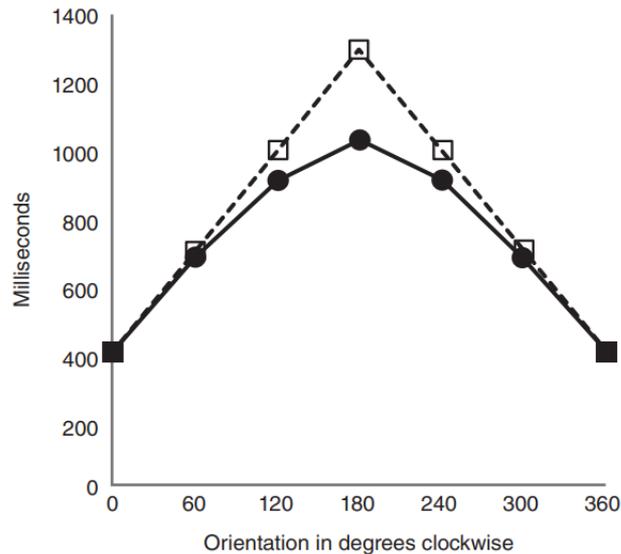
# Mental rotation

Results showed a strong linear relationship between the degree of angular separation between the two objects and RT.



# Mental rotation

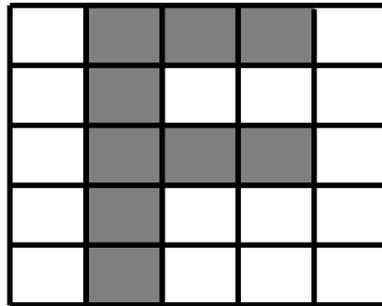
A non-pictorial representation explanation (i.e., Pylyshyn) predicts that RTs should be relatively short at 180° rotation.....



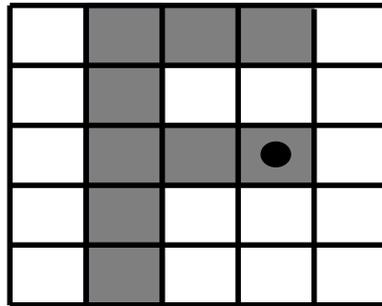
This is because a symbolic representation of rotated images should be easier to process at 180°; the coding is just reversed.

# **Equivalence of imagery and perception**

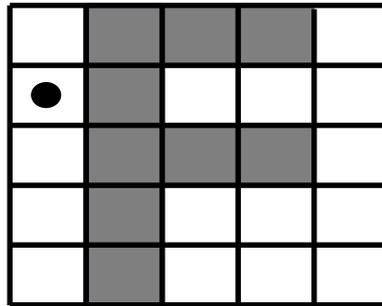
# Podgorny & Shepard (1978)



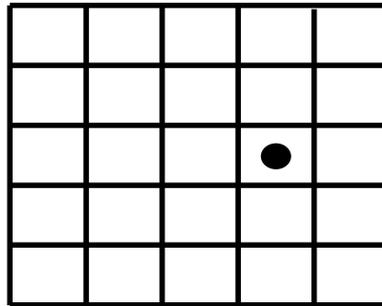
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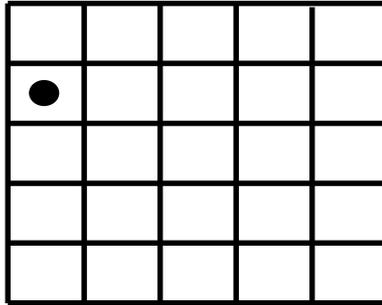
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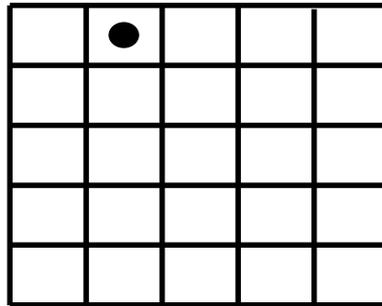
# Podgorny & Shepard (1978)



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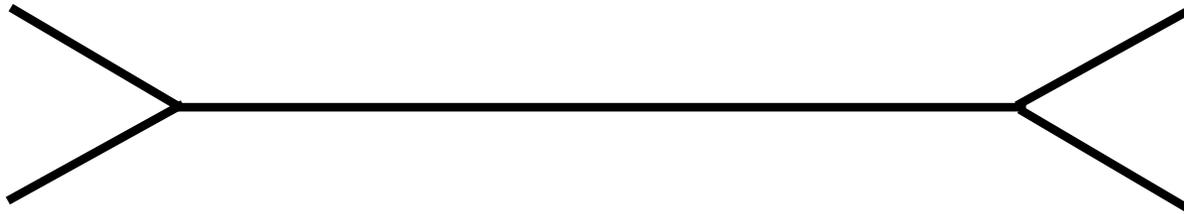
Found the effects with real and imagined letters.

