



# Cognition: Methods and Models

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PSYC 2040

L2: Mental Imagery



# recap



- what we covered:
  - L0: Getting Started
  - L1: What is Cognition
- your to-dos were:
  - *complete*: L1 quiz and/or writing assignment + meme
  - *read*: L2 (mental imagery) chapter
  - *complete*: experiment on Canvas

# today's agenda



- mental **imagery**
  - early explorations and introspection
  - imagery and memory
  - the imagery debate

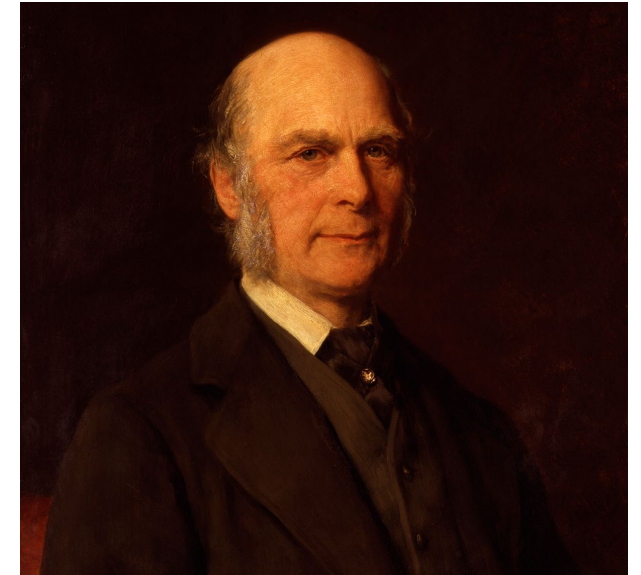
# so, what is mental imagery?



- a *subjective* experience of perception-like sensations
  - visual: “seeing” with your mind’s eyes
  - auditory: “hearing” sounds/voices/music in your head
  - olfactory/gustatory: “smelling” or “tasting” things
- why study mental imagery?
  - it’s cool and might be key to our *imaginative abilities*
  - it can inform how we learn and teach people with *different abilities*
  - it can help develop *better models/AI*

# studying mental imagery

- studying *subjective* experience is hard
- **method #1**: ask people to **introspect!**
- **Breakfast Table Task** (Sir Galton Francis, 1880)
  - asked 100 people to rate their mental image of what they had for breakfast on three scales:
  - illumination, definition, coloring

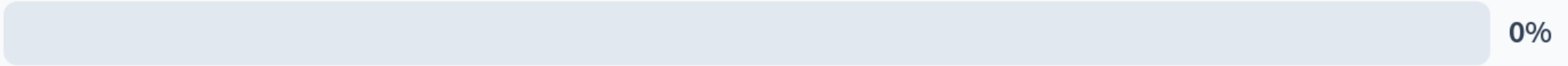


# how well can you visualize your room?

- **extremely vivid**, as if you are back on your bed again
  - “brilliant, distinct, never blotchy”
  - “I feel as though I was dazzled”
- **vivid**, pretty clear picture
  - “fairly clear as a general image; details rather misty”
- **fuzzy**, not super clear image but you can “see” some things
  - “dim and indistinct, yet I can give an account”
- **nada**, no mental pictures
  - “my powers are zero”, “I recollect...but do not see it”

## how well you can visualize your room?

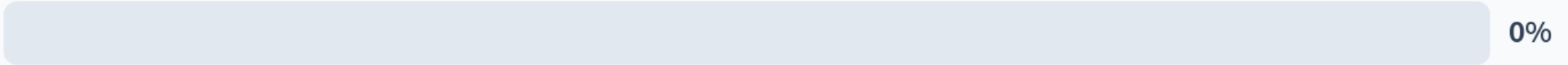
extremely vivid



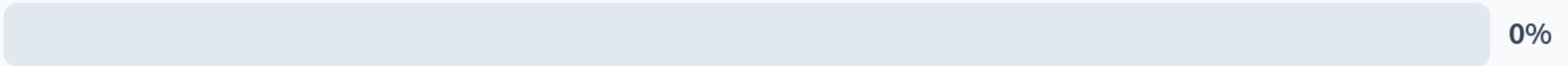
vivid



fuzzy

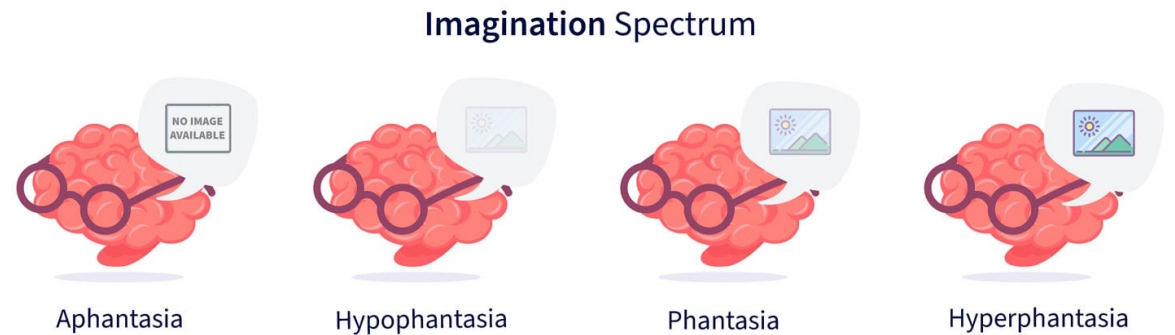


nada, no imagery



# individual differences in imagery

- Galton found **wide individual differences** in reports of mental imagery
- fast-forward: Adam Zeman & colleagues coined **aphantasia** (little or no mental imagery) and **hyperphantasia** (heightened mental imagery, visions)
  - [Aphantasia Network](#)





