Cognitive Psychology

Philipp Koehn

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two systems

System 1

- How does this woman feel

System 1

- How does this woman feel

- Intuitive, fast, non-conscious, automatic

System 2

- Compute:

$$13 \times 27$$

System 2

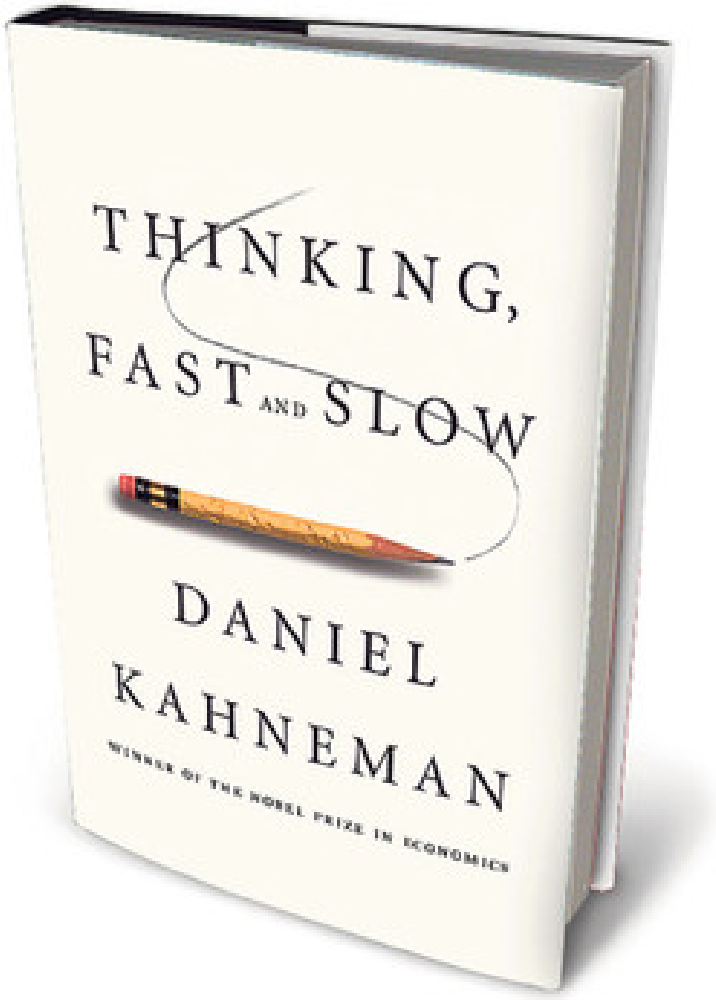
- Compute:

$$13 \times 27$$

- Reflection, slow, conscious, controlled

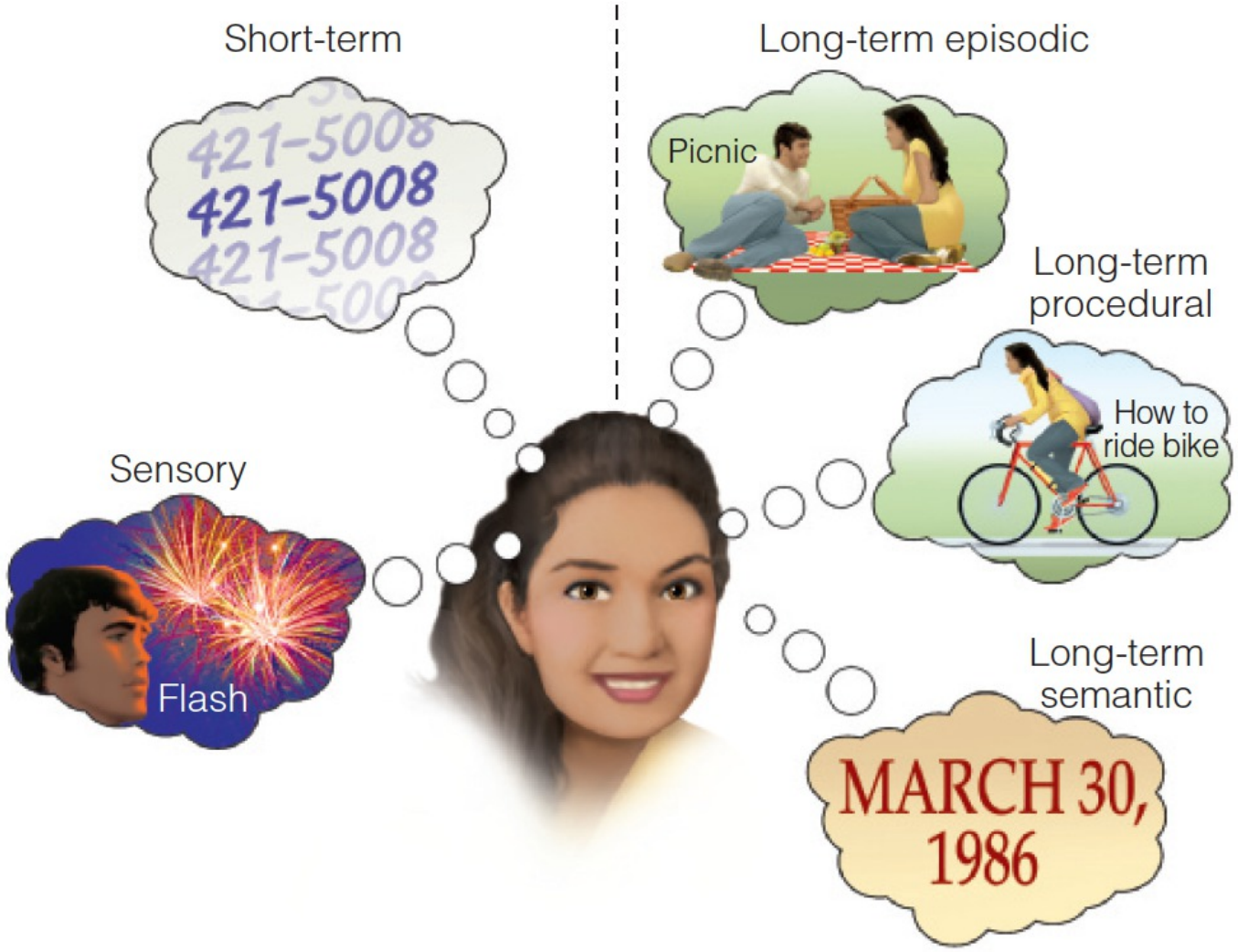
Cognition

- Human mind uses both System 1 and 2
- They interact
- They are occasionally in conflict



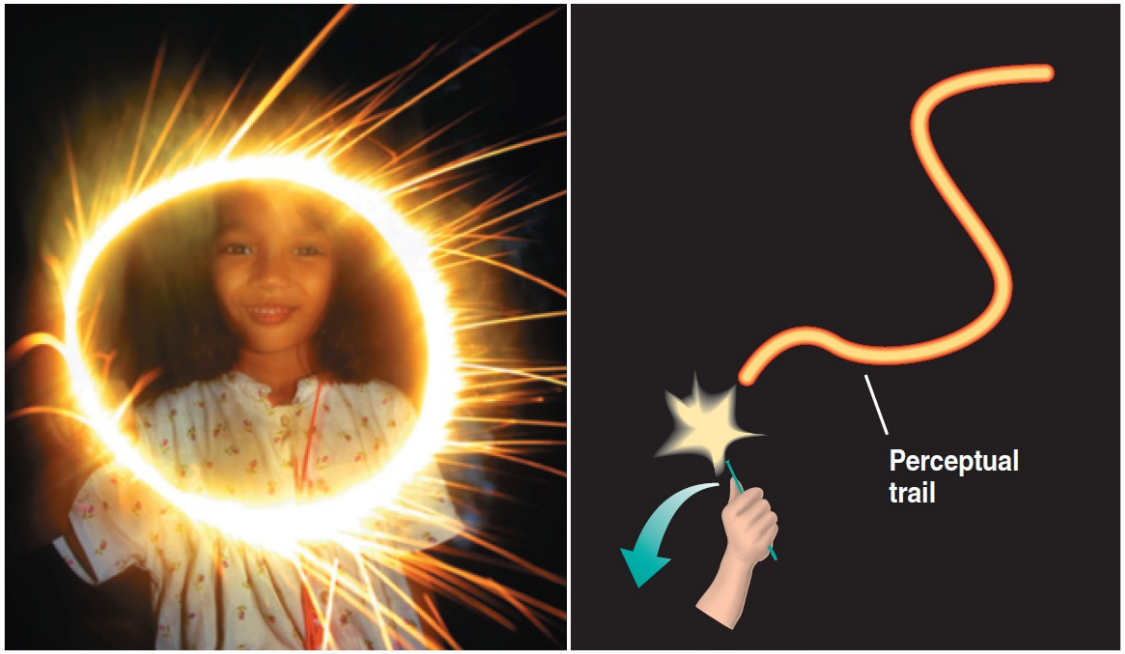
memory

Memory


Short-term
421-5008
421-5008
421-5008
Long-term episodic
Picnic
Long-term
procedural
How to
ride bike
Sensory
Flash
Long-term
semantic
MARCH 30,
1986

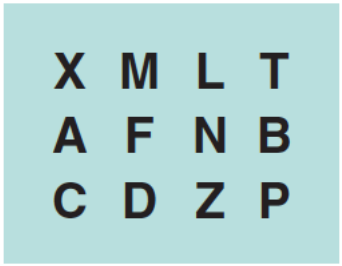
sensory memory

Sensory Memory



- Retention of effects of sensory stimulation
- Persistence of vision: continued perception image after shown
- Lasts only fractions of second

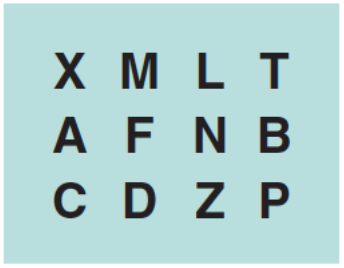
Capacity and Duration of Sensory Memory



- display 12 letters for 50ms
- ask to recall letters

$\rightarrow$ on average 4.5/12 correct

Capacity and Duration of Sensory Memory



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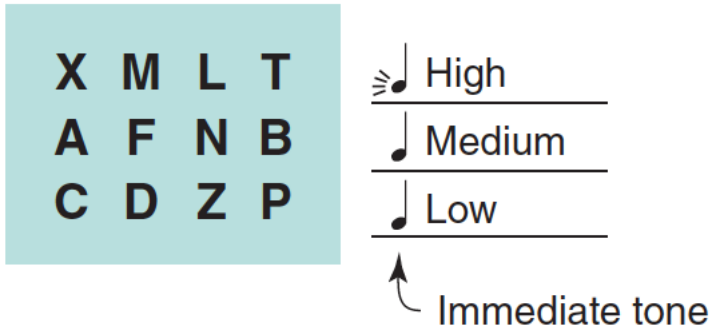
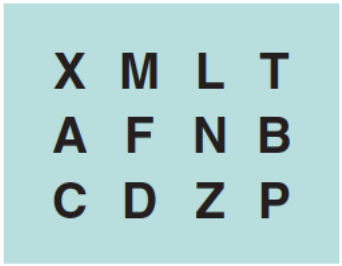


