

General Principles of Human and Machine Learning



Tutorial 7: Compression and resource constraints

David G. Nagy

<https://hmc-lab.com/GPHML.html>

Date	Remarks	Lecture	Tutorial	TA	Readings
Week 1:		Oct 15: Introduction (slides)	Oct 16 (slides)	Alex	Spicer & Sanborn (2019). What does the mind learn?
Week 2:		Oct 22: Origins of biological and artificial learning (slides)	Oct 23 (slides)	Turan	[1] Behaviorism [2] What is a perceptron? (Blog post)
Week 3:		Oct 29: Symbolic AI and Cognitive maps (slides)	Oct 30 (Quiz #1)	Alex	[1] Gamelo & Shanahan (2019) [2] Bozman et al., 2021
Week 4:		Nov 5: Introduction to RL (slides)	Nov 8 (slides)	Turan	Sutton & Barto (Ch. 1 & 2)
Week 5:		Nov 12: Advances in RL (slides)	Nov 13 (Quiz #2)	Turan	Neftci & Averbeck (2019)
Week 6:	Guest lecturer: Alexandra Witt	Nov 19: Social learning (slides)	Nov 20 (slides)	Alex	Witt et al., (2024)
Week 7:	Guest lecturer: Dr. David Nagy	Nov 26: Compression and resource constraints (slides)	Nov 27	David	Nagy et al., (2020)
Week 8:		Dec 3: Concepts and Categories	Dec 4	Hanqi	Murphy (2023)
Week 9:		Dec 10: Supervised and Unsupervised learning	Dec 11	Hanqi	Bishop (Ch. 4)
	Holiday break				
Week 10:		Jan 14: Function learning	Jan 15	Alex	Wu, Medar, & Schulz (2024)
Week 11:		Jan 21: No Lecture	Jan 22: No Tutorial		
Week 12:		Jan 28: Language and semantics	Jan 29	TBD	Kamath et al., (2024)
Week 13:		Feb 4: General Principles	Feb 5	Charley	Gershman (2023)

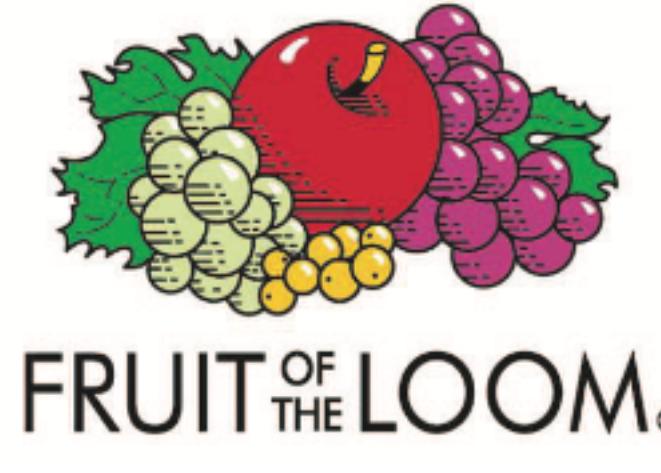
Quiz #3?



plan for today

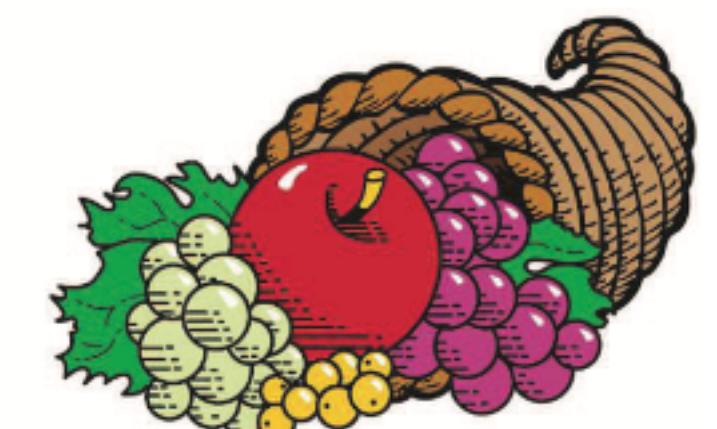
1. visual mandela effect memory experiment
2. informative questions and compression
3. bayesian inference and perception