## Pylyshyn (2002)

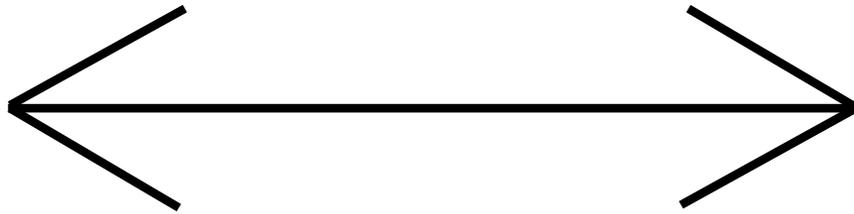
*“a more parsimonious account is that in imagining the figure in this task, subjects merely attended to the rows and columns in which the imagined figure would have appeared.... Focusing attention in this way is all that is needed in order to generate the observed pattern of reaction times”.*



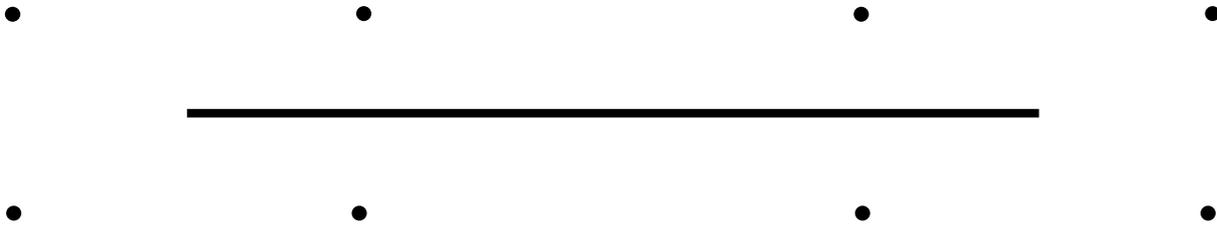
# The Muller-Lyer illusion



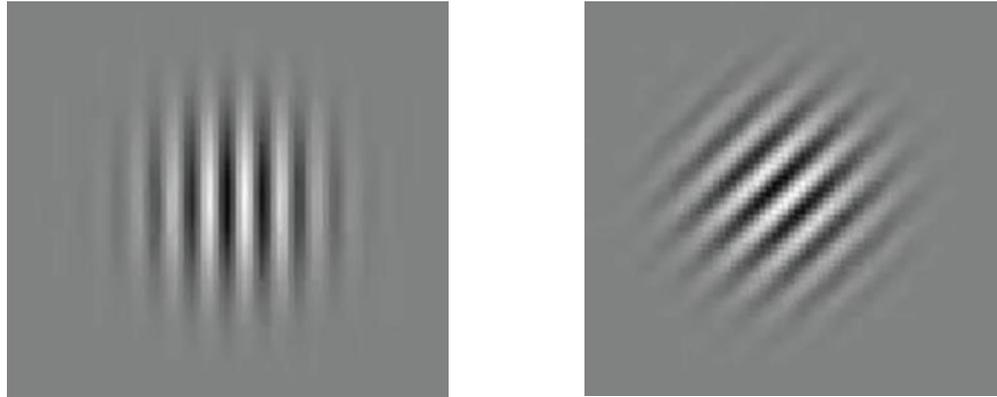
# The Muller-Lyer illusion



# Bernbaum & Chung (1981)



## The Oblique effect



The threshold for seeing a vertical peripheral grating is lower than for a diagonal grating.

Kosslyn et al. found the same effect for mental images of gratings. Not easily explained by the Pylyshyn simulation account.

# Smooth pursuit eye movements

If imagery and perception are equivalent, one should expect *smooth pursuit* for an **imagined movement**.

People can track objects in the absence of visual input (Barnes, 2008, review).

This does not occur for imagined motion.



# **Reconstructing mental images**

# Can we reinterpret images?

For Kosslyn, the image retrieved from LTM is fully formed.

*“the implication is always that whatever is retrieved must be perceptually interpreted (or re-perceived) before it becomes meaningful”.*



*“In other words, the appearance of a memory image precedes its interpretation by the usual perceptual processes”.*

# A fundamental problem....

Recall: Kosslyn argues that information can be gleaned from an image. It is “looked at” using perceptual mechanisms.

The problem: When asking a participant to form a mental image, **they always know what the object/image is.**

## A fundamental problem....

Recall: Kosslyn argues that information can be gleaned from an image. It is “looked at” using perceptual mechanisms.

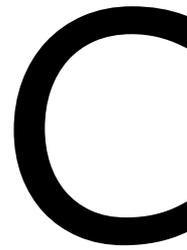
The problem: When asking a participant to form a mental image, **they always know what the object/image is.**

Slezak (1995) devised a way of circumventing this issue.....

