Cognition: Methods and Models

PSYC 2040

L2: Mental Imagery

Part 2

recap: Jan 23, 2023

- what we covered:
  - L2: Mental imagery
  - individual differences, mnemonics, paired associate learning
- your to-dos were:
  - *fill out:* project preference survey
  - *complete:* L2
    - including Marks (1973) tutorial
  - *post:* L2 conceptual question
    - due Thursday morning
  - *look at:* L2 writing assignments

today's agenda

- conceptual questions
- the mental imagery debate
  - pictorial vs. propositional representations
- representation-process tensions
  - the aftermath
  - newer research
  - broader connections beyond imagery

conceptual question #1

- “At the end of the reading, Crump revealed that a significant driving force behind Galton's research into mental imagery was the desire to discover if it was a varied, heritable factor between certain types of people. Does having such a discriminatory motive immediately bias research (with self-fulfilling prophecies, perhaps)? Is it possible for researchers to remain completely unbiased?”
  - early psychological research was conducted was several problematic reasons and there were definitely confirmation biases and self-fulfilling prophecies in such research (as we will cover in L3)
  - best open-science practices therefore require “researcher-blind” experiments and ideally also analyses, so that we can minimize such biases from creeping into our designs and inferences

the imagery debate

- in the 1960s and 70s, there were several studies that suggested the need for mental imagery to perform a variety of cognitive tasks
- this led to a fundamental debate in the field about what exactly happens when people are engaged in mental imagery
- broadly, the imagery debate was about representation

what is a mental representation?

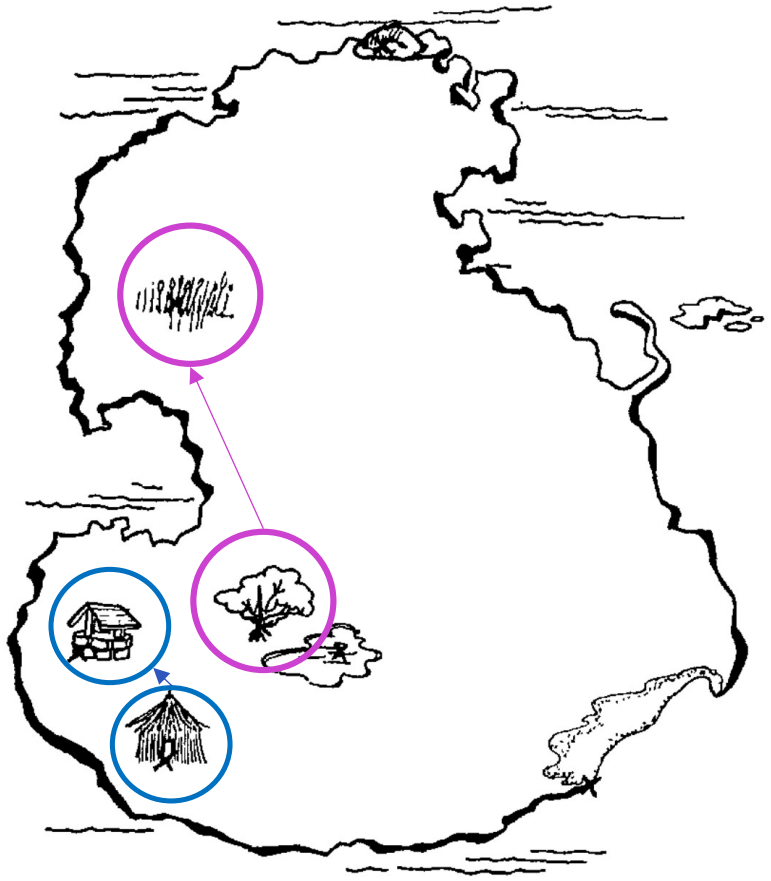
- the idea of a mental representation implies that we have some kind of *internal* "format" for storing information
- external knowledge has formats
  - images on your computer: pixels
  - any information on machines: binary (0/1) digits
  - words and letters: squiggles
- what is the *format* of internal knowledge?
- when you "see" a beach, what are you "seeing"?

mental imagery representations

- pictorial representation
  - image-like representation
  - just like actually seeing a picture
- propositional representation
  - representation based on symbols and rules (like grammar)
  - not image-like at all
- fundamentally different proposals for how we represent knowledge: do we actively imagine everything in a pictorial manner or do we represent what we see through propositions?