- display 12 letters for 50ms
- immediately followed by sound indicating row
- ask to recall letters in row

→ on average 3.3/4 correct

Capacity and Duration of Sensory Memory



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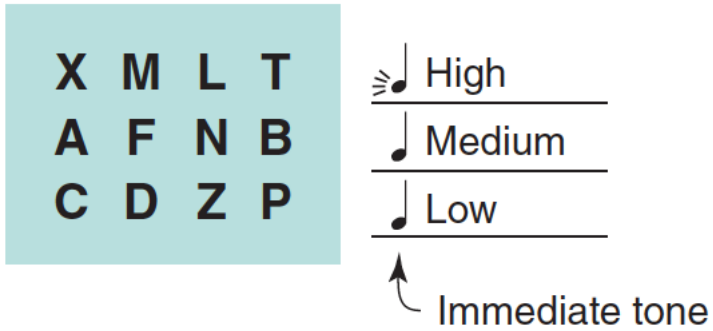
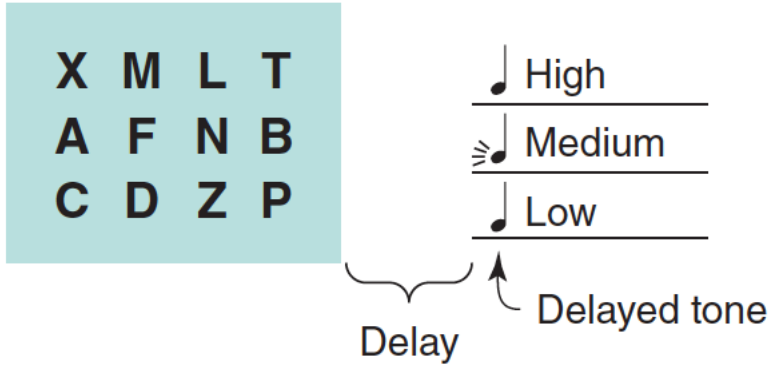


- display 12 letters for 50ms
- immediately followed by sound indicating row
- ask to recall letters in row

→ on average 3.3/4 correct



- display 12 letters for 50ms
- with delayed sound
- ask to recall letters in row

→ on average 1/4 correct

short term memory

Short Term Memory

- Storing a few items for brief time
- Small: maybe just 4 items
- Short time: 15-20 seconds

Size: Numbers

- Experiment
  - have a piece of paper ready
  - you will be shown a sequence of numbers
  - then, these will be hidden
  - write down the sequence

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- 3 9 6 7 8

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- 7 3 8 2 0 1 5

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- 6 4 9 7 8 4
- 7 3 8 2 0 1 5
- 8 4 2 6 4 1 3 2

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- 3 9 6 7 8
- 6 4 9 7 8 4
- 7 3 8 2 0 1 5
- 8 4 2 6 4 1 3 2
- 4 8 2 3 9 2 8 0 7

Size: Numbers

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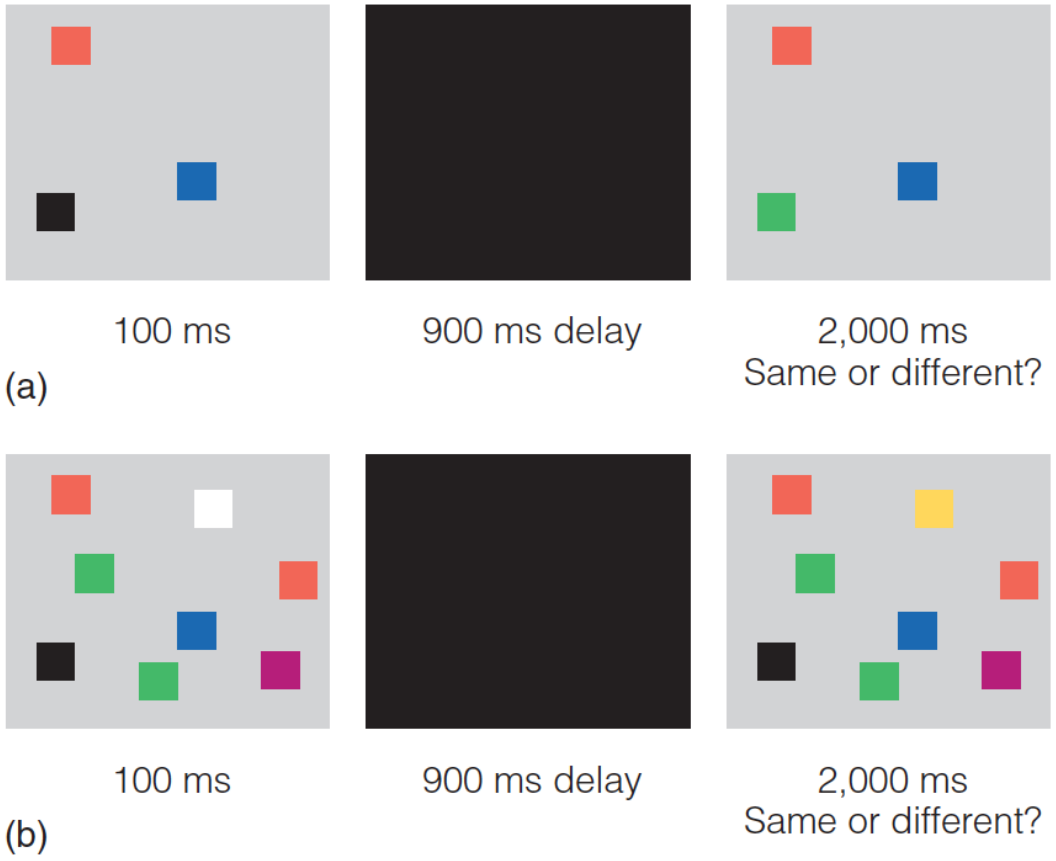
  - write down the sequence
- 2 1 4 9
- 3 9 6 7 8
- 6 4 9 7 8 4
- 7 3 8 2 0 1 5
- 8 4 2 6 4 1 3 2
- 4 8 2 3 9 2 8 0 7
- 5 8 5 2 9 8 4 6 3 7

Size: Shapes



- Asked to remember shapes
- Subjects can only remember up to 4

Size: Letters

- Remember a sequence of letters
- First experiment

B C I F C N C A S I B B

Size: Letters

- Remember a sequence of letters
- First experiment

B C I F C N C A S I B B

- Second experiment

C I A F B I N B C C B S

- Second example much easier
  - exactly same letters
  - but: CIA, FBI, NBC, CBS are known acronyms

Chunking

- Short term memory only holds few items
- Items can be more complex chunks
- Grouping elementary items into larger meaning chunks

  $\rightarrow$ more elementary items (e.g., letters) can be remembered

Working Memory

- Multiply 43×6

Working Memory

- Multiply 43×6

- One way to solve this problem
  - visualize 43×6
  - multiply 3×6 = 18
  - hold 18 in memory
  - multiply 6×4 = 24
  - mentally transform this to 6×40 = 240
  - remember the 18
  - add 240+18=258

- In memory
  - holding information (18)
  - processing information (the calculations)

- Short term memory = working memory

Components of Working Memory

- Phonological loop
  stores verbal and auditory information

- Visuospatial sketch pad
  contains visual and spatial information

- Central executive
  contains information currently being processed

- Each component can contain information independent of the others

long term memory

Long Term Memory

- What do you remember about today?
  - when did you get up?
  - what did you have for breakfast?
  - what other classes did you have?
  - who did you talk to?
  - where have you been so far?
  - what ”things to do” where on your mind this morning?

- Take some time to write these down

Long Term Memory

- What do you remember about **the day of the first lecture of this course**?
  - when did you get up?
  - what did you have for breakfast?
  - what other classes did you have?
  - who did you talk to?
  - where have you been so far?
  - what ”things to do” where on your mind this morning?

- Compare with you memories of today

Long Term Memory

- What do you remember about **your first day of taking classes at college**?
  - when did you get up?
  - what did you have for breakfast?
  - what other classes did you have?
  - who did you talk to?
  - where have you been so far?
  - what ”things to do” where on your mind this morning?

Long Term Memory

- What do you remember about **your first day of taking classes at college**?
  - when did you get up?
  - what did you have for breakfast?
  - what other classes did you have?
  - who did you talk to?
  - where have you been so far?
  - what ”things to do” where on your mind this morning?

- Do you remember more basic facts about that day
  - where did you live that day?
  - who were you best friends that time?
  - what was your general mood that day?

Experiment

There is an interesting story about the telescope. In Holland, a man named Lippershey was an eyeglass maker. One day his children were playing with some lenses. They discovered that things seemed very close if two lenses were held about a foot apart. Lippershey began experimenting, and his "spyglass" attracted much attention. He sent a letter about it to Galileo, the great Italian scientist. Galileo at once realized the importance of the discovery and set about building an instrument of his own.

Experiment

- Which of the following sentences was in the story:

1. *Galileo, the great Italian scientist, sent him a letter about it.*
2. *He sent a letter about it to Galileo, the great Italian scientist.*
3. *A letter about it was sent to Galileo, the great Italian scientist.*
4. *He sent Galileo, the great Italian scientist, a letter about it.*

Experiment

- Which of the following sentences was in the story:

  1. *Galileo, the great Italian scientist, sent him a letter about it.*
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  4. *He sent Galileo, the great Italian scientist, a letter about it.*

- Correct answer is 2, but some subject mis-identify 3 or 4.

- Semantic coding: literal words forgotten, but meaning is remembered.

