

THINKING

John Gabrieli 9.00

THINKING

7/8 divided by 3/4

**How many square feet in a
square yard?**

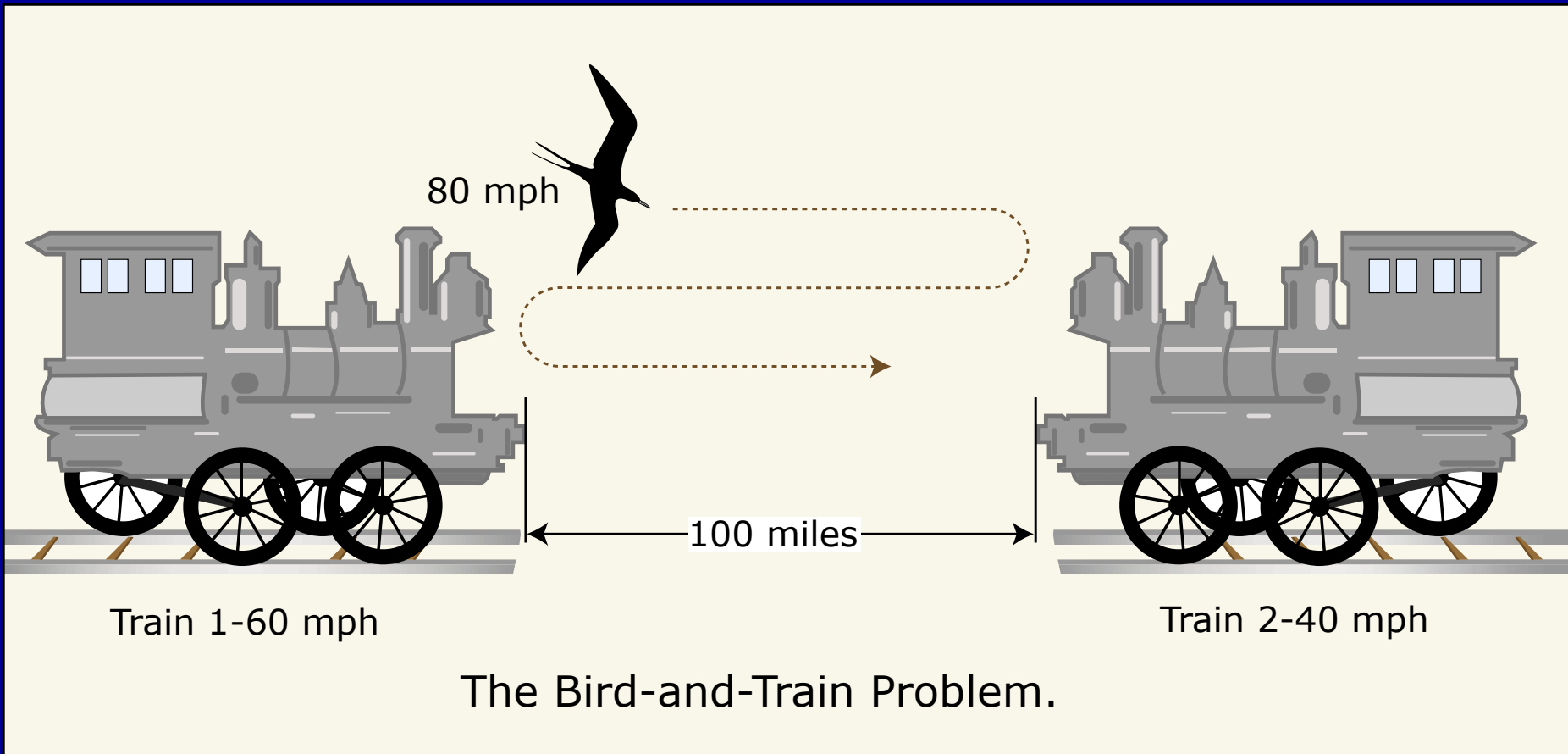
THINKING

A. Problem Solving

B. Judgment & Decision Making

C. Frontal Lobes & Thinking

Two train stations are 100 miles apart. At 2pm one Saturday afternoon the two trains start toward each other, one from each station. One train travels at 60 miles per hour, the other at 40 miles per hour. Just as the trains pull out of their stations, a bird springs into the air in front of the first train, and flies ahead to the front of the second train. When the bird reaches the second train, it turns back without losing any speed and flies directly toward the first train. The bird continues to fly back and forth between the trains at a rate of 80 miles per hour. How many miles will the bird have flown before the trains meet?



The Bird-and-Train Problem.

Image by MIT OpenCourseWare.

THINKING

1. Mental Set

functional fixedness

2. Overcoming Obstacles

restructuring

representation

analogy

In English, many words are pronounced somewhat differently from the way they are spelled.

OLK/OAK

Can you give me a synonym for PEOPLE or FAMILY that fits this pattern?

FOLK

Can you give me the name of an American President at the time of the Mexican War?

POLK

Can you give me a word that means egg white?

YOLK

Goal: Tie strings together

39% in
10 minutes



Image by MIT OpenCourseWare.