# introspectionism to experimental psychology

- introspectionism was criticized by behaviorists but is still very much a part of psychological research
  - e.g., Big Five personality questionnaire, clinical questionnaires, etc.
- other methods of studying psychological phenomena
  - associationism, behaviorism, cognitive revolution, etc.
- when mental imagery did come back in the 1960s, it came back as a possible explanation for other cognitive abilities such as memory

# Paivio's (1963) memory task

- **question:** do words have imageable qualities? are some words easier to imagine and if so, are they easier to remember?
- Paivio asked if remembering word pairs would be easier if they were more **concrete vs. abstract**



*A concrete word comes with a higher rating and refers to something that exists in reality; you can have immediate experience of it through your senses (smelling, tasting, touching, hearing, seeing) and the actions you do. The easiest way to explain a word is by pointing to it or by demonstrating it (e.g. To explain 'sweet' you could have someone eat sugar; To explain 'jump' you could simply jump up and down or show people a movie clip about someone jumping up and down; To explain 'couch', you could point to a couch or show a picture of a couch).*

*An abstract word comes with a lower rating and refers to something you cannot experience directly through your senses or actions. Its meaning depends on language. The easiest way to explain it is by using other words (e.g. There is no simple way to demonstrate 'justice'; but we can explain the meaning of the word by using other words that capture parts of its meaning).*

# Paivio's (1963) memory task

- each person learned **half concrete, half abstract word pairs** and then were given the adjective and had to recall the noun
- Paivio found that concrete pairs were easier to remember than abstract word pairs
- why?

Concrete pairs	Abstract Pairs
ingenious-inventor	ingenious-interpretation
technical-advertisement	technical-discourse
massive-granite	massive-rebellion
subtle-magician	subtle-prejudice
profound-philosopher	profound-analysis
colorful-maple	colorful-scenery
reliable-luggage	reliable-merchandize
expressive-actress	expressive-temperament
amazing-circus	amazing-crusade
noisy-trumpet	noisy-gossip
fashionable-overcoat	fashionable-apparel

# possible explanations/inferences

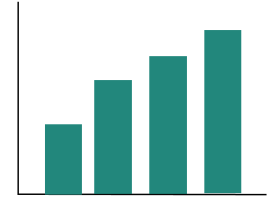
- concrete pairs are more “imageable”
  - imagery!
- concrete pairs were already highly associated (e.g., noisy-trumpet vs. noisy-gossip)
  - no need for imagery!
- how would you tease these two explanations apart?

Concrete pairs	Abstract Pairs
ingenious-inventor	ingenious-interpretation
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# **follow-up experiment: Paivio (1965)**