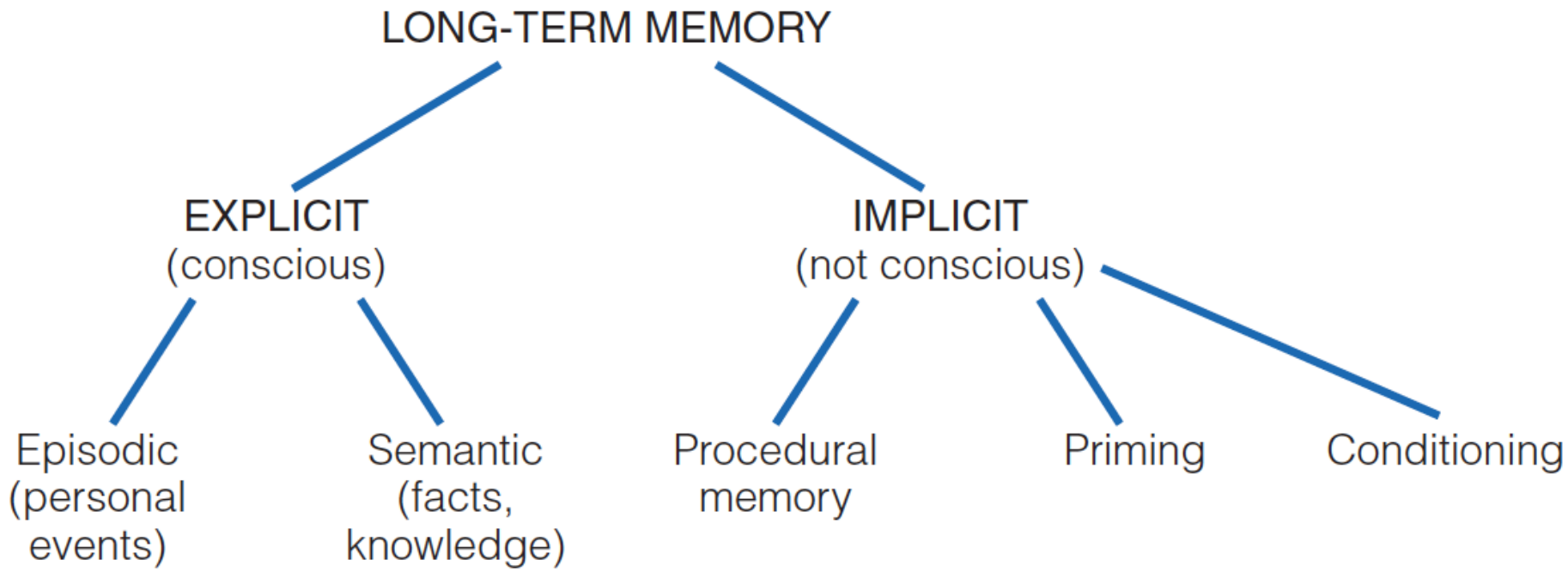
Episodic vs. Semantic Memory

- Episodic memory
  - mental time travel
  - remembering specific personal experiences
- Semantic memory
  - knowledge of facts
  - disconnected from the experience of learning them
- Interaction
  - autobiographical: both episodic and semantic components

    I went to the Levering cafeteria Thursday two weeks ago.

    The cafeteria is 5 minutes from my room and open for lunch.

Types of Long Term Memory

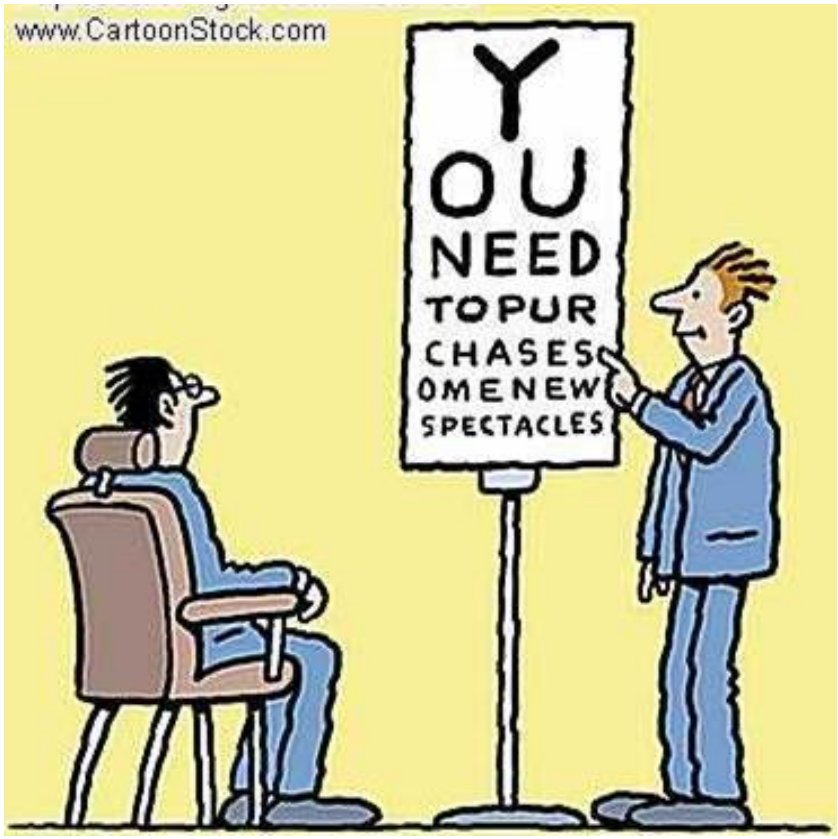


Procedural Memory

- Skill memory
  - tying your shoes
  - riding a bicycle
- Learned by practicing
- Hard to explain, but done effortless
- In fact, focusing on the task makes it harder

Priming

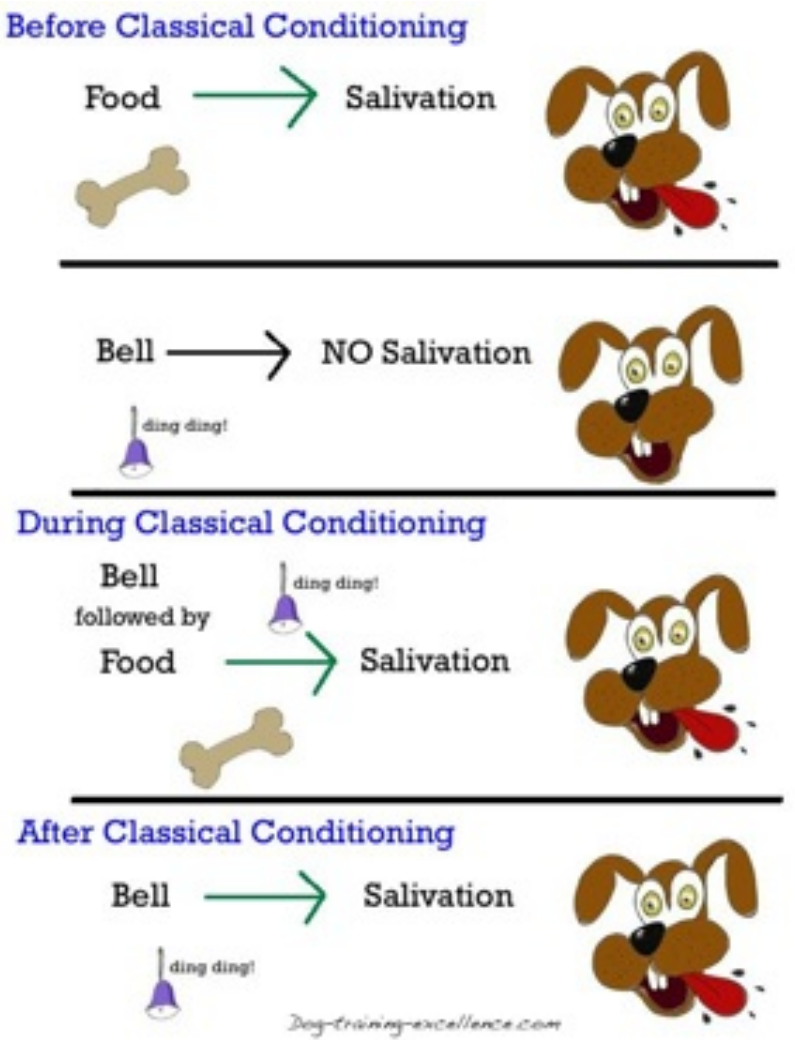
- Repetition priming
  - showing the word *bird*
  - later, quicker response to word *bird* than unseen ones
  - even, if no explicit memory of seeing the word
- Propaganda effect
  - exposed to messages ("X is good!")
  - later, unconscious bias towards X



Classical Conditioning

- Pairing of two stimuli
  - neutral stimulus
  - conditioning stimulus with natural response
- Classic example
  - dog hears sounds
  - dog gets food

$\Rightarrow$ Neutral stimulus evokes response



Encoding Methods

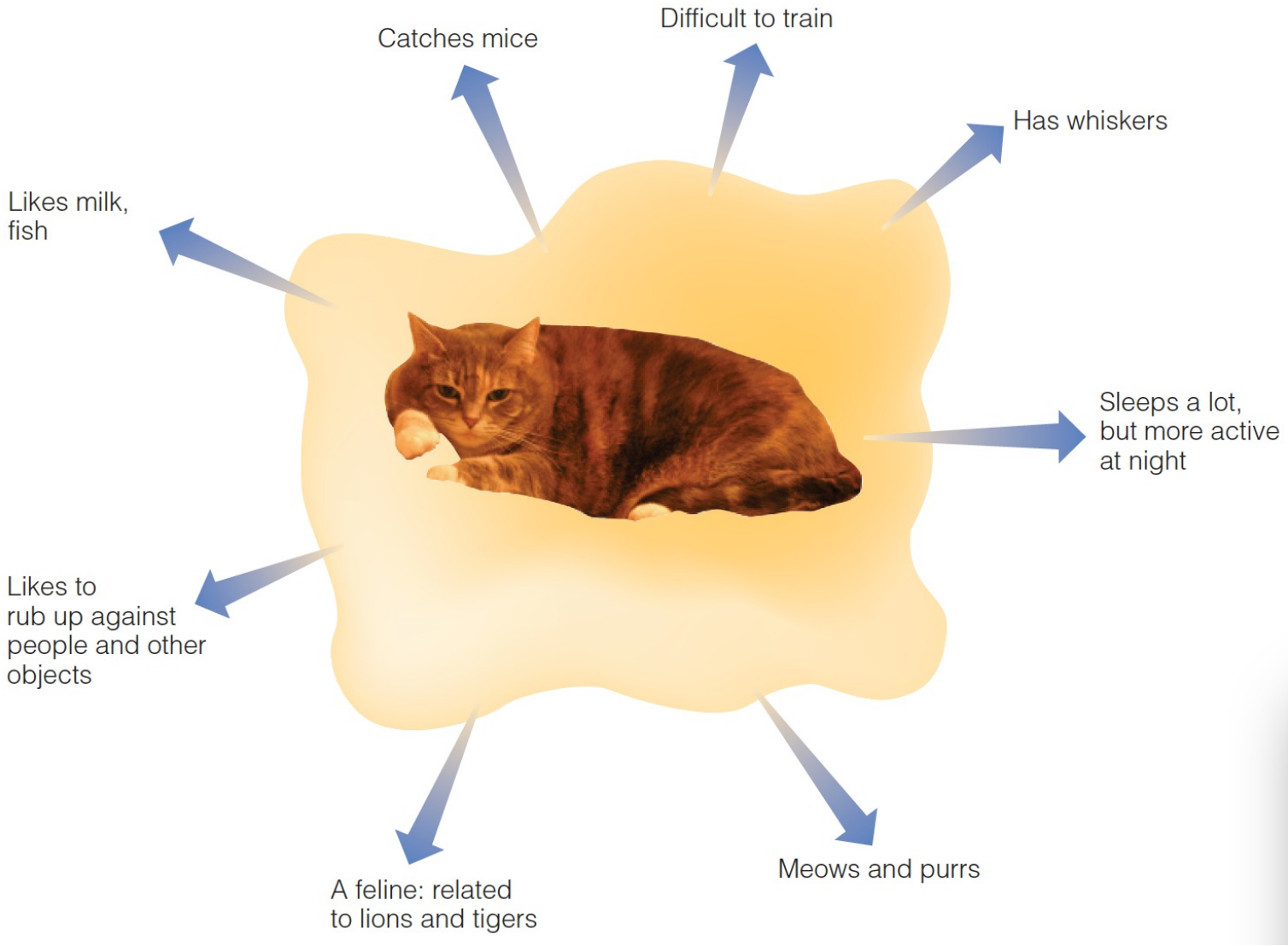
- Encoding = transferring information into long term memory
- Rehearsal (repeating information over and over again)
  - maintenance rehearsal works poorly (*5611 5611 5611 5611 5611*)
  - better if elaborated (*56 is my house number and 11 is the month I was born*)
- Forming visual images
- Linking words to yourself
- Organize information (e.g., put in categories)
- Retrieval practice (test yourself)
- Matching conditions of encoding and retrieval