Goal: Support a candle on the door



23%
correct

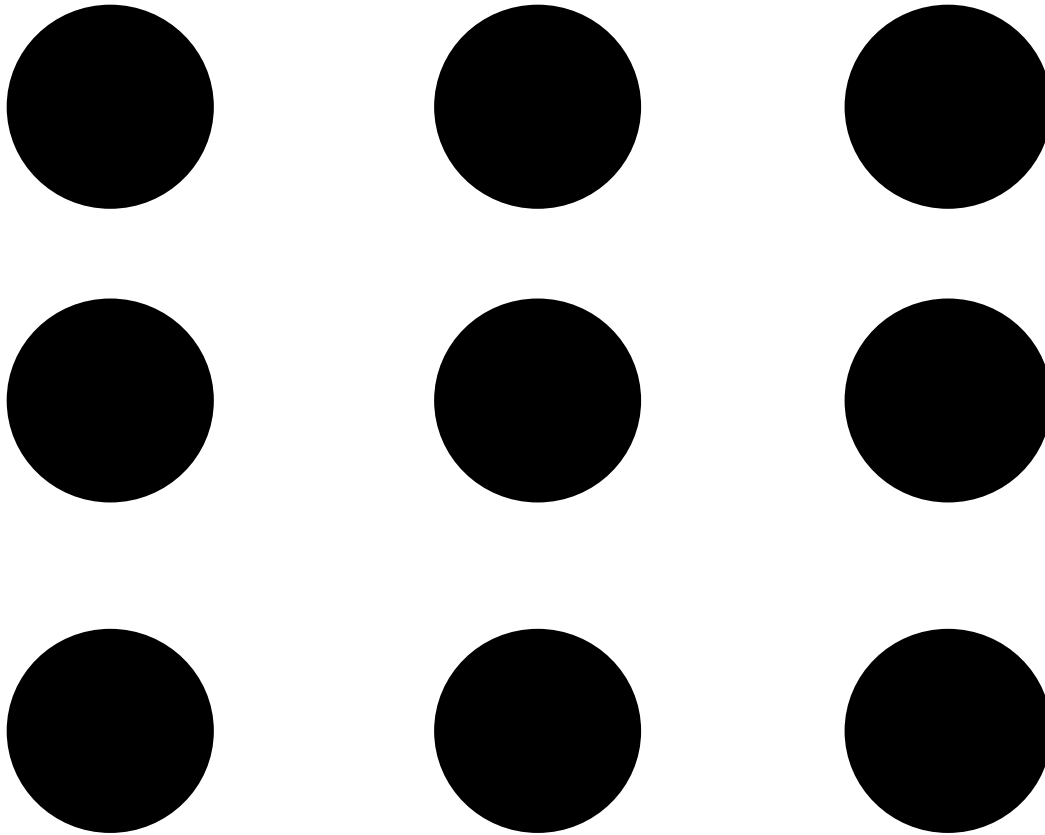
Goal: Support a candle on the door



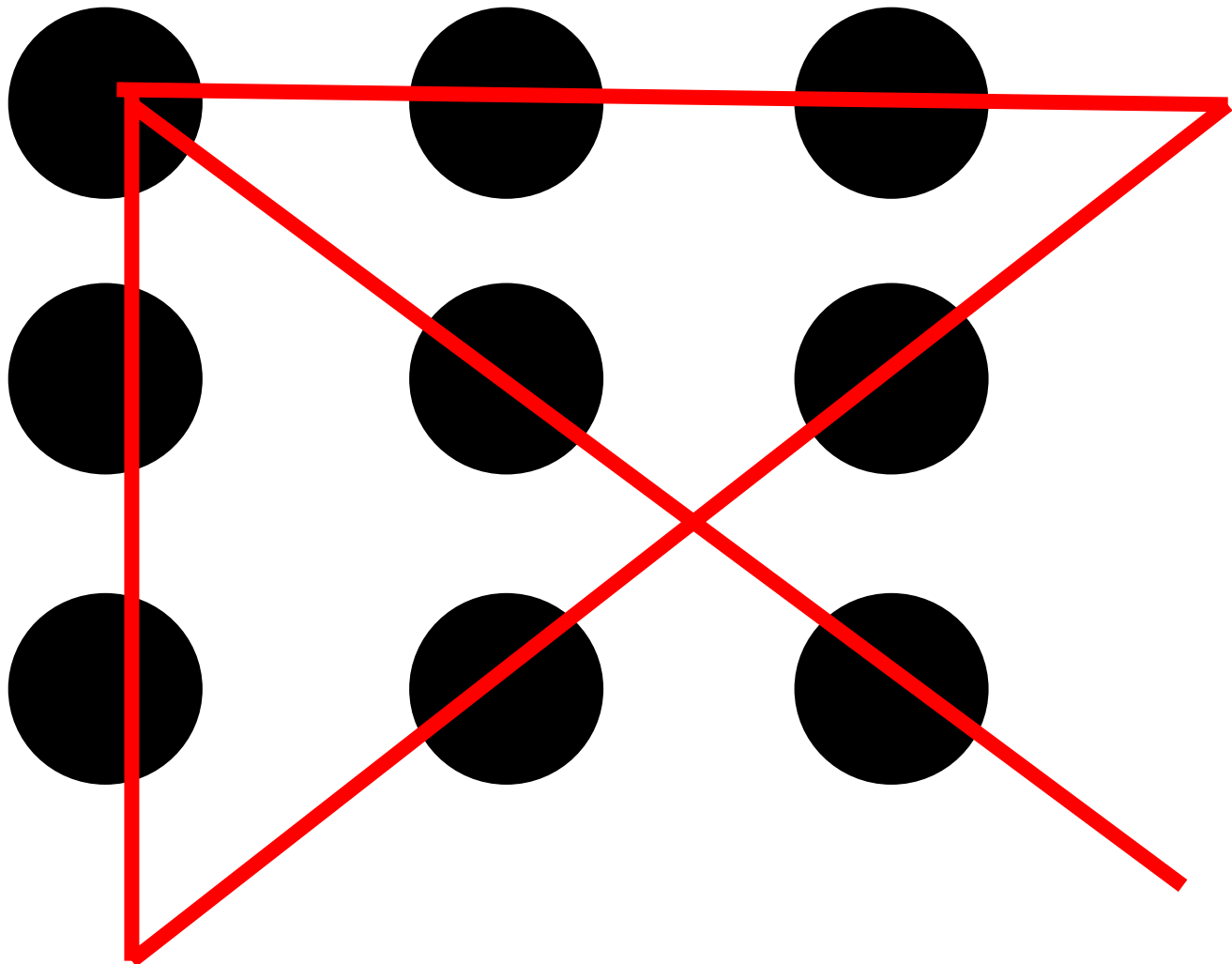
Image by MIT OpenCourseWare.