visual mandela effect



FRUIT OF THE LOOM.®

A



FRUIT OF THE LOOM.®

B



A



B



A



B



A



B



A



B



A



B



A



B



The Berenstein Bears

A



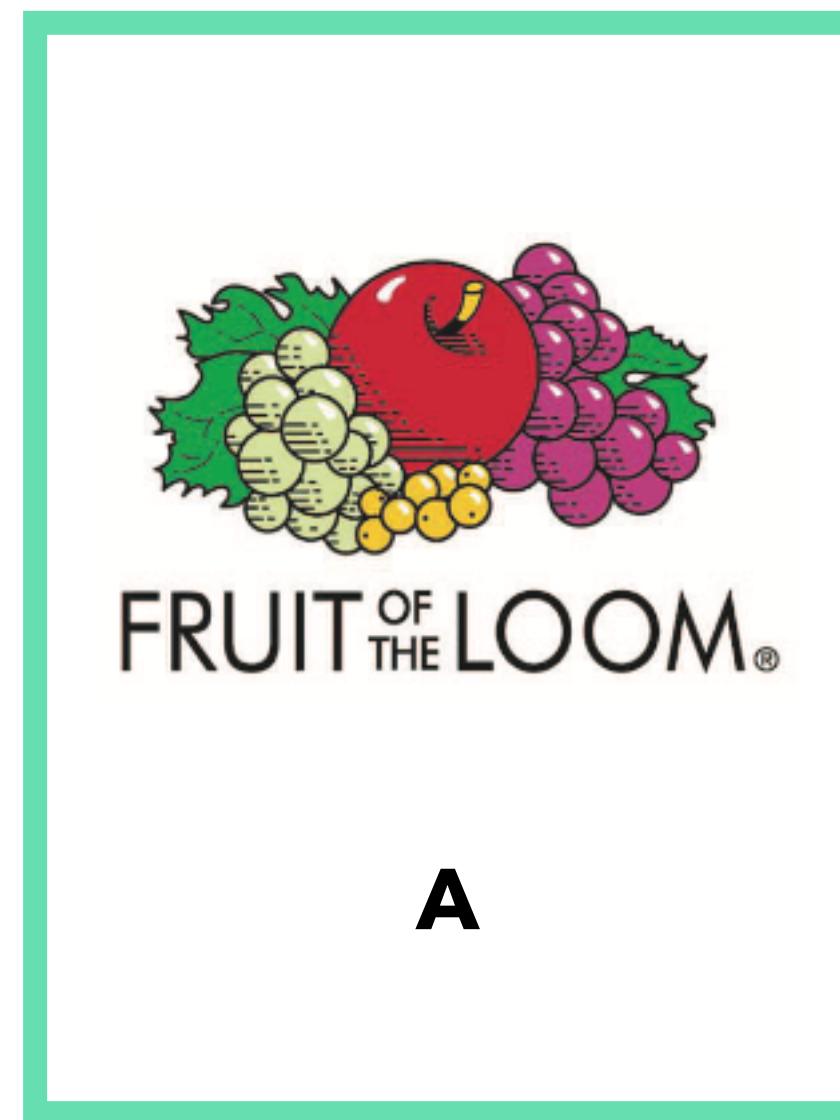
The Berenstain Bears

B

visual mandela effect

correct answers

visual mandela effect



A



B

visual mandela effect



A



B

visual mandela effect

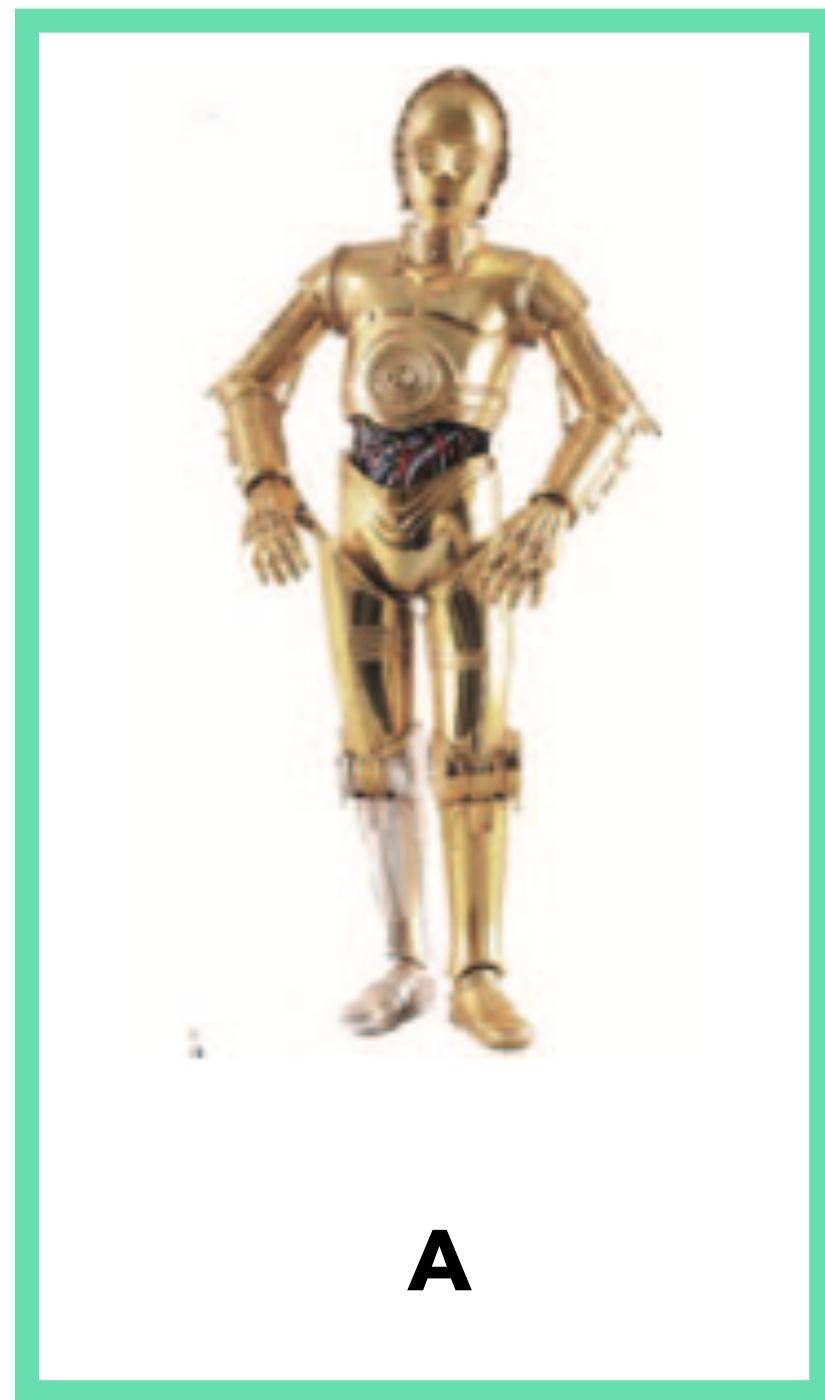


A



B

visual mandela effect



A



B

visual mandela effect



A

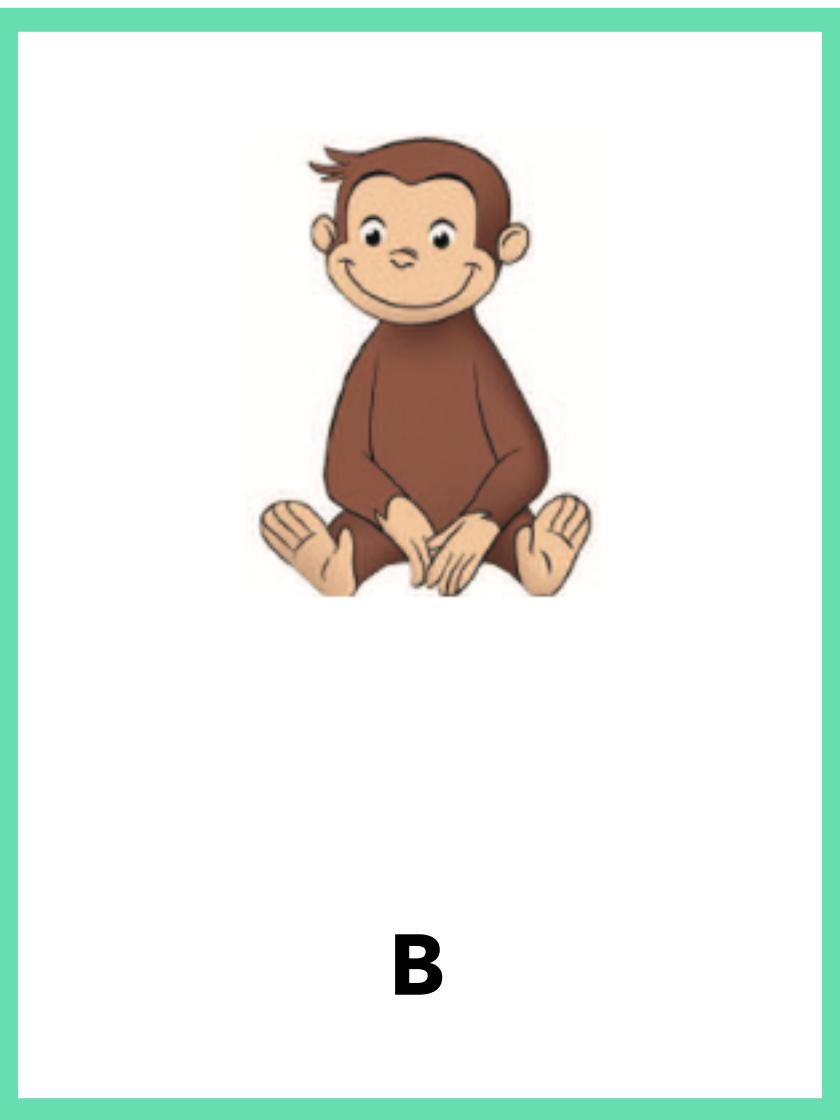


B

visual mandela effect



A



B

visual mandela effect



A



B

visual mandela effect



The Berenstain Bears

A

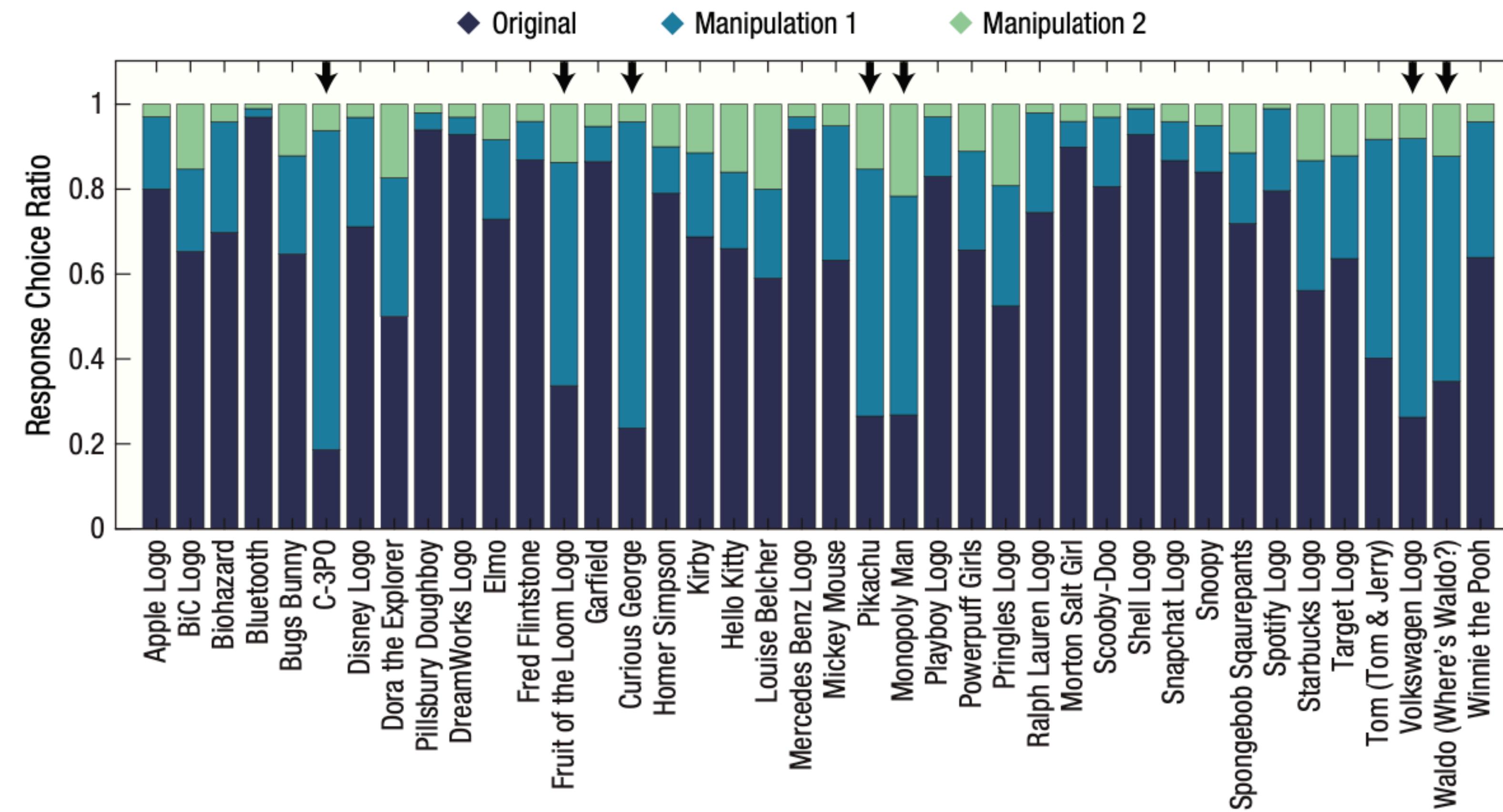


The Berenstain Bears

B

visual mandela effect

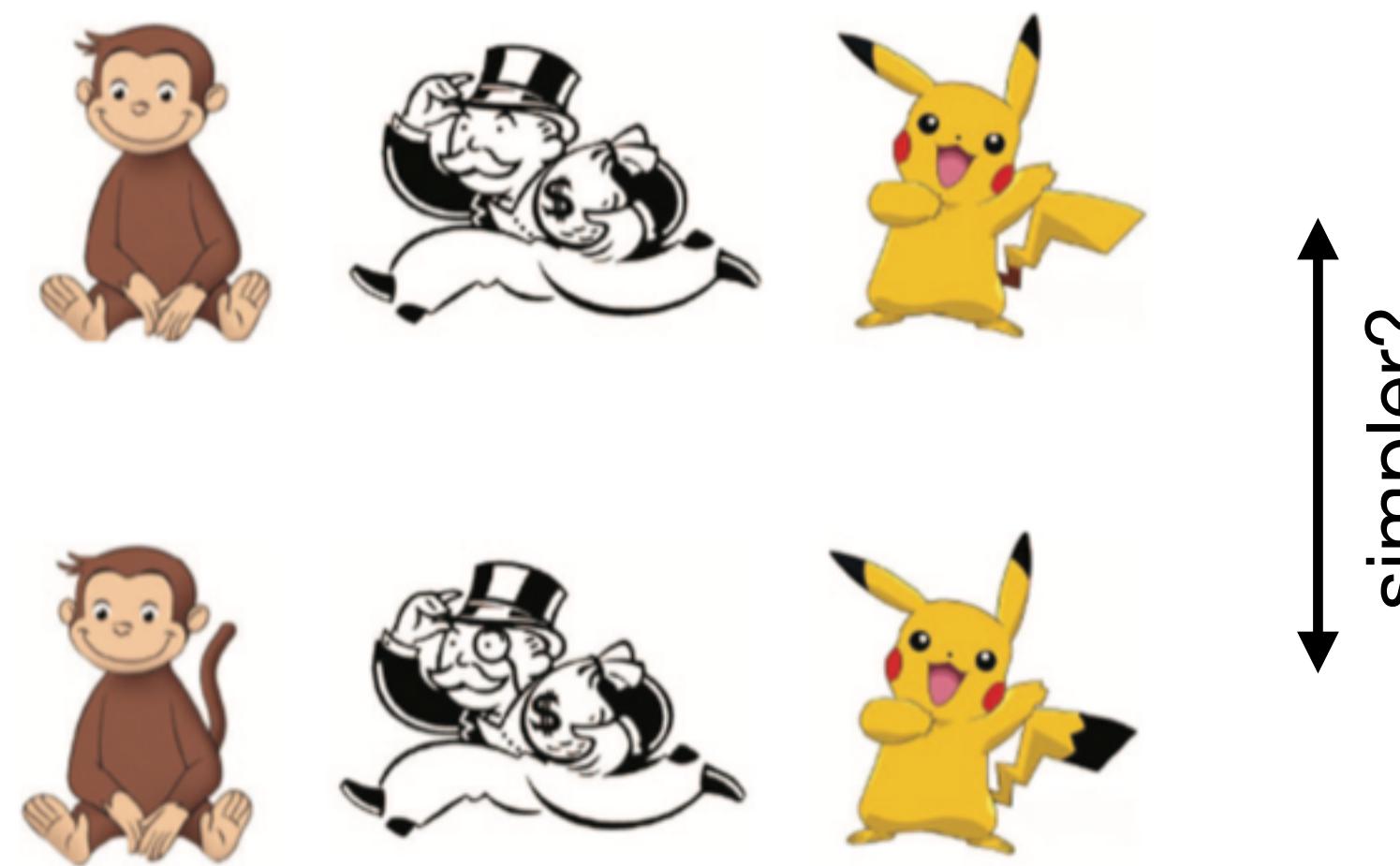
Ratio of Response Choices by Images



visual mandela effect

- have you noticed a pattern in the distortions?
- how would you explain the VME effect?

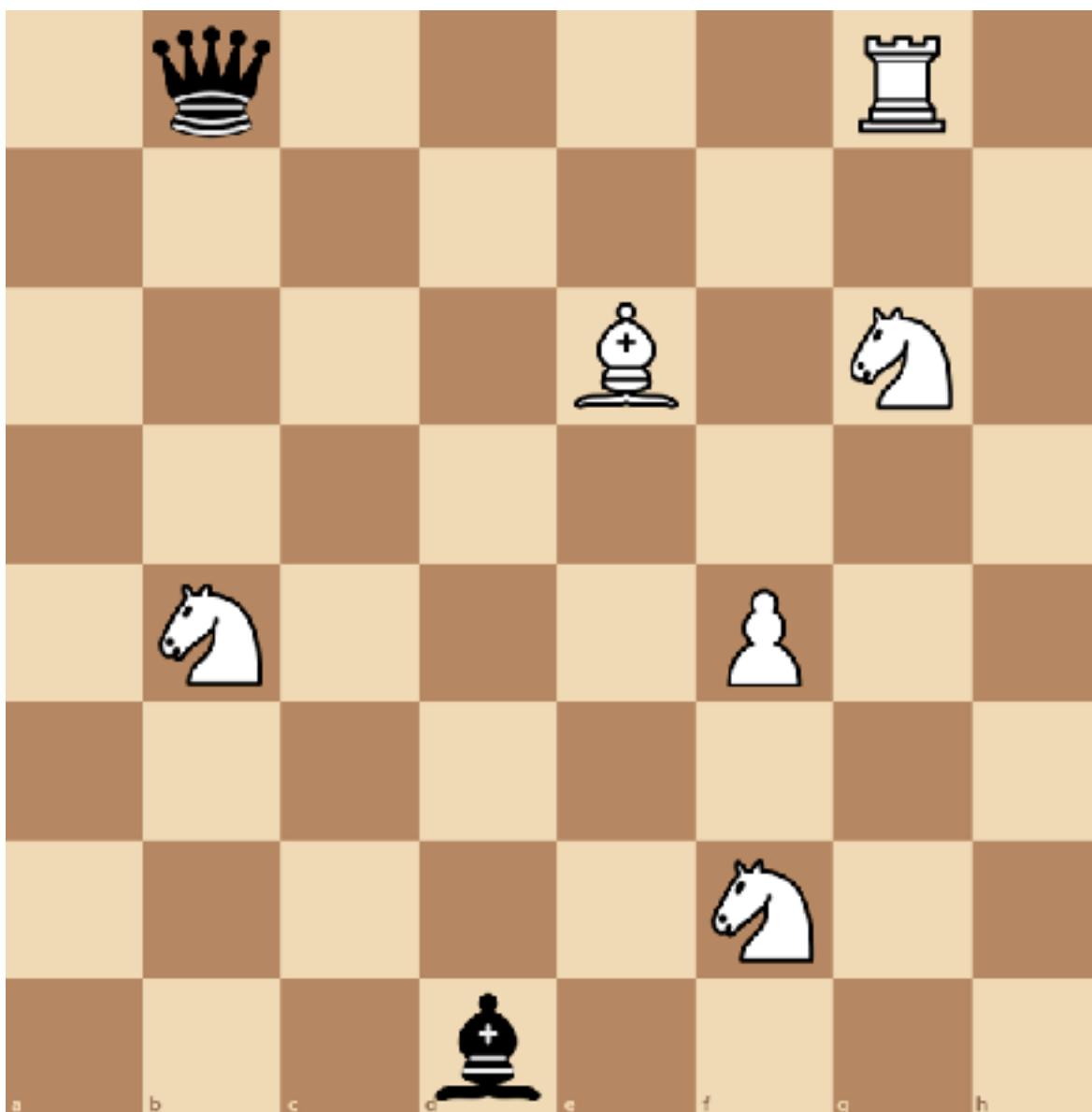
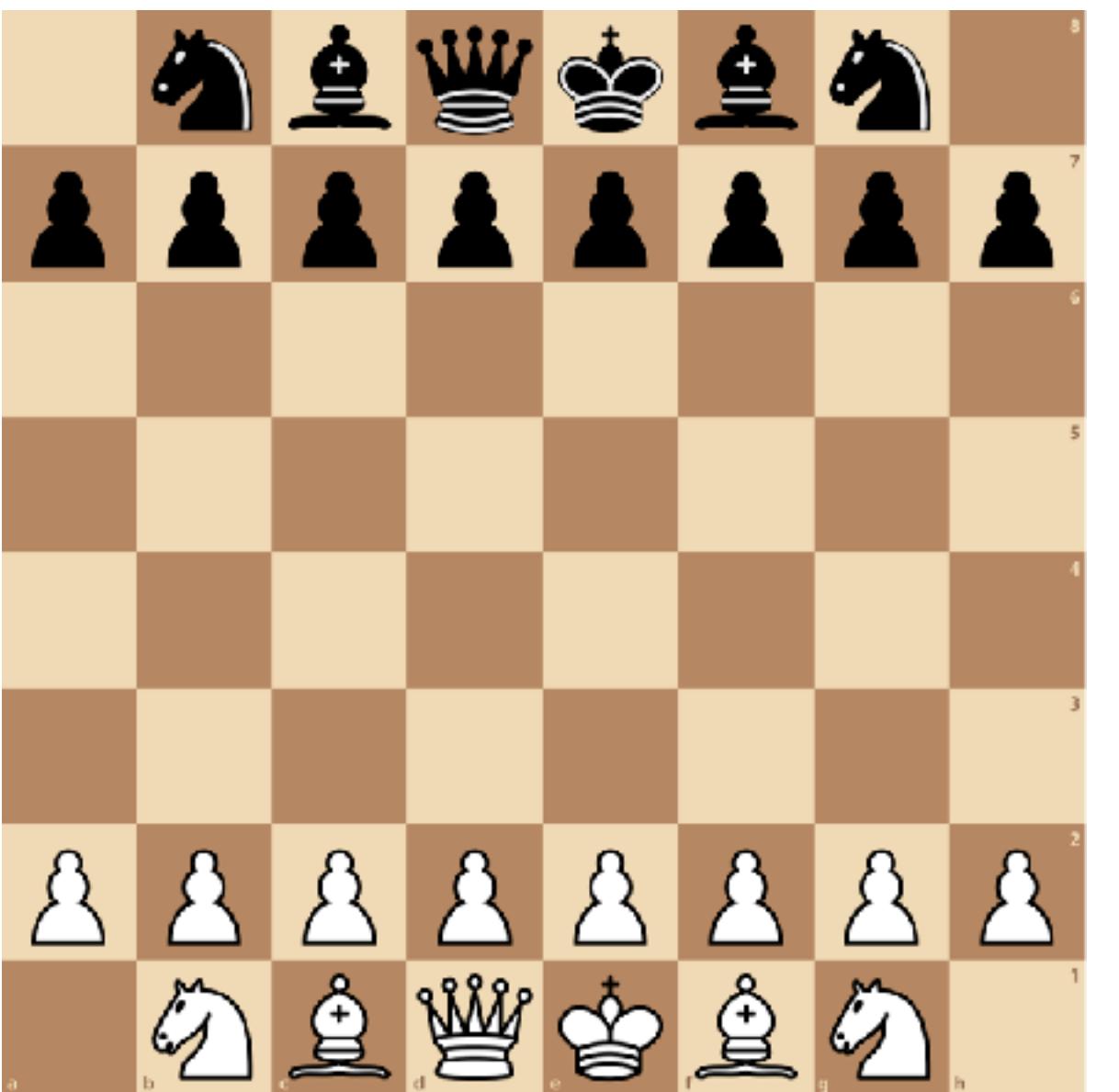
visual mandela effect



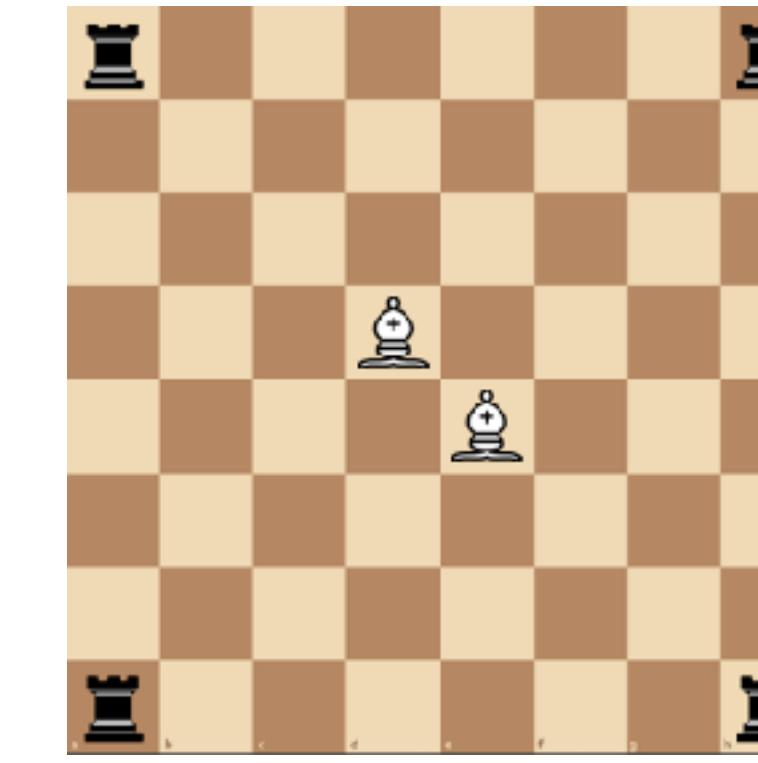
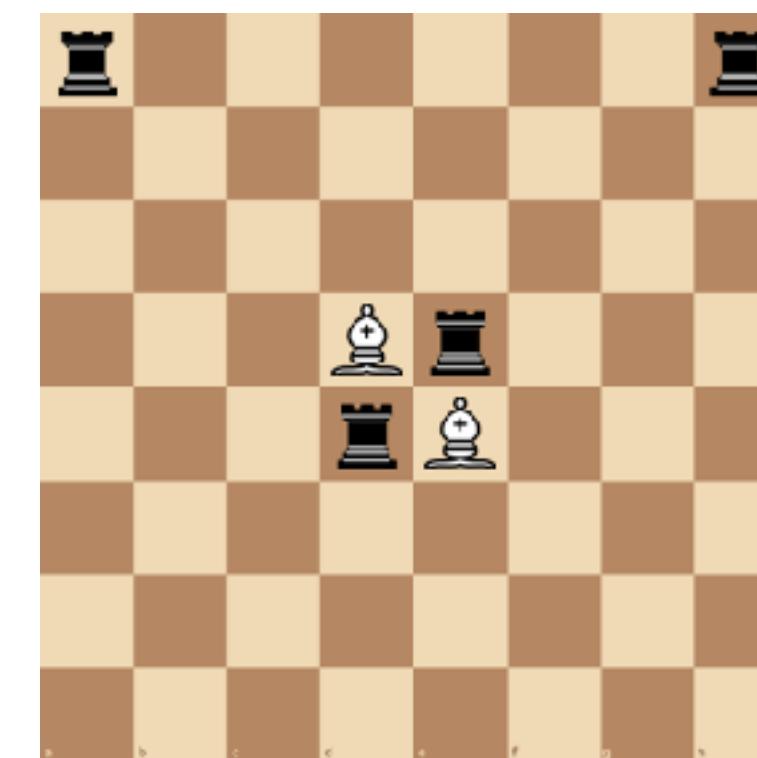
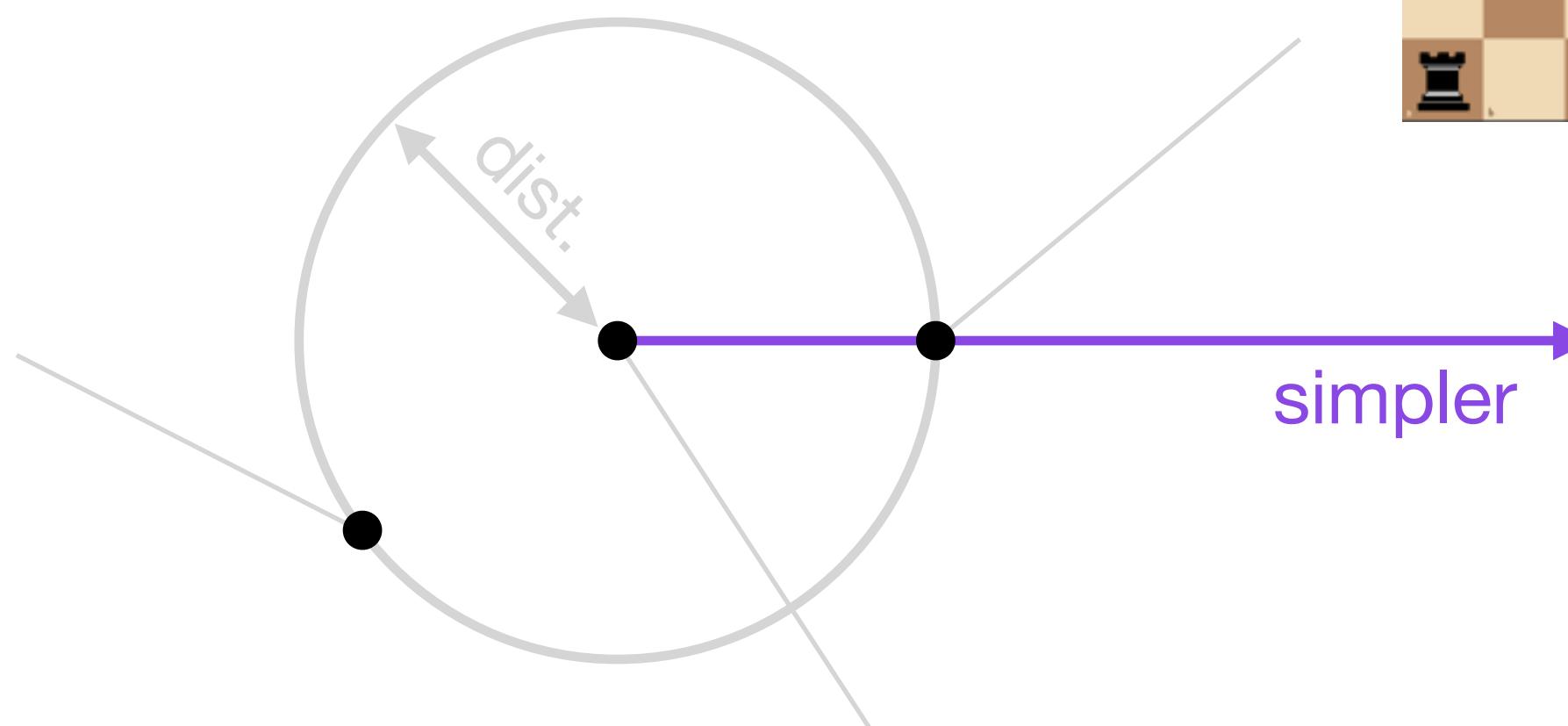
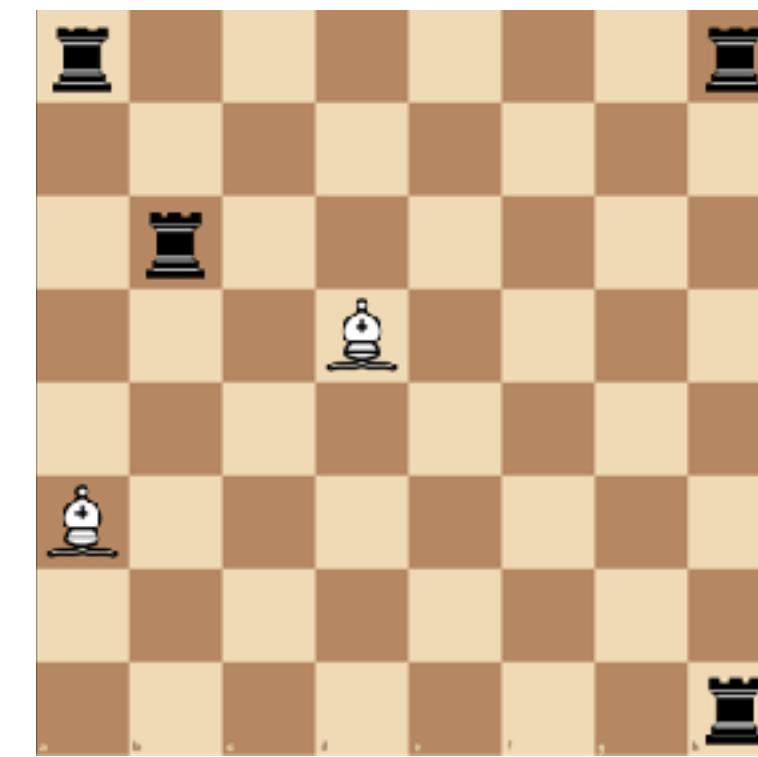
visual mandela effect