categories

Concepts and Categories

- Concept
  - meaning of objects, events, and abstract ideas
  - example: *what is a cat?*
- Category
  - set of all possible examples of a concept
- Categorization
  - placing things into categories

Category *Cat*



Definitional Approach

- Category defined by features
- Very unlikely a good explanation of human categories
- Example: *chair* $\Rightarrow$

(a)

(b)

(c)

(d)

Wittgenstein's Family Resemblance

- Recall: *game*
- Not all instances of a category share the same features
- But: each instance shares features with some other instances

Prototypical Approach

- What is a typical pet?

Prototypical Approach

- What is a typical pet?
  - cat
  - dog

- What is a typical piece of furniture?

Prototypical Approach

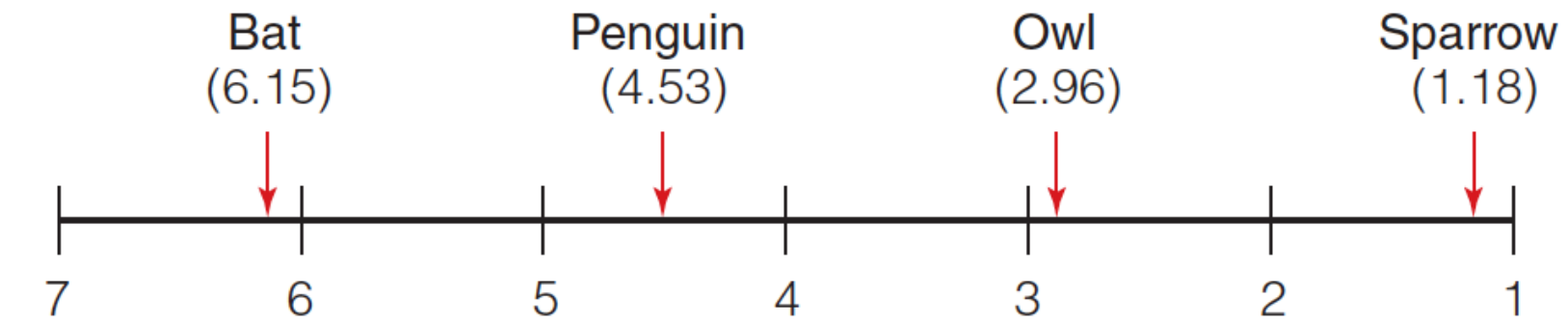
- What is a typical pet?
  - cat
  - dog

- What is a typical piece of furniture?
  - chair
  - table
  - shelf

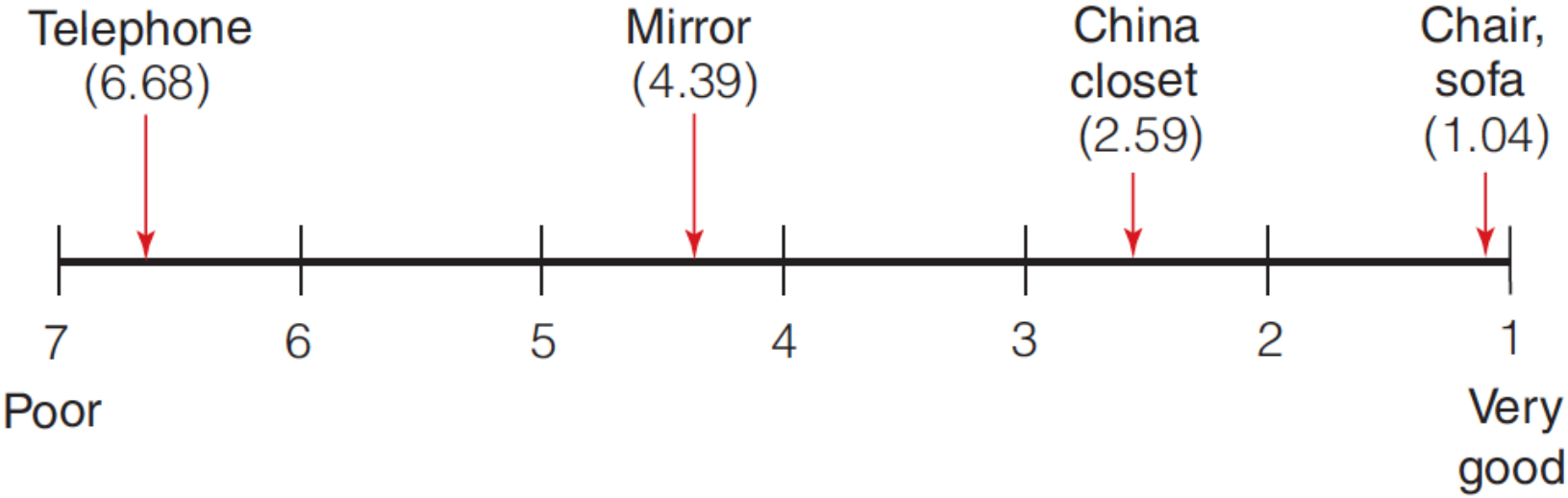
Average Case

- Mental image: average of all instances of class
- Does not have to be a real instance

Typicality



(a) Category = birds



(b) Category = furniture

Tests for Typicality

- Sentence verification technique
  - Measure reaction time for

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    - *An apple is a fruit.*

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Tests for Typicality

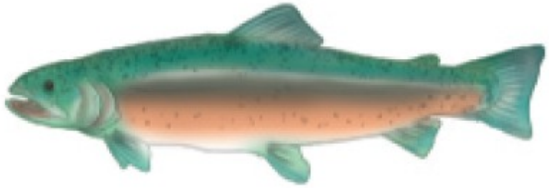
- Sentence verification technique
  - Measure reaction time for
    - *An apple is a fruit.*
    - *A pomegranate is a fruit.*
  - Faster reaction time for typical example

- Typical examples are named first

- Stronger priming effect

Exemplar Approach

- Prototype = one average example, possibly artificial
- Examplars = multiple real examples
- People seem to be use both
  - initially build prototype
  - when learning more about category, exemplars are added (e.g., penguin for bird)
  - exemplar approach for small categories (U.S. presidents) prototype approach better for bigger categories (birds)