- you learned some word pairs and were asked to retrieve them

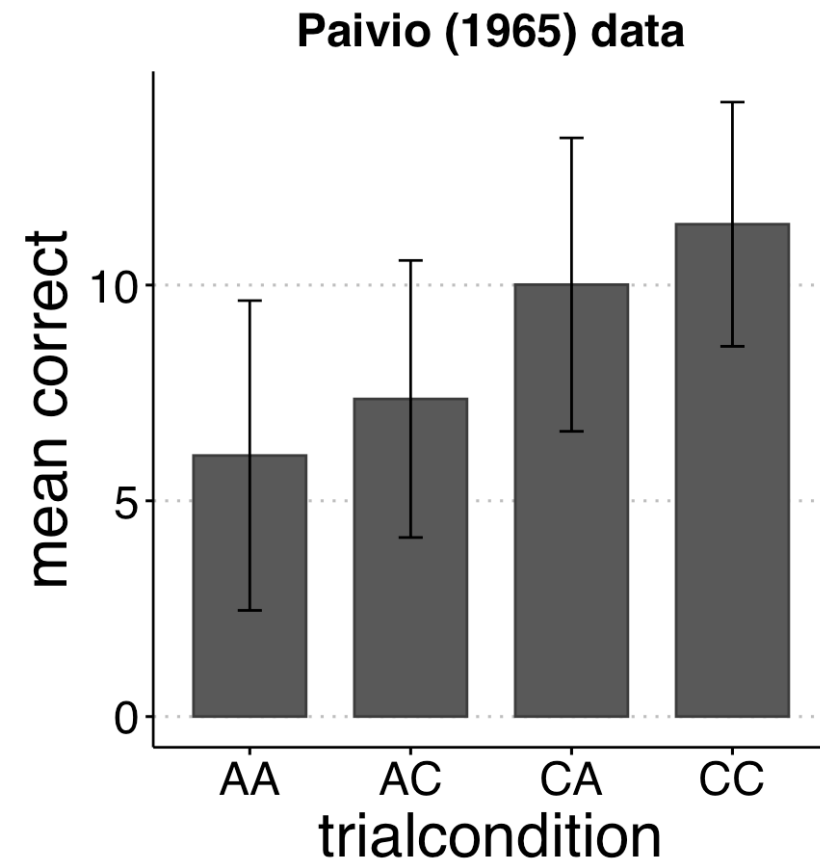
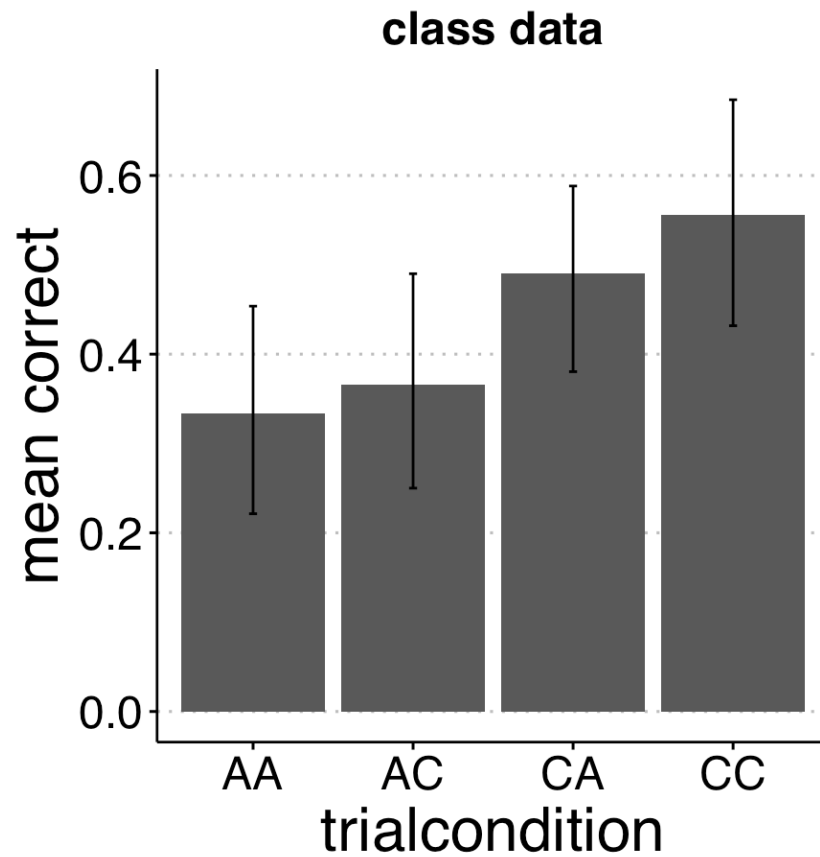
# follow-up experiment: Paivio (1965)



- used only **noun-noun** pairs
  - concrete-concrete (CC) / concrete-abstract (CA) / abstract-concrete (AC) / abstract-abstract (AA)
- obtained **ratings** for all nouns on imagery, meaningfulness (m), and familiarity
- **discuss** in groups:
  - plot a **predicted pattern of results**
  - which conditions should produce the best/worst recall?
  - come up with a figure and reasoning

word pair	condition
string-pencil	CC
wheat-dress	CC
star-garden	CC
chair-flower	CC
magazine-virtue	CA
woman-moment	CA
river-idea	CA
coffee-effort	CA
history-potato	AC
theory-star	AC
health-house	AC
fact-tree	AC
soul-opinion	AA
freedom-series	AA
truth-duty	AA
fate-event	AA

# yours vs. Paivio's results



# follow-up experiment: Paivio (1965)

- potential evidence for imagery
- but ...
  - are concrete words also more meaningful or easily verbalized?
  - the words could also differ on several other dimensions (e.g., frequency, valence, etc.)
- bottom line: concreteness is related to imagery but could have alternative explanations

TABLE 1  
MEAN TOTAL NUMBER OF CORRECT RESPONSES  
ON FOUR TRIALS AS A FUNCTION OF STIMULUS  
AND RESPONSE ABSTRACTNESS

Stimulus	Response			
	Concrete		Abstract	
	Mean	<i>SD</i>	Mean	<i>SD</i>
Concrete	11.41	2.83	10.01	3.21
Abstract	7.36	3.40	6.05	3.59