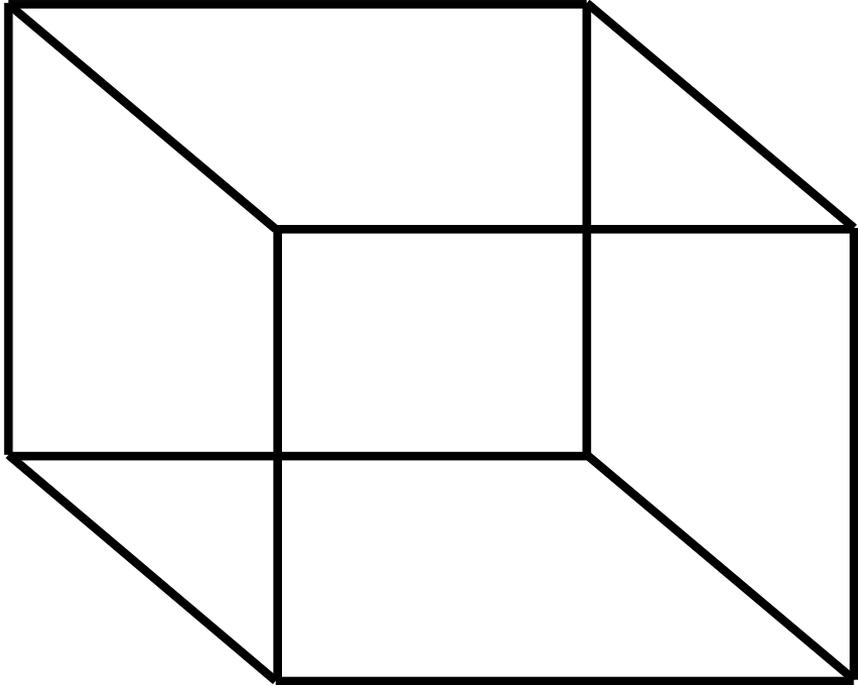




C



Slezak (1995) controlled for complexity of images by getting participants to **draw** their image and rotate it.