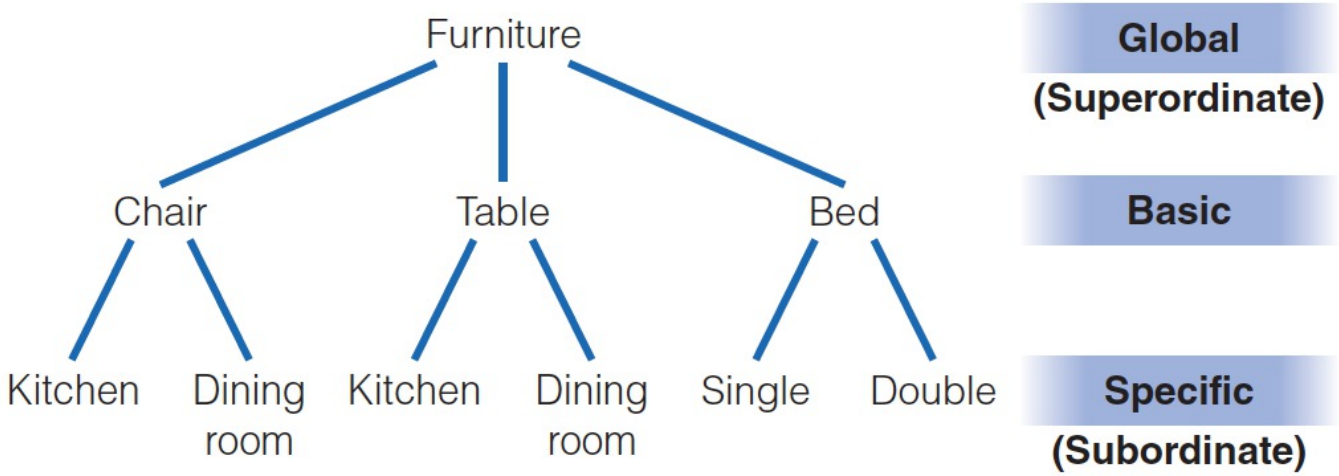
Levels of Categories

musical instrument
guitar

fish
trout

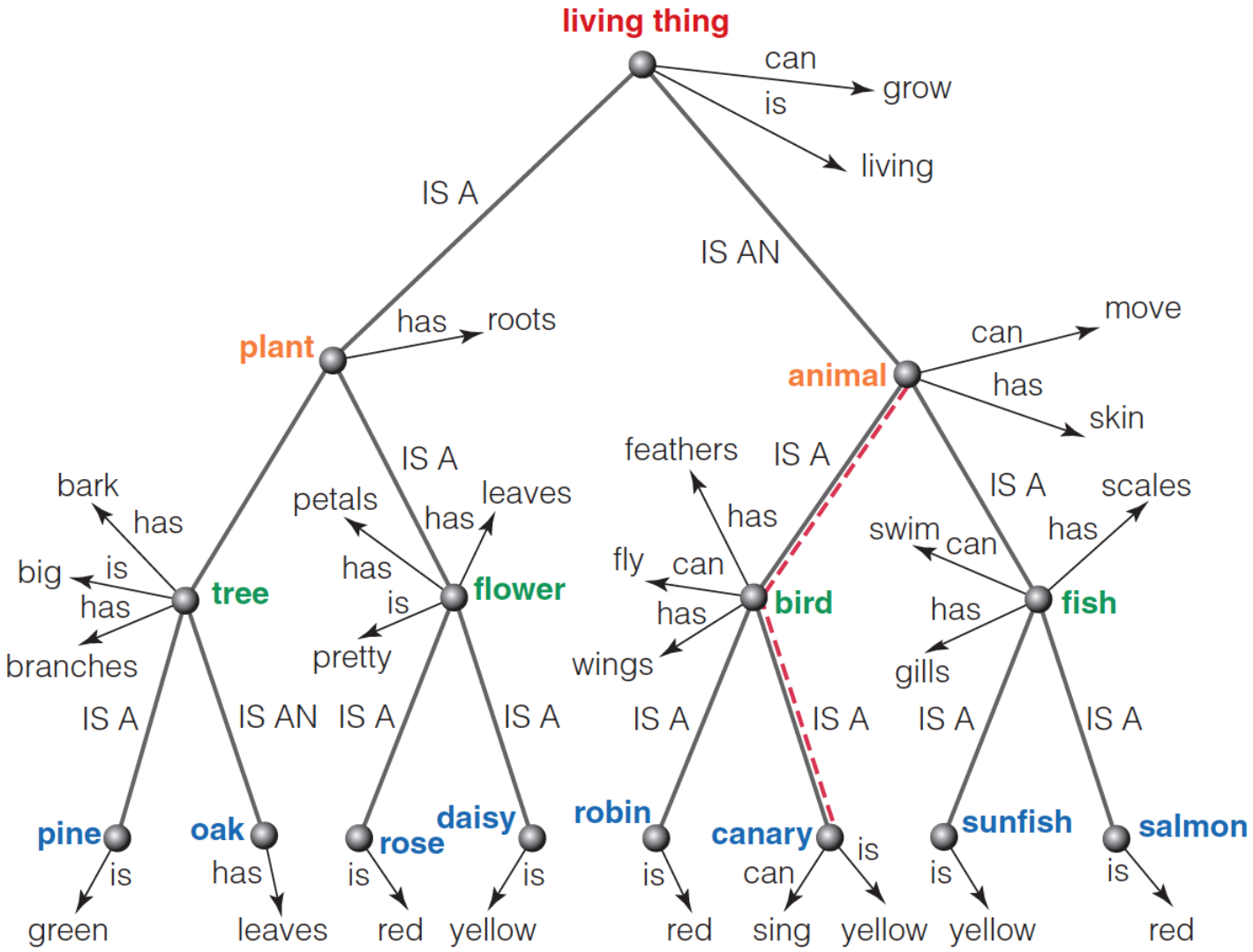
clothing
pants
jeans

Basic Level Categories



- Methods to establish what basic level is
  e.g., quickly determine if picture is *car* vs. *vehicle*
- Basic level not common among people
- For instance: *oak* vs. *tree, sparrow* vs. *bird*

Semantic Networks



Semantic Networks

- Relationships between concepts
  - `is-a` relationships defines hierarchy
  - `is` relationships defines properties
  - `has` relationship defines parts
  - `can` relationship defines possible actions
- Relationship marked at most general concept
  but can be overruled by more specific
  - *a bird can fly*
  - *a penguin cannot fly*

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- Response time for questions related to distance in network
  - *is a canary a bird?* (fast)
  - *is a canary an animal?* (slower)

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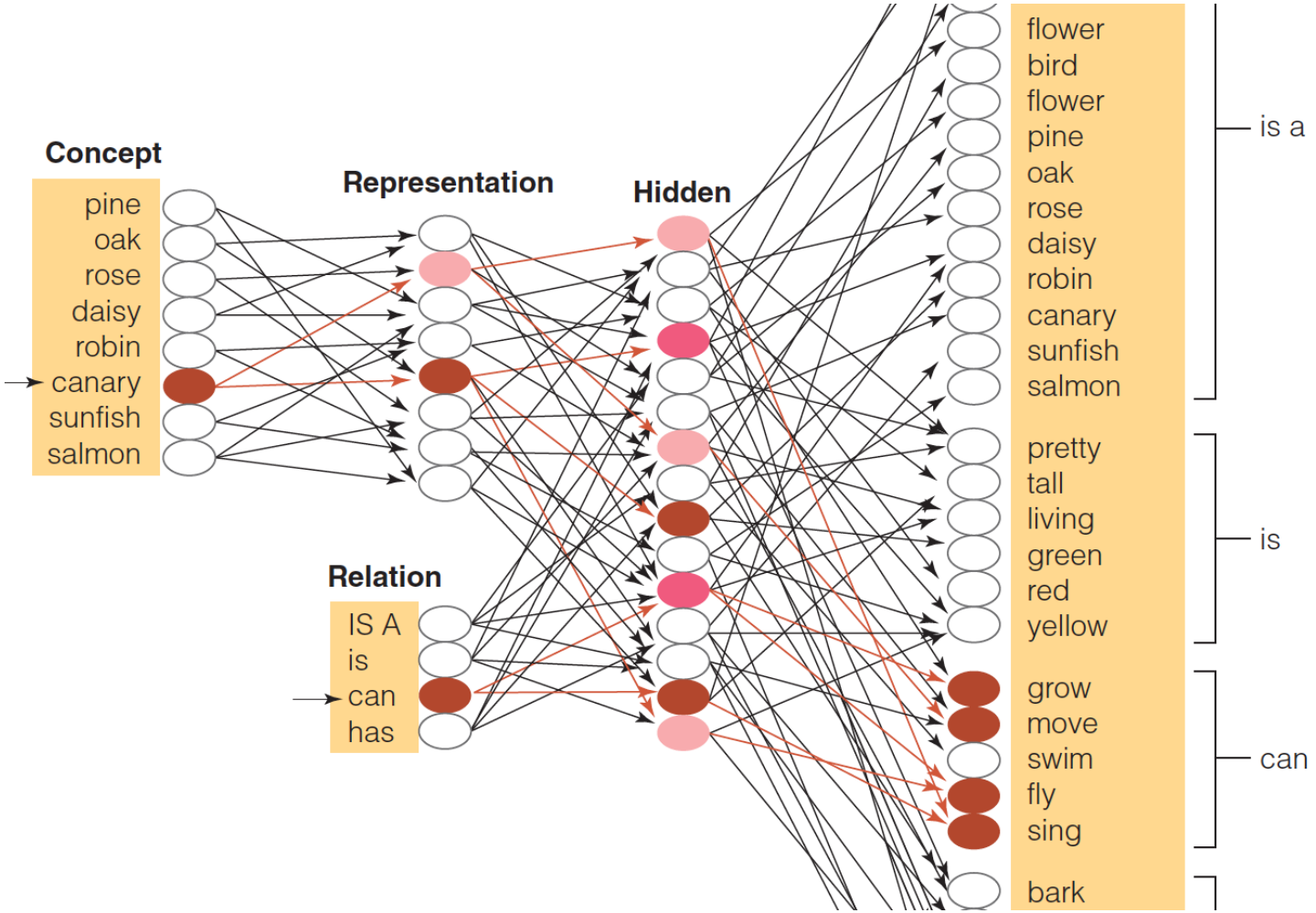
  - *a bird can fly*
  - *a penguin cannot fly*
- Response time for questions related to distance in network
  - *is a canary a bird?* (fast)
  - *is a canary an animal?* (slower)
- But does not always work
  - *is a pig a mammal?* (slow)
  - *is a pig an animal?* (faster)

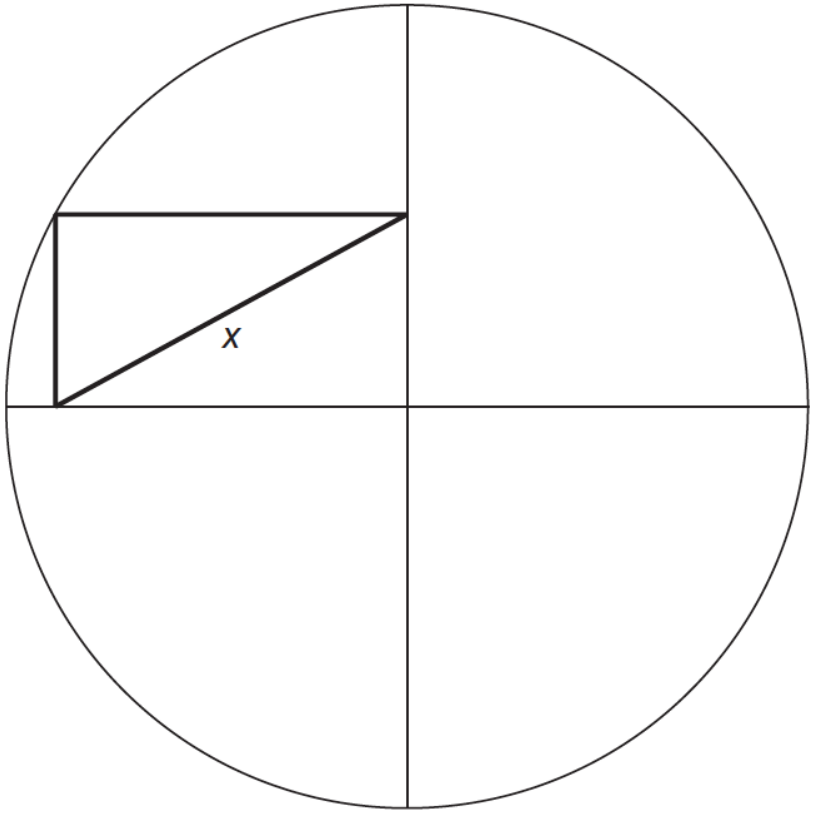
Connectionism



- Hidden layer representations for concepts and concept relationships

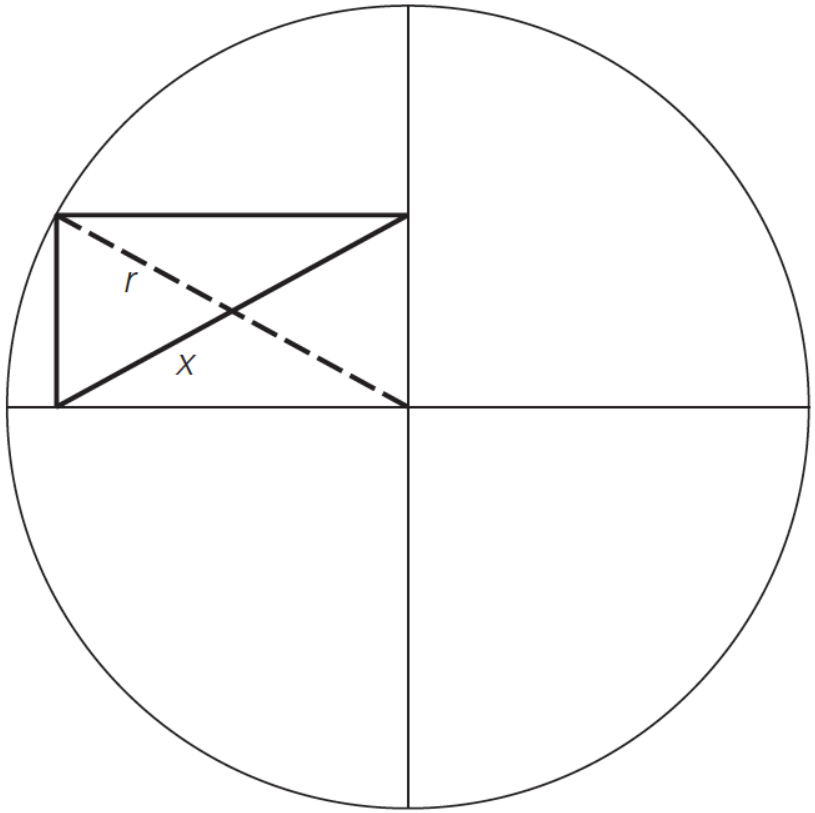
problem solving

Problem



If the length of the circle's radius is r, what is the length of the line x?