Duncker, 1945

Place tacks next to box? 10

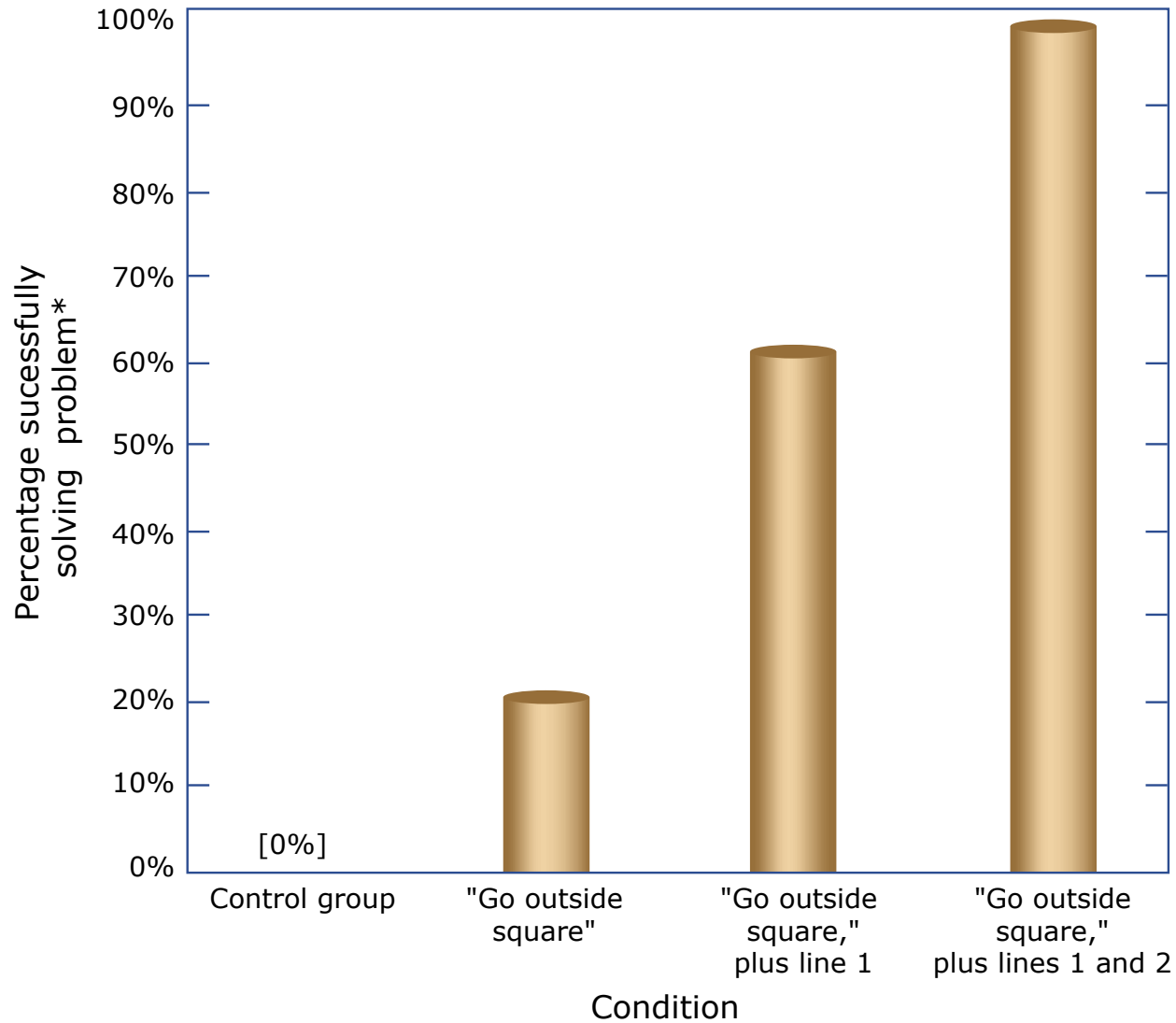


**Connect all the dots with 4 straight
lines without lifting pencil**



Nine-dot Problem Study

Effect of clues on ability to solve the problem



* Participants who solved without hints were eliminated from the study

THINKING

1. Mental Set

functional fixedness

2. Overcoming Obstacles

restructuring

representation

analogy

Picture a large piece of paper, 1/100th of an inch thick. In your imagination, fold it once (now you have two layers), and continue folding it over on itself 50 times. It is true that it is impossible to fold any actual piece of paper 50 times. But for the sake of the problem imagine that you can. About how thick would the 50-times-folded paper be?

Adapted from Glass, A. L., and K. J. Holvoak. Cognition. Random House, 1985.

**50 folds = 2^{50} = 1,100,000,000,000,000 =
distance from earth to sun**

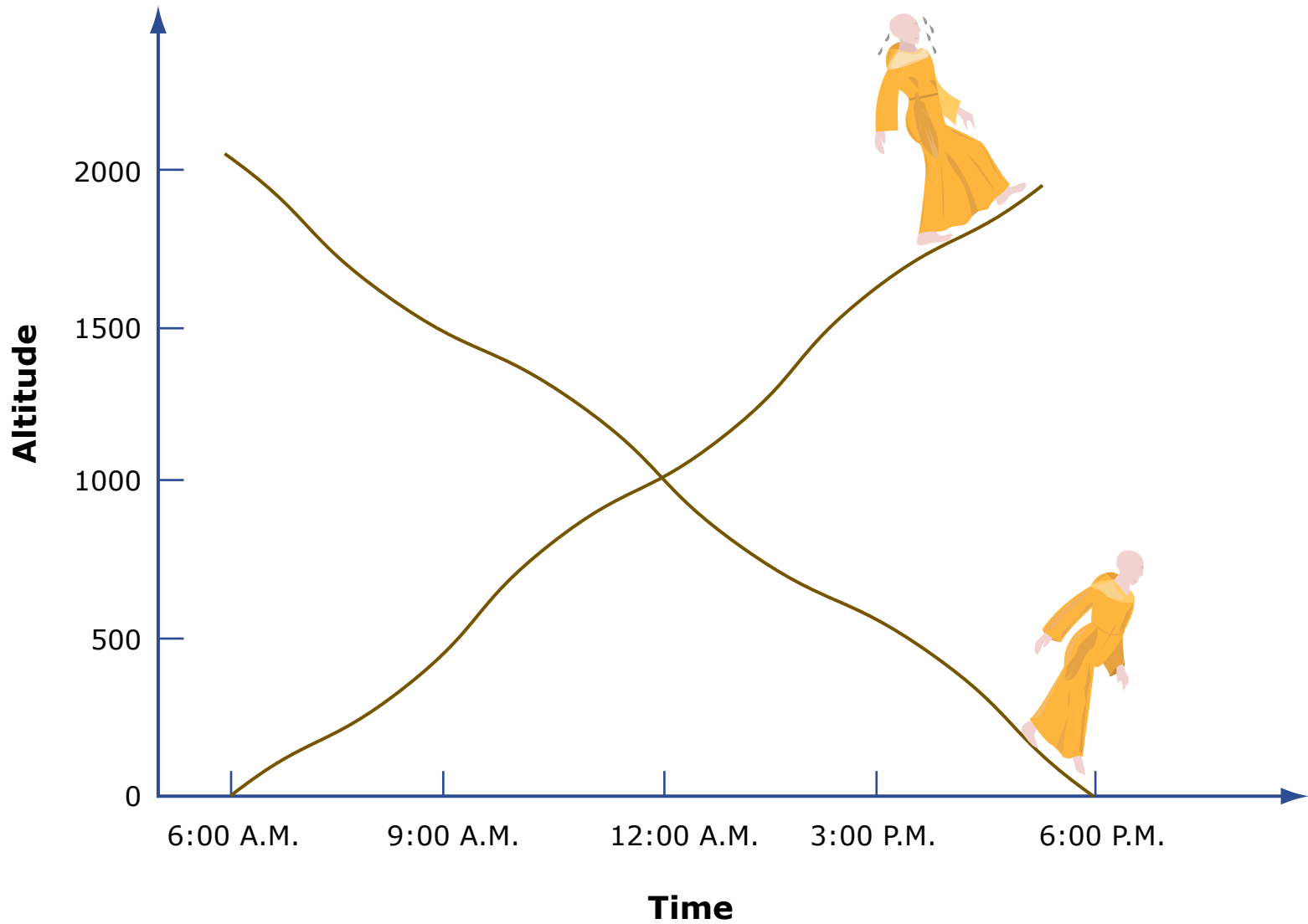
Buddhist monk problem

One morning, exactly at sunrise, a Buddhist monk began to climb a tall mountain. A narrow path, no more than a foot or two wide, spiraled around the mountain to a glittering temple at the summit. The monk ascended at varying rates of speed, stopping many times along the way to rest and eat dried fruit he carried with him. He reached the temple shortly before sunset. After several days of fasting and meditation he began his journey back along the same path, starting at sunrise and again walking at variable speeds, with many pauses along the way. His average speed descending was, of course, greater than his average climbing speed. Show that there is a spot along the path that the monk will occupy on both trips at precisely the same time of day.

Problem by Carl Duncker, as cited in Arthur Koestler's *The Act of Creation* (Macmillan, 1964).

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A Graphic Representation of the Buddhist Monk Problem