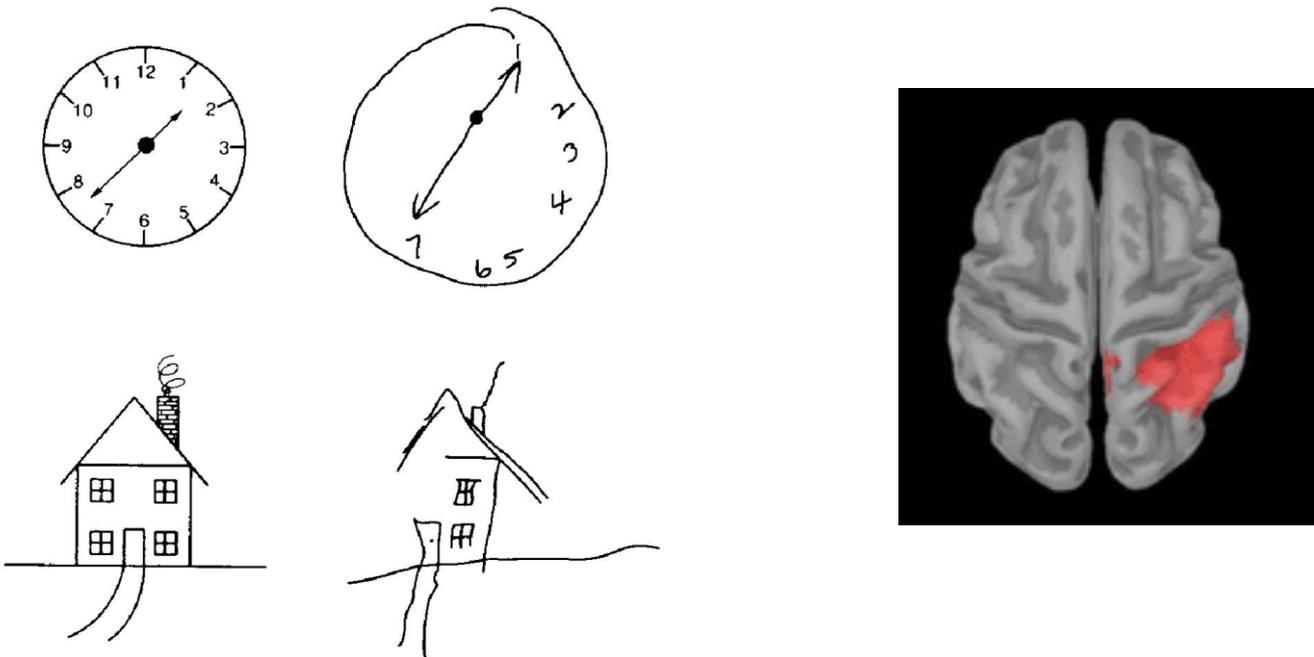


# **Evidence from neuroscience**

## **1) Brain damage**

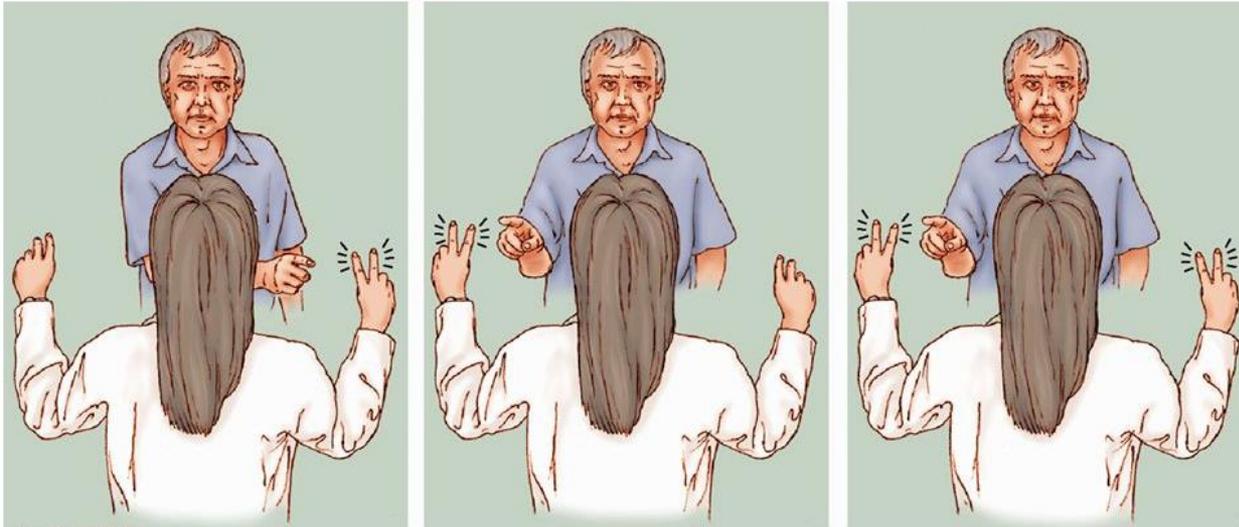
# Visual neglect

The failure to attend to one side of visual space



# Visual neglect

Is not purely a vision phenomenon.



# Visual neglect

Bisiach and Luzzatti (1978) asked neglect patients to imagine a familiar place from a particular perspective and describe what they see.

The patients ignored one side of their mental images; the same side as the visual/attentional deficit.

# Visual hemianopia

Farah, Soso, & Dasheiff (1992) described a 36-year-old female who suffered with right occipital epilepsy.

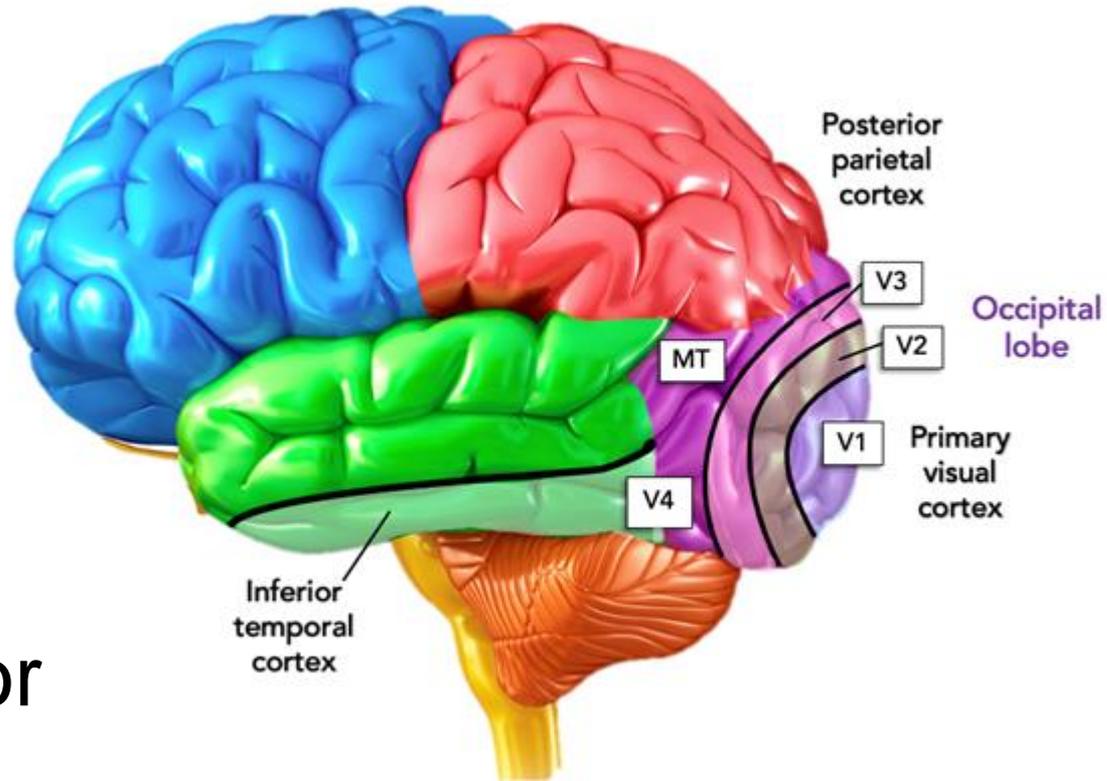
Had a portion of this brain area removed. This resulted in left hemianopia; partial loss of vision in the left field.