Solution



$$r = x$$

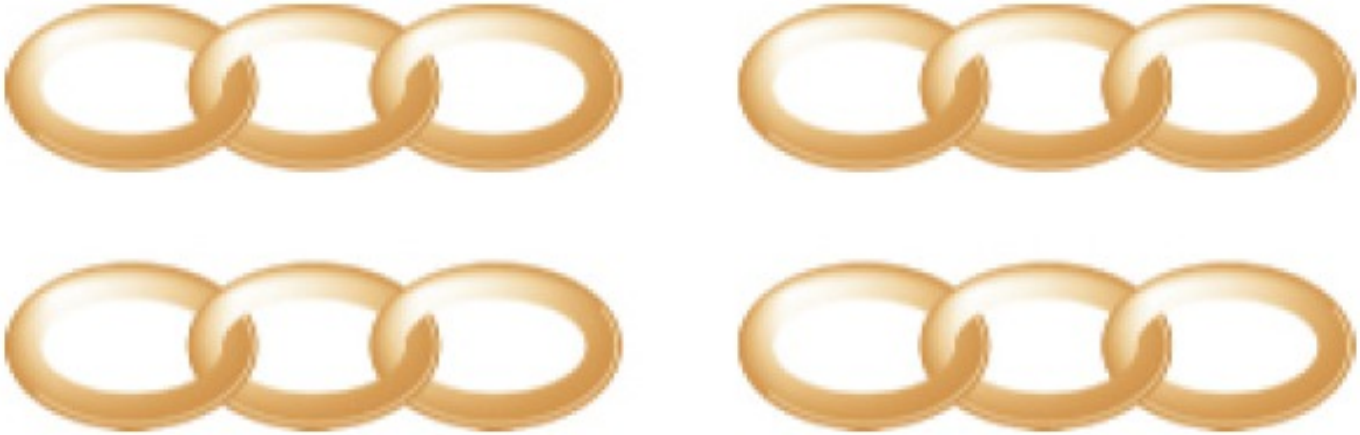
Problem Solving

- Obstacle between present state and goal
- Difficult, solution not immediately obvious
- When found, solution obviously correct
- Solution requires sudden "insight"

Problem Solving Methods

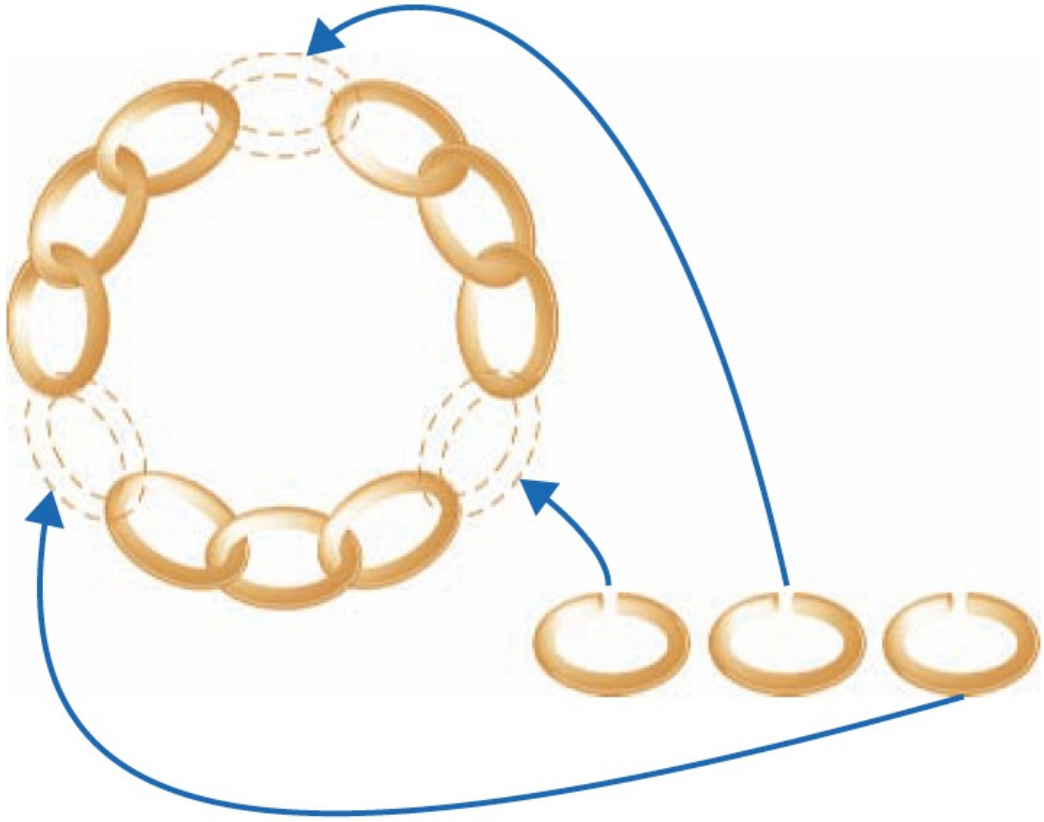
- Restructuring
- Overcoming fixation
- Reaching solution through subgoals
- Find a better representation
- Analogical transfer

Problem



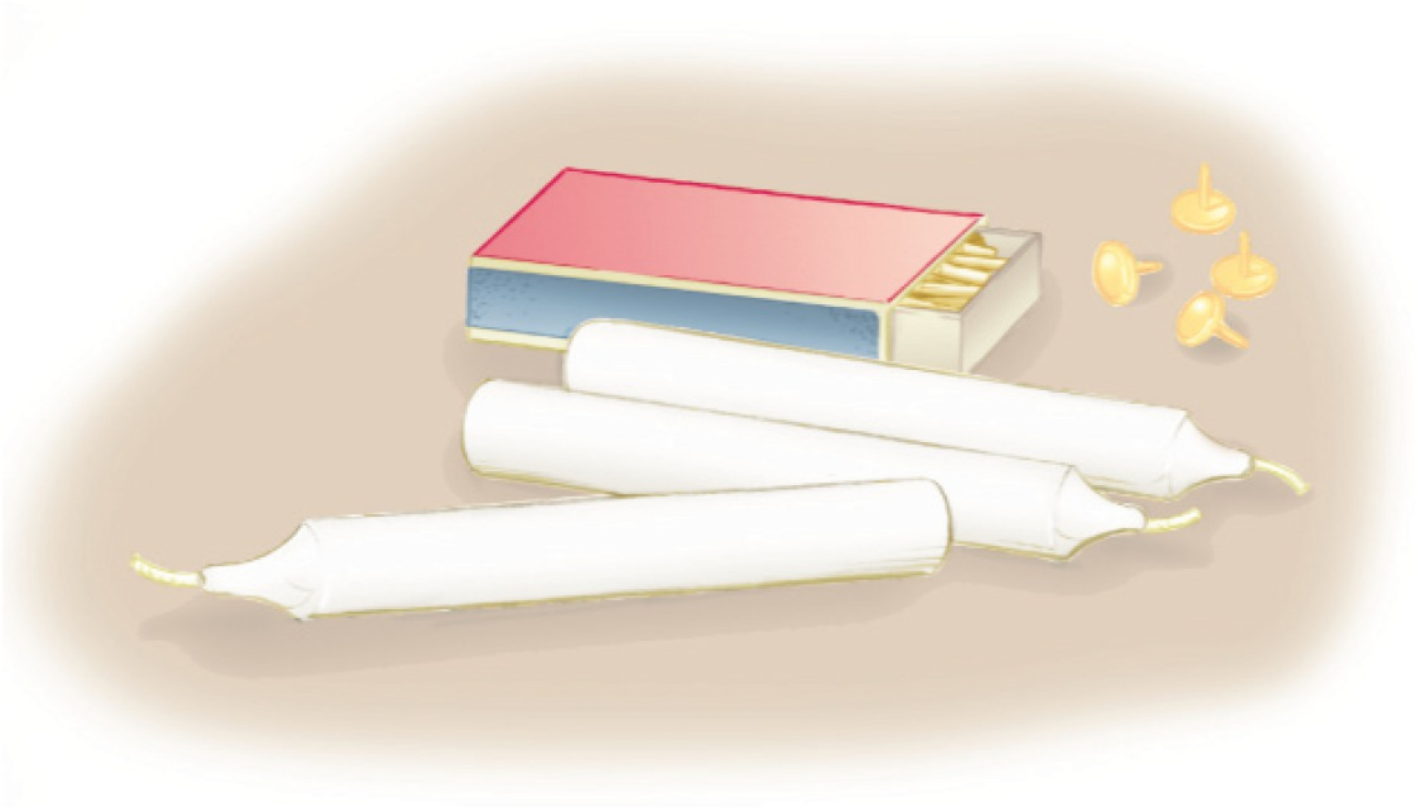
- Connect the chains into a single linked chain
- Only allowed to open and close 3 links

Overcoming Fixation



Fixation = Focus on specific characteristics of problem
(here: 4 equal chain parts)