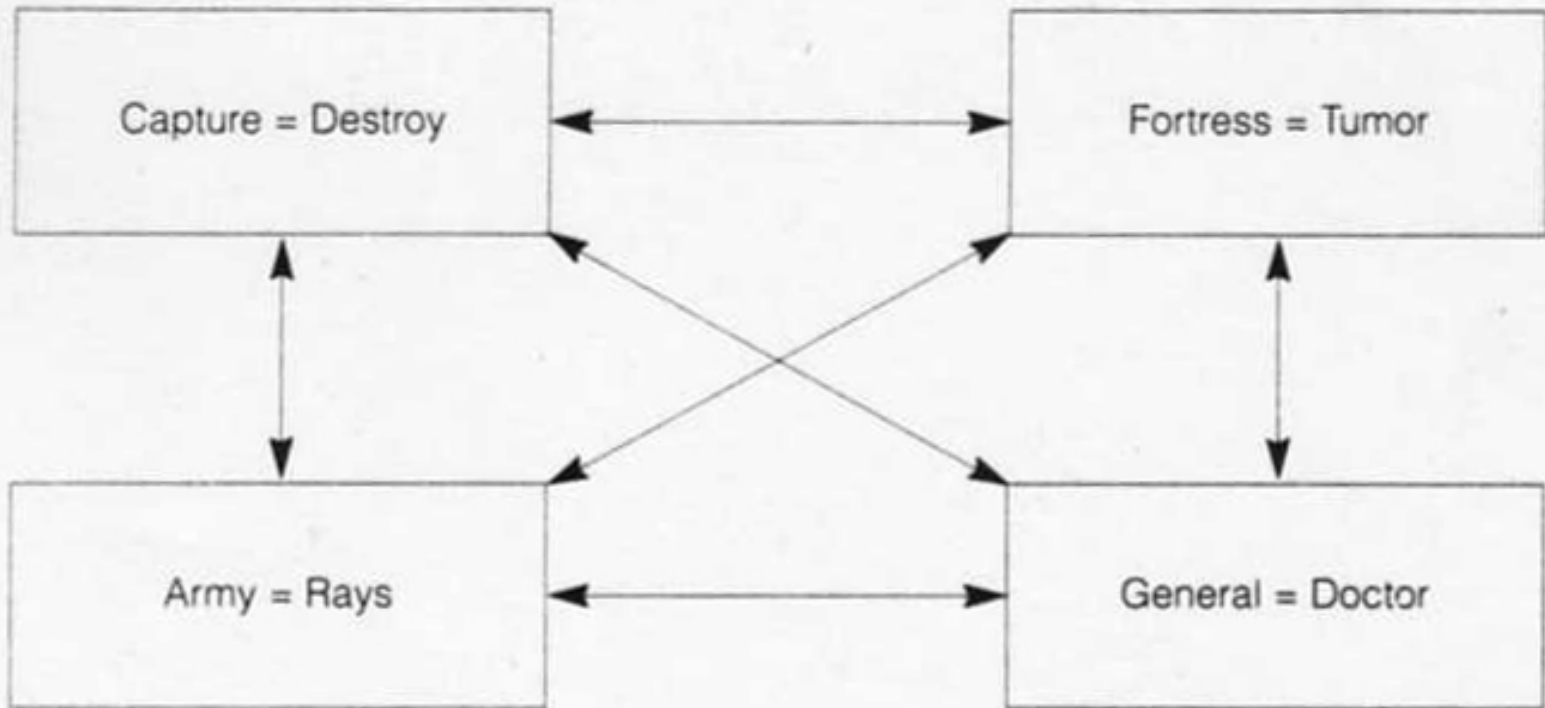
Suppose you are a doctor faced with a patient who has a malignant tumor in his stomach. It is impossible to operate on the tumor, but unless the tumor is destroyed the patient will die. There is a kind of ray that can be used to destroy the tumor. If the rays reach the tumor all at once at a sufficiently high intensity, the tumor will be destroyed. Unfortunately, at this high intensity the healthy tissue that the rays pass through on the way to the tumor will also be destroyed. At lower intensities, the rays are harmless to healthy tissue, but they will not affect the tumor either. What type of procedure might be used to destroy the tumor with the rays, and at the same time avoid destroying the healthy tissue?

10% solve

Adapted from K. Duncker by Gick, M. L., and K. J. Holyoak in "Analogical problem solving." *Cognitive Psychology* 12, no. 3 (1980): 306-355.

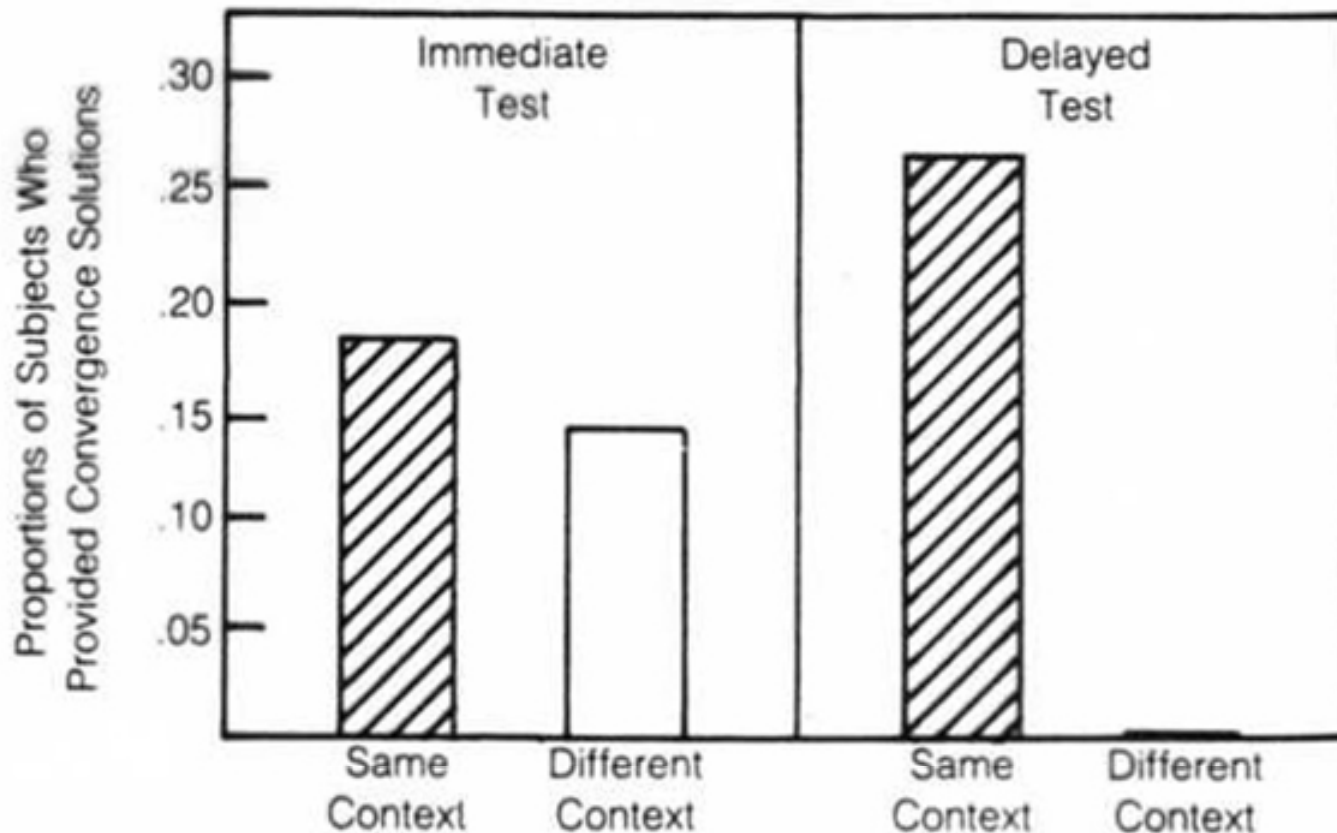
A dictator ruled a small country from a fortress. The fortress was situated in the middle of the country and many roads radiated outward from it, like spokes on a wheel. A great general vowed to capture the fortress and free the country of the dictator. The general knew that if his entire army could attack the fortress at once it could be captured. But a spy reported that the dictator had planted mines on each of the roads. The mines were set so that small bodies of men could pass over them safely, since the dictator needed to be able to move troops and workers about, however, any large force would detonate the mines. Not only would this blow up the road, but the dictator would destroy many villages in retaliation. A full-scale direct attack on the fortress therefore seemed impossible.

The general, however, was undaunted. He divided his army up into small groups and dispatched each group to the head of a different road. When all was ready he gave the signal, and each group charged down a different road. All of the small groups passed safely over the mines, and the army then attacked the fortress in full strength. In this way the general was able to capture the fortress.



An outline of Holyoak's model of analogical correspondences between the tumor problem and the fortress problem.

100% explicit transfer (warning)
35% implicit transfer (no warning)
structural vs. surface similarity



Transfer when solving similar types of problems, as function of
 (1) immediate vs. delayed after training problems
 (2) same vs. different context
 (Data from Spencer and Weisberg, 1986).