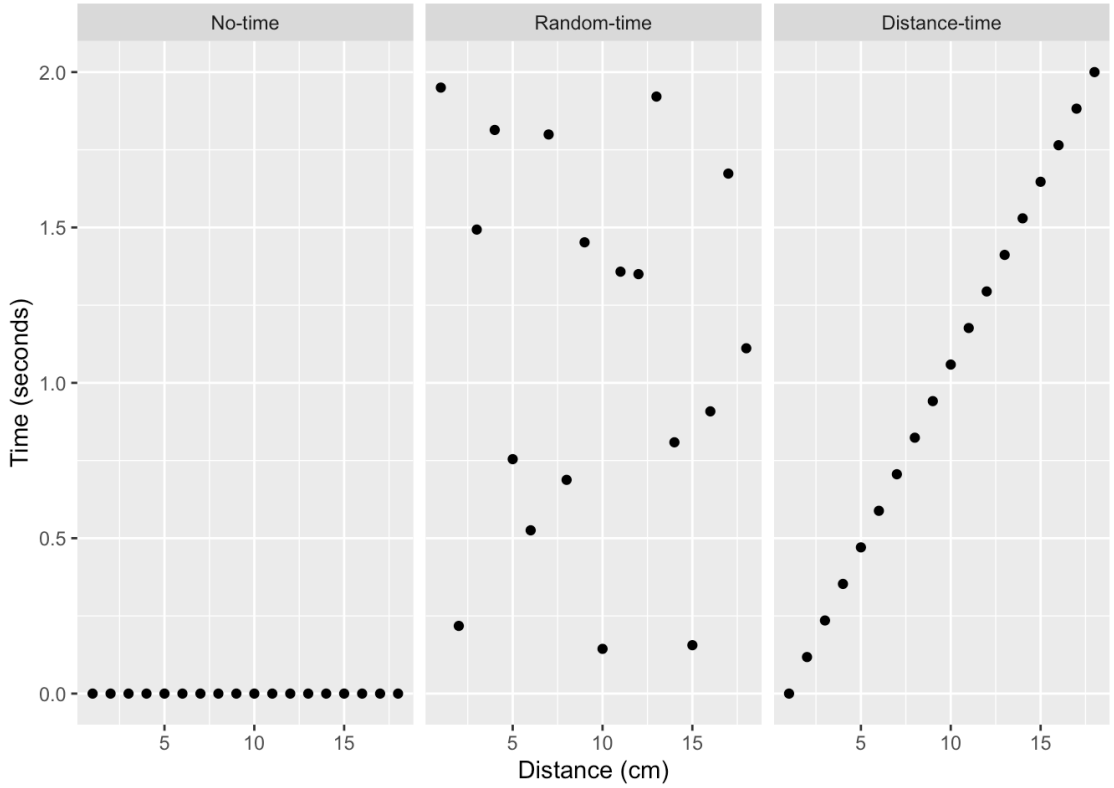
testing the format of representations

- Stephen Kosslyn and colleagues came up with clever mental scanning experiments
- participants were asked to mentally navigate different locations on the map, some close and some far
- pair up and find out :
  - independent variable
  - dependent variable
  - key question



possible predictions of pattern

- when plotting patterns (predicted or actual), independent variables are often the X-axis and dependent variables are the Y-axis
- what would a “same-time” prediction look like?



Kosslyn et al. (1978) results and inferences

- finding: reaction time was linearly predicted by the distance between the objects
- inference: the time to mentally scan an image is influenced by the actual distances
- support for the pictorial format of the representation
  - why??

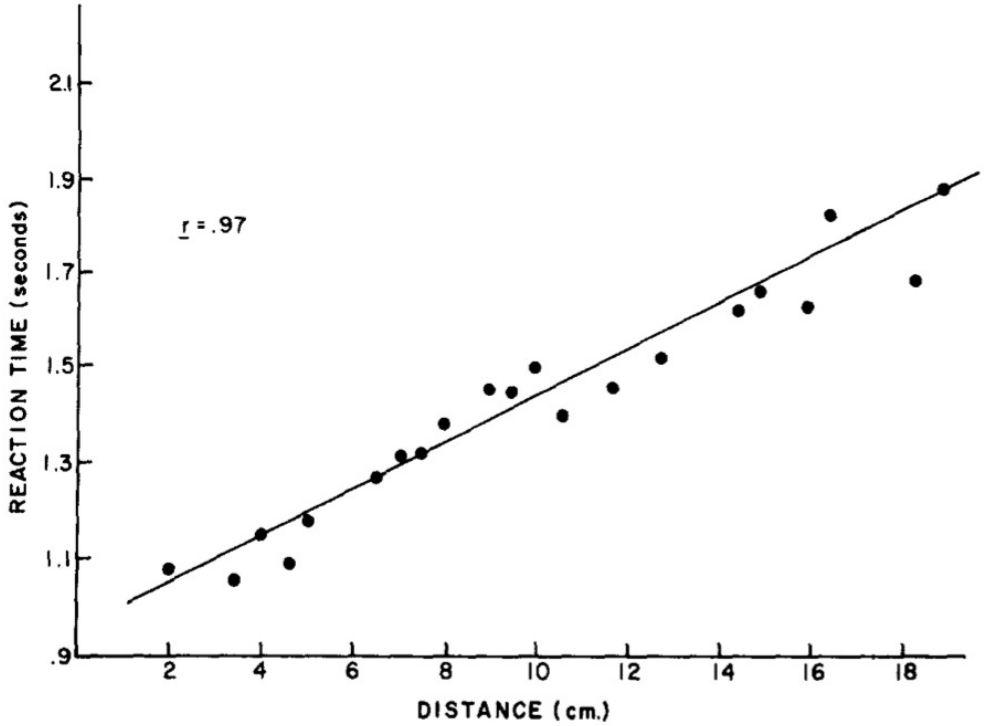
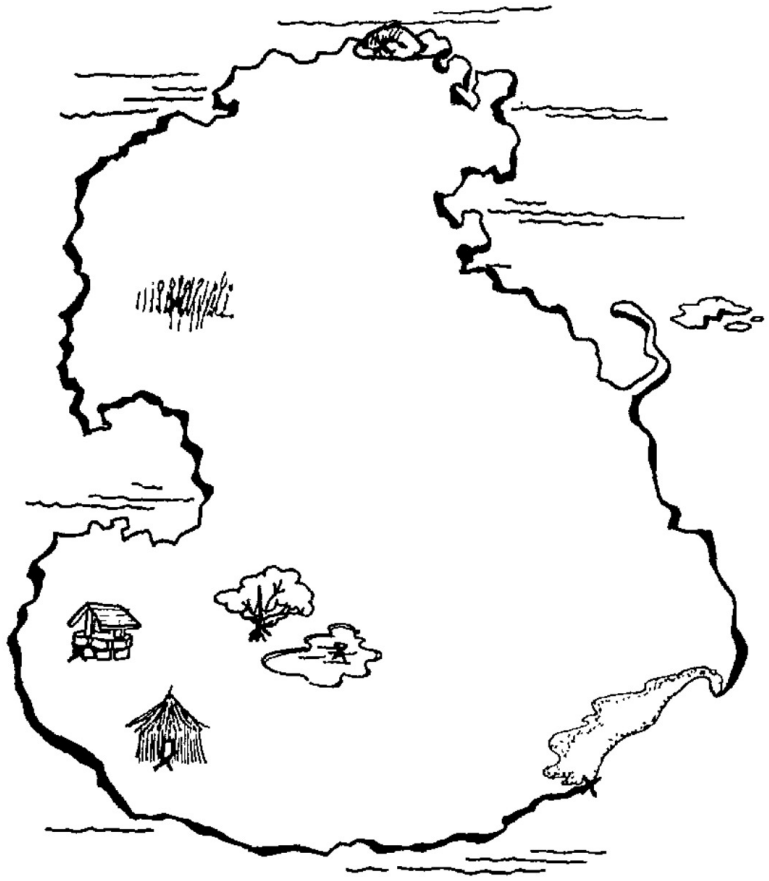