# 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”?

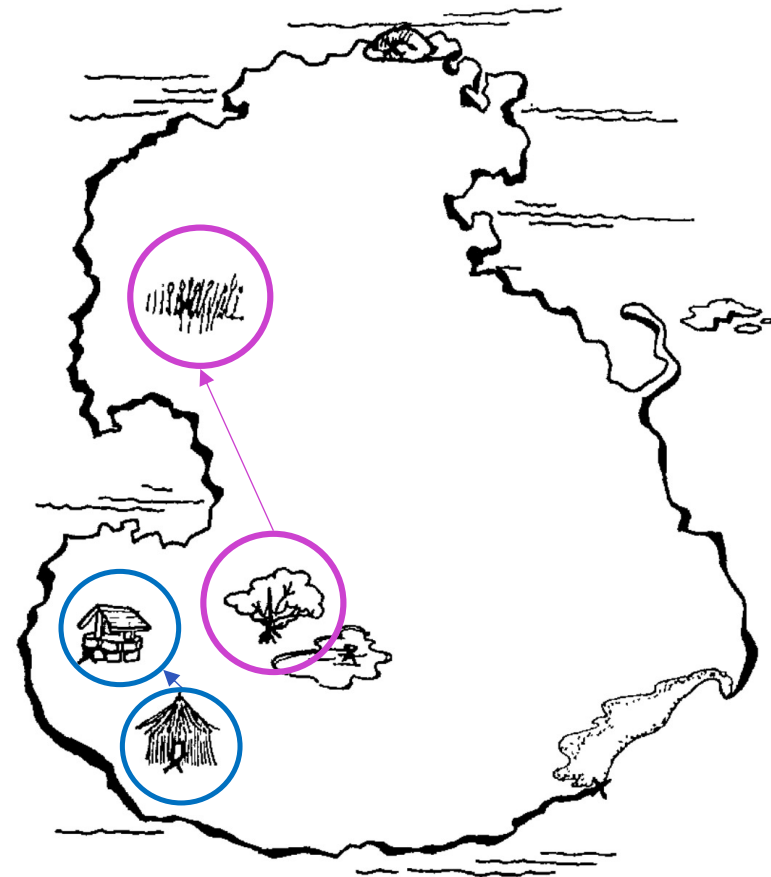
# mental imagery representations

- **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



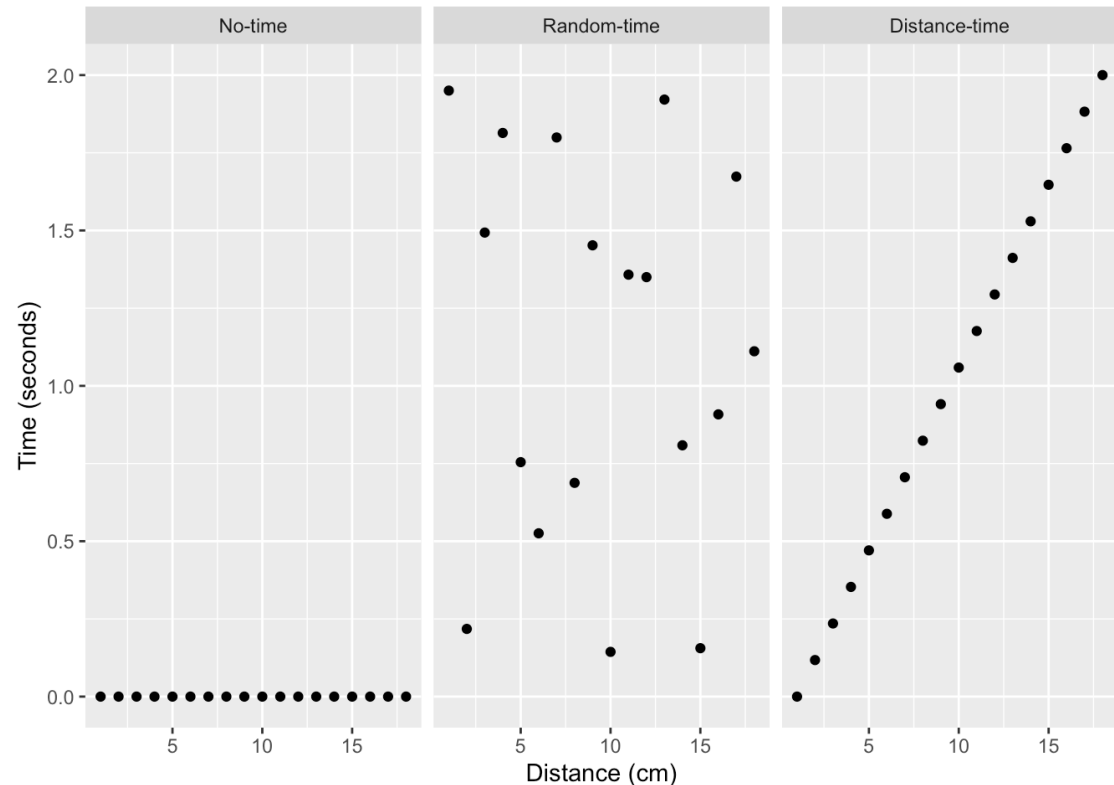
# testing the **format** of representations