Which chess board state is easier to recall, one with **28 figures** or **8 figures**?

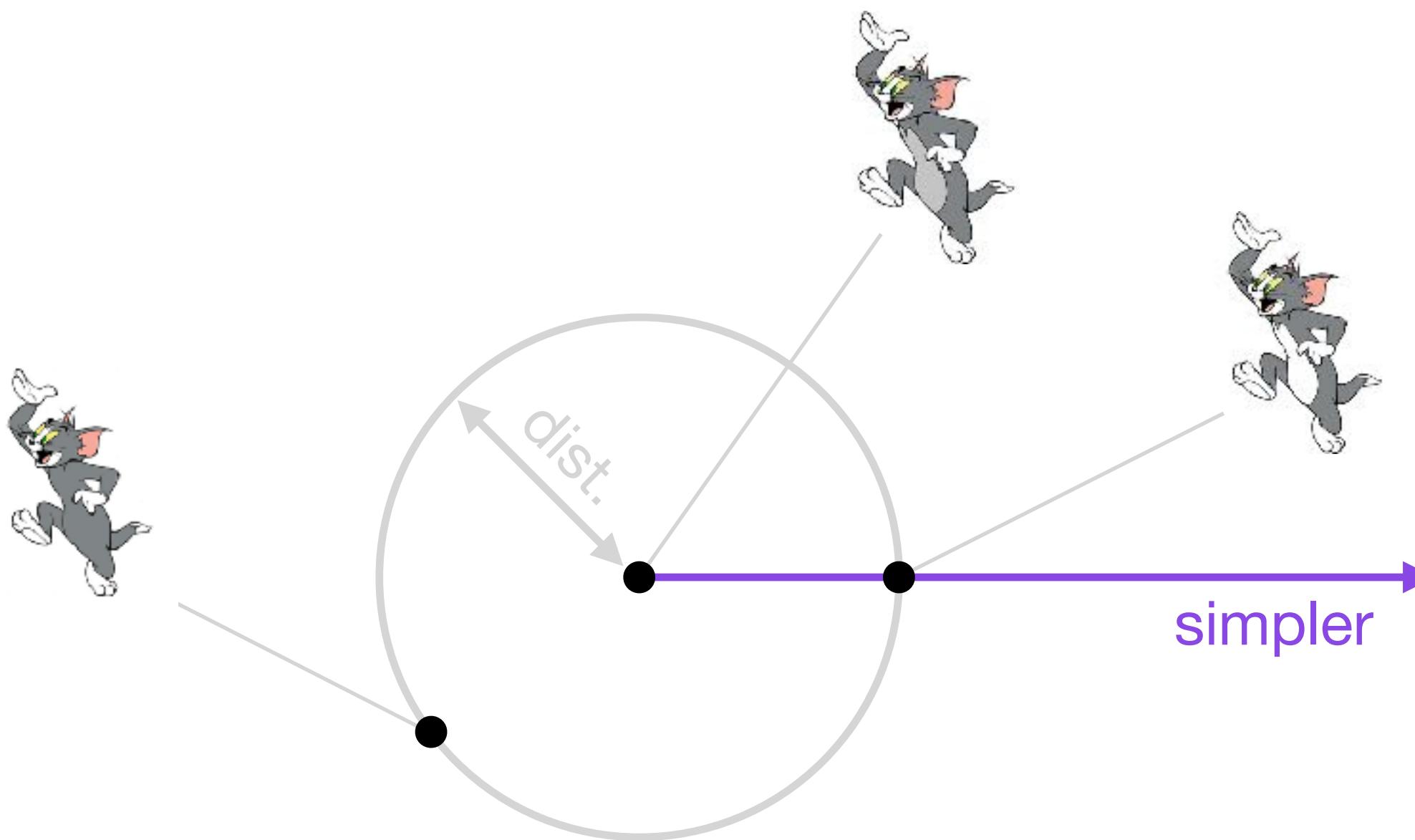
visual mandela effect



visual mandela effect



visual mandela effect



compression

I walked my four legged animal that barks on the day before today after the huge glowing ball of fire left the sky

compression

I walked my dog on the day before today after the huge glowing ball of fire left the sky

compression

I walked my dog yesterday after the huge glowing ball of fire left the sky

compression

I walked my dog yesterday after sunset

*

capitalist cartoon man



description length of

<

capitalist cartoon man without
monocles



description length of

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description length of



description length of



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golden humanoid robot

golden humanoid robot **with**
silver right leg

*

description length of



<

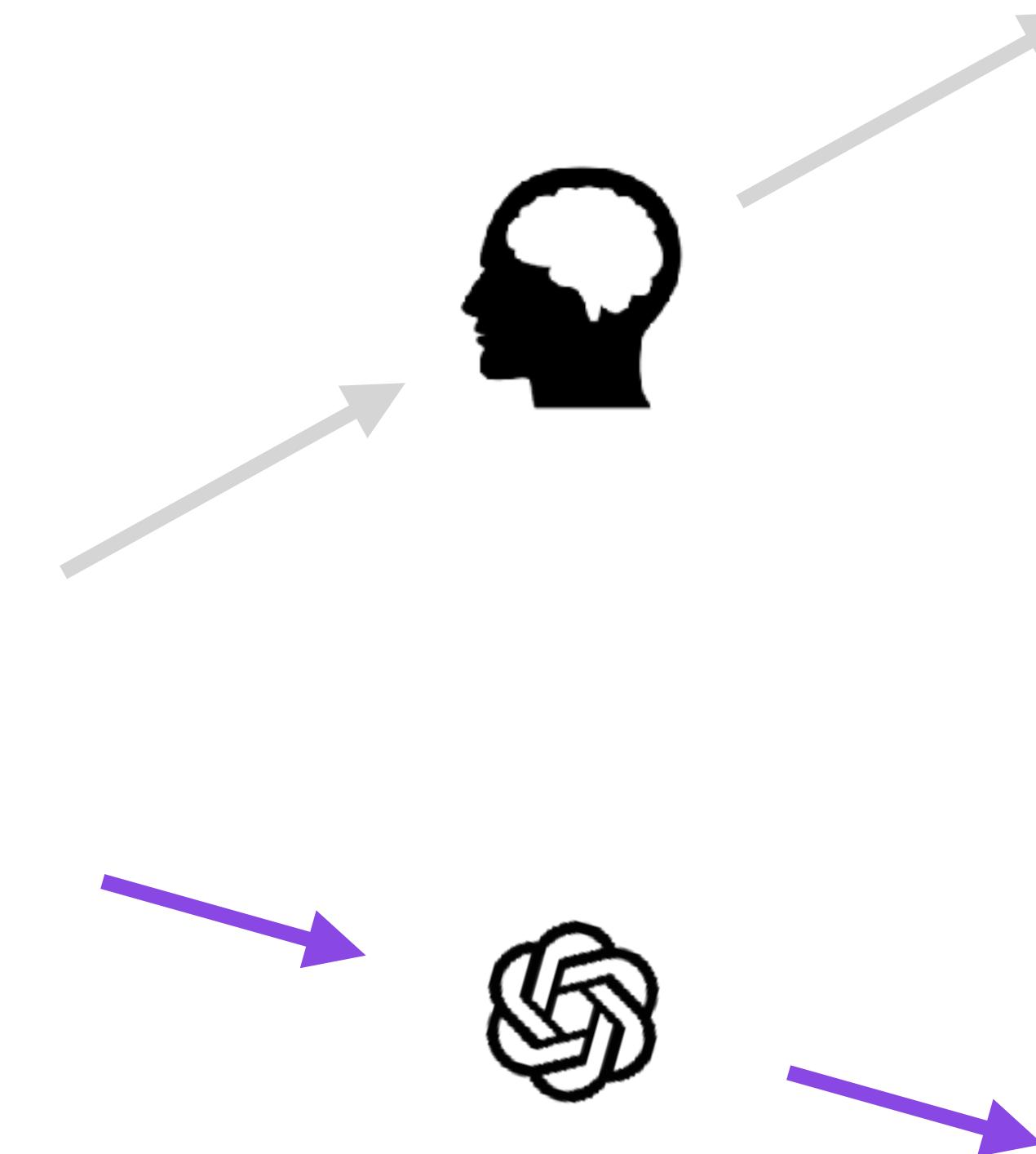
description length of



cartoon cat with grey fur and
white accents

cartoon cat with grey fur and
white accents **and light gray**
belly

*



*



Describe this image to someone who speaks english but is otherwise not familiar with western culture



ChatGPT

This image shows a cartoon of an anthropomorphic cat, which means it has human-like characteristics. The cat is standing on its two hind legs, similar to a human posture. It has a large head compared to its body, a common trait in cartoons to emphasize expressions and emotions. Its fur is primarily grey with a white belly and muzzle. The cat has a mischievous and somewhat exaggerated facial expression with large green eyes wide open, ears perked up, and its mouth open as if caught by surprise or shouting.

HU You

*



Please describe the attached image to someone who will have to draw the image based solely on your description. The person who will draw it speaks english but is otherwise not familiar with western culture. You should make the description as short as possible, while still having the details necessary for the drawer to recreate the image.



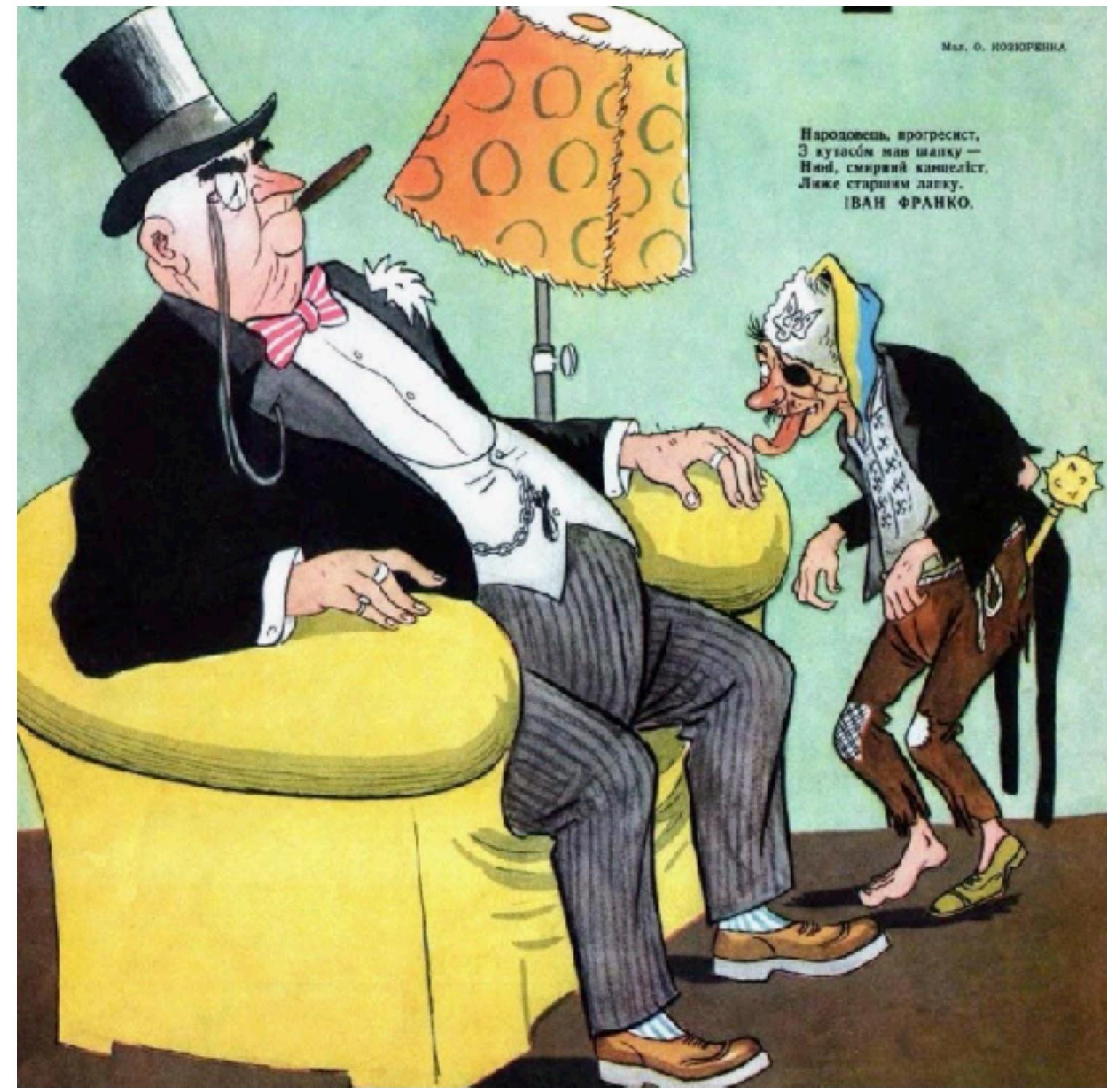
ChatGPT

The image is of a humanoid robot. The robot stands upright with its arms slightly away from its body. Its entire surface has a metallic gold finish. The design is intricate with visible joints at the shoulders, elbows, hips, and knees, suggesting flexibility. The head is oval with two horizontal eye slots that appear as a black visor, giving the impression of eyes. The mouth is a simple, narrow horizontal slit.

- * "it is possible that for some VME images (e.g., C-3PO, Volkswagen, Where's Waldo), **the error may be driven by filling in these perceptual gaps with schematic knowledge**, creating a more schema-typical false memory (Koutstaal & Schacter, 1997; Miller & Gazzaniga, 1998; Seamon et al., 2000). However, this is unlikely to apply to all VME- apparent images. For some icons, the feature of interest is almost always shown (e.g., the Monopoly Man's face), and **some VME features are intuitively atypical to the schema** (e.g., a cornucopia for the Fruit of the Loom logo)."

"Furthermore, it is unclear how such schemas are formed for new image classes; for example, as Pokémon's most popular character, **Pikachu is likely the basis for that schema, yet people falsely remember a black tip on its tail.** Future research into VME should examine the schema consistency of VME features compared with other manipulations."

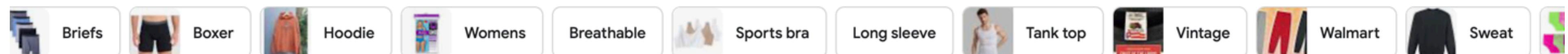
We showed that the **VME cannot be universally explained by a single account**. Instead, perhaps different images cause a VME for different reasons—some related to schema, some related to visual experience, and some related to something entirely different about the images themselves."