Figure 3. The results of Experiment 2: Time to scan between all pairs of locations on the imaged map.

Pylyshyn's propositional account

- could the findings be explained by the time to process the propositions that store information about the map?
  - the grass is on the north-west side
  - the tree and well are on the south-west
  - the lake is south-east of the tree and close
- if mental imagery is necessary for this task, could aphantasics help us resolve this debate?
  - individual differences help us constrain our theories and predictions



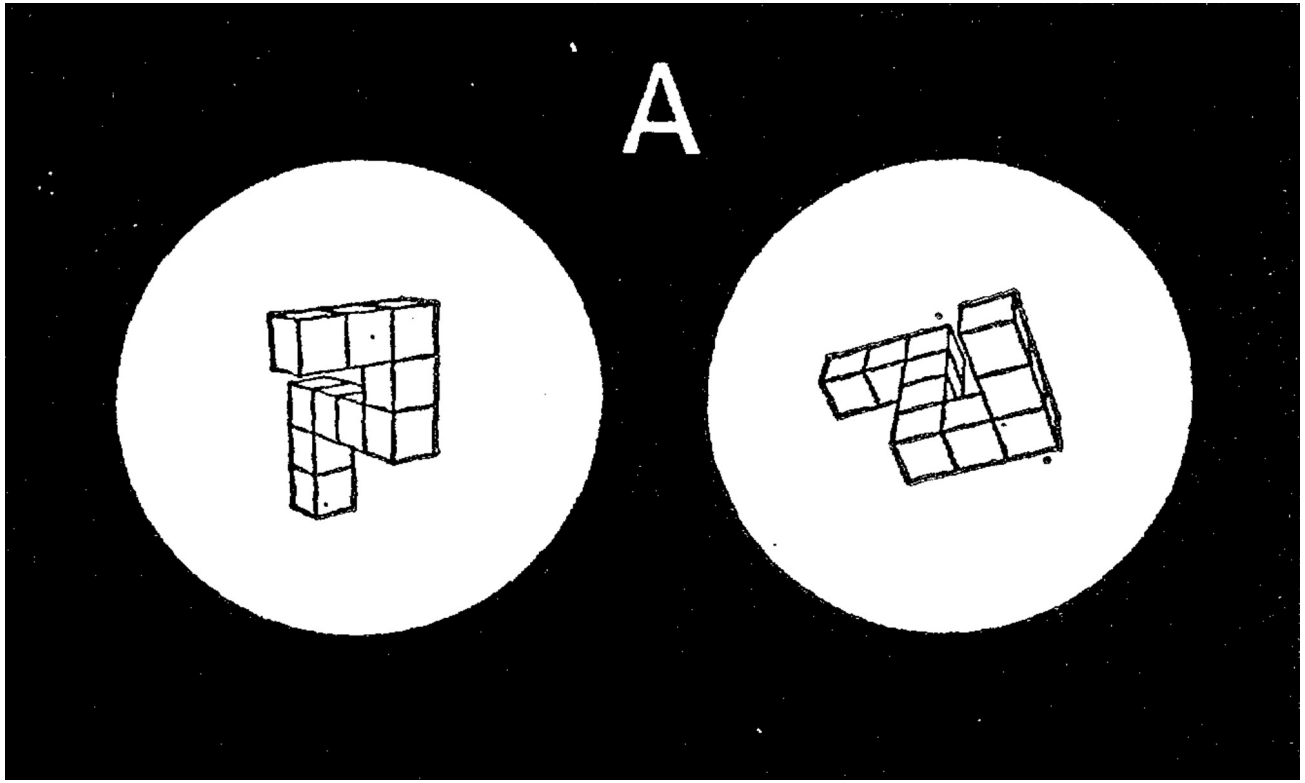
conceptual question #2

- “Crump asks a question I had about the map distance and mental imagery study discussed in this section. If this study was done on people with aphantasia, would the trend continue? What would we expect to see in results for people who cannot create mental images in their heads? It seems that the relationship between distance and time would maybe not be linear and level off at a certain point where shortcuts in memorization might make different distances equally difficult to recall. Crump also offers that they might just refuse to do the task or be incapable of doing it reliably. These seem like likely alternatives also.”
  - what would the propositional account predict
  - what would the pictorial account predict?

another experiment

- you will be shown two three-dimensional objects
- your task is to decide whether these objects are the same object in different orientations or entirely different objects
- we will then debrief in groups

another experiment



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A: same or different?