Her ability to form mental images was also affected. This loss mirrored her visual loss.

# **Evidence from neuroscience**

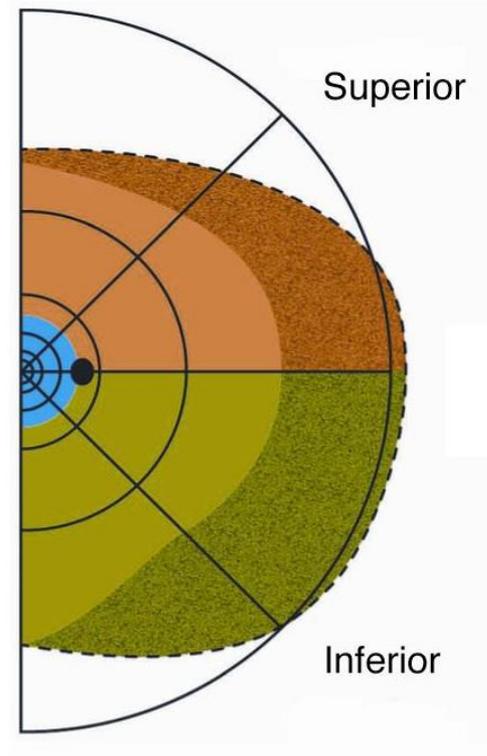
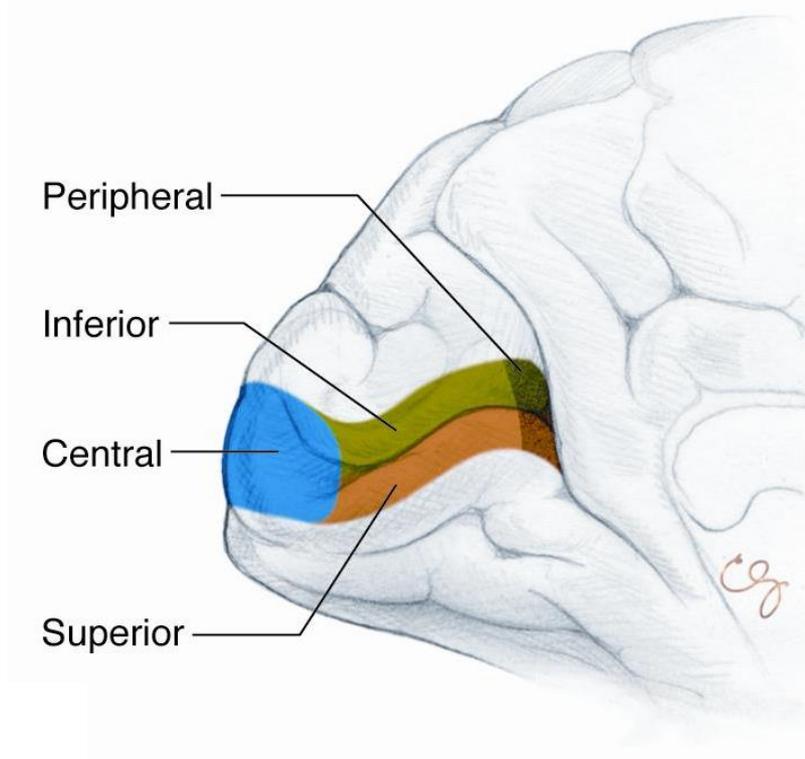
## **2) Brain imaging**

# The primary visual cortex



AKA: V1 or  
Area 17.