Problem

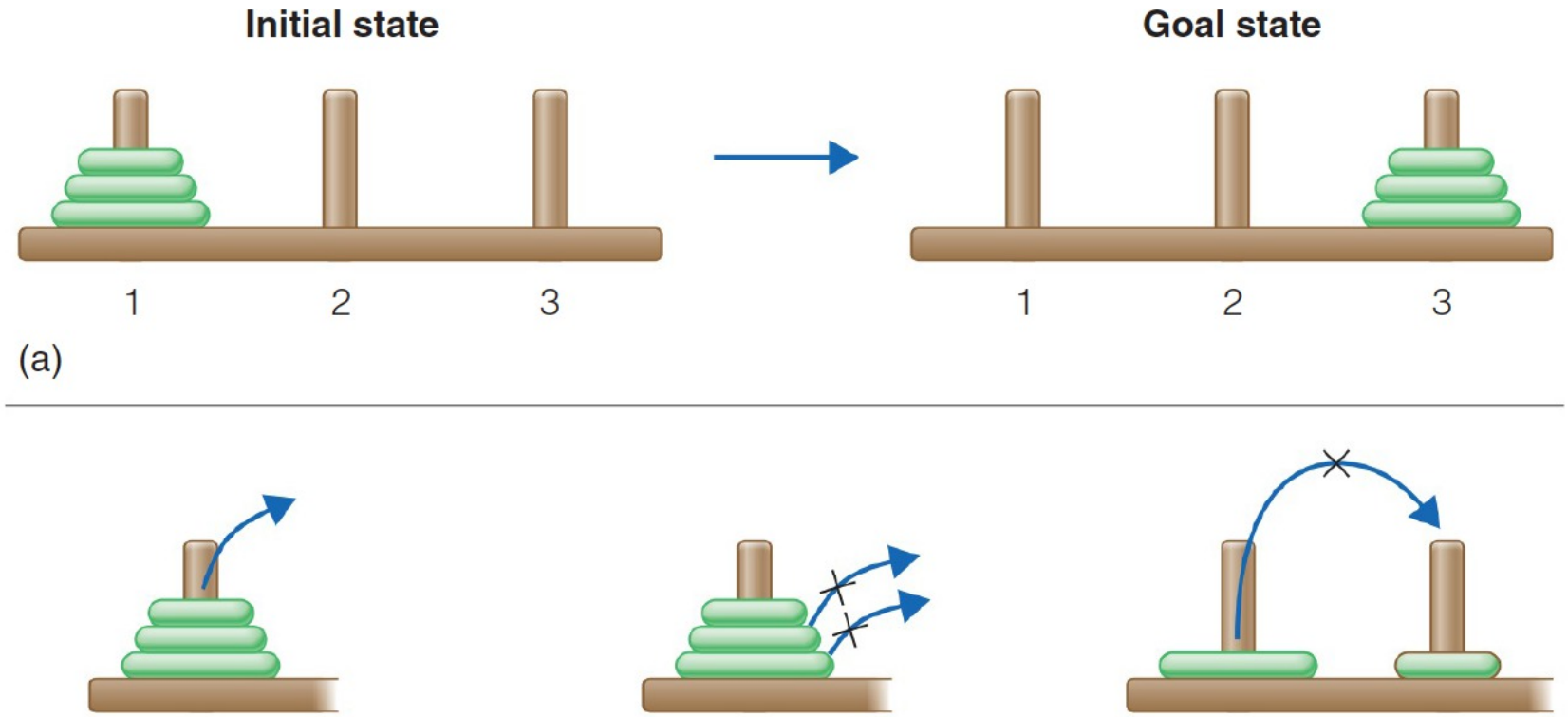


You are in a room with a corkboard.
Mount the candle, so no dripping wax on the floor!

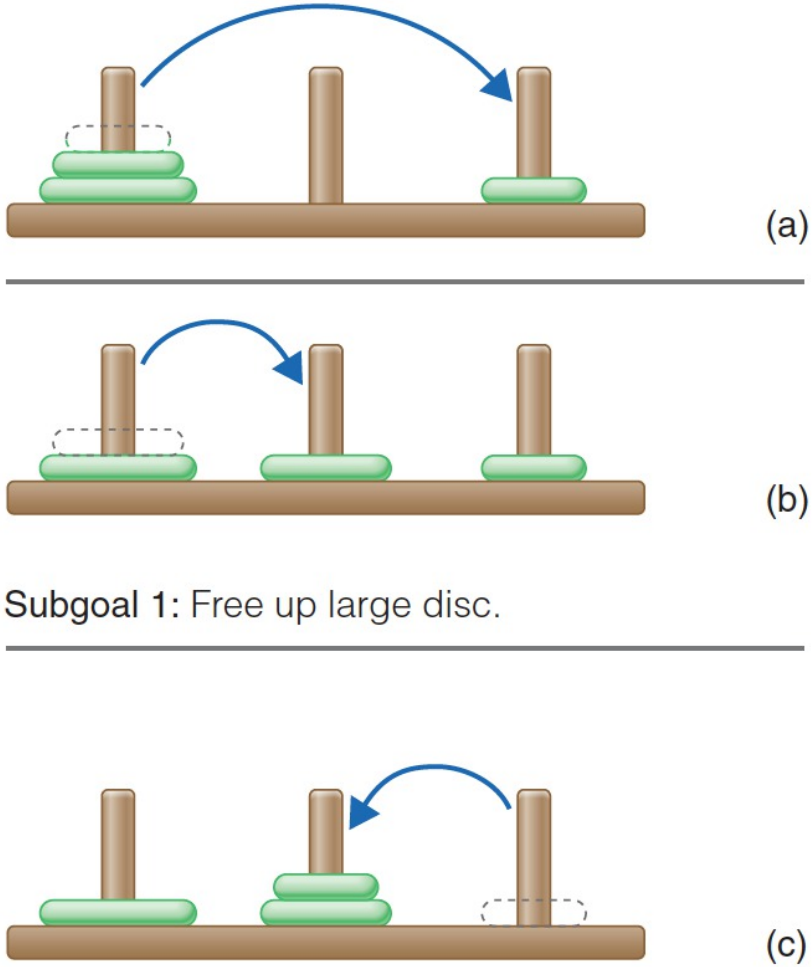
Overcoming Functional Fixation

Functional fixation = function of box is a container

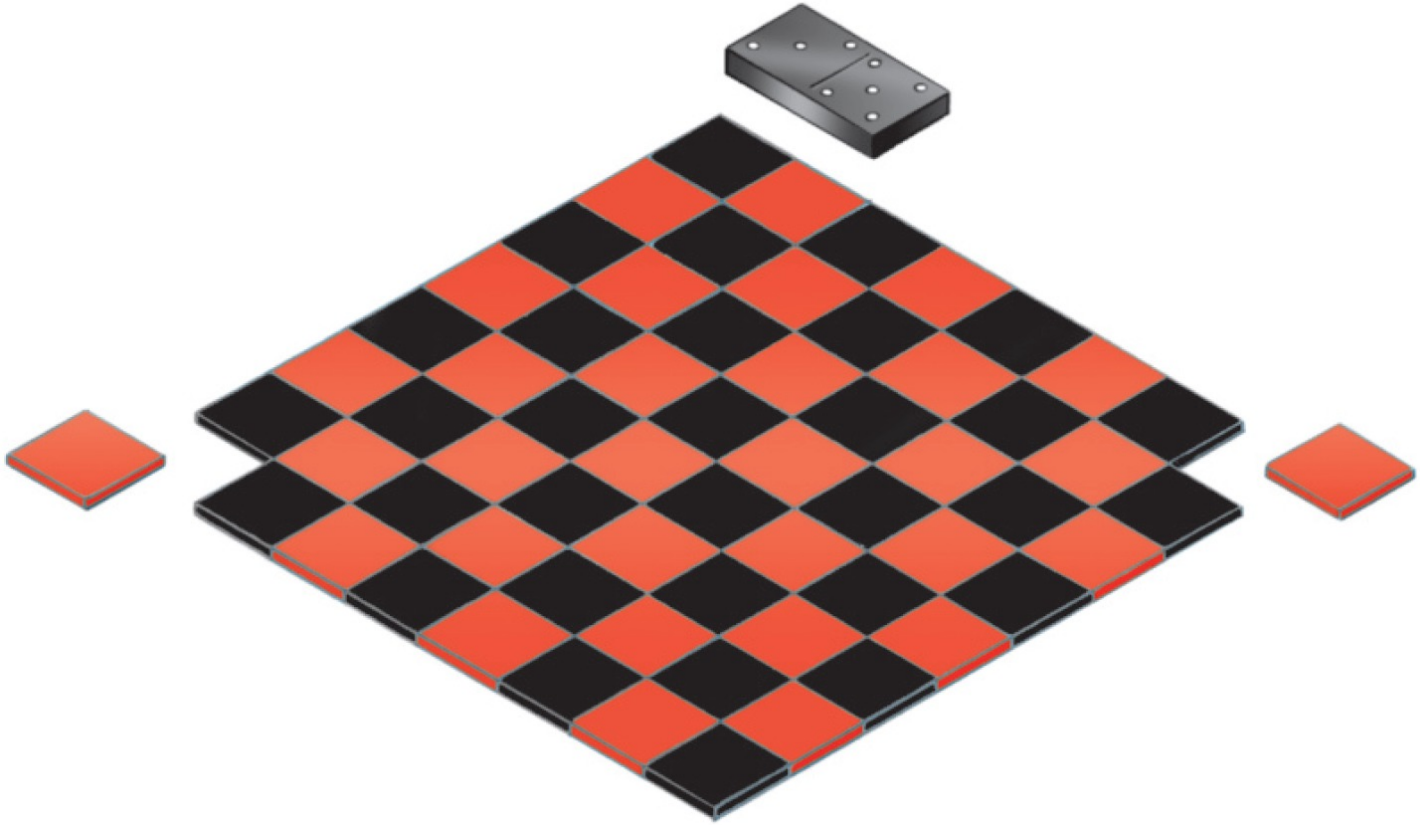
Tower of Hanoi



Reaching Solution through Subgoals

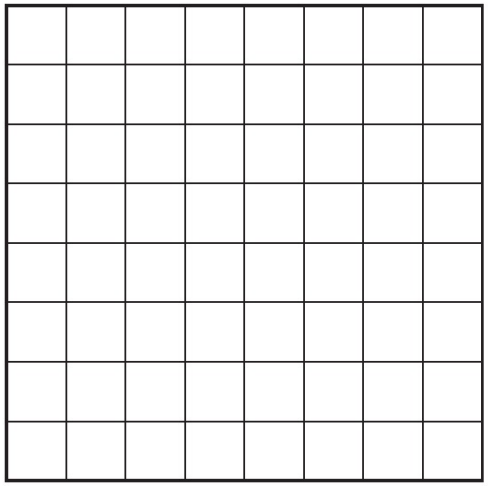


Mutilated Checkerboard

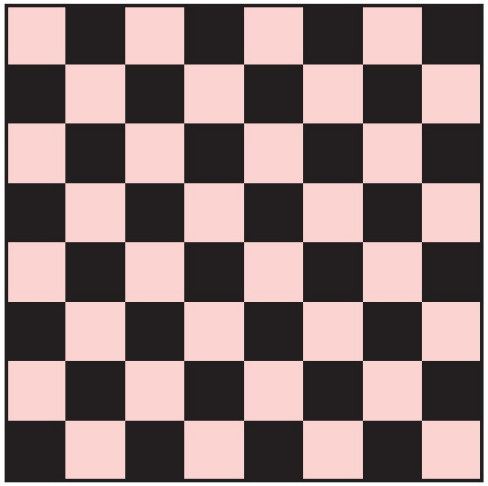


After removing two corners,
can you fill the checkerboard with dominos?