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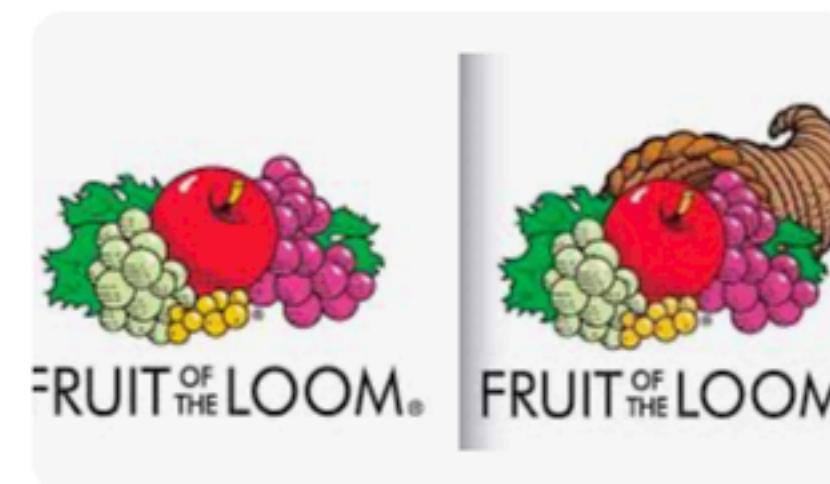
Tools



Wikipedia
Fruit of the Loom - Wikipedia



1000 Logos
Fruit of the Loom Logo and...



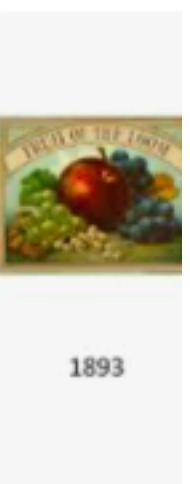
Fast Company
The great Fruit of the Loom logo ...



Wikipedia
Fruit of the Loom - Wikipedia



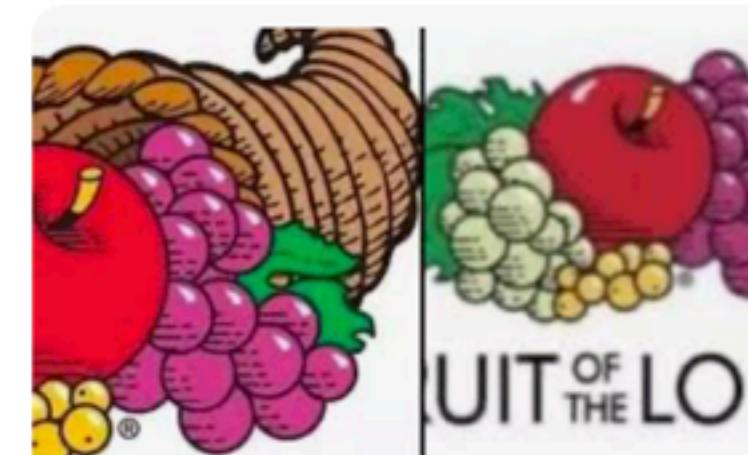
YouTube
Fruit of the Loom Logo ...



Aka-Tex
Das Logo v



Yahoo Finance
'ruit of the Loom' Logo ...



LADbible
Fruit Of The Loom 'Mandela Effect ...



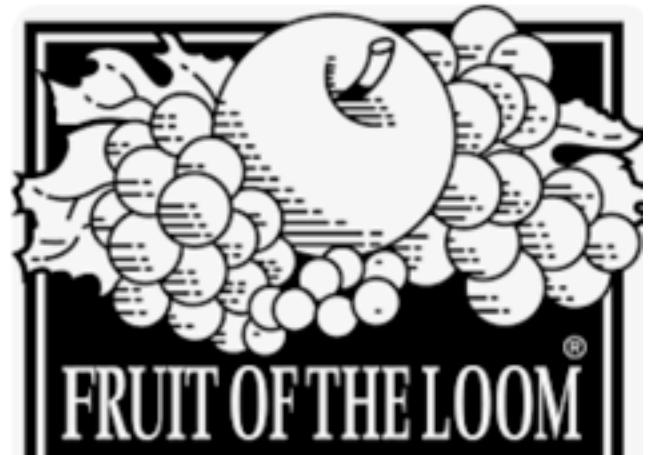
Nornine · In stock
FOTL Vintage Tee Large ...



Reddit
The Fruit of the Lo...



Freebie Supply
Fruit Of The Loom Logo ...



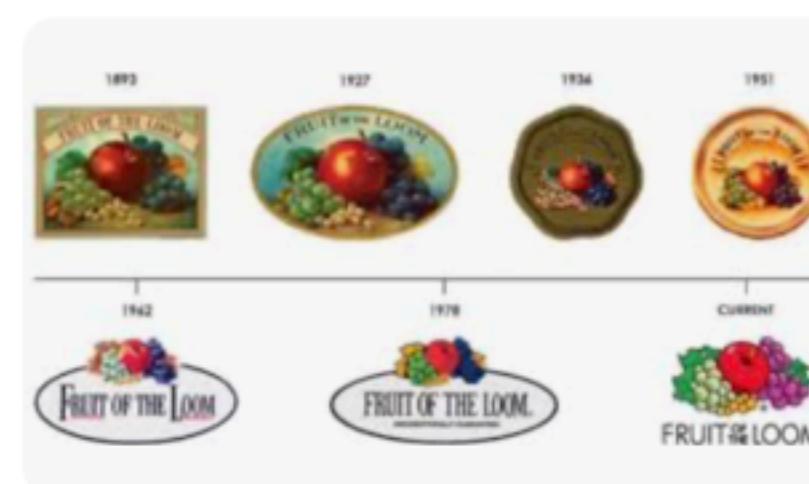
Worldvectorlogo
FRUIT OF THE LOOM Vector Log...



Logowik
'ruit of the Loom Logo PNG ve...



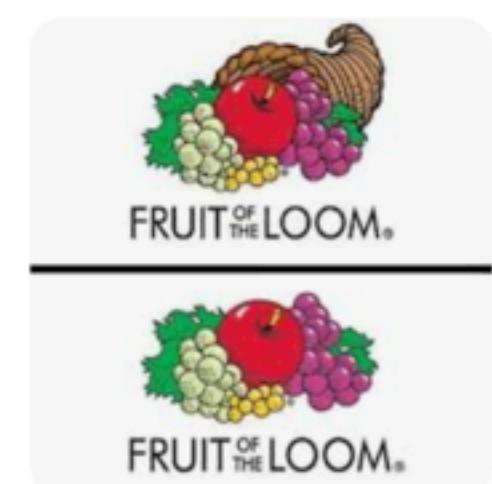
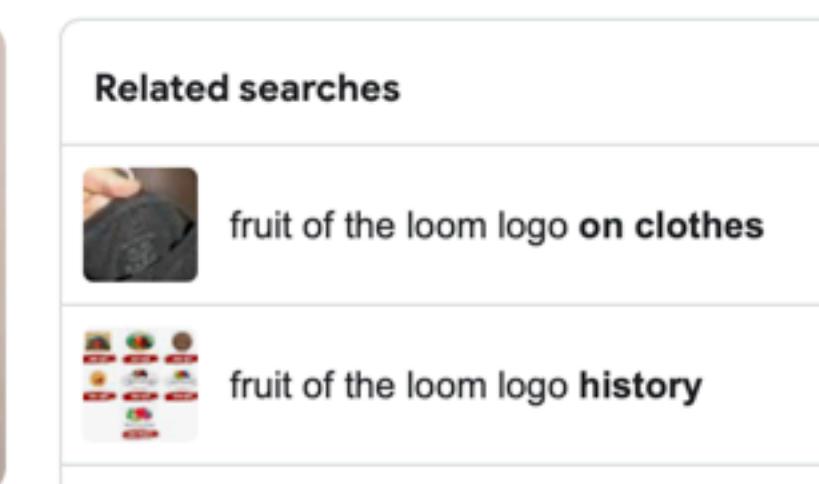
Fruit Activewear
Fruit of the Loom: Wholes...



Yahoo
Fruit Of The Loom Fires Back At ...



basic-shirts.de
the Loom Vintage ...



Facebook
Ranker - Do you reme...

*



Cornucopia



< All

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Maps

More

Tools

Saved

SafeSearch



drawing



clipart



hunger games



coloring



thanksgiving



printable



transperer



Plantscapers

Cornucopia and its Greek Origins ...



Easy Drawing Guides

How to Draw a Cornucopia - Reall...



Amazon · In stock

Beistle 1 x dekorative...



Europosters.de · In stock

Cornucopia Foto, Poster, Wandbilder bei ...



The Pioneer Woman

Cornucopia and What Does It Sy...



Gourmet Gift Baskets

the Cornucopia: The Thanksgiving ...



Photo Prints & Wall Art

CORNUCOPIA. Wood engraving, ...

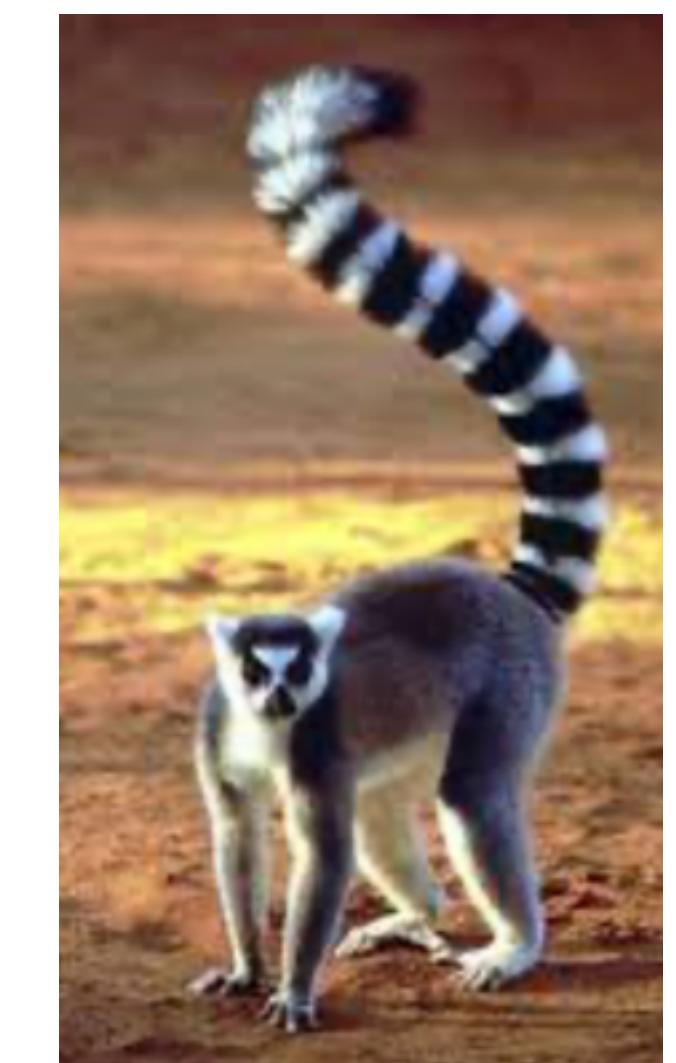
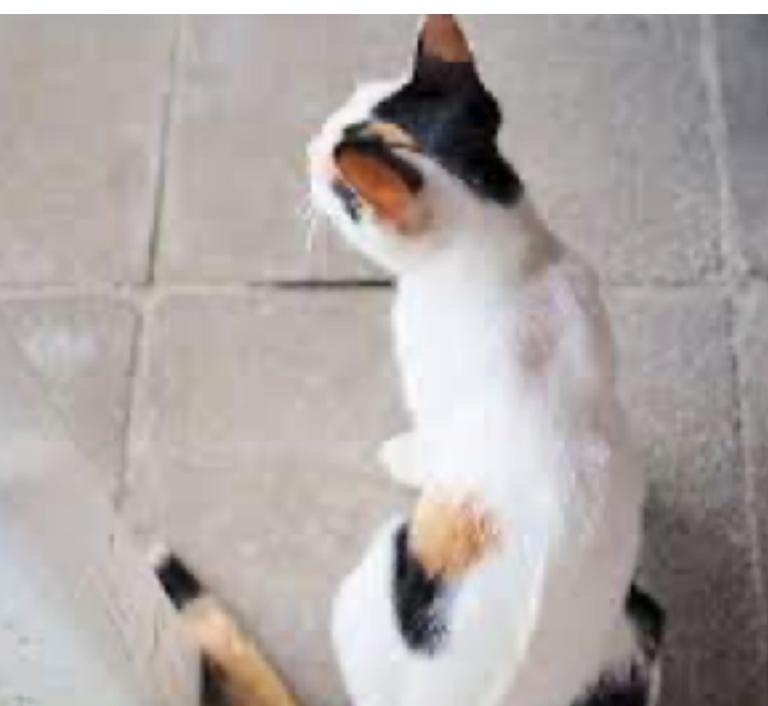


iStock

Autumn Cornucopia With Pumpkins V...