# Is retinotopically mapped



## **Visual Mental Imagery Activates Topographically Organized Visual Cortex: PET Investigations**

**Stephen M. Kosslyn,\*† Nathaniel M. Alpert,† William L. Thompson,\*  
Vera Maljkovic,\* Steven B. Weise,† Christopher F. Chabris,\* Sania E.  
Hamilton,\* Scott L. Rauch,† and Ferdinando S. Buonanno†**

\*Harvard University and †Massachusetts General Hospital



Found that a **large** imagined object activated anterior areas of V1. **Small** imagined objects did not.

# Aphantasia

CORTEX 73 (2015) 378–380

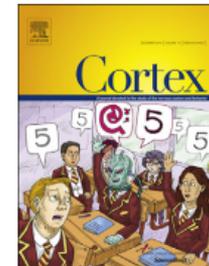


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## Letter to the Editor

## Lives without imagery – Congenital aphantasia



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# Aphantasia

In 2010 we reported a particularly ‘pure’ case of imagery generation disorder, in a 65 year old man who became unable to summon images to the mind's eye after coronary angioplasty (Zeman et al., 2010). Following a popular description of our paper (Zimmer, 2010), we were contacted by over twenty individuals who recognised themselves in the article's account of ‘blind imagination’, with the important difference that their imagery impairment had been lifelong. Here we describe the features of their condition, elicited by a questionnaire, and suggest a name – *aphantasia* – for this poorly recognised phenomenon.

φαντασία, *phantasia*, is the classical Greek term for imagination, defined by Aristotle as the ‘faculty/power by which a *phantasma* [image or mental representation] is presented to us’ (Aristotle, translated Hamlyn, 1968). We propose the use of the term ‘*aphantasia*’ to refer to a condition of reduced or absent voluntary imagery. Terms used previously in related contexts include ‘defective revisualisation’ (Botez, Olivier, Vezina, Botez, & Kaufman, 1985) and ‘visual irremembrance’ (Nielsen, 1946).

Sceptics could claim that *aphantasia* is itself a mere fantasy: describing our inner lives is difficult and undoubtedly liable to error (Hurlburt & Schwitzgebel, 2007). We suspect, however, that *aphantasia* will prove to be a variant of neuropsychological functioning akin to *synaesthesia* (Barnett & Newell, 2008) and to congenital *prosopagnosia* (Gruter, Gruter, Bell, & Carbon, 2009). Indeed, *aphantasia* may have some specific relationship to these disorders,



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# The blind mind: No sensory visual imagery in aphantasia



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## ABSTRACT

For most people the use of visual imagery is pervasive in daily life, but for a small group of people the experience of visual imagery is entirely unknown. Research based on subjective phenomenology indicates that otherwise healthy people can completely lack the experience of visual imagery, a condition now referred to as aphantasia. As congenital aphantasia has thus far been based on subjective reports, it remains unclear whether individuals are really unable to imagine visually, or if they have very poor metacognition – they have images in their mind, but are blind to them. Here we measured sensory imagery in subjectively self-diagnosed aphantasics, using the binocular rivalry paradigm, as well as measuring their self-rated object and spatial imagery with multiple questionnaires (VVIQ, SUIQ and OSIQ). Unlike, the general population, experimentally naive aphantasics showed almost no imagery-based rivalry priming. Aphantasic participants' self-rated visual object imagery was significantly below average, however their spatial imagery scores were above average. These data suggest that aphantasia is a condition involving a lack of sensory and phenomenal imagery, and not a lack of metacognition. The possible underlying neurological cause of aphantasia is discussed as well as future research directions.



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## Consciousness and Cognition

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# The prevalence of aphantasia (imagery weakness) in the general population