- 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**



# 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??

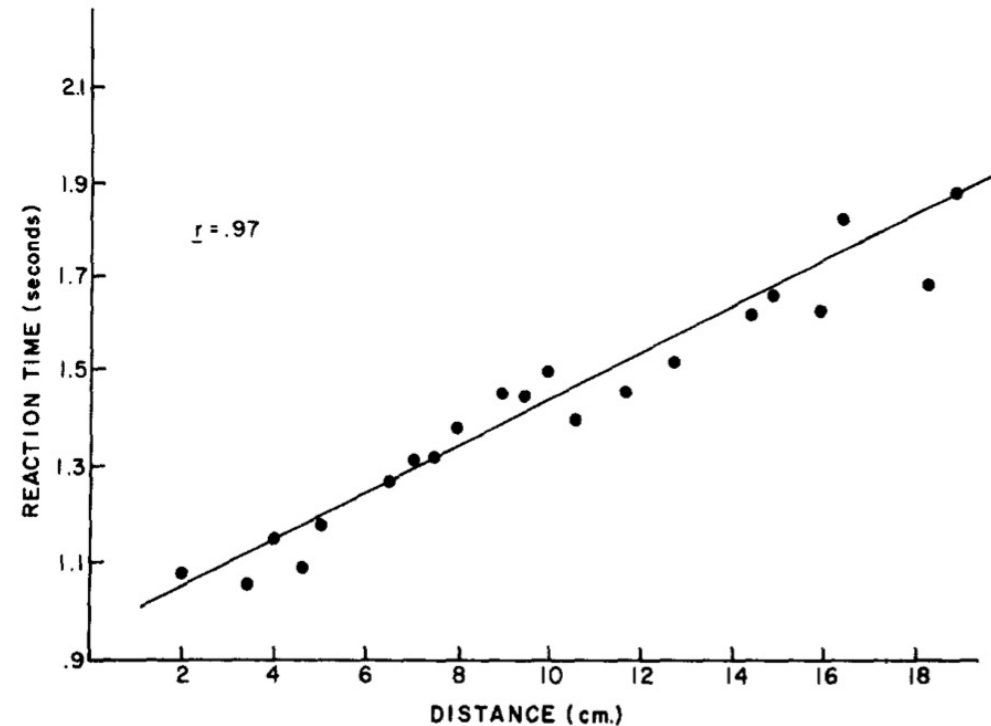
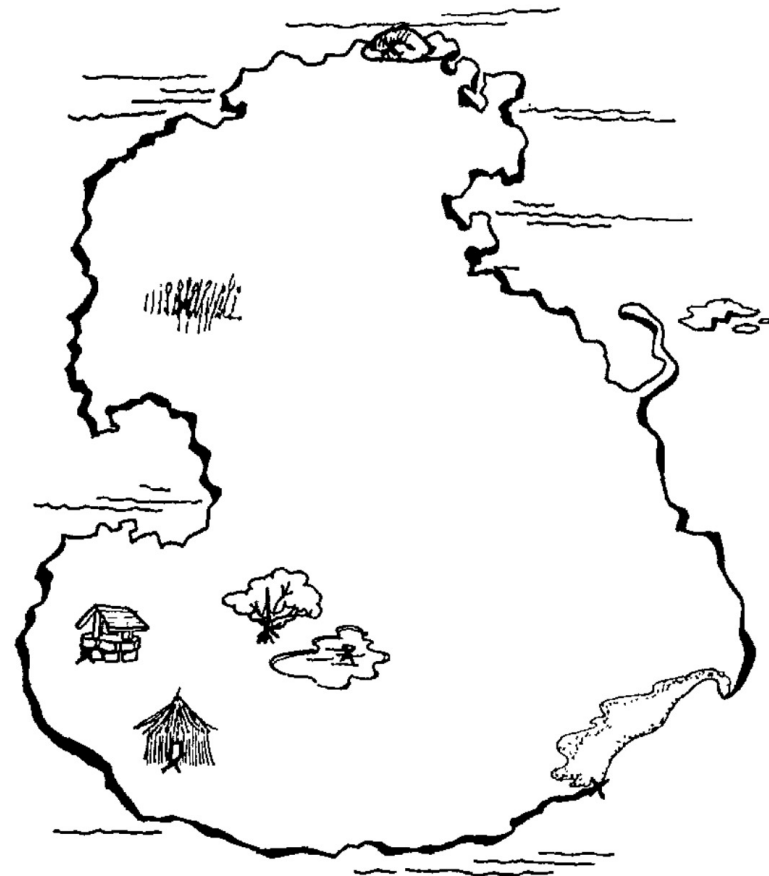


Figure 3. The results of Experiment 2: Time to scan between all pairs of locations on the imaged map.