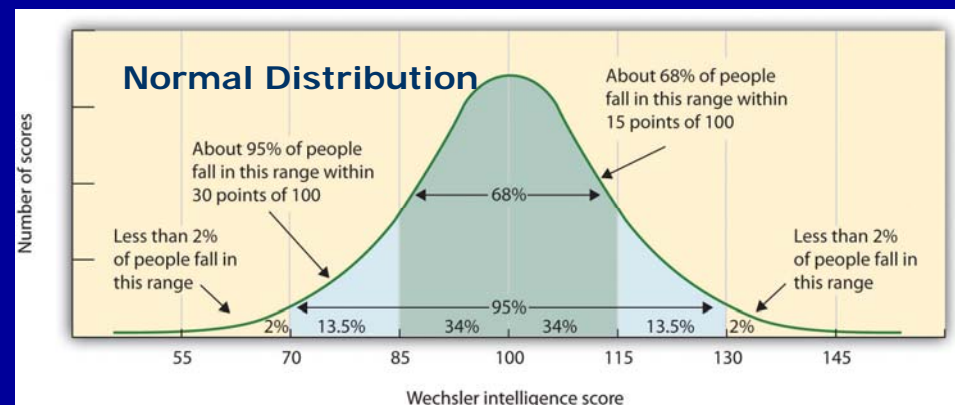
The instructors in a flight school adopted a policy of consistent positive reinforcement recommended by psychologists. They verbally reinforced each successful execution of a flight maneuver. After some experience with this training approach, the instructors claimed that contrary to psychological doctrine, high praise for good execution of complex maneuvers typically results in a decrement of performance on the next try.

Are they correct?

Adapted from Kahneman, D., and A. Tversky. "On the psychology of prediction."
Psychological Review 80, no. 4 (Jul 1973): 237-251.

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regression to the mean



Source: Stangor, C. *Introduction to Psychology*. Flatworld Knowledge, 2010. Courtesy of Flatworld Knowledge.

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Regression to the mean

Is there a hot hand in sports?

Judgment and Decision Making

Algorithms vs. heuristics

- representativeness •
- availability
- anchoring & adjustment
- framing

Suppose that you have a normal penny with a head (H) and a tail (T). You toss it six times. Which of these outcomes is most likely?

- a) H H H H H H**
- b) H H H T T T**
- c) T H H T H T**
- d) can't tell**
- e) all the same**

Suppose that you have a normal penny with a head (H) and a tail (T). You toss it six times. Which of these outcomes is most likely ?

- a) H H H H H H
- b) H H H T T T
- c) T H H T H T
- d) can't tell
- e) all the same***

There are 30 people in a group. You get the month and date of each person's birthday. What is the approximate probability that two of the people will have the exact same birthday?

- a) 90%**
- b) 70%**
- c) 50%**
- d) 30%**
- e) 10%**

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a) 90%

b) 70%***

c) 50%

d) 30%

e) 10%

Imagine a college in which the average height of men was 175 cm. You randomly measure the heights of 3 men. Which of these two outcomes is more likely:

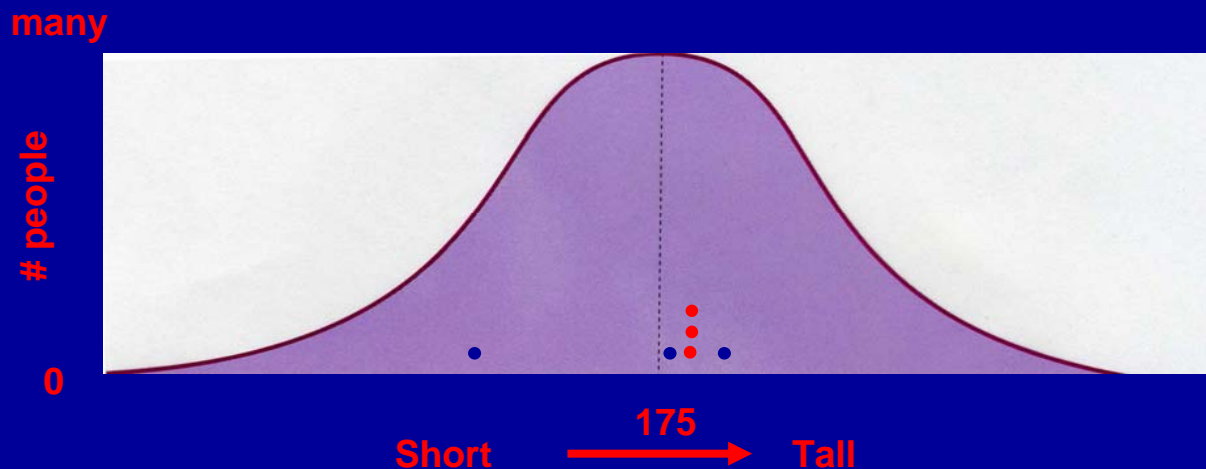
**A. John - 178 cm; Mike 170 cm;
Bob 176 cm**

**B. John - 177 cm; Mike 177 cm;
Bob 177 cm**

Imagine a college in which the average height of men was 175 cm. You randomly measure the heights of 3 men. Which of these two outcomes is more likely:

A. John - 178 cm; Mike 170 cm; Bob 176 cm **(selected by 178/188 subjects)** 3 cm

B. John - 177 cm; Mike 177 cm; Bob 177 cm ***** 40% more likely** 2 cm



A nearby town is served by two hospitals. About 45 babies are born each day in the larger hospital. About 15 babies are born each day in the smaller hospital. Approximately 50% of all babies are boys (as you know). However, the exact percentage of babies who are boys will vary from day to day. Some days it may be higher than 50%, some days it may be lower. For a period of one year, both the larger hospital and the smaller hospital recorded the number of days on which more than 60% of the babies born were boys. Which hospital do you think recorded more such days?

- A. The larger hospital**
- B. The smaller hospital**
- C. About the same (within 5% of each other)**

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- A. The larger hospital
- B. The smaller hospital
- C. About the same (within 5% of each other)**
most common answer

Law of Large Numbers vs. Law of small numbers

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. Now rank the following options in terms of their likelihood in describing Linda. Give a ranking of 1 to the most likely option and a ranking of 8 to the least likely option:

- a. _____ Linda is a teacher in elementary school**
- b. _____ Linda works in a bookstore and takes Yoga classes**
- c. _____ Linda is active in the feminist movement**
- d. _____ Linda is a psychiatric social worker**
- e. _____ Linda is a member of the League of Women Voters**
- f. _____ Linda is a bank teller**
- g. _____ Linda is an insurance salesperson**
- h. _____ Linda is a bank teller and is active in the feminist movement**

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. Now rank the following options in terms of their likelihood in describing Linda. Give a ranking of 1 to the most likely option and a ranking of 8 to the least likely option:

f. _____ Linda is a bank teller

h. _____ Linda is a bank teller and is active in the feminist movement

more likely – conjunction fallacy undergrads

first year grad students with a stats course

doctoral students in decision science program at business school

Judgment and Decision Making

Algorithms vs. heuristics

- representativeness
- availability •
- anchoring & adjustment
- framing

Some experts studied the frequency of appearance of various letters in the English language. They studied a typical passage in English and recorded the relative frequency with which various letters of the alphabet appeared in the first and the third positions in words. For example, in the word *language*, L appears in the first position and N appears in the third position. In this study, words with less than three letters were not examined. Consider the letter K.