*



informative questions

informative questions

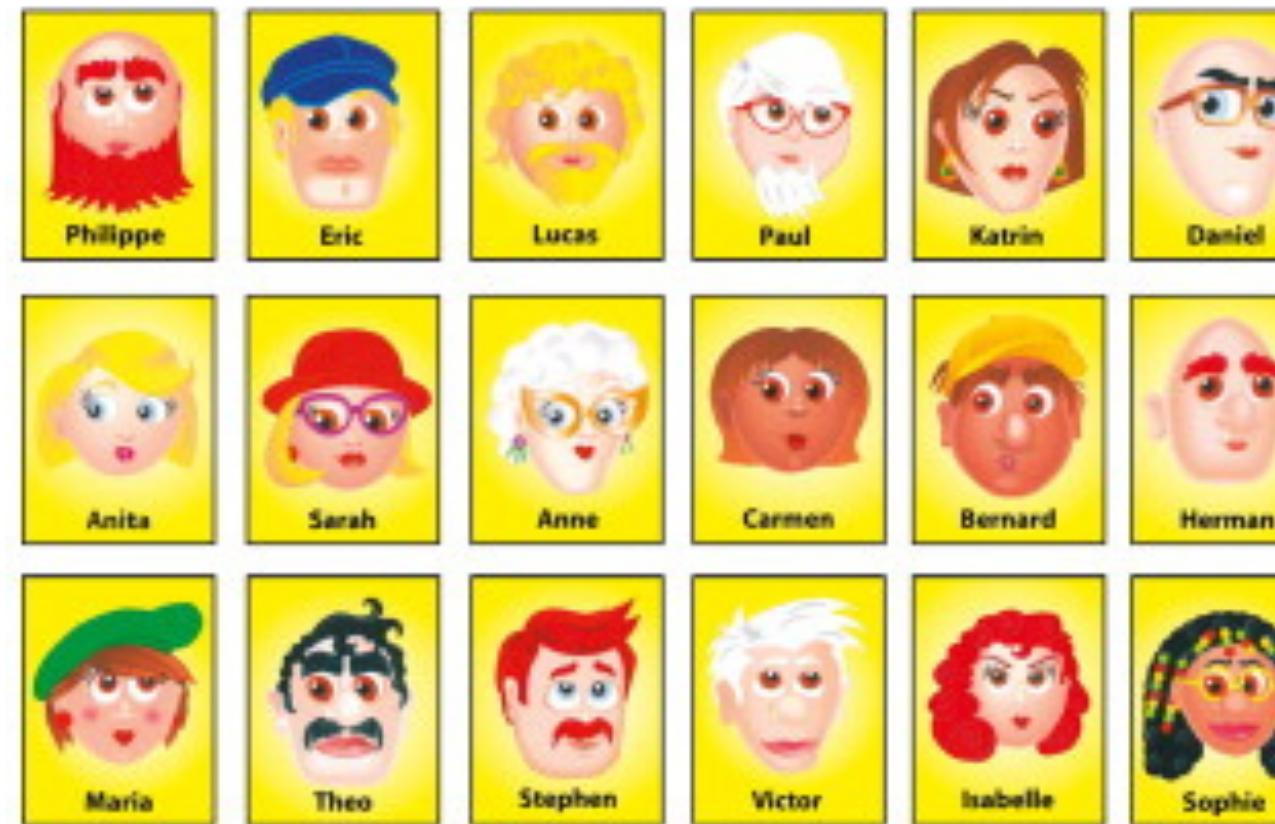


informative questions

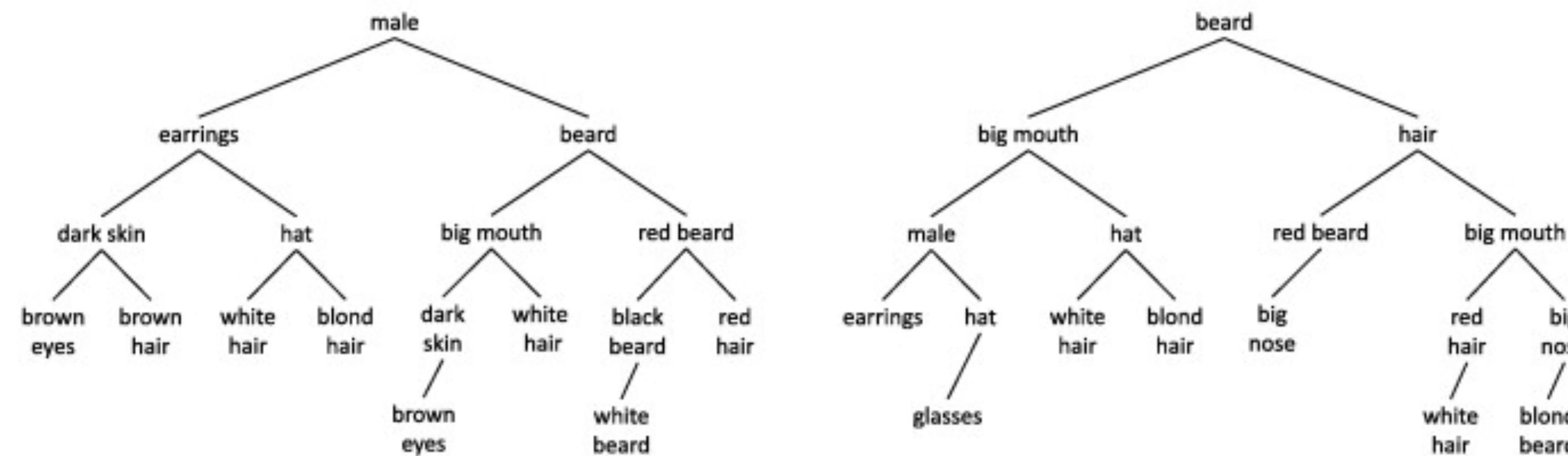


informative questions

Representative Environment



Nonrepresentative Environment

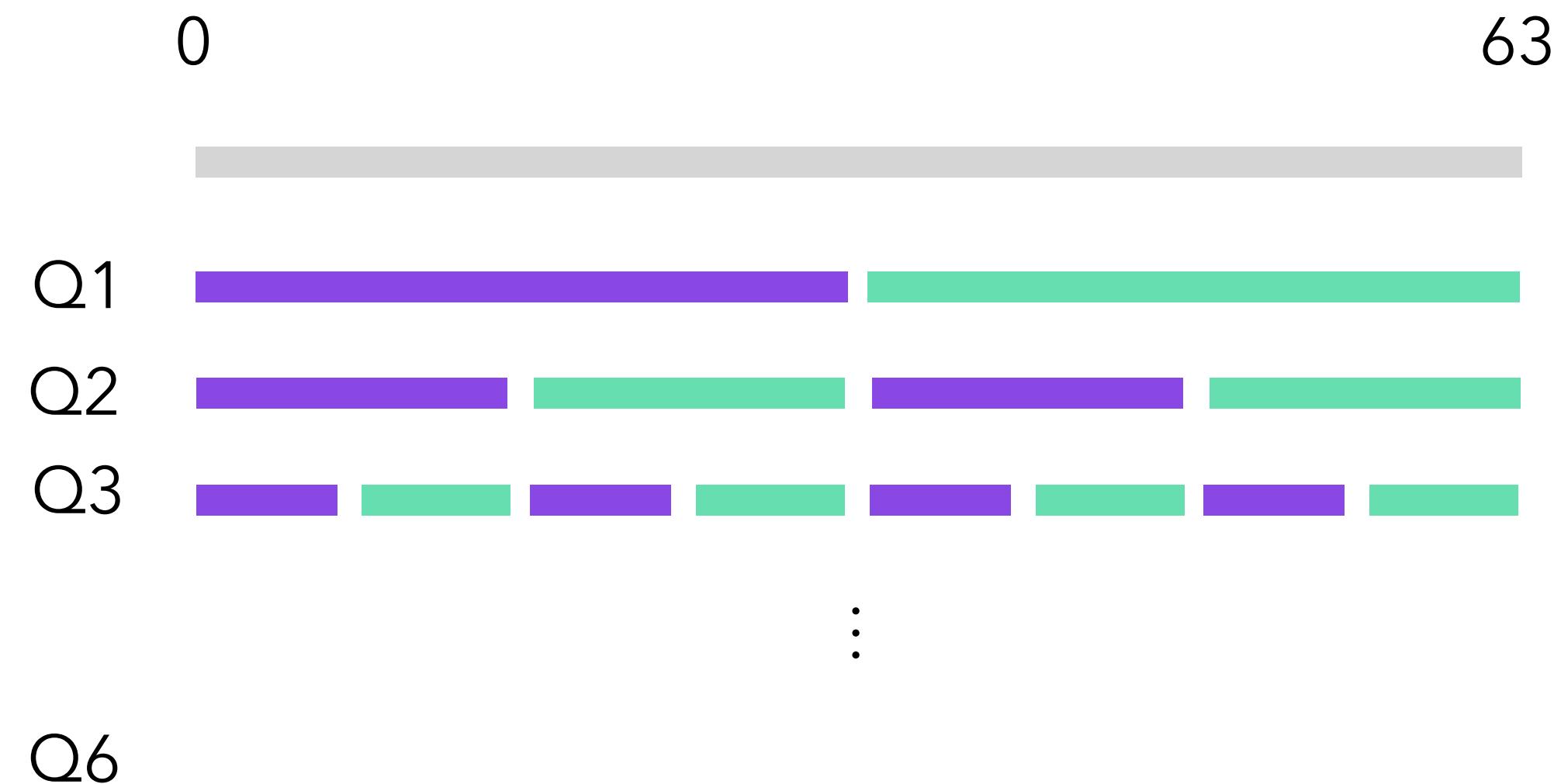


- how would you measure the information content of a question?
- how is the twenty questions game different?

informative questions

- I have thought of a number between 0 and 63
 - at least how many yes/no questions do you need to ask to determine which one?
 - what are the questions?

- 1: is $x \geq 32?$ **y/n**
- 2: is $x \bmod 32 \geq 16?$
- 3: is $x \bmod 16 \geq 8?$
- 4: is $x \bmod 8 \geq 4?$
- 5: is $x \bmod 4 \geq 2?$
- 6: is $x \bmod 2 = 1?$



informative questions

- I have thought of a number between 0 and 63
 - at least how many yes/no questions do you need to ask to determine which one?
 - what are the questions?
- **what is the information content of a single question?**

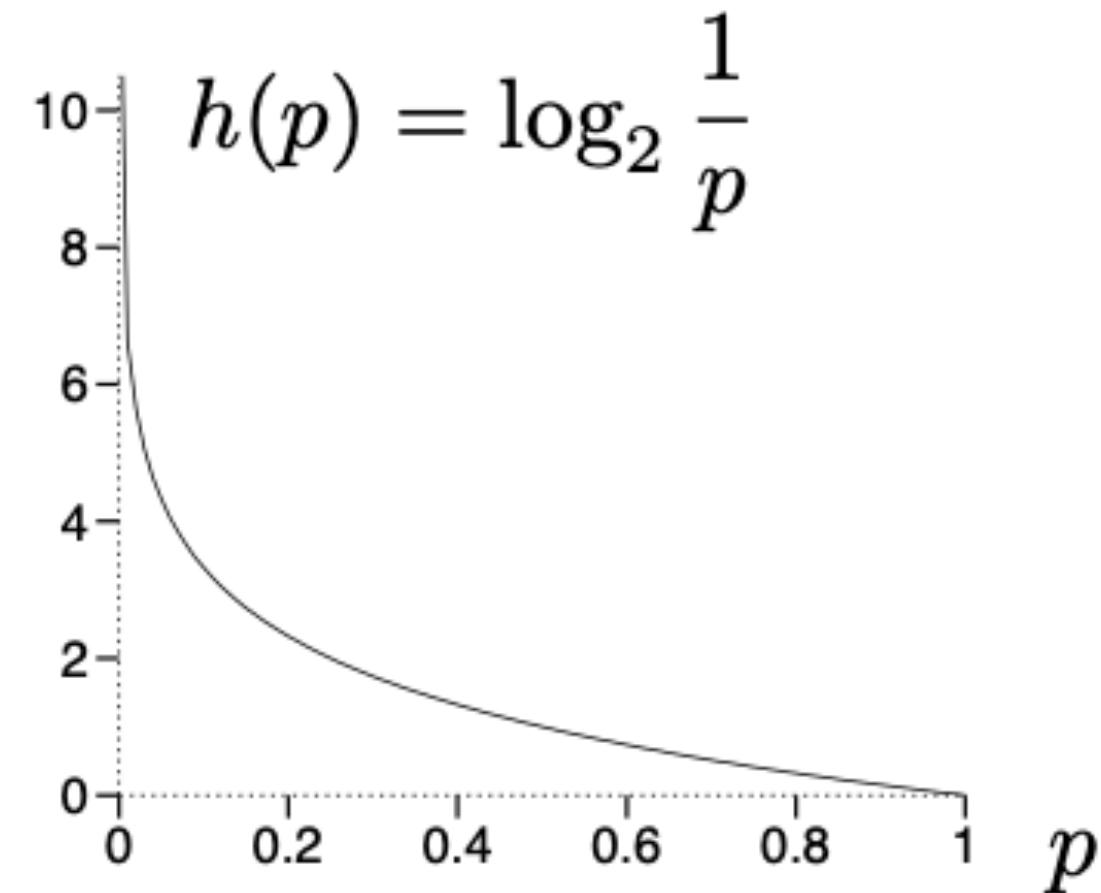
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- 5: is $x \bmod 4 \geq 2?$
- 6: is $x \bmod 2 = 1?$



informative questions

information content of a single outcome

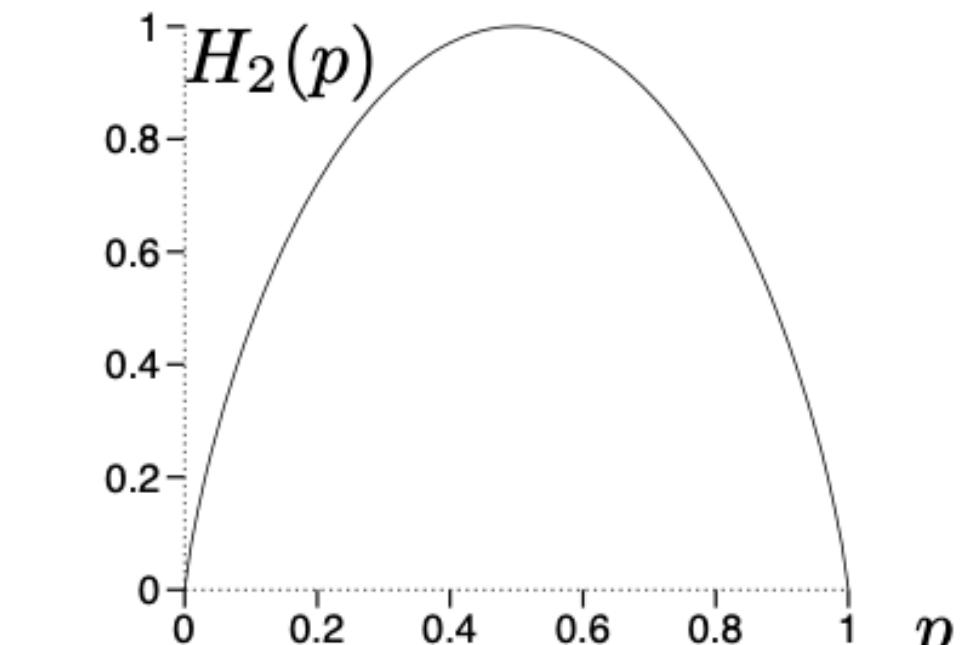
$$h(x = a_i) \equiv \log_2 \frac{1}{p_i}$$



average information content of a distribution

$$H(X) = \sum_i p_i \log_2 \frac{1}{p_i}$$

$$H_2(p) = H(p, 1-p) = p \log_2 \frac{1}{p} + (1-p) \log_2 \frac{1}{(1-p)}$$



$$h(x, y) = h(x) + h(y),$$

if x and y are independent.

$$H(X, Y) = H(X) + H(Y).$$

average information content of the answer to a binary question where probability of 'yes' is p

MacKay, 2003 (Chapter 4)

informative questions

- I have thought of a number between 0 and 63
 - at least how many yes/no questions do you need to ask to determine which one?
 - what are the questions?
- **what is the information content of a single question?**

$$h(x=a_i) \equiv \log_2 \frac{1}{p_i}$$

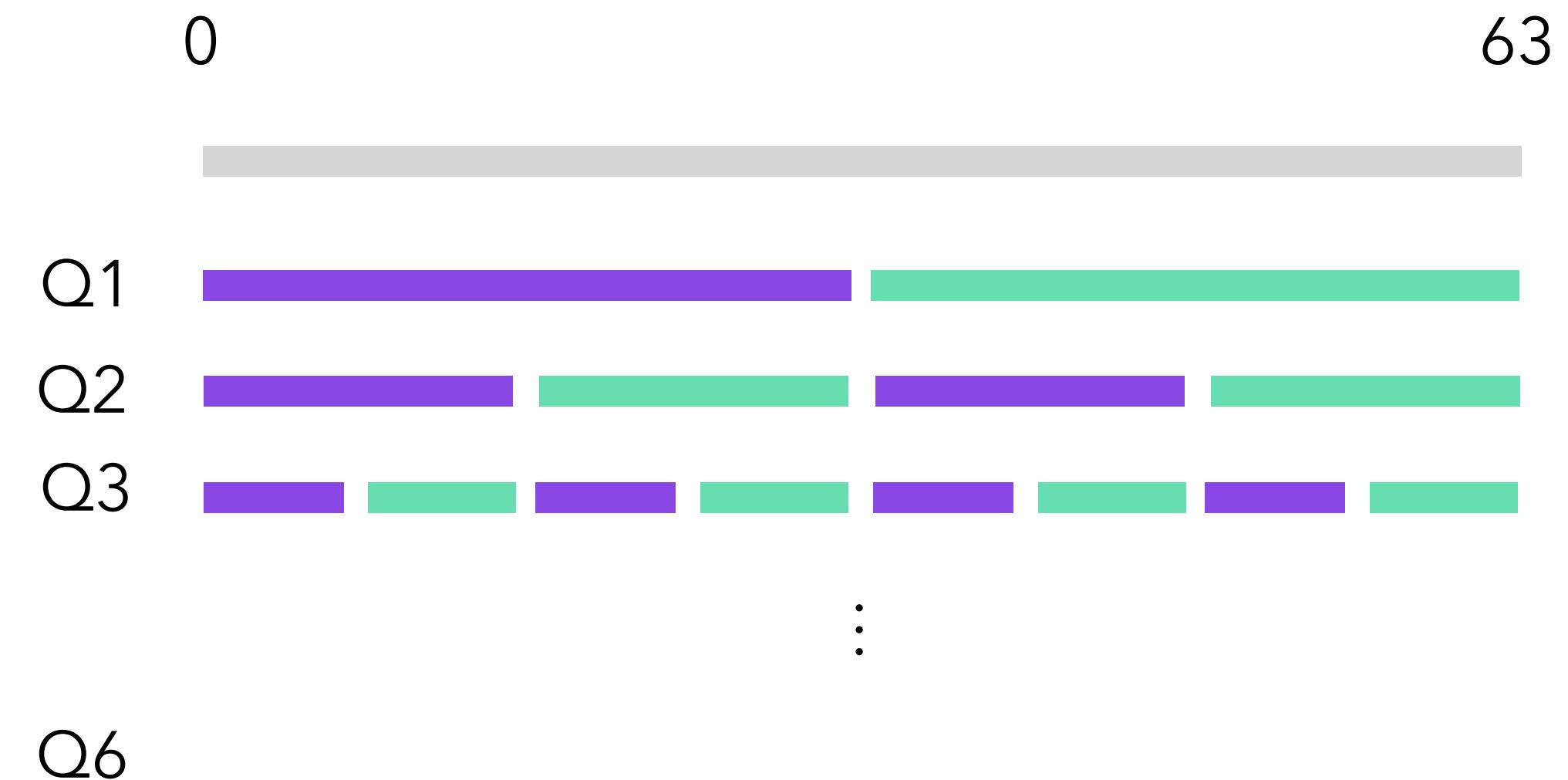
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informative questions

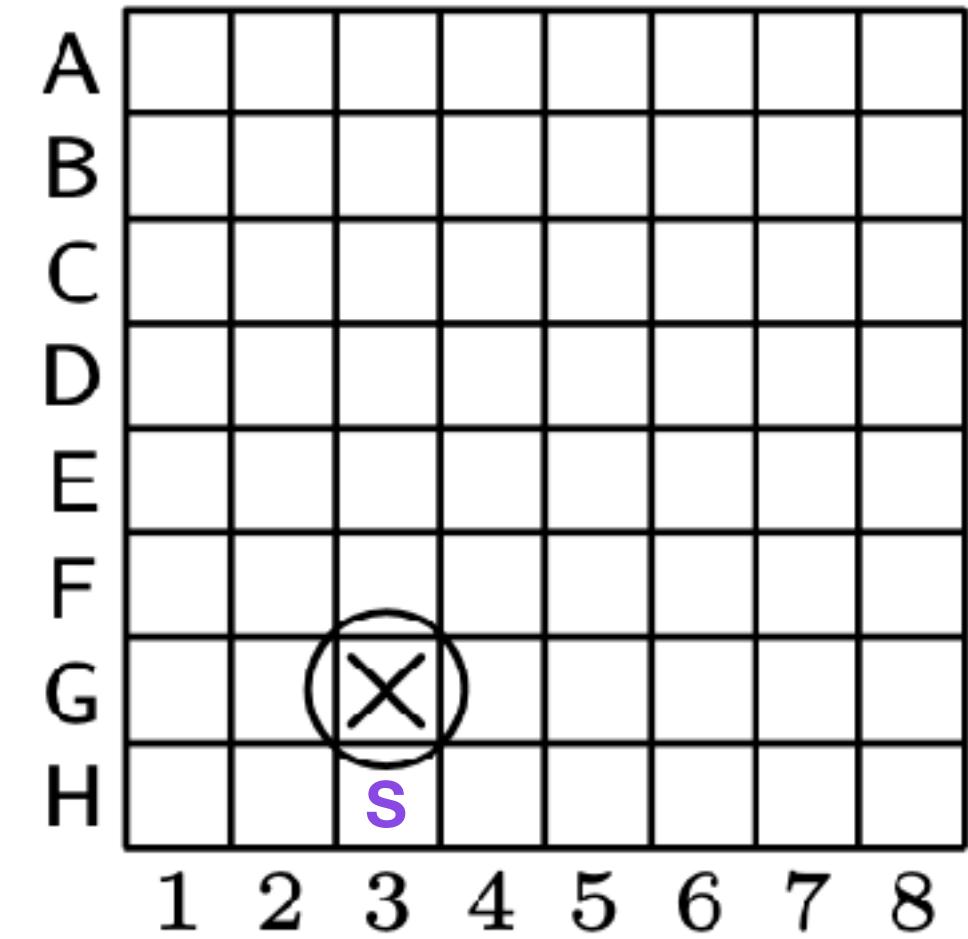
- I have thought of a number between 0 and 63
 - at least how many yes/no questions do you need to ask to determine which one?
 - what are the questions?
- what is the information content of a single question?
- **how could we create an optimal binary code for the numbers in many iterations of this game? how long would the code have to be?**
 - information content 6 bits → 6 bit compressed file

- 1: is $x \geq 32?$ **y/n**
- 2: is $x \bmod 32 \geq 16?$
- 3: is $x \bmod 16 \geq 8?$
- 4: is $x \bmod 8 \geq 4?$
- 5: is $x \bmod 4 \geq 2?$
- 6: is $x \bmod 2 = 1?$



informative questions

- what is the **information content** of
 - missing the first shot?
 - hitting the submarine in a single shot?
 - missing the first two shots?
 - missing 32 times?



hint:

$$h(x=a_i) \equiv \log_2 \frac{1}{p_i}$$

informative questions

- what is the **information content** of
 - missing the first shot?
 - hitting the submarine in a single shot?
 - missing the first two shots?
 - missing 32 times?