# 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

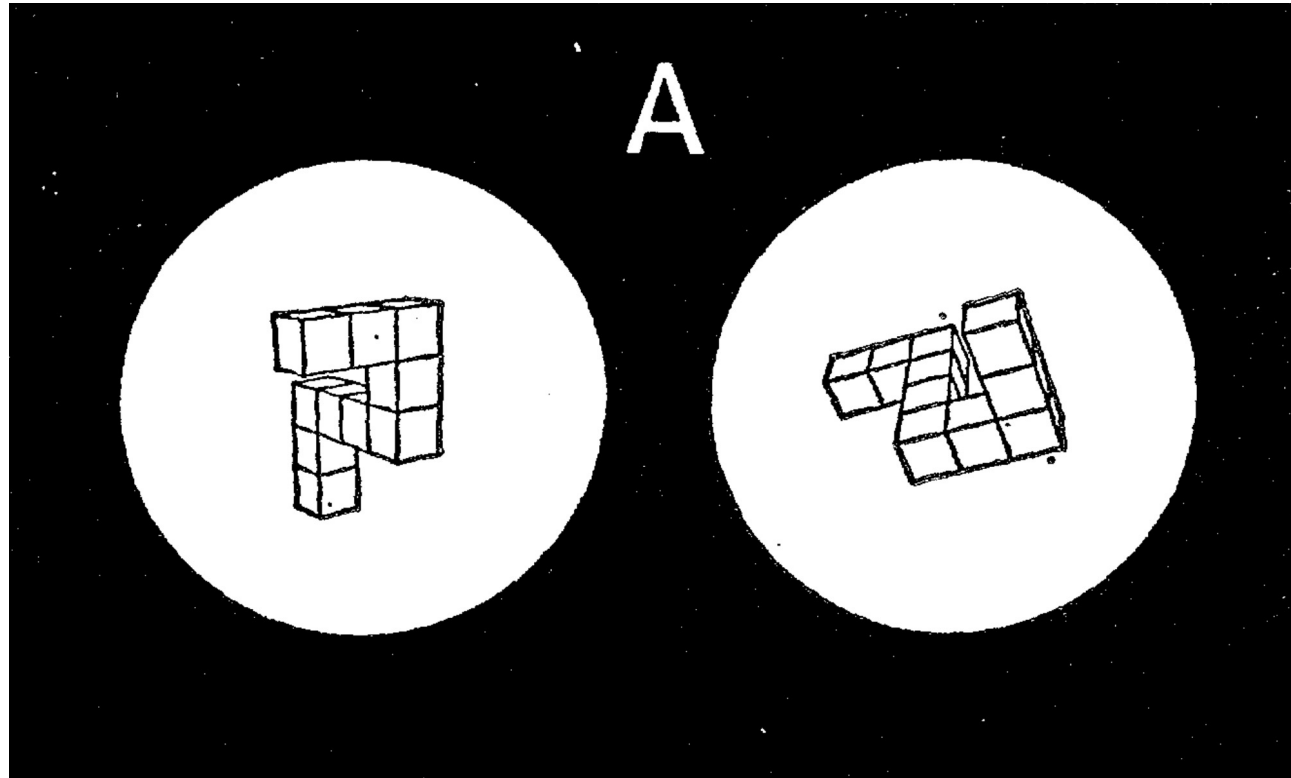


# another experiment

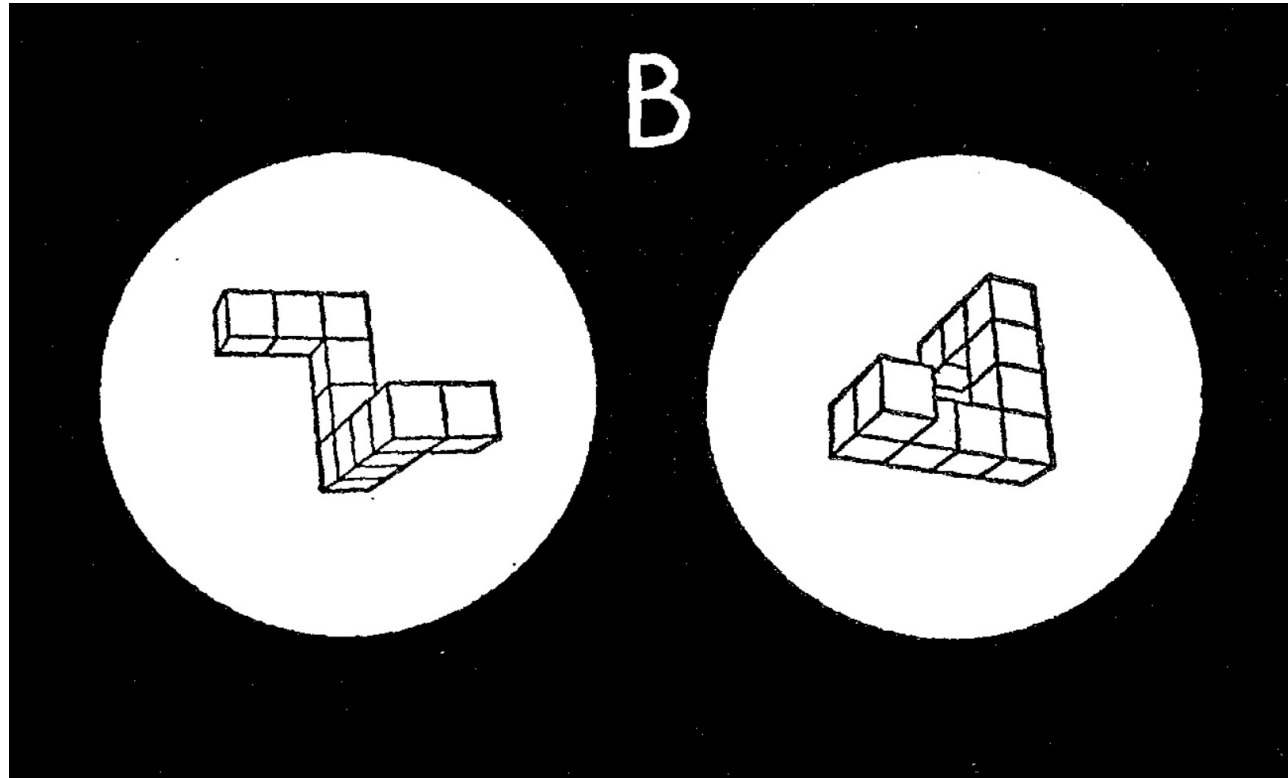
- you will be shown two **three-dimensional objects**
- your task is to decide whether these objects are the **same** object in different orientations or entirely **different** objects
- we will then debrief in groups