Do you think that the letter K is more likely to appear in the first position or in the third position? Now estimate the ratio for the number of times it appeared in the first position in comparison to the number of times it appeared in the third position; if you guess 1:2, this means that it appeared in the third position twice as often as in the first position.

Your estimate: ____ : ____

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Your estimate: 2 : 1

Really 1:2 kind vs. like

***More likely to drown in bathtub or die
from terrorist attack in US?***

	BRAIN TUMOR	
DIZZINESS	<i>Present</i>	<i>Absent</i>
<i>Present</i>	160	40
<i>Absent</i>	40	10

Is dizziness associated with having a brain tumor?

	BRAIN TUMOR	
DIZZINESS	<i>Present</i>	<i>Absent</i>
<i>Present</i>	160	40
<i>Absent</i>	40	10

Is dizziness associated with having a brain tumor?

Most say “yes” – answer is “no”

Pr of tumor given dizziness = 4:1; Pr without = 4:1

Imagine that XYZ syndrome is a serious condition that affects one person in 1,000. Imagine also that the test to diagnose the disease always indicates correctly that a person who has the XYZ virus actually has it. Finally, suppose that this test occasionally misidentifies a healthy individual as having XYZ. The test has a false positive rate of 5%, meaning that the test wrongly indicates that the XYZ virus is present in 5% of the cases where the person does not have the virus.

Choose a person at random, administer test, and person tests positive for XYZ syndrome. What is probability (0-100%) that the person really has XYZ?

Stanovich, K. E. "Rational and Irrational Thought: The Thinking That IQ Tests Miss." *Scientific American Mind* 20 (2009): 34-39.

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Most common answer = 95%, wrong

1/1000 base rate; other 999 are tested, about 50 (.05 x 999) will be told they have XYZ; for every 51 who test positive, only 1 has it; answer = 1/51, about 2%.

Judgment and Decision Making

Algorithms vs. heuristics

- representativeness
- availability
- anchoring & adjustment •
- framing

Estimate the answer to this multiplication problem (spend no more than 5 seconds doing the estimate)

$$8 \times 7 \times 6 \times 5 \times 4 \times 3 \times 2 \times 1 = \underline{\hspace{2cm}}$$

or

$$1 \times 2 \times 3 \times 4 \times 5 \times 6 \times 7 \times 8 = \underline{\hspace{2cm}}$$

Estimate the answer to this multiplication problem (spend no more than 5 seconds doing the estimate)

$$8 \times 7 \times 6 \times 5 \times 4 \times 3 \times 2 \times 1 = \underline{2250}$$

or

$$1 \times 2 \times 3 \times 4 \times 5 \times 6 \times 7 \times 8 = \underline{512}$$

40,320

How many African nations are there in the U.N.?

Wheel of fortune from 1 to 100

More or Less? How many?

wheel - 65 UN estimate 45

wheel - 10 UN estimate 25

Is the Mississippi River longer or shorter than 500 miles? How long is it actually, do you think?

or

Is the Mississippi River longer or shorter than 5000 miles? How long is it actually, do you think?

Is the Mississippi River longer or shorter than 500 miles? How long is it actually, do you think? 1000

or

Is the Mississippi River longer or shorter than 5000 miles? How long is it actually, do you think? 2000

2348 miles

Judgment and Decision Making

Algorithms vs. heuristics

- representativeness
- availability
- anchoring & adjustment
- framing •

Imagine that the United States is preparing for the outbreak of an unusual South American disease, which is expected to kill 600 people. Two alternative programs to combat the disease have been proposed. Assume that the exact scientific estimate of the consequences of the programs are as follows:

If Program A is adopted, 200 people will be saved.

If Program B is adopted, there is a one-third probability that 600 people will be saved, and a two-thirds probability that no people will be saved.

Which Program do you favor?

Adapted from Tversky, A., and D. Kahneman. "The framing of decisions and the psychology of choice." *Science* 211, no. 4481 (1981): 453-458.

Imagine that the United States is preparing for the outbreak of an unusual South American disease, which is expected to kill 600 people. Two alternative programs to combat the disease have been proposed. Assume that the exact scientific estimate of the consequences of the programs are as follows:

If Program A is adopted, 400 people will die.

If Program B is adopted, there is a one-third probability that nobody will die, and a two-thirds probability that 600 people will die.

Which Program do you favor?

Adapted from Tversky, A., and D. Kahneman. "The framing of decisions and the psychology of choice." *Science* 211, no. 4481 (1981): 453-458.

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If Program A is adopted, 200 people will be saved. **(72%) - Lives saved**

If Program B is adopted, there is a one-third probability that 600 people will be saved, and a two-thirds probability that no people will be saved.

Which Program do you favor?

If Program A is adopted, 400 people will die. **(22%) - Lives lost**

If Program B is adopted, there is a one-third probability that nobody will die, and a two-thirds probability that 600 people will die.

Which Program do you favor?

Would you rather have

(a) a sure gain of \$75 or

(b) a lottery with 75% chance of winning \$100 and 25% chance of winning nothing at all

or

(a) a sure loss of \$75 or

(b) a lottery with 75% chance of losing \$100 and 25% chance of losing nothing at all

Would you rather have

*84% (a) a sure gain of \$75 or

(b) a lottery with 75% chance of winning \$100 and 25% chance of winning nothing at all

(a) a sure loss of \$75 or

*87% (b) a lottery with 75% chance of losing \$100 and 25% chance of losing nothing at all

risk averse for gains

risk taking for losses

Jack is looking at Anne, but Anne is looking at George. Jack is married, but George is not. Is a married person looking at an unmarried person?

A) Yes

B) No

C) Cannot be determined

Jack is looking at Anne, but Anne is looking at George. Jack is married, but George is not. Is a married person looking at an unmarried person?

A) Yes**

B) No

C) Cannot be determined (>80%)

Anne – marital status unknown

If married (A), she is looking at unmarried George

If unmarried (A), married Jack looking at unmarried Anne.

FULLY DISJUNCTIVE REASONING – all possibilities

A bat and a ball cost \$1.10 in total. The bat costs \$1 more than the ball. How much does the ball cost?

A bat and a ball cost \$1.10 in total. The bat costs \$1 more than the ball. How much does the ball cost?

10 cents most common answer

But then bat would have to cost \$1.10 and total would be \$1.20.

Imagine that the U.S. Department of Transportation has found that a particular German car is eight times more likely than a typical family car to kill occupants of another car in a crash. The federal government is considering restricting sale and use of this German car. Do you think sales of the German car should be banned in the U.S.? Do you think the German car should be banned from being driven on US streets?

Stanovich, K. E. "Rational and Irrational Thought: The Thinking That IQ Tests Miss."
Scientific American Mind 20 (2009): 34-39.)

Imagine that the U.S. Department of Transportation has found that the Ford Explorer is eight times more likely than a typical family car to kill occupants of another car in a crash. The German government is considering restricting sale and use of the Ford Explorer. Do you think sales of the Ford Explorer should be banned in the Germany? Do you think the Ford Explorer should be banned from being driven on German streets?