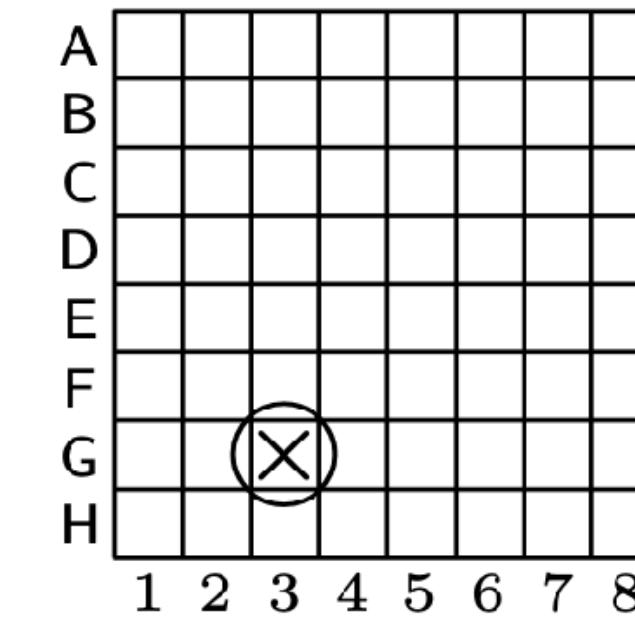
first shot

$$P_{1st}(yes) = 1/64 \longrightarrow h_{1st}(y) = -\log(1/64) = \log(2^6) = 6$$

$$P(no)_{1st} = 63/64 \longrightarrow h_{1st}(n) = -\log(63/64) = \log(64/63) = 0.0227 \text{ bit}$$

second
shot

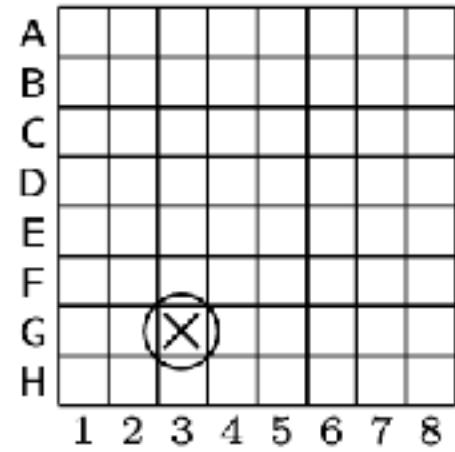
$$P(no)_{2nd} = 62/63 \longrightarrow h_{1st}(n) = -\log(62/63) = \log(63/62) = 0.023 \text{ bit}$$



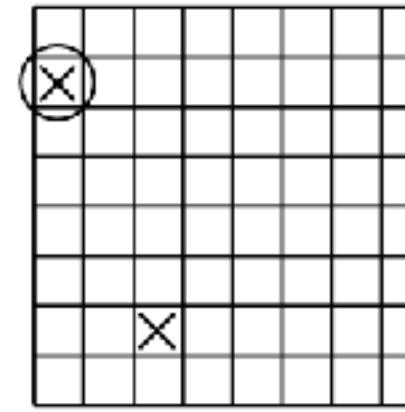
$$h(x=a_i) \equiv \log_2 \frac{1}{p_i}$$

informative questions

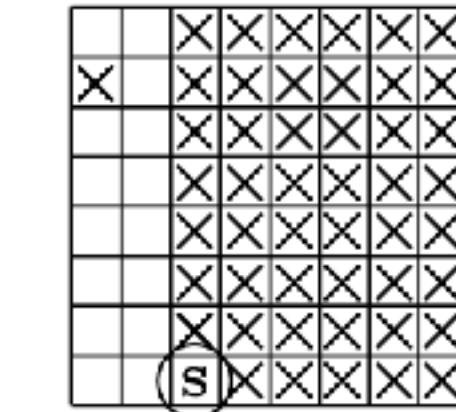
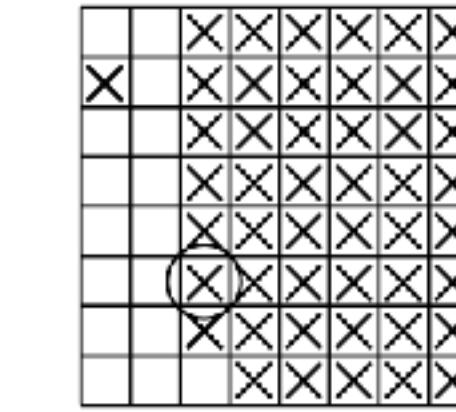
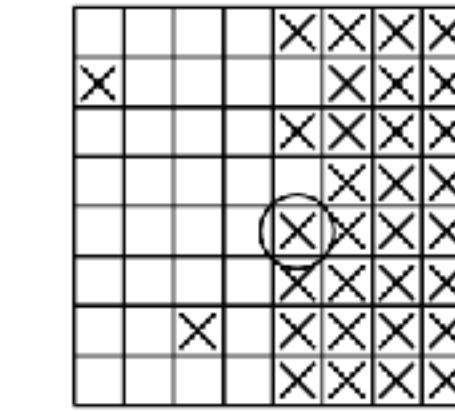
missing
the first
shot?



missing
the second
shot?



missing 32
times?



move #	1	2	32	48	49
question	G3	B1	E5	F3	H3
outcome	$x = \mathbf{n}$	$x = \mathbf{n}$	$x = \mathbf{n}$	$x = \mathbf{n}$	$x = \mathbf{y}$
$P(x)$	$\frac{63}{64}$	$\frac{62}{63}$	$\frac{32}{33}$	$\frac{16}{17}$	$\frac{1}{16}$
$h(x)$	0.0227	0.0230	0.0443	0.0874	4.0
Total info.	0.0227	0.0458	1.0	2.0	6.0

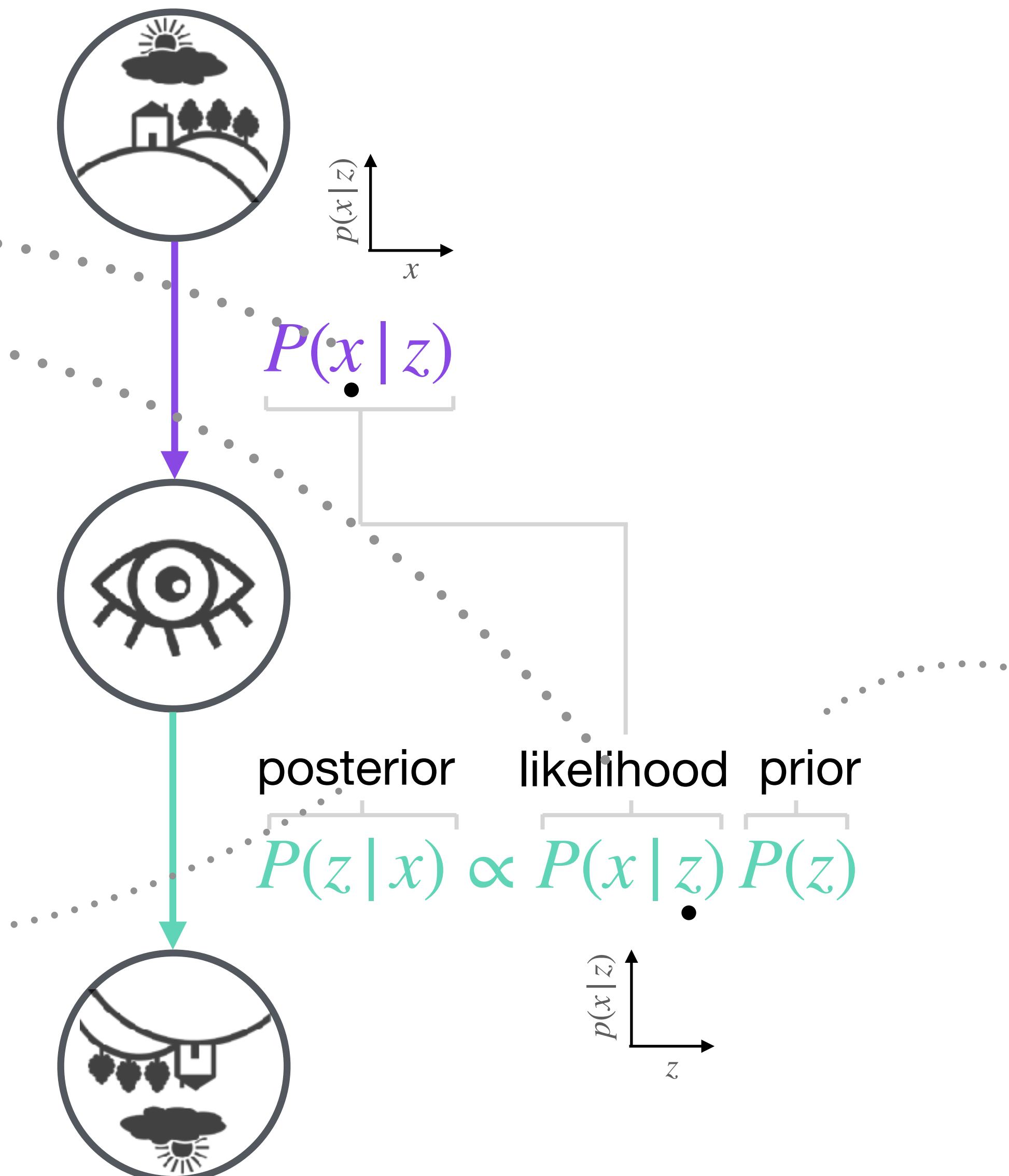
perception as inference

perception as inference



perception as inference

- if the environment was in state z , what would I observe (x)?



- if I observe x , what state z is the environment in?

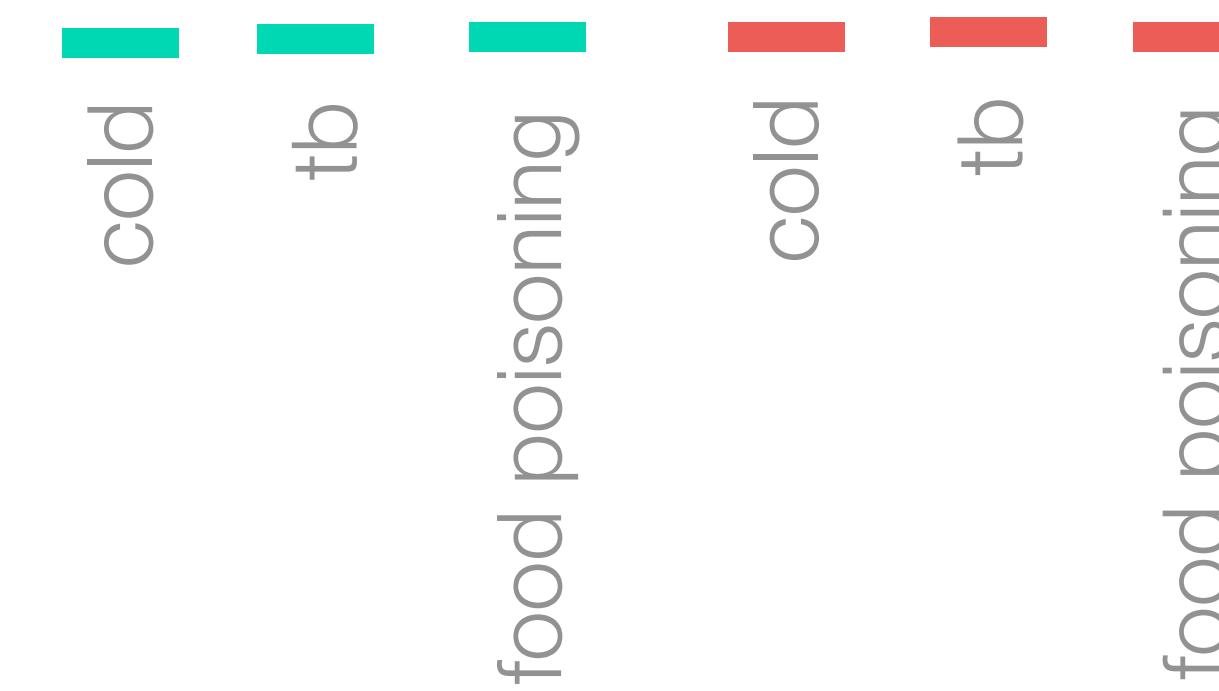
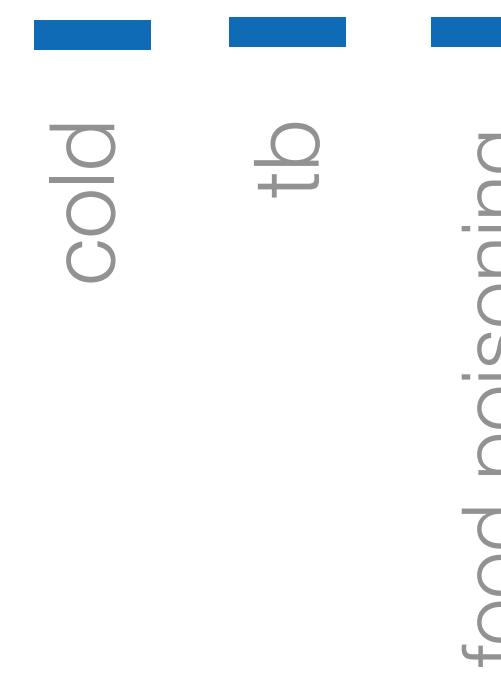
- how often is the environment in state z ?

perception as inference

- there are three possible illnesses:
cold, tb and food poisoning
- I observe that I'm coughing
- I want to infer why am I coughing
- how would you cast this as a
Bayesian inference problem?

perception as inference

- for any given person, the probability that they have a cold is 30%, tb is 5%, food poisoning is 15%
- if a person has cold or tb they are coughing in 80% of cases, if they have food poisoning, then in 10% of cases (for some independent reason)



$$P(\text{illness}|\text{symptom}) \propto P(\text{symptom}|\text{illness})P(\text{illness})$$

perception as inference

- what question does the prior ask and what are the probabilities?

$$P(\text{illness}|\text{symptom}) \propto P(\text{symptom}|\text{illness})P(\text{illness})$$

how common is

cold
tb
food poisoning

cold
tb
?

food poisoning

perception as inference

$$P(\text{illness}|\text{symptom}) \propto P(\text{symptom}|\text{illness})P(\text{illness})$$

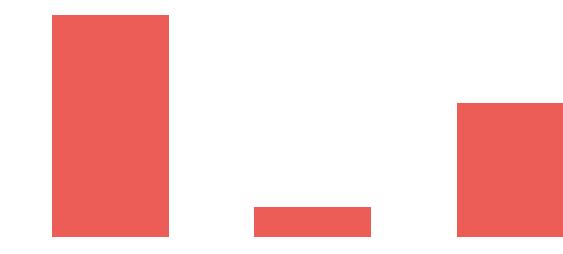
how common is

food poisoning

cold

tb

?