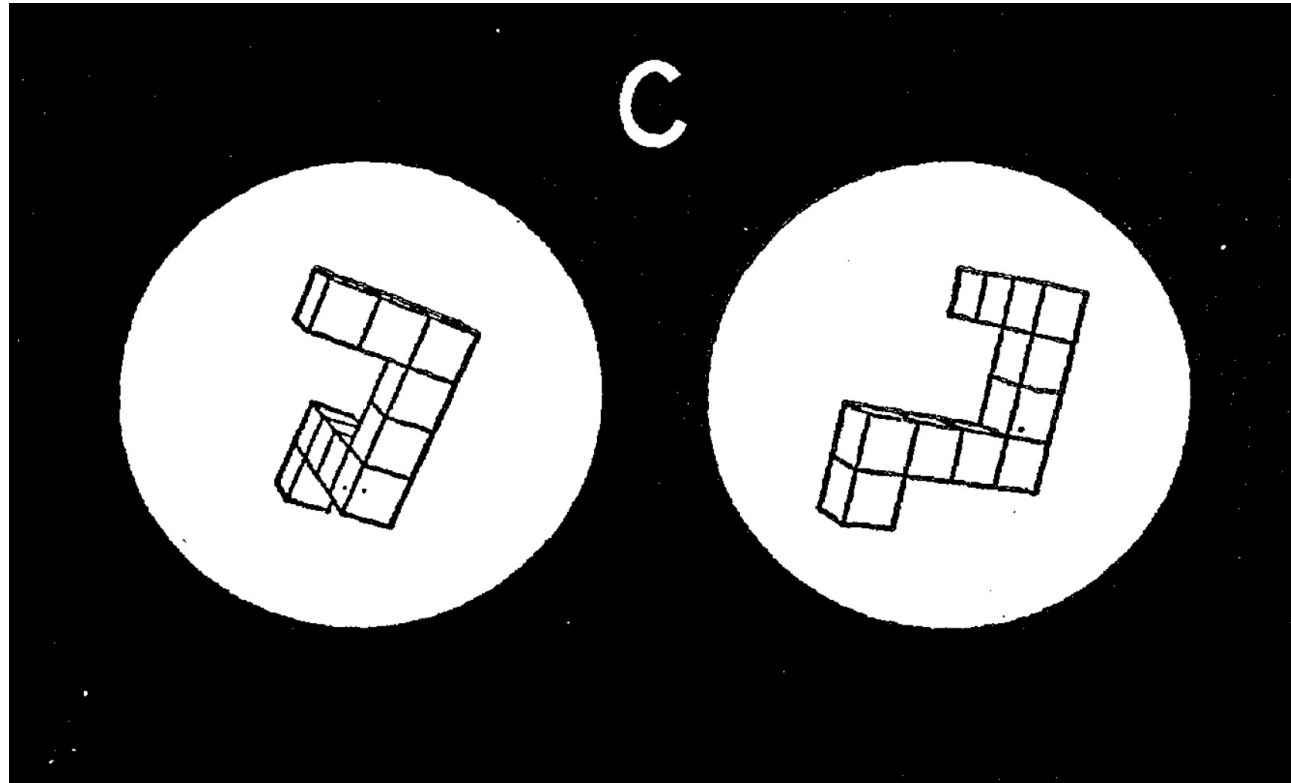
same or different?



same or different?



same or different?

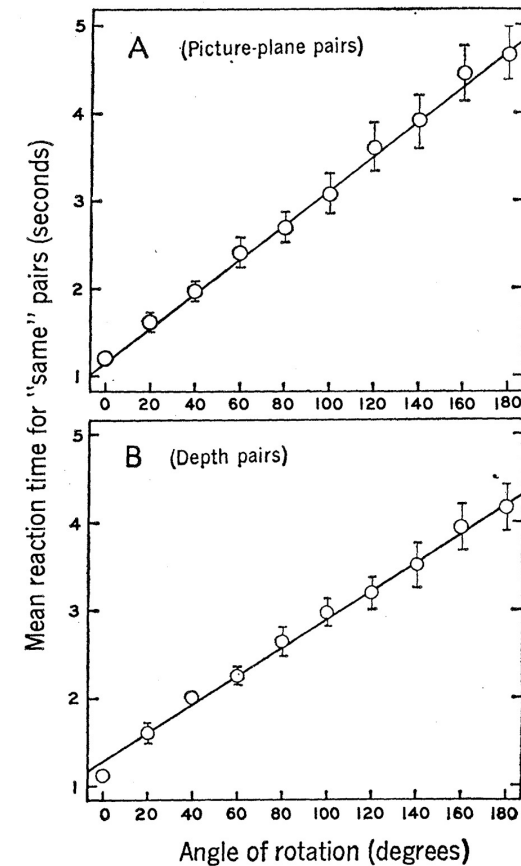


# debrief

- 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

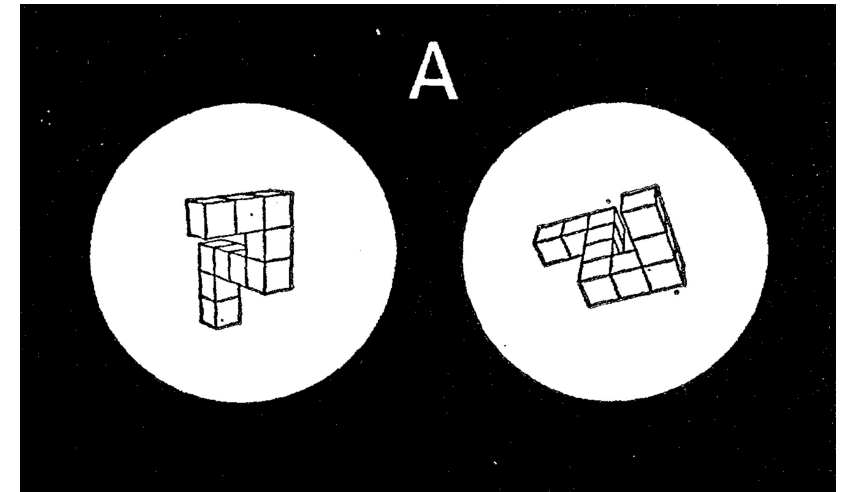
# mental rotation experiment

- 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
- alternative explanations: could also be using informative or “landmark” features / other strategies