same

different

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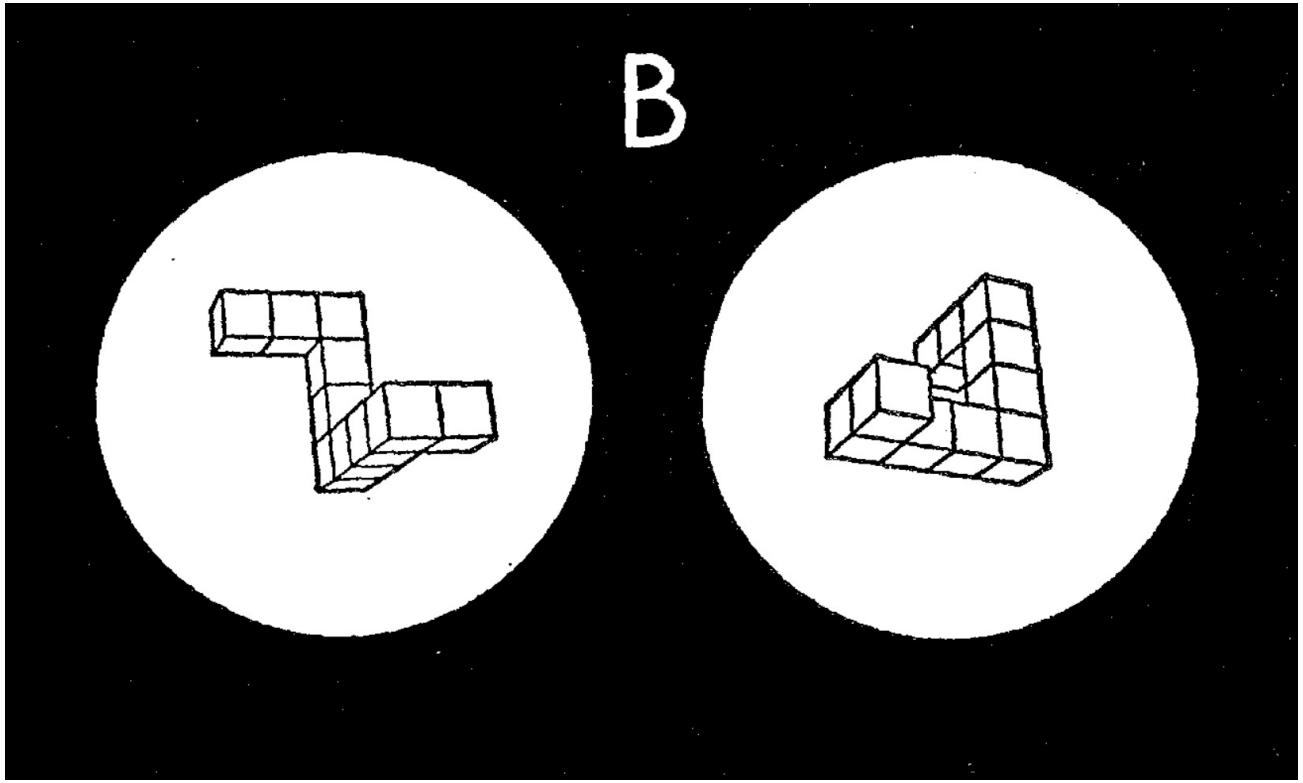
another experiment



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B: same or different?

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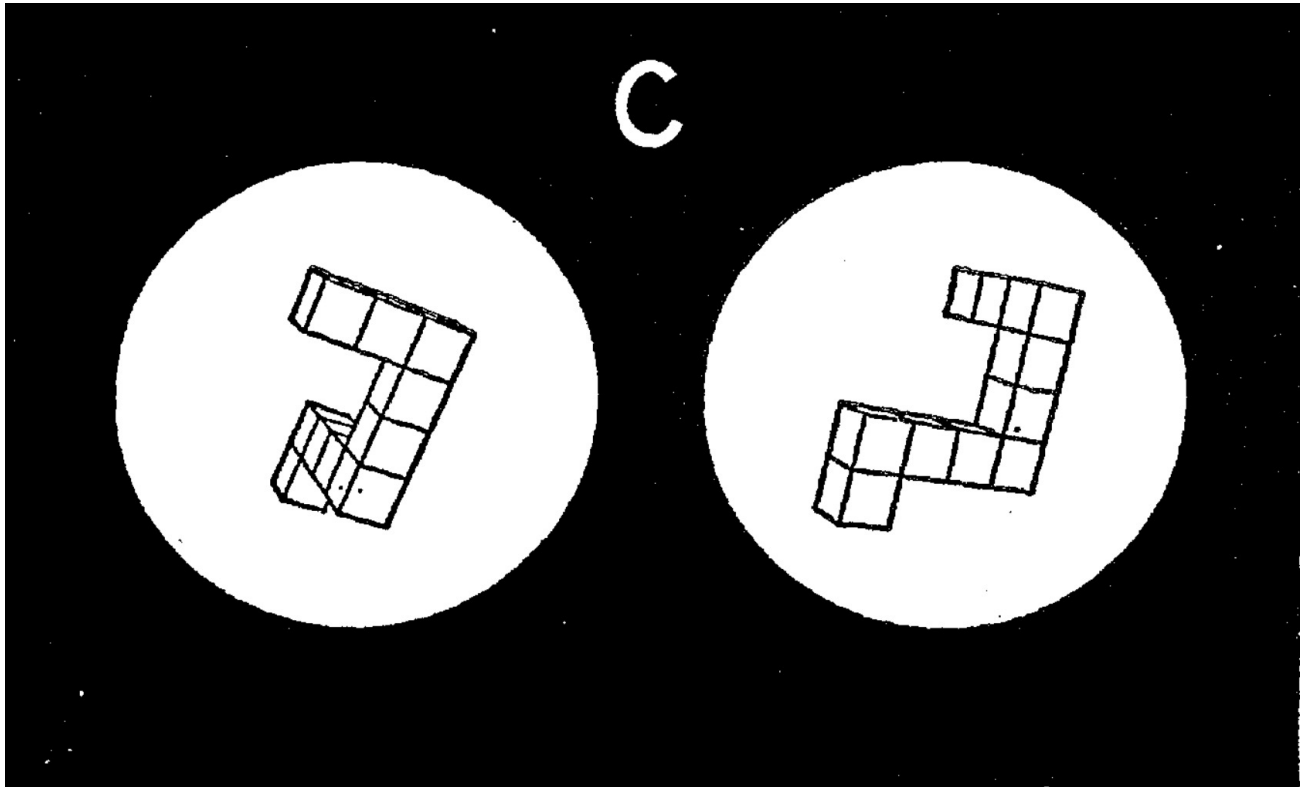
another experiment