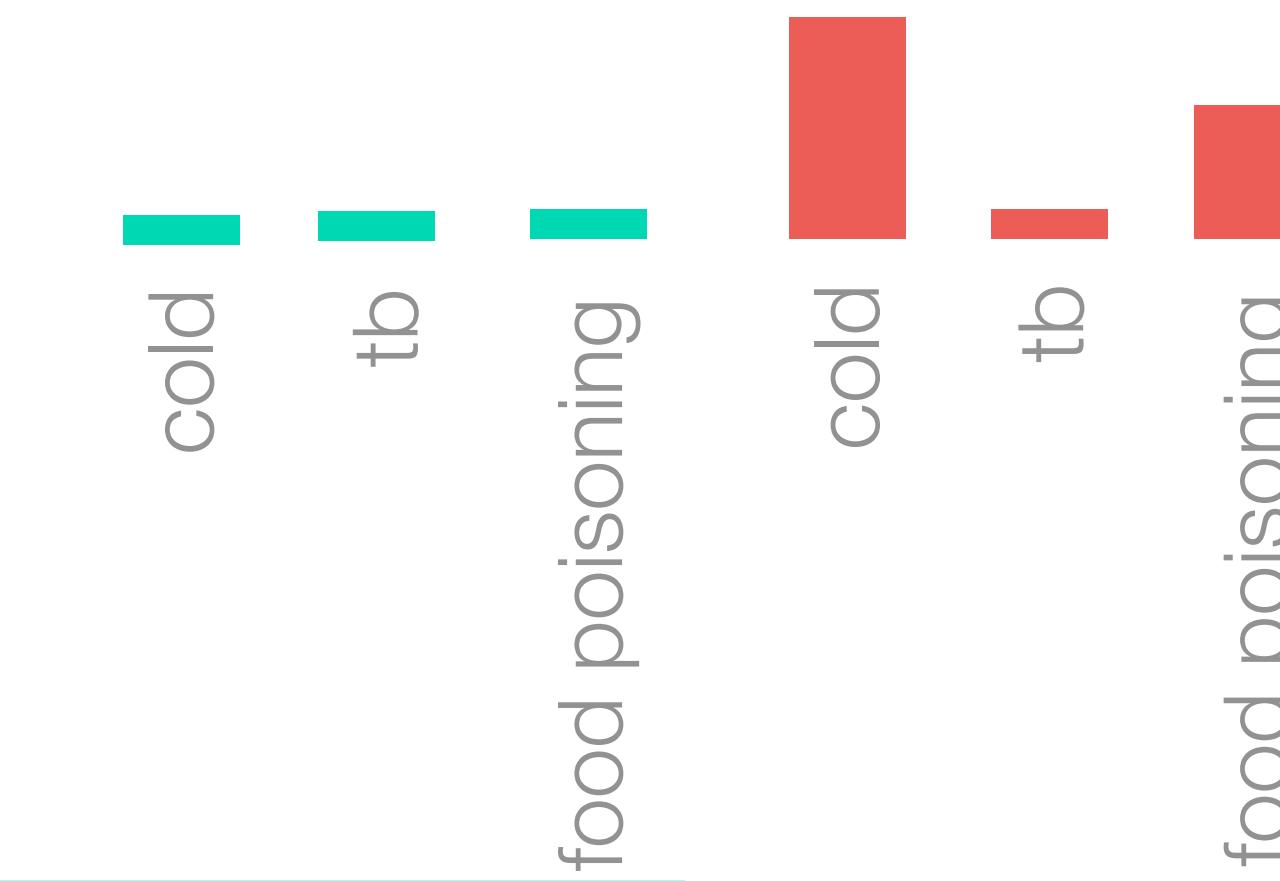
cold
tb
food poisoning

perception as inference

- what question does the likelihood ask and what are the likelihoods?

$$P(\text{illness}|\text{symptom}) \propto P(\text{symptom}|\text{illness})P(\text{illness})$$

cold
tb how likely is it that I would be coughing?
food poisoning



perception as inference

$$P(\text{illness}|\text{symptom}) \propto P(\text{symptom}|\text{illness})P(\text{illness})$$

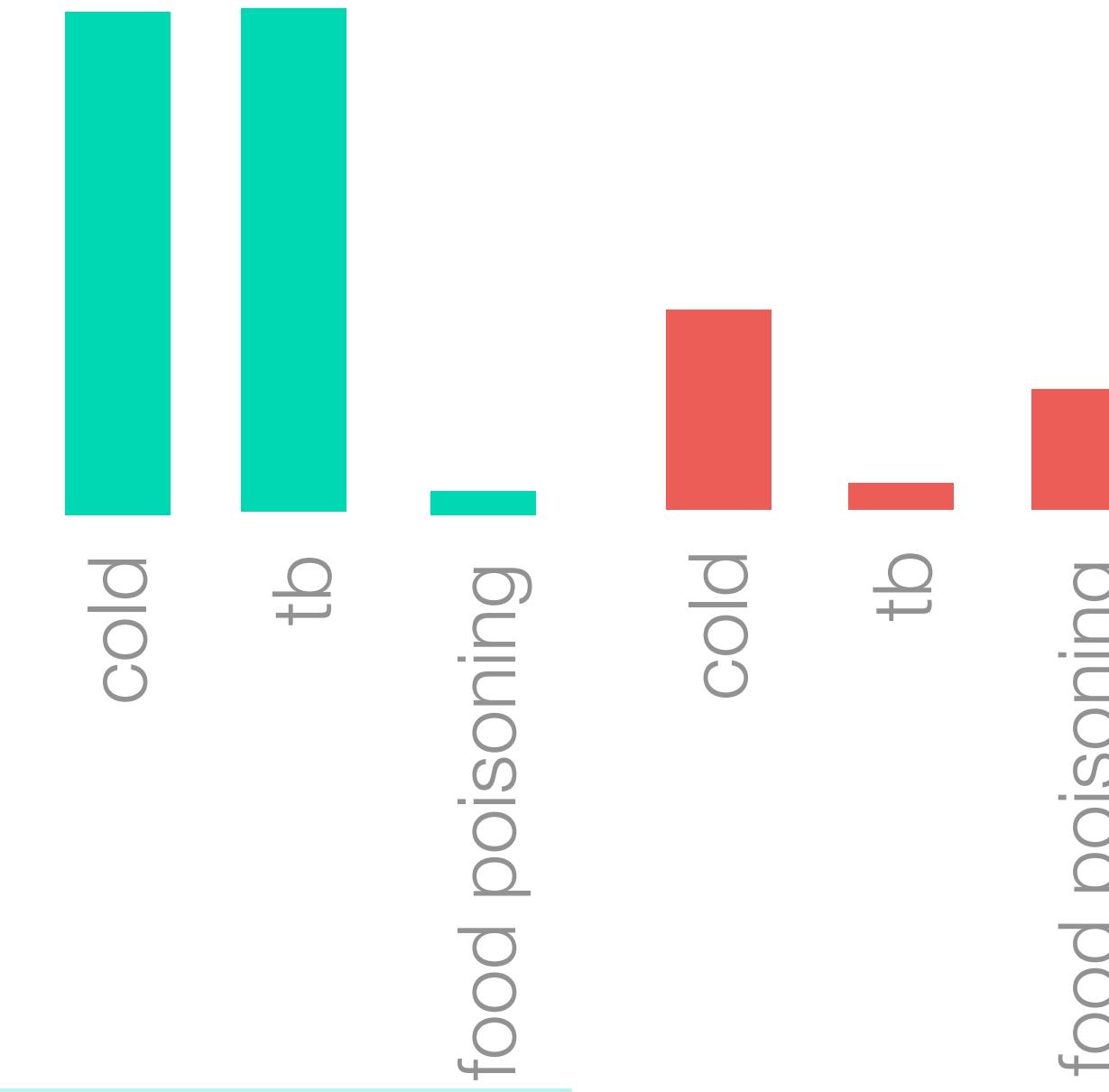
if I had

cold

tb

how likely is it that I would be coughing?

food poisoning

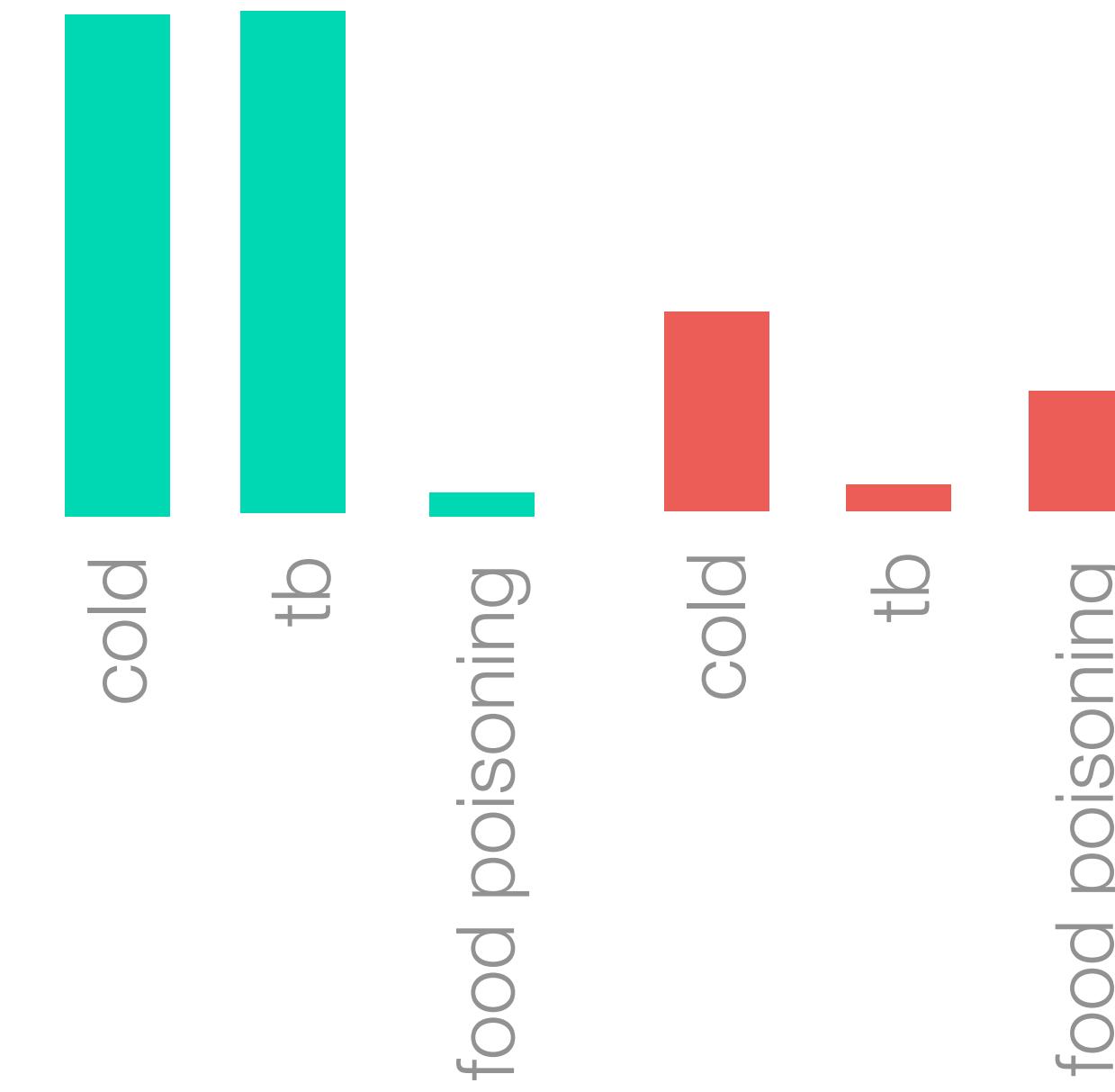


perception as inference

- what question does the posterior ask and what are the probabilities?

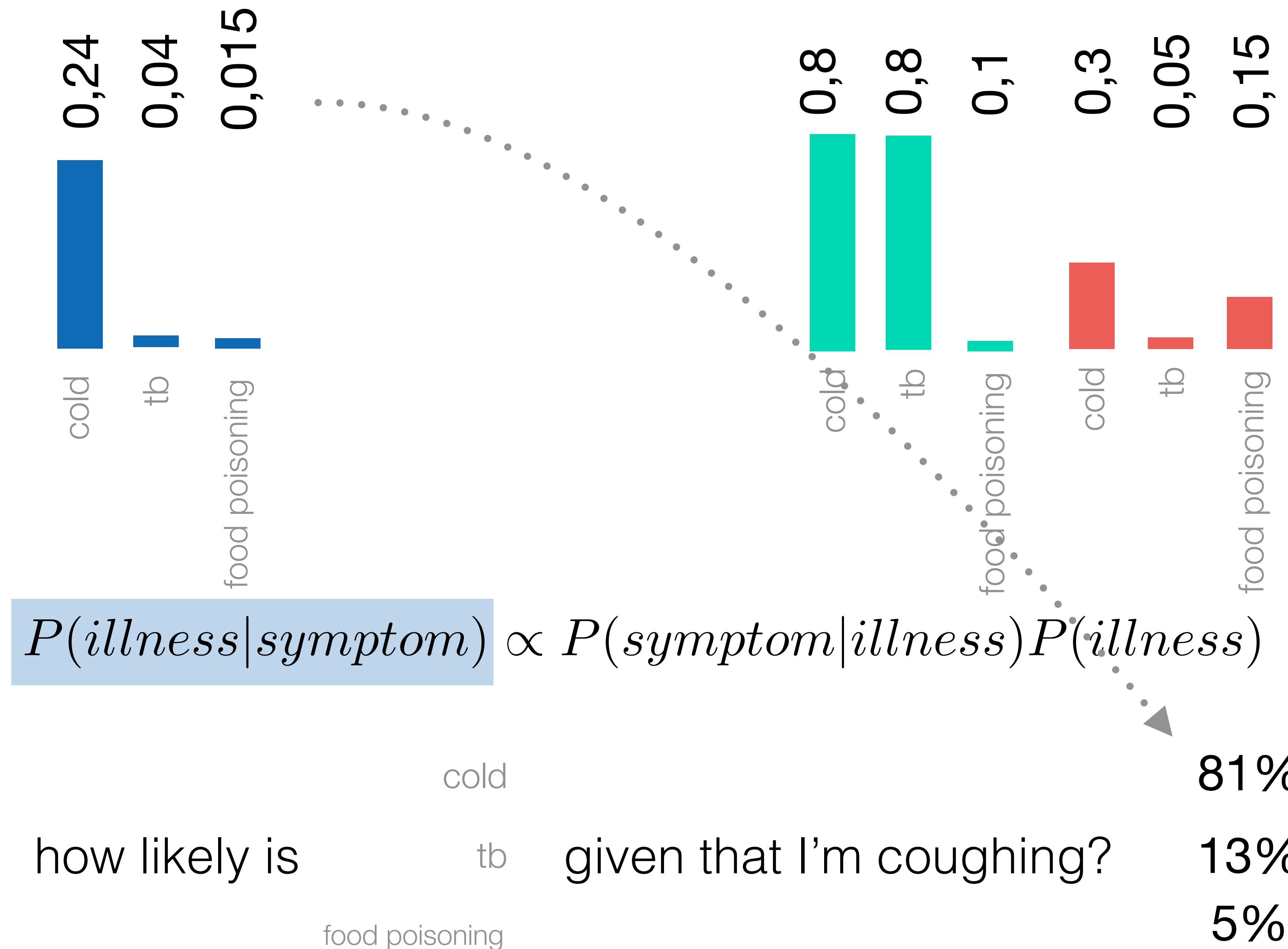


$$P(\text{illness}|\text{symptom}) \propto P(\text{symptom}|\text{illness})P(\text{illness})$$



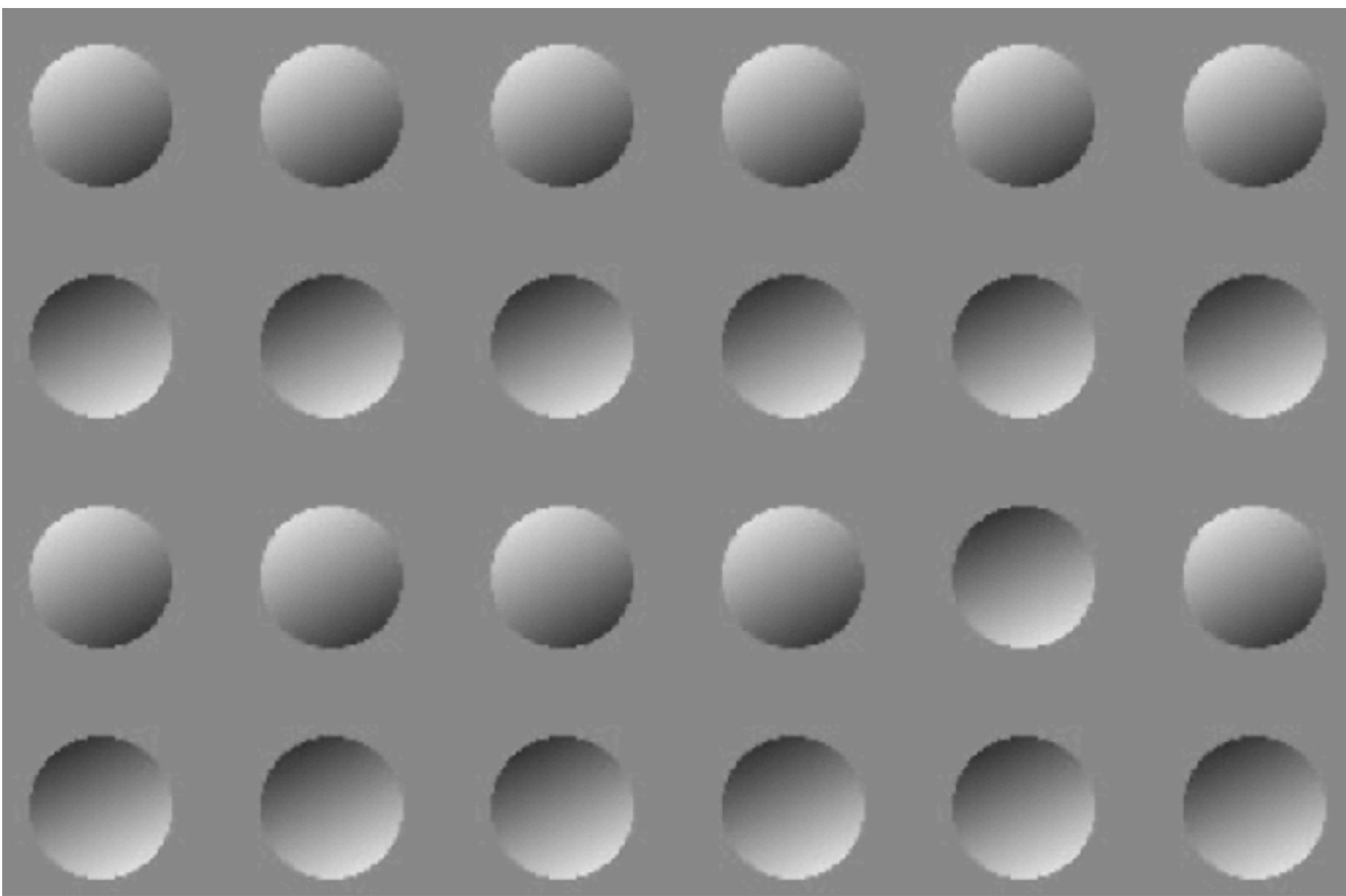
how likely is tb given that I'm coughing?
cold
food poisoning