# 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

- 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

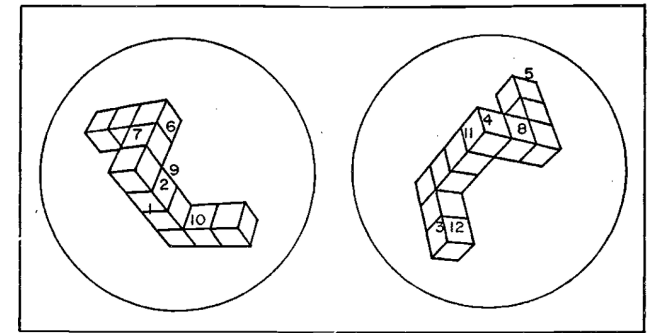
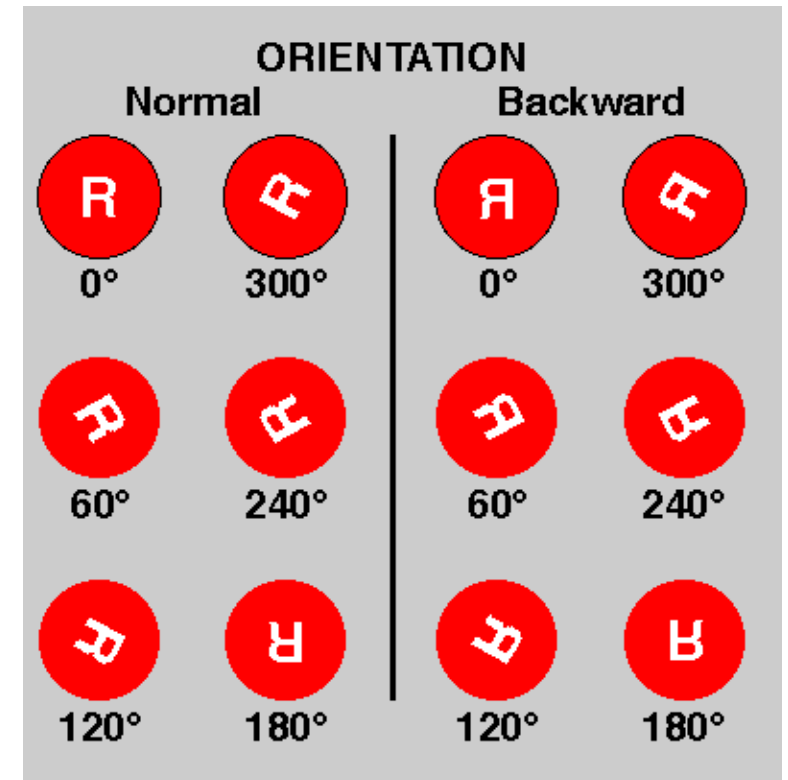


Figure 5. The figure indicates the sequence of fixations on a correct Same trial in which the disparity was  $80^\circ$ . The subject's total response latency was 3574 msec, of which 9% had no visible eye spot. The locus and duration of the fixations are as follows:

<u>Fixation</u>	<u>Figure</u>	<u>Location</u>	<u>Duration</u>
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

# 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


- 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.

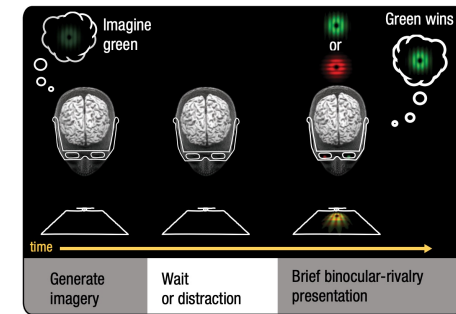
# big takeaways



- 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

# some newer research on imagery

- 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](#)

# applications of mental imagery

## MENTAL ROTATION OF LETTERS, PICTURES, AND THREE-DIMENSIONAL OBJECTS IN GERMAN DYSLEXIC CHILDREN

Jascha Rüsseler,<sup>1,2</sup> Janka Scholz,<sup>1,3</sup> Kirsten Jordan,<sup>4</sup> and Claudia Quaiser-Pohl<sup>3</sup>

<sup>1</sup>Department of Psychology II, Neuropsychology Unit, <sup>2</sup>General Psychology Unit, <sup>3</sup>Department of Psychology I, Developmental and Educational Psychology Unit, Otto-von-Guericke University, Magdeburg, Germany, and <sup>4</sup>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,<sup>1</sup> A. H. Shah,<sup>2</sup> C. M. Divino,<sup>2</sup> S. Schluender,<sup>2</sup> B. Gurland,<sup>1</sup> E. Shlasko,<sup>1</sup> A. Szold<sup>3</sup>

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

Arnoud Arntz , Meike Tiesema, Merel Kindt<sup>1</sup>

*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-

## 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.

# next class



- **before class:**
  - *read*: L3 (Eugenics + Intelligence Testing chapters)
  - *watch*: video on eugenics & Galton
  - *skim through*: APA historical chronology
- **during class:**
  - a history of how psychology began (and went wrong) + what is intelligence?