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### ARTICLE INFO

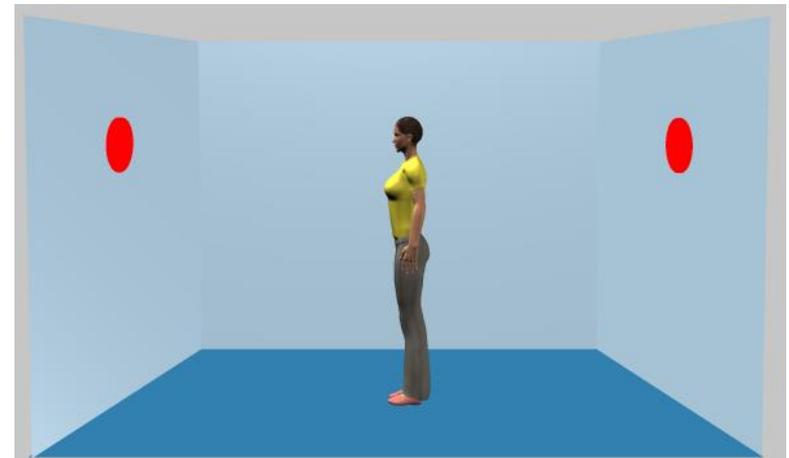
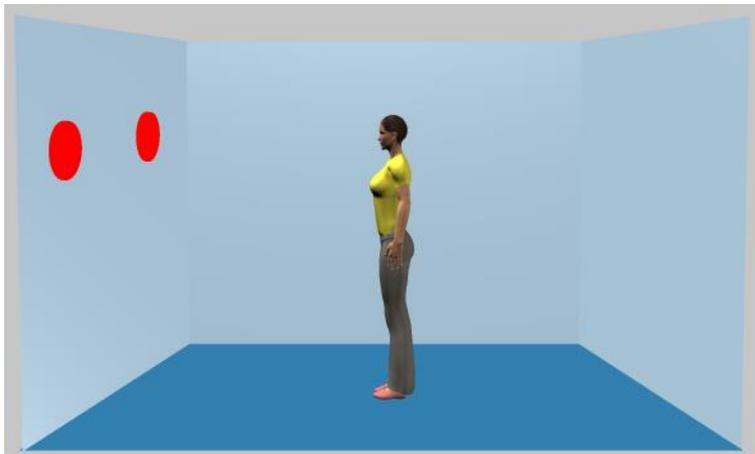
**Keywords:**  
Aphantasia  
Imagery  
Prevalence  
Imagination  
VVIQ

### ABSTRACT

Visual mental imagery is the ability to create a quasi-perceptual visual picture in the mind's eye. For people with the rare trait of *aphantasia*, this ability is entirely absent or markedly impaired. Here, we aim to clarify the prevalence of aphantasia in the general population, while overcoming limitations of previous research (e.g., recruitment biases). In Experiment 1, we screened a cohort of undergraduate students (n502) using the Vividness of Visual Imagery Questionnaire (Marks, 1973) and found that 4.2% had aphantasia. To establish the reliability of our estimate, we then screened a new sample of people (n502) at an online crowdsourcing marketplace, again finding that approximately four percent (3.6%) had aphantasia. Overall, our combined prevalence from over a thousand people of 3.9% – which shows no gender bias – provides a useful index for how commonly aphantasia occurs, based on measures and diagnostic thresholds in line with contemporary aphantasia literature.

# Imagery and visual perspective taking

Samson et al. (2010).



RT to determine the number of red discs is shorter when the agent can see the same number as the participant.

# Spontaneous Vicarious Perception of the Content of Another's Visual Perspective

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*Method:* Participants decided whether a letter was a flipped mirror image or not. It could occur at various rotations and there also happened to be an agent in the display.

# Spontaneous Vicarious Perception of the Content of Another's Visual Perspective

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*Results:* RT was influenced by the letter's orientation relative to the participant (cf. Shepard & Metzler, 1971). Importantly, RT was also influenced by the **agent's** perspective.



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### A return of mental imagery: The pictorial theory of visual perspective-taking

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(see also Cole et al. 2016; Cole et al. 2017. Cole & Millett, 2019; Cole et al. 2020).

# Reading...

BEHAVIORAL AND BRAIN SCIENCES (2002) 25, 157–238

*Printed in the United States of America*

## Mental imagery: In search of a theory

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**Abstract:** It is generally accepted that there is something special about reasoning by using mental images. The question of how it is special, however, has never been satisfactorily spelled out, despite more than thirty years of research in the post-behaviorist tradition. This article considers some of the general motivation for the assumption that entertaining mental images involves inspecting a picture-like object. It sets out a distinction between phenomena attributable to the nature of mind to what is called the cognitive architecture, and ones that are attributable to tacit knowledge used to simulate what would happen in a visual situation. With this distinction in mind, the paper then considers in detail the widely held assumption that in some important sense images are *spatially displayed* or are *depictive*, and that examining images uses the same mechanisms that are deployed in visual perception. I argue that the assumption of the spatial or depictive nature of images is only explanatory if taken literally, as a claim about how images are physically instantiated in the brain, and that the literal view fails for a number of empirical reasons – for example, because of the cognitive penetrability of the phenomena cited in its favor. Similarly, while it is arguably the case that imagery and vision involve some of the same mechanisms, this tells us very little about the nature of mental imagery and does not support claims about the pictorial nature of mental images. Finally, I consider whether recent neuroscience evidence clarifies the debate over the nature of mental images. I claim that when such questions as whether images are depictive or spatial are formulated more clearly, the evidence does not provide support for the picture-theory over a symbol-structure theory of mental imagery. Even if all the empirical claims were true, they do not warrant the conclusion that many people have drawn from them: that mental images are depictive or are displayed in some (possibly cortical) space. Such a conclusion is incompatible with what is known about how images function in thought. We are then left with the provisional counterintuitive conclusion that the available evidence does not support rejection of what I call the “null hypothesis”; namely, that reasoning with mental images involves the same form of representation and the same processes as that of reasoning in general, except that the content or subject matter of thoughts experienced as images includes information about how things would look.