Variations of Representing the Problem



Blank



Color

black	pink	black	pink	black	pink	black	pink
pink	black	pink	black	pink	black	pink	black
black	pink	black	pink	black	pink	black	pink
pink	black	pink	black	pink	black	pink	black
black	pink	black	pink	black	pink	black	pink
pink	black	pink	black	pink	black	pink	black
black	pink	black	pink	black	pink	black	pink
pink	black	pink	black	pink	black	pink	black

Black and pink

butter	bread	butter	bread	butter	bread	butter	bread
bread	butter	bread	butter	bread	butter	bread	butter
butter	bread	butter	bread	butter	bread	butter	bread
bread	butter	bread	butter	bread	butter	bread	butter
butter	bread	butter	bread	butter	bread	butter	bread
bread	butter	bread	butter	bread	butter	bread	butter
butter	bread	butter	bread	butter	bread	butter	bread
bread	butter	bread	butter	bread	butter	bread	butter

Bread and butter

"Bread and Butter" solved twice as fast than "Blank", required fewer hints

Analogical Transfer

- Applying a known solution to a different problem
- Steps
  - noticing that there is a analogous relationship
  - mapping between source and target problem
  - applying mapping to generate solution
- Apparently very common in real world
- Arguably, major driver in technology
  - methods established in one field applied to another
  - younger researchers ignoring common practice
  - main problem: disproving bad ideas

decision making

Judgment, Decisions, Reasoning

- We constantly have to make choices
- We typically have insufficient information
- Still, what is the best choice?

Inductive Reasoning

- *All swans in Baltimore are white.*
- *I visited New York. The swans are white there, too.*

$\Rightarrow$ *Swans are white everywhere.*

- Strength of inductive reasoning
  - number of observations
  - representativeness of observations
  - quality of evidence

Problem

- What is a more likely cause of death in these pairs?

homicide	vs.	appendicitis
auto-train collision	vs.	drowning
asthma	vs.	tornado
appendicitis	vs.	pregnancy

Availability Heuristic

- What is a more likely cause of death in these pairs?

homicide (20 times)	vs.	appendicitis	9% pricked wrong
auto-train collision	vs.	drowning (5 times)	34% pricked wrong
asthma (20 times)	vs.	tornado	58% pricked wrong
appendicitis (2 times)	vs.	pregnancy	83% pricked wrong

- More easily remembered examples judged as more probable

Representativeness Heuristic

- People often make decisions based on how two events resemble

- Possible pitfalls
  - ignoring base rate
  - ignoring conjunction rule
  - ignoring law of large numbers

Problem

- *We randomly pick one male from the population of the United States. That male, Robert, wears glasses, speaks quietly, and reads a lot.*

- Is it more likely that Robert is a librarian or a farmer?

Ignoring Base Rate

- *We randomly pick one male from the population of the United States. That male, Robert, wears glasses, speaks quietly, and reads a lot.*

- Is it more likely that Robert is a librarian or a farmer?

- There are many more farmers than librarians
  (currently 10 times more male farmers than male librarians)

$\Rightarrow$ more likely that he is a farmer

Problem

- *Linda is 31 years old, single, outspoken, and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in antinuclear demonstrations.*

- Which of the following alternatives is more probable?

1. *Linda is a bank teller.*
2. *Linda is a bank teller and is active in the feminist movement.*

Ignoring Conjunction Rule

- *Linda is 31 years old, single, outspoken, and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in antinuclear demonstrations.*

- Which of the following alternatives is more probable?

  1. *Linda is a bank teller.*
  2. *Linda is a bank teller and is active in the feminist movement.*

- 2 is subsumed by 1, so 1 is always more likely

Problem

- *A certain town is served by two hospitals. In the larger hospital about 45 babies are born each day, and in the smaller hospital about 15 babies are born each day. As you know, about 50 percent of all babies are boys. However, the exact percentage varies from day to day. Sometimes it may be higher than 50 percent, sometimes lower. For a period of 1 year, each hospital recorded the days on which more than 60 percent of the babies born were boys.*

- Which hospital do you think recorded more such days?
  - The larger hospital?
  - The smaller hospital?
  - About the same

Law of Large Numbers

- *A certain town is served by two hospitals. In the larger hospital about 45 babies are born each day, and in the smaller hospital about 15 babies are born each day. As you know, about 50 percent of all babies are boys. However, the exact percentage varies from day to day. Sometimes it may be higher than 50 percent, sometimes lower. For a period of 1 year, each hospital recorded the days on which more than 60 percent of the babies born were boys.*

- Which hospital do you think recorded more such days?
  - The larger hospital?
  - The smaller hospital?
  - About the same

- Results: 22% each picked the larger or smaller, 56% picked the same

- But in a hospital with fewer births, larger variation from mean more likely

Confirmation Bias

- When presented with evidence, e.g., about political issues
- Confirming evidence is judged more credible
- Contradicting evidence is rejected

Deduction

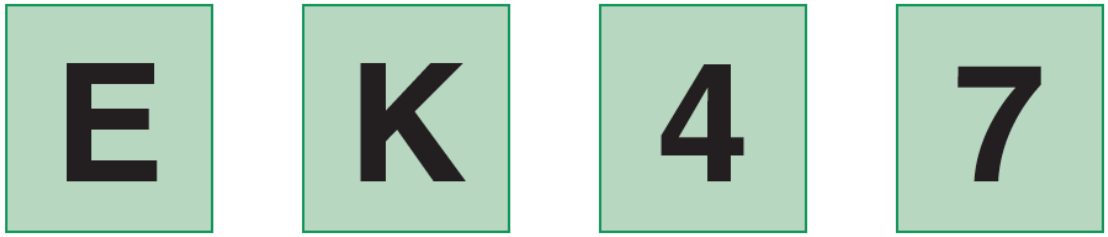
- Syllogism
  - *all birds are animals*
  - *all animals eat food*

  $\rightarrow$ *birds eat food*

- Conditional Syllogism
  - if a then b
  - predictions

given	conclusion	valid?	judged correctly?
a	b	yes	97%
not b	not a	yes	60%
b	a	no	40%
not a	not b	no	40%

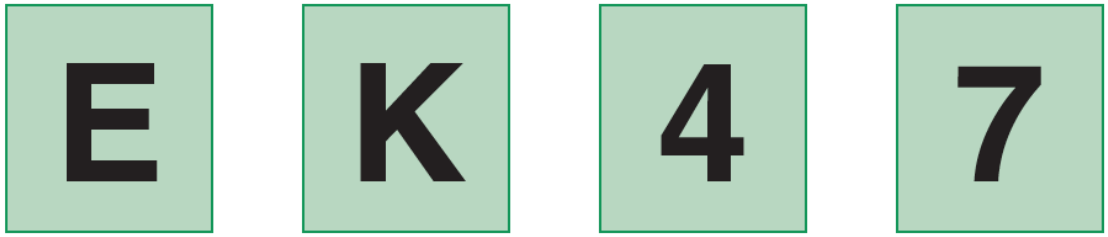
Conditional Syllogism: Abstract Example



- Each card has a letter on one side, a number on the other
- Which cards need to turned to check the rule

if the letter is a vowel, then the number is even

Conditional Syllogism: Abstract Example

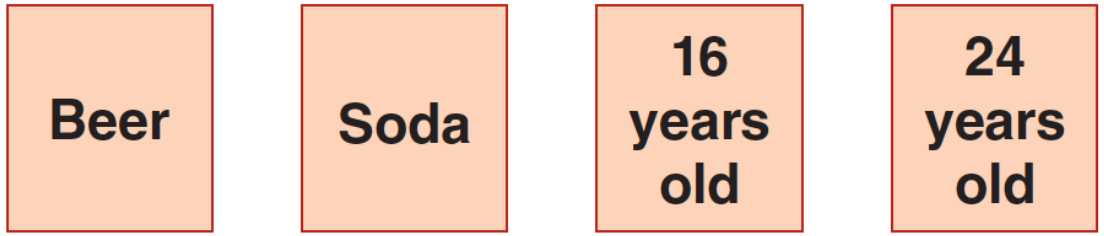


- Each card has a letter on one side, a number on the other
- Which cards need to turned to check the rule

  if the letter is a vowel, then the number is even

- Correct answer: card *E* and *7*

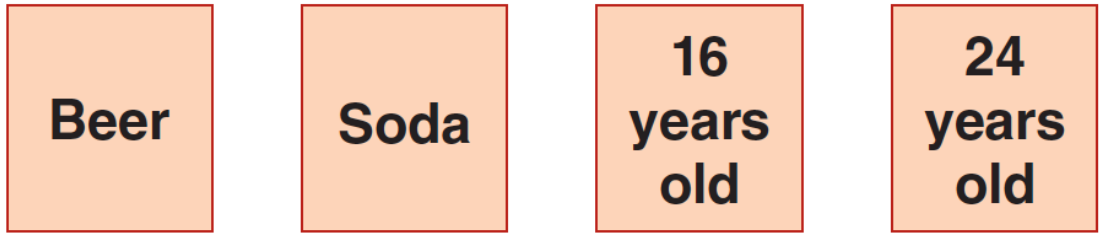
Conditional Syllogism: Concrete Example



- Each card has the age on one side, a beverage on the other
- Which cards need to turned to check the rule

if a person is drinking beer, then the person must be over 21 years old

Conditional Syllogism: Concrete Example



- Each card has the age on one side, a beverage on the other
- Which cards need to turned to check the rule

  if a person is drinking beer, then the person must be over 21 years old

- Correct answer: card *Beer* and *16 years old*

two systems, revisited

Problem

- *a bat and a ball cost $1.10*
- *the bat costs $1 more than the ball*
- *how much does the ball cost?*

Problem

- *a bat and a ball cost $1.10*
- *the bat costs $1 more than the ball*
- *how much does the ball cost?*

- Immediate response (system 1): 10 cents
- Careful consideration (system 2): 5 cents

- System 2 can be better, in daily life, we do not always have time for it