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C: same or different?

same

different

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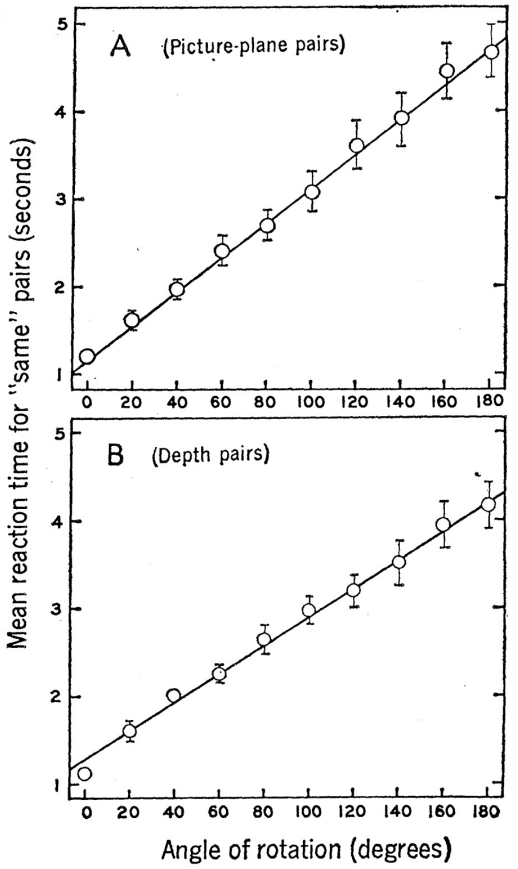
debrief

- in groups, discuss:
  - how did you do this task?
  - did you utilize mental imagery?
  - is this a better test of mental imagery than Paivio's memory experiment?
- come back and share with the class

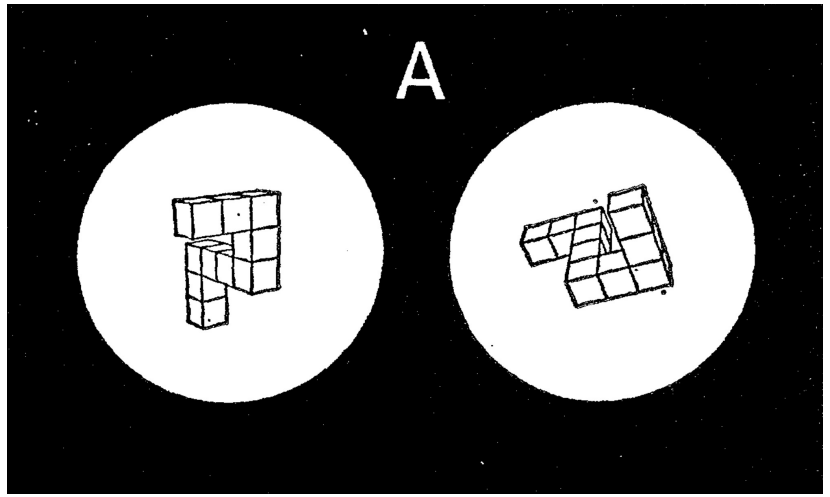
mental rotation experiment

- Shepard and Metzler (1971) asked participants whether two drawings were of the same object or whether they were of different objects
- finding: reaction time to determine "same" pairs was linearly predicted by the angle of rotation
- inference: people mentally rotate the object holistically during the task



duh?

- this finding is surprising: why would we rotate? why not match features and relations?
- how would propositional theory explain this pattern?
  - there is no straightforward way to describe these objects via propositions, although that does not mean that it is not possible (“the long part at the top comes down and takes a sharp left”)
- other explanations??



alternative explanation #1

- Just and Carpenter (1976) repeated the experiment using eye-tracking and suggested that the linear result found by Shepard & Metzler (1971) was simply because people were comparing features and made more eye movements when the angle of rotation was greater between the objects

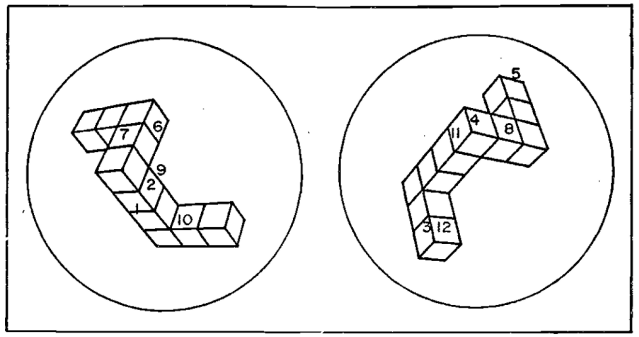


Figure 5. The figure indicates the sequence of fixations on a correct Same trial in which the disparity was 80°. The subject's total response latency was 3574 msec, of which 9% had no visible eye spot. The locus and duration of the fixations are as follows:

Fixation	Figure	Location	Duration
1.	Left	Center	200 msec
2.		Center	301 msec
3.	Right	Open arm	167 msec
4.		Center	150 msec
5.		Closed arm	167 msec
6.	Left	Closed arm	200 msec
7.		Closed arm	317 msec
8.	Right	Closed arm	501 msec
9.	Left	Center	250 msec
10.		Open arm	200 msec
11.	Right	Center	484 msec
12.		Open arm	317 msec

alternative explanation #2

- Hochberg and Gellman (1977) questioned whether the experiment truly required complete rotation or could be accomplished based on comparing distinguishing, “landmark”, “informative” features
- when shapes were more complex and had less informative features, more comparisons had to be made, hence the linear pattern

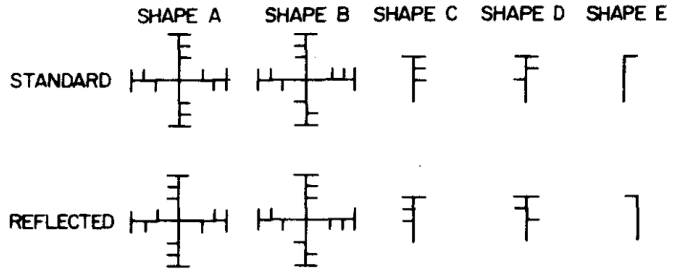
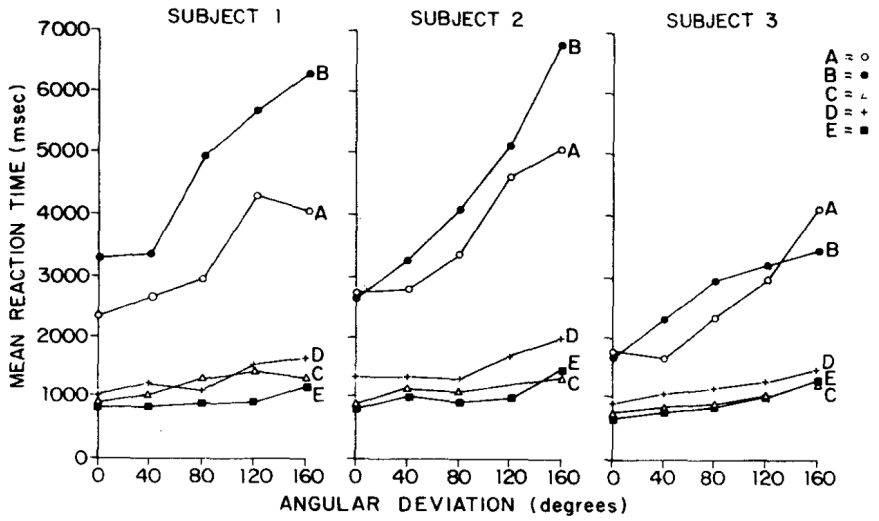
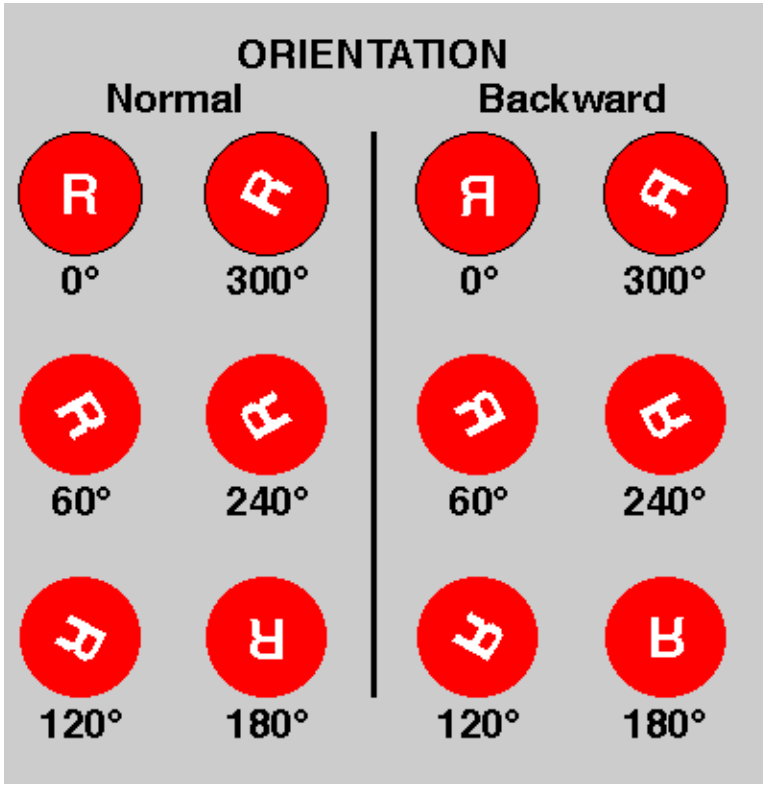


Figure 1. Stimulus shapes in standard and reflected form.



more evidence for mental rotation

- more work from Shepard & Cooper (Cooper, 1975; 1976) across a range of stimuli (letters, objects, etc.) and instructions (use mental imagery vs. no instructions) showed robust replication of the linear pattern
- bottom line: people do seem to perform some type of rotation in most tasks, but not consistently



the aftermath of the imagery debate

- after many years of back and forth, the field decided that behavioral data alone could not resolve the debate about formats (Anderson, 1978)
  - “dual-code theory”
  - physiological data might be needed (e.g., eye tracking, brain imaging, etc.)
  - arguing over the format of representations without specifying a process was pointless

The following is a summary of the conclusions of the article:

1. The picture metaphor is the only current explicit interpretation of the image theory.
2. The frequent criticisms made of the picture metaphor are not valid. One can have a viable dual-code model involving picture and verbal representations (see Figure 2).
3. The arguments for the necessity of a propositional representation are far from compelling. The best have to do with the utility of such a representation for inference making.
4. The arguments for imaginal representations based on introspections, computational considerations, empirical results, and physiological considerations are not convincing.
5. It is not possible to decide between imaginal and propositional representations strictly on the basis of behavioral data.
6. The criteria of parsimony and efficiency may allow a decision about whether there are different types of internal representation or just one abstract representation. This would be based on a research program that investigated whether verbal and visual information displayed similar properties.

the aftermath of the imagery debate

- evidence from neuroscience has been helpful in assessing the utility and presence of visual/pictorial/depictive representations
- there is now general consensus that mental representations likely make use of multiple formats
- there may be a functional role to depictive/pictorial representations
  - “wiring optimization principle”
  - memory & reasoning

The heterogeneity of mental representation: Ending the imagery debate

Joel Pearson and Stephen M. Kosslyn Authors Info & Affiliations

Edited by Daniel L. Schacter, Harvard University, Cambridge, MA, and approved June 25, 2015 (received for review March 21, 2015)

July 14, 2015 | 112 (33) 10089-10092 | https://doi.org/10.1073/pnas.1504933112

19,706 | 94

Abstract

The possible ways that information can be represented mentally have been discussed often over the past thousand years. However, this issue could not be addressed rigorously until late in the 20th century. Initial empirical findings spurred a debate about the heterogeneity of mental representation: Is all information stored in propositional, language-like, symbolic internal representations, or can humans use at least two different types of representations (and possibly many more)? Here, in historical context, we describe recent evidence that humans do not always rely on propositional internal representations but, instead, can also rely on at least one other format: depictive representation. We propose that the debate should now move on to characterizing all of the different forms of human mental representation.

imagery, mental simulation, and embodiment

- "embodied cognition" is the idea that our cognitive experience is directly tied to our perceptual and sensorimotor experiences with the world (Barsalou, 1999)
- when you hear the word "chair", you simulate what the chair looks like, feels like, etc.
- ideas of dual codes are echoed in this field as well, and also extend to broader theories of how we learn and represent meaning and language
- "mental simulation" is also critical to current ideas about human intelligence and intuitive physical reasoning (Allen et al., 2019)

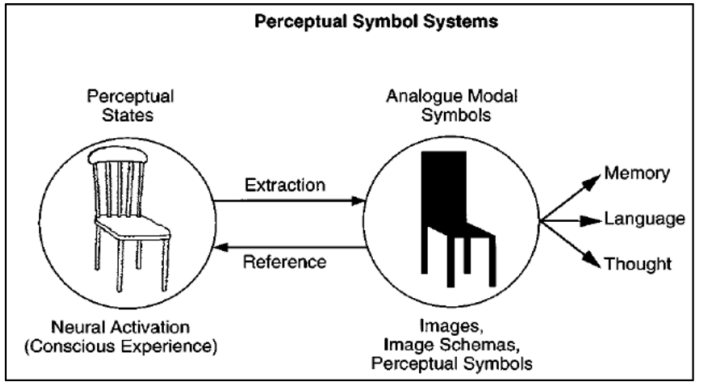
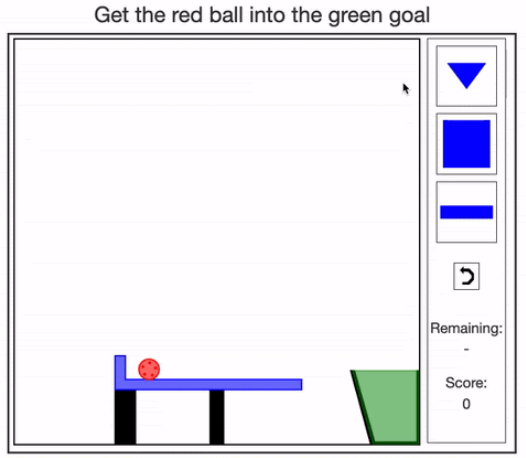


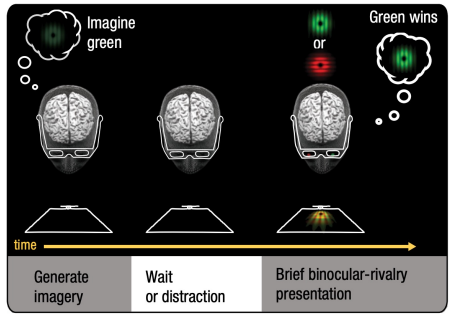
Figure 3.1 Barsalou's Perceptual Symbol System



https://sites.google.com/view/virtualtoolsgame/home

some newer research on imagery

- binocular rivalry task (Pearson, 2014)
- fMRI decoding (Lee et al., 2012)
- findings about the mechanisms & strategies underlying sex differences in mental rotation (generally unclear)
- mental imagery in animals?!



Article | Open Access | Published: 19 December 2019

Investigating sex differences, cognitive effort, strategy, and performance on a computerised version of the mental rotations test via eye tracking

Adam J. Toth & Mark J. Campbell

Scientific Reports **9**, Article number: 19430 (2019) | Cite this article
9410 Accesses | **15** Citations | **166** Altmetric | Metrics

Mental imagery in animals: Learning, memory, and decision-making in the face of missing information

Aaron P. Blaisdell

Learning & Behavior **47**, 193–216 (2019) | Cite this article
5085 Accesses | **3** Citations | **17** Altmetric | Metrics

conceptual questions #aphantasia

Does aphantasia affect the academic performance of those who have it? I wonder if there is any research to prove or disprove whether aphantasia makes life more difficult for those who have it, or if mental imagery isn't integral to academic success.