perception as inference



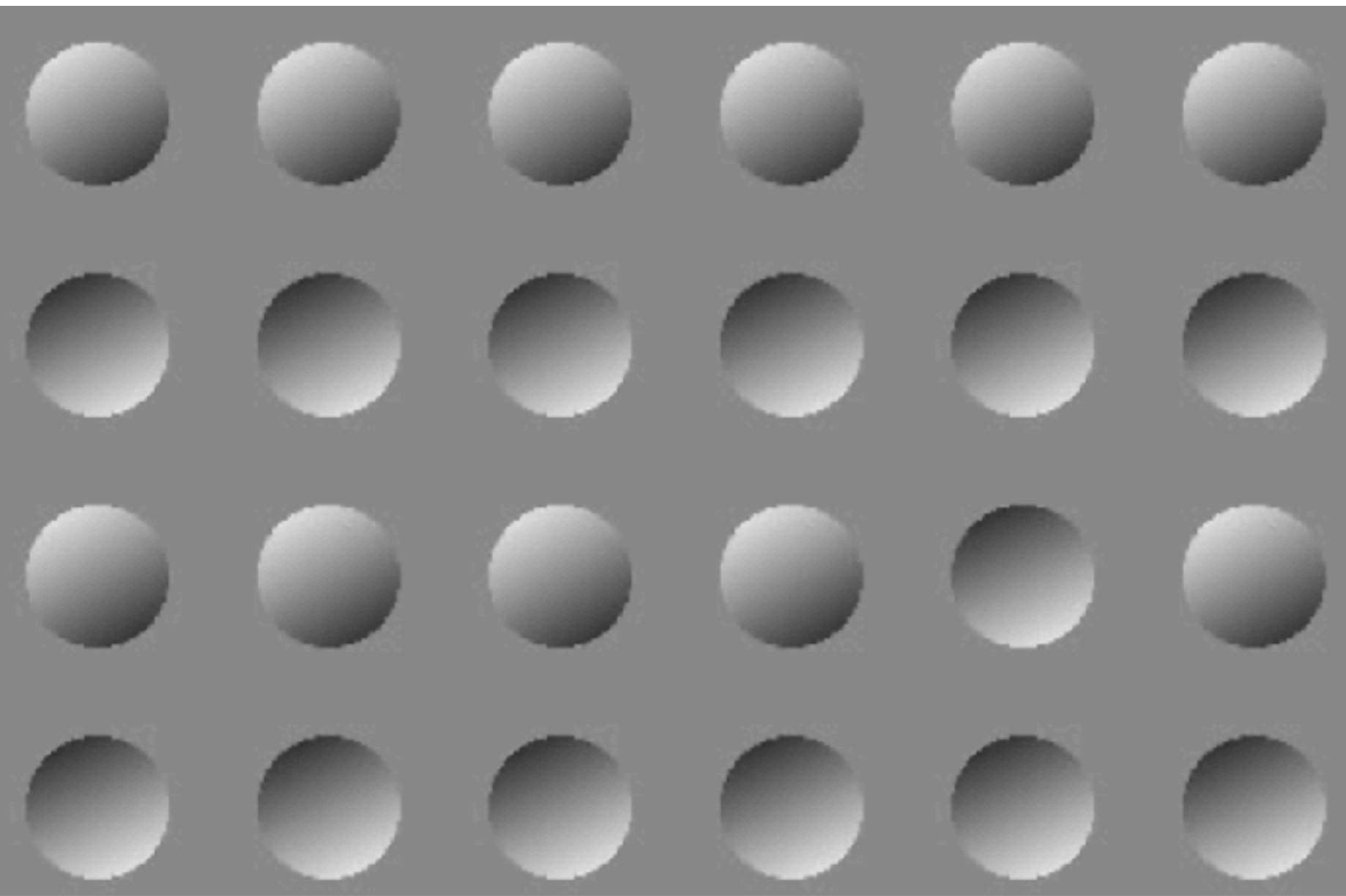
perception as inference

bump or dent? ➔



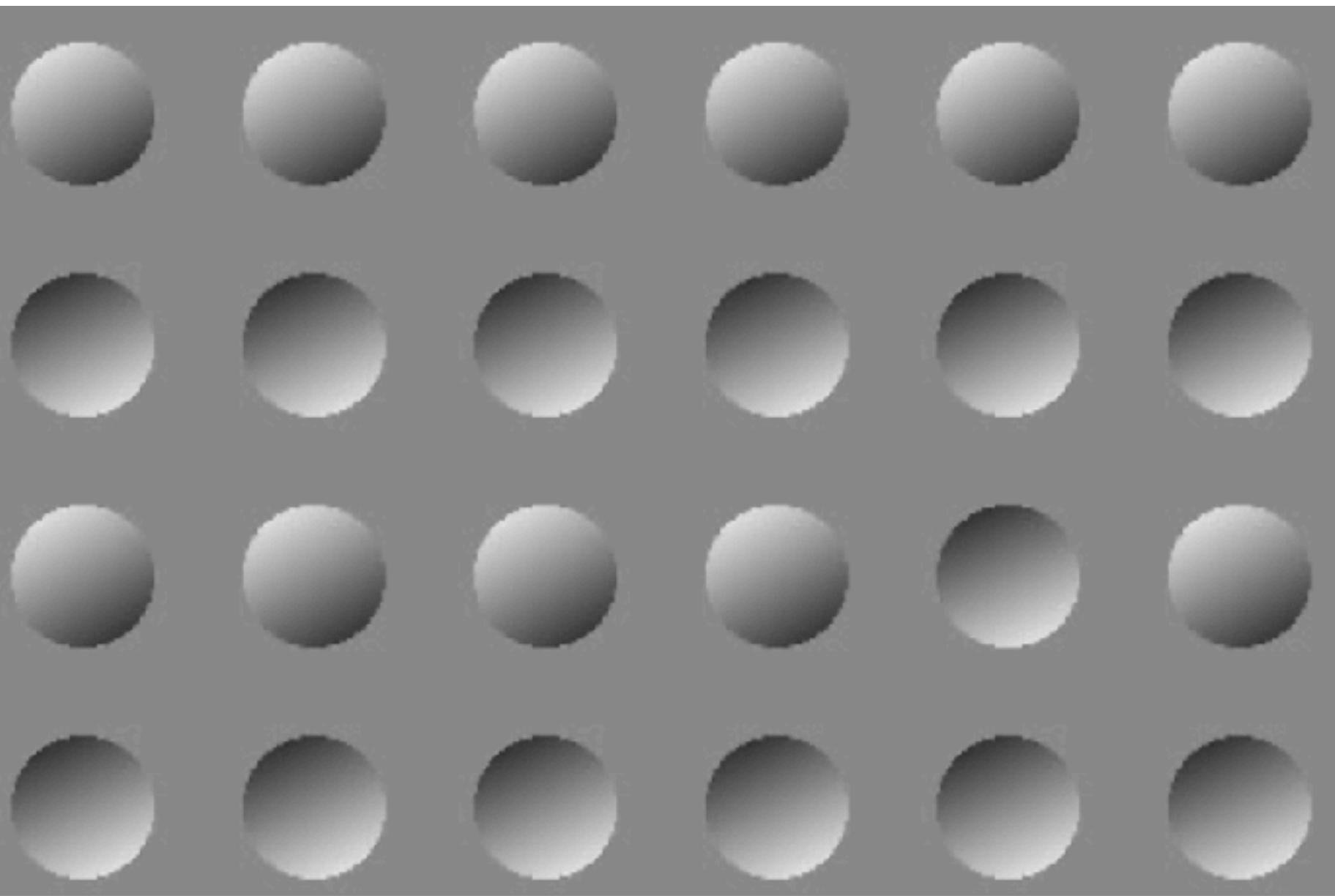
perception as inference

bump or dent? →

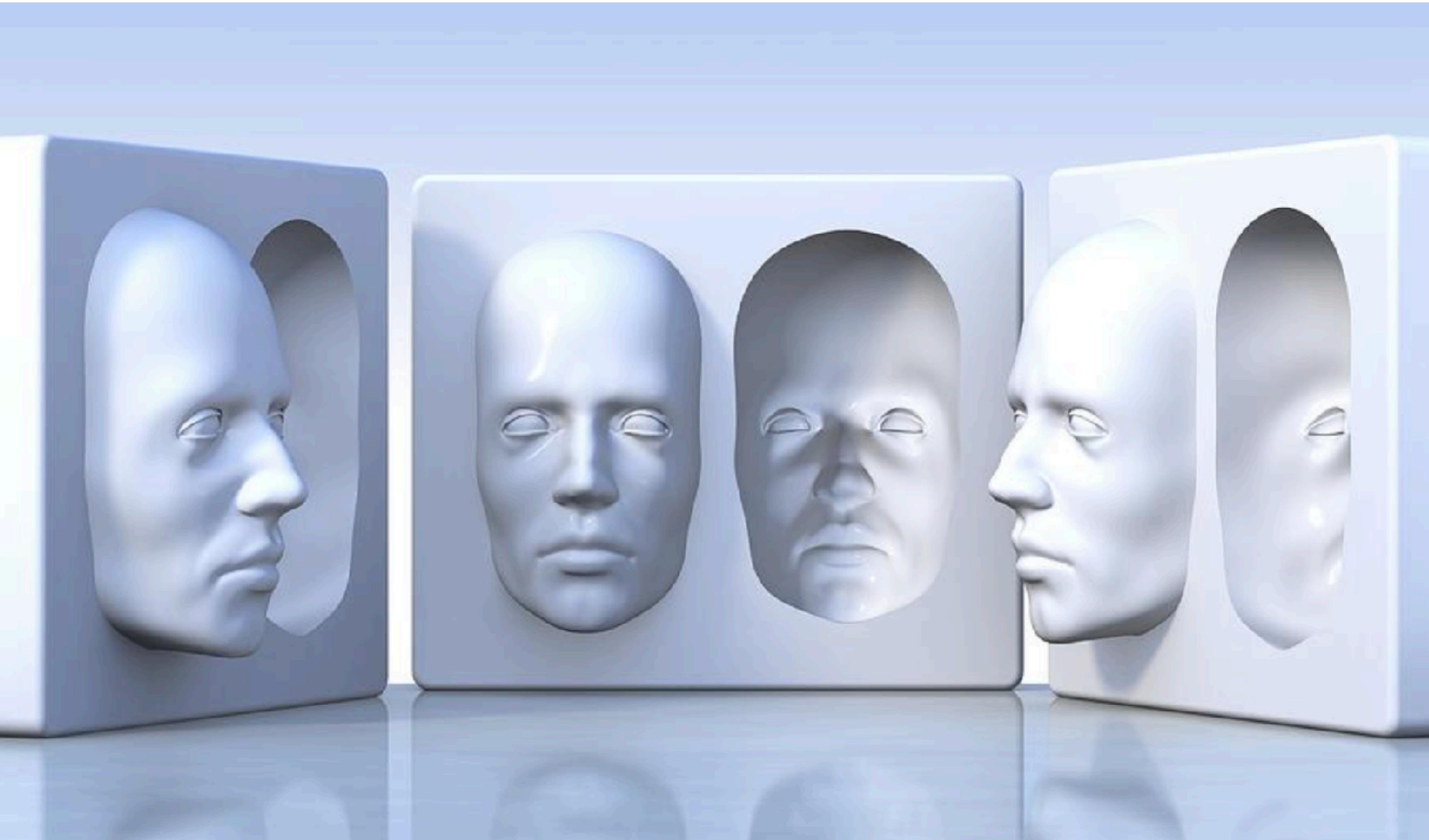


perception as inference

- what is the target of the inference?
- what interpretations is the observation consistent with?
- why does the brain choose the one we perceive?



perception as inference



<https://michaelbach.de/ot/fcs-hollowFace/index.html>

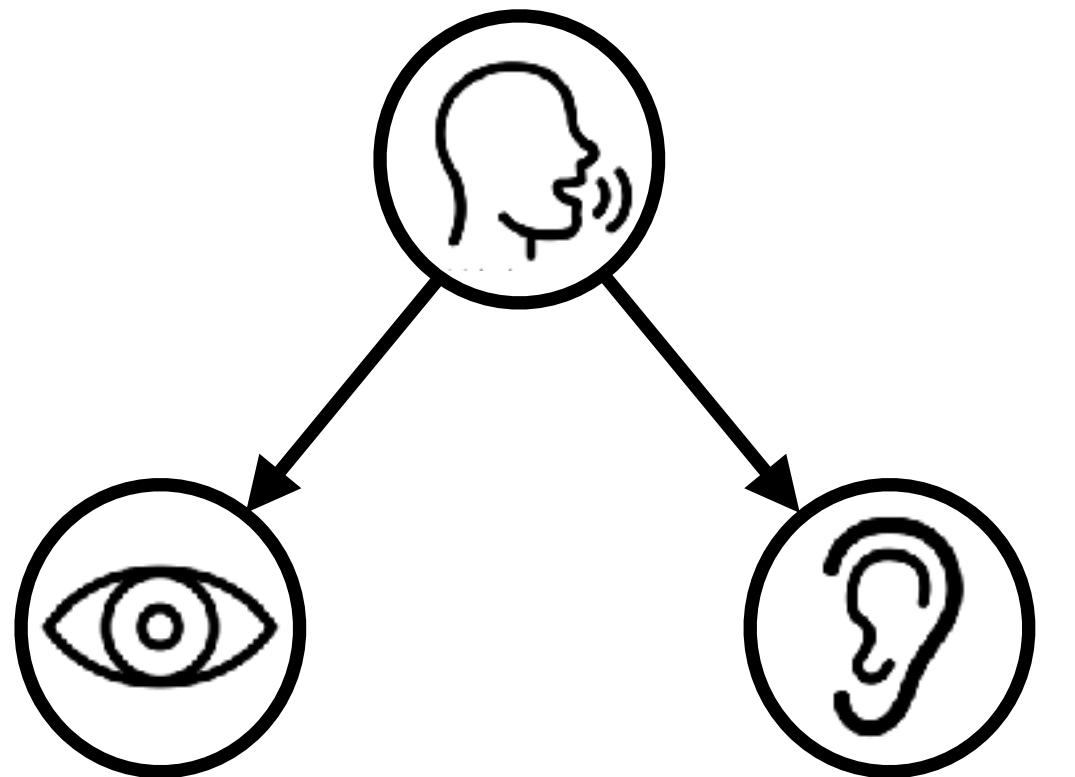
perception as inference

- what is the target of the inference?
- what interpretations is the observation consistent with?
- why does the brain choose the one we perceive?



perception as inference

where is the sound coming from?



seems
like
coming
from
puppet

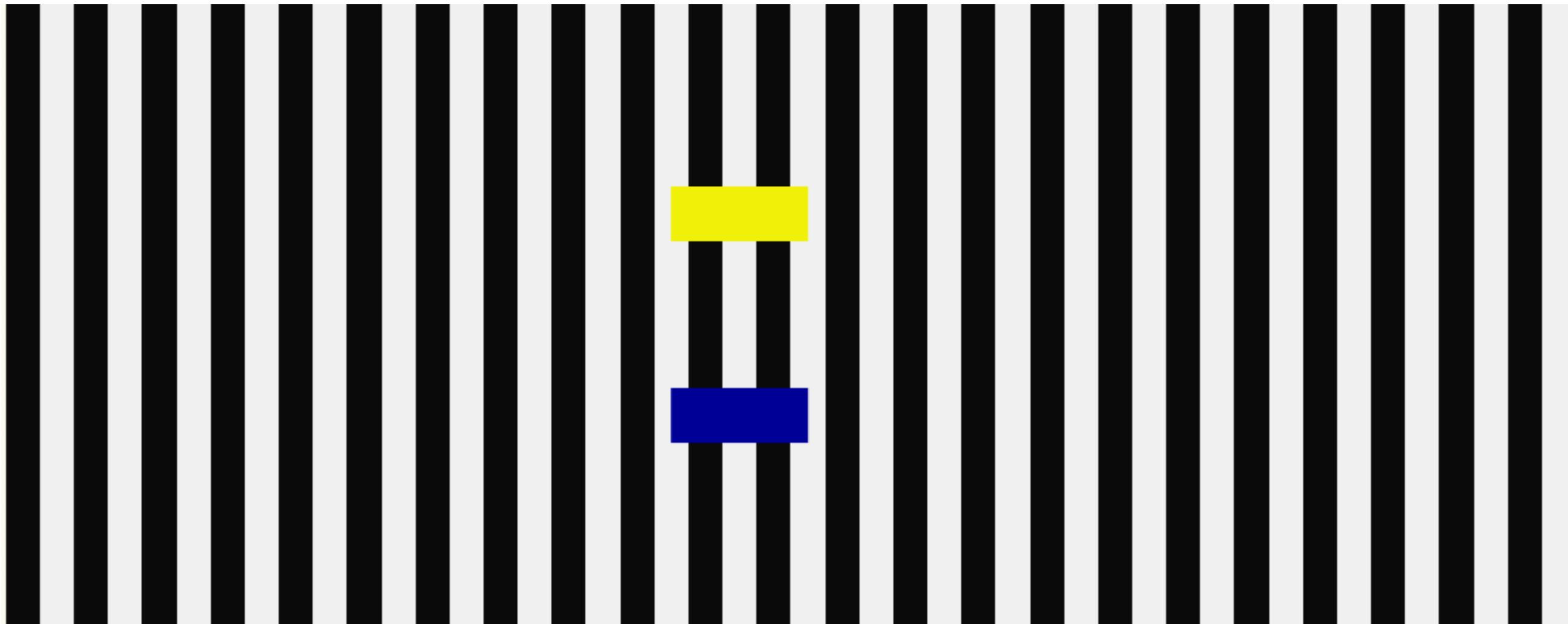
sounds
like
coming
from
human



+ visual measurement of location is
more accurate than auditory

perception as inference

- what is the target of the inference?
- what interpretations is the observation consistent with?
- why does the brain choose the one we perceive?



<https://michaelbach.de/ot/mot-feetLin/>

perception as inference

<https://michaelbach.de/ot/fcs-ghostlyGaze/index.html>

perception as inference