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American subjects

**German car, off the streets in U.S. –
73.7%**

**American car, off the streets in
Germany – 39.2%**

PERSPECTIVE

FRONTAL LOBES & THINKING

Frontal Lobes

1. Primary and Premotor areas
2. Orbitofrontal (desires)
3. Dorsolateral (decisions)

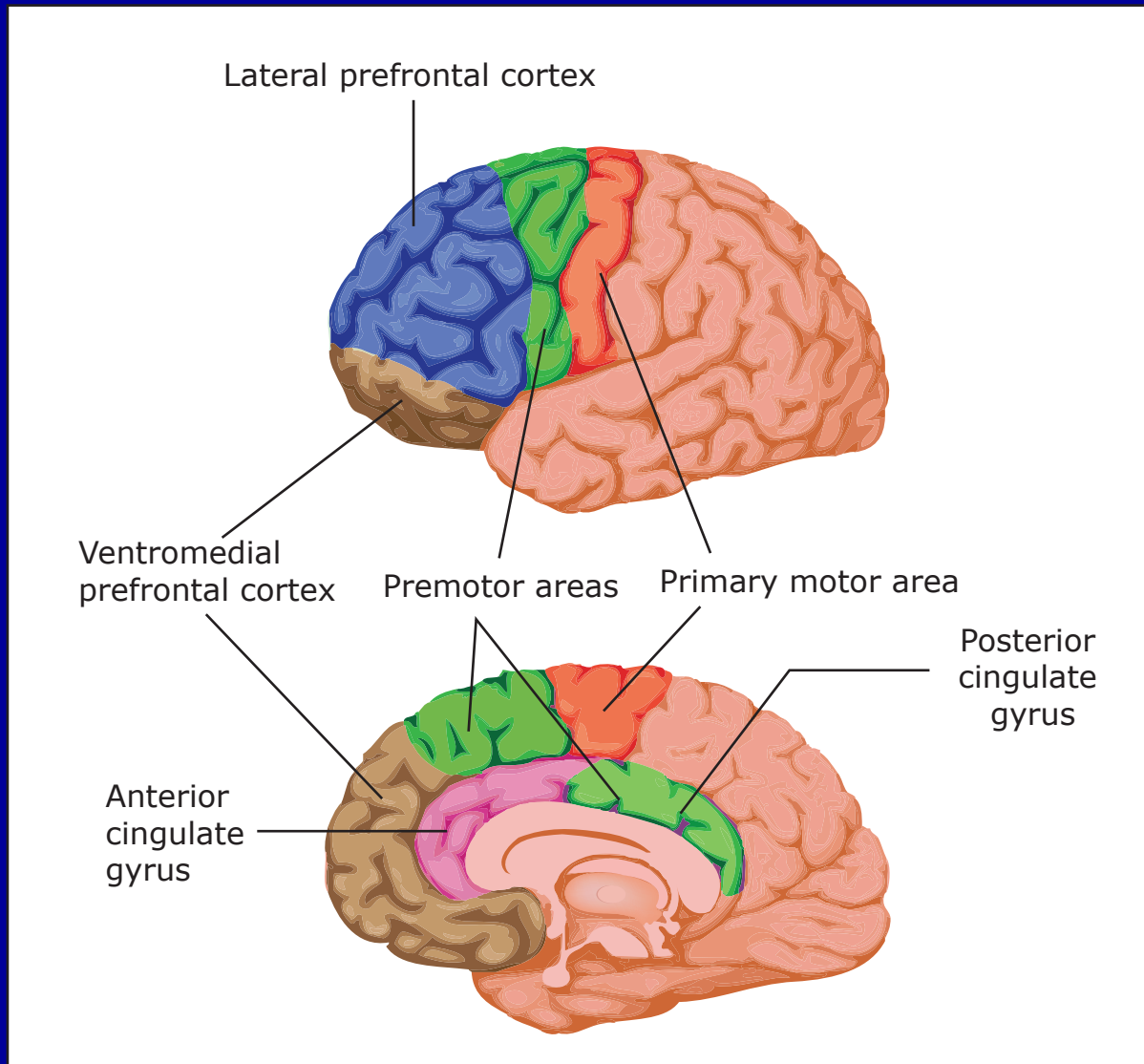

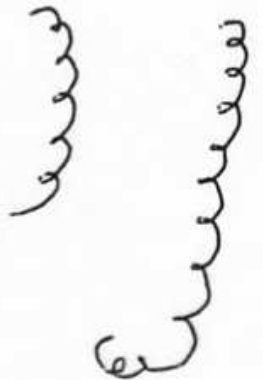


Image by MIT OpenCourseWare.

 = Model

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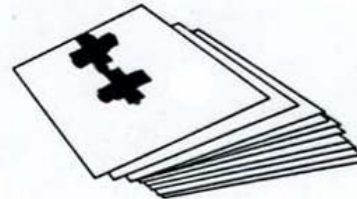
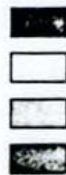
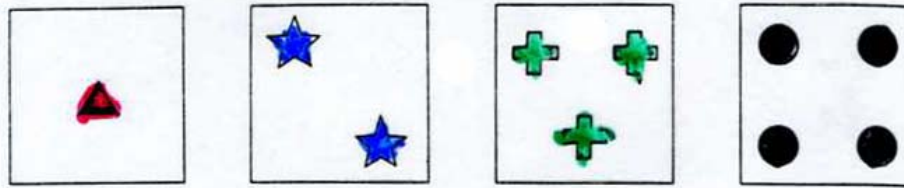
 = Model

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Perseveration on tasks of repetitive writing in a patient with a right frontal lobe gunshot wound.

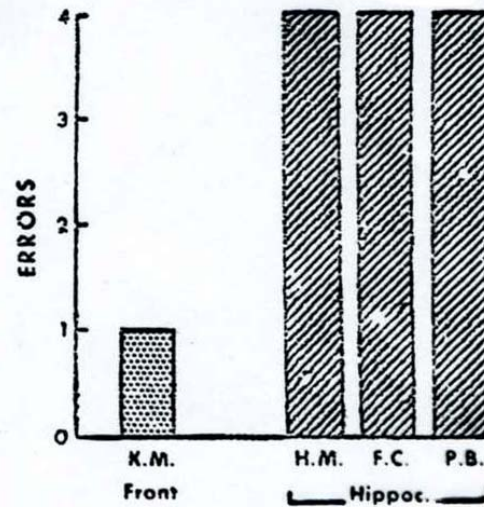
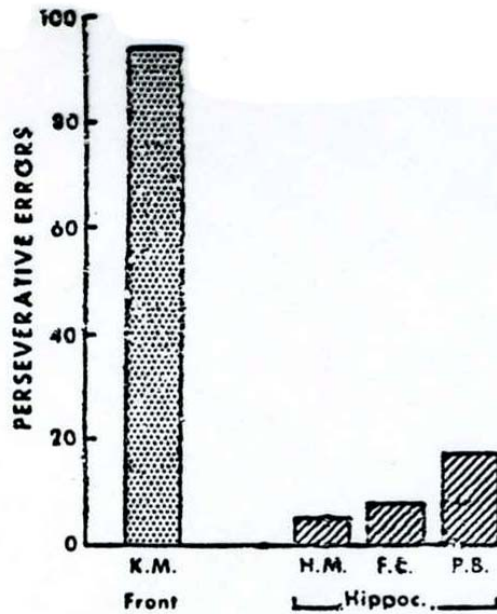
Cartoon illustrating the Wisconsin Card Sorting Task removed due to copyright restrictions. Fig 12.4 in Gazzaniga, M. S., R. B. Ivry, and G. R. Mangun. Cognitive Neuroscience. 2nd edition. WW Norton & Co., 2002.

See lecture video.