# Reading...

THE BEHAVIORAL AND BRAIN SCIENCES (1979) 2, 535-581

*Printed in the United States of America*

## On the demystification of mental imagery

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**Steven Pinker**

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**Steven P. Schwartz**

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**Abstract:** What might a theory of mental imagery look like, and how might one begin formulating such a theory? These are the central questions addressed in the present paper. The first section outlines the general research direction taken here and provides an overview of the empirical foundations of our theory of image representation and processing. Four issues are considered in succession, and the relevant results of experiments are presented and discussed. The second section begins with a discussion of the proper form for a cognitive theory, and the distinction between a theory and a model is developed. Following this, the present theory and computer simulation model are introduced. This theory specifies the nature of the internal representations (data structures) and the processes that operate on them when one generates, inspects, or transforms mental images. In the third, concluding, section we consider three very different kinds of objections to the present research program, one hinging on the possibility of experimental artifacts in the data, and the others turning on metatheoretical commitments about the form of a cognitive theory. Finally, we discuss how one ought best to evaluate theories and models of the sort developed here.

# Reading...

Draft of Mehler Festschrift paper

Pylyshyn, Z.W.

## IS THE IMAGERY DEBATE OVER? IF SO, WHAT WAS IT ABOUT?

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### Background

*Jacques Mehler was notoriously charitable in embracing a diversity of approaches to science and to the use of many different methodologies. One place where his ecumenism brought the two of us into disagreement is when the evidence of brain imaging was cited in support of different psychological doctrines, such as the picture-theory of mental imagery. Jacques remained steadfast in his faith in the ability of neuroscience data (where the main source of evidence has been from clinical neurology and neuro-imaging) to choose among different psychological positions. I personally have seen little reason for this optimism so Jacques and I frequently found ourselves disagreeing on this issue, though I should add that we rarely disagreed on substantive issues on which we both had views. This particular bone of contention, however, kept us busy at parties and during the many commutes between New York and New Jersey, where Jacques was a frequent visitor at the Rutgers Center for Cognitive Science. Now that I am in a position where he is a captive audience it seems an opportune time to raise the question again.*

# Reading...



## Return of the mental image: are there really pictures in the brain?

Zenon Pylyshyn

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**In the past decade there has been renewed interest in the study of mental imagery. Emboldened by new findings from neuroscience, many people have revived the idea that mental imagery involves a special format of thought, one that is pictorial in nature. But the evidence and the arguments that exposed deep conceptual and empirical problems in the picture theory over the past 300 years have not gone away. I argue that the new evidence from neural imaging and clinical neuropsychology does little to justify this recidivism because it does not address the format of mental images. I also discuss some reasons why the picture theory is so resistant to counterarguments and suggest ways in which non-pictorial theories might account for the apparent spatial nature of images.**

# Reading...

Vol. 80, No. 1

JULY 1973

## Psychological Bulletin

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### WHAT THE MIND'S EYE TELLS THE MIND'S BRAIN: A CRITIQUE OF MENTAL IMAGERY<sup>1</sup>

ZENON W. PYLYSHYN<sup>2</sup>

*University of Western Ontario*

This paper presents a critique of contemporary research which uses the notion of a *mental image* as a theoretical construct to describe one form of memory representation. It is argued that an adequate characterization of "what we know" requires that we posit abstract mental structures to which we do not have conscious access and which are essentially *conceptual* and *propositional*, rather than sensory or pictorial, in nature. Such representations are more accurately referred to as symbolic descriptions than as images in the usual sense. Implications of using an imagery vocabulary are examined, and it is argued that the picture metaphor underlying recent theoretical discussions is seriously misleading—especially as it suggests that the image is an entity to be perceived. The relative merits of several alternative modes of representation (propositions, data structures, and procedures) are discussed. The final section is a more speculative discussion of the nature of the representation which may be involved when people "use" visual images.

# Reading...

COGNITIVE NEUROPSYCHOLOGY, 2005, 22 (3/4), 333–347

 Psychology Press  
Taylor & Francis Group

## MENTAL IMAGES AND THE BRAIN

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Stephen M. Kosslyn

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One theory of visual mental imagery posits that early visual cortex is also used to support representations during imagery. This claim is important because it bears on the “imagery debate”: Early visual cortex supports depictive representations during perception, not descriptive ones. Thus, if such cortex also plays a functional role in imagery, this is strong evidence that imagery does not rely exclusively on the same sorts of representations that underlie language. The present article first outlines the nature of a processing system in which such a dual use of early visual cortex (in perception and in imagery) makes sense. Following this, literature bearing on the claim that early visual cortex is used in visual mental imagery is reviewed, and key issues are discussed.