We've discussed aphantasia as an inability to consciously conjure up imagery in one's minds eye. I wonder if people with aphantasia are able to have mental imagery when they are unconscious, if they dream, and if those dreams are visual. If so I wonder if aphantasia is a lack of mental imagery entirely or an inability to access this consciously?

Is there any correlation between hyperphantasia and mental disorders? Would someone with heightened mental imagery experience heightened sensory perception (auditory, visual, tactile) that might be a symptom of autism spectrum disorder, ADHD, etc...?

If there are instances of unconscious mental imagery (i.e. using mental imagery to remember concepts/word pairings without consciously picturing an image) how would this be measured since it cannot be self reported? Is there any way of measuring mental imagery more concretely, i.e. any specific way the process shows up in particular measurements of brain activity? Or is this simply not measurable given our current technological capabilities?

conceptual questions #aphantasia

A cognitive profile of multi-sensory imagery, memory and dreaming in aphantasia

Alexei J. Dawes[1] ✉, Rebecca Keogh[1], Thomas Andrillon[1,2] & Joel Pearson[1]

For most people, visual imagery is an innate feature of many of our internal experiences, and appears to play a critical role in supporting core cognitive processes. Some individuals, however, lack the ability to voluntarily generate visual imagery altogether – a condition termed "aphantasia". Recent research suggests that aphantasia is a condition defined by the absence of visual imagery, rather than a lack of metacognitive awareness of internal visual imagery. Here we further illustrate a cognitive "fingerprint" of aphantasia, demonstrating that compared to control participants with imagery ability, aphantasic individuals report decreased imagery in other sensory domains, although not all report a complete lack of multi-sensory imagery. They also report less vivid and phenomenologically rich autobiographical memories and imagined future scenarios, suggesting a constructive role for visual imagery in representing episodic events. Interestingly, aphantasic individuals report fewer and qualitatively impoverished dreams compared to controls. However, spatial abilities appear unaffected, and aphantasic individuals do not appear to be considerably protected against all forms of trauma symptomatology in response to stressful life events. Collectively, these data suggest that imagery may be a normative representational tool for wider cognitive processes, highlighting the large inter-individual variability that characterises our internal mental representations.

applications of mental imagery

MENTAL ROTATION OF LETTERS, PICTURES, AND THREE-DIMENSIONAL OBJECTS IN GERMAN DYSLEXI(CHILDREN

Jascha Rüsseler,[1,2] Janka Scholz,[1,3] Kirsten Jordan,[4] and Claudia Quaiser-Pohl[3]

[1]Department of Psychology II, Neuropsychology Unit, [2]General Psychology Unit, [3]Department of Psychology I, Developmental and Educational Psychology Unit, Otto-von-Guericke University, Magdeburg, Germany, and [4]Department of Medical Psychology, University of Göttingen, Germany

This study examines mental rotation ability in children with developmental dyslexia. Prior investigations have yielded equivocal results that might be due to differences in stimulus material and testing formats employed. Whereas some investigators found dyslexic readers to be impaired in mental rotation, others did not report any performance differences or even superior spatial performance for dyslexia. Here, we report a comparison of mental rotation for letters, three-dimensional figures sensu Shepard and Metzler, and colored pictures of animals or humans in second-grade German dyslexic readers. Findings indicate that dyslexic readers are impaired in mental rotation for all three kinds of stimuli. Effects of general intelligence were controlled. Furthermore, dyslexic children were deficient in other spatial abilities like identifying letters or forms among distracters. These results are discussed with respect to the hypotheses of a developmental dysfunction of the parietal cortex or a subtle anomaly in cerebellar function in dyslexic readers.

The role of mental rotation and memory scanning on the performance of laparoscopic skills

A study on the effect of camera rotational angle

J. Conrad,[1] A. H. Shah,[2] C. M. Divino,[2] S. Schluender,[2] B. Gurland,[1] E. Shlasko,[1] A. Szold[3]

Results: There was an increasing deterioration in suturing performance as the degree of image rotation was increased. Participants showed a statistically significant 20–120% progressive increase in time to completion of the tasks ($p = 0.004$), with error rates increasing from 10% to 30% ($p = 0.04$) as the angle increased from 0° to 90°. Knot-tying performance similarly showed a decrease in performance that was evident in the less experienced surgeons ($p = 0.02$) but with no obvious effect on the advanced laparoscopic surgeons. *Conclusions:* When evaluated independently and as a group, both novice and experienced laparoscopic surgeons showed significant prolongation to completion of suturing tasks with increased errors as the rotational angle increased. The knot-tying task shows that experi-

Treatment of PTSD: A comparison of imaginal exposure with and without imagery rescripting

Arnoud Arntz, Meike Tiesema, Merel Kindt [1]

The critical role of mental imagery in human emotion: insights from Aphantasia

Marcus Wicken, Rebecca Keogh, & Joel Pearson

The School of Psychology, University of New South Wales, Sydney Australia.

big takeaways

- the subjective experience of mental imagery produces wide individual differences
- the field has moved from introspection to behavioral experiments to physiology & brain imaging (therefore invoking multiple levels of analysis)
- understanding the experience of mental imagery can inform how people learn or interact with the world and improve their quality of life
- many debates have arisen and taken new forms over the years; regarding the format of representations when engaging in mental imagery, whether imagery is necessary for certain tasks, what processes are involved during imagery, and why imagery might be useful/functional
- tensions between representation and process continue to reappear in different forms

next class

- **before** class:
  - *attend/read & submit reflection*: Jasmine Mena's talk
  - *complete:* L2 quiz + writing assignments
  - *read:* L3 (Eugenics + Intelligence Testing chapters)
- **during** class:
  - a history of how psychology began (and went wrong)