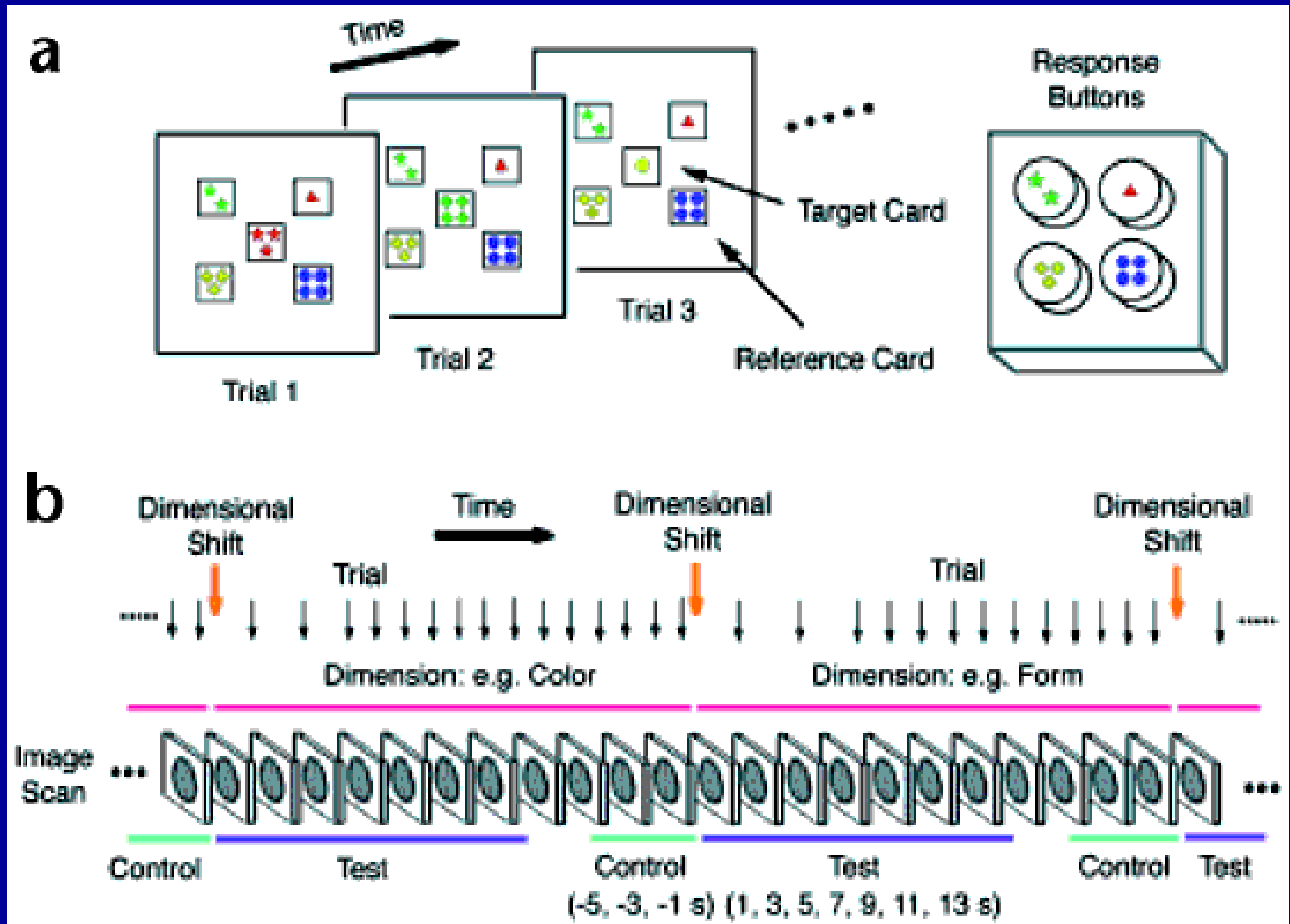


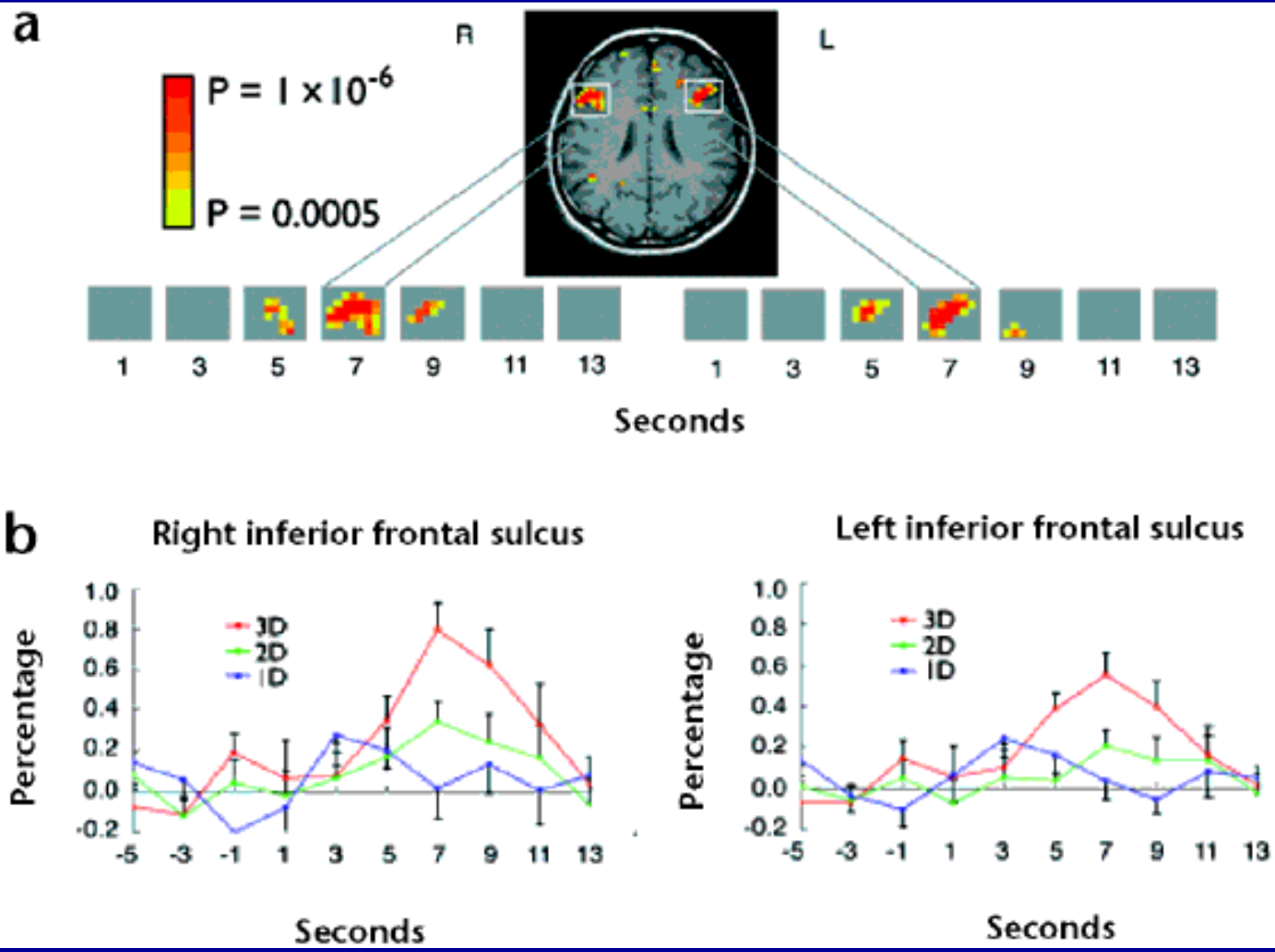
CARD SORTING

FACE RECOGNITION



Source: Milner, B. "Some Effects of Frontal Lobectomy in Man." In *The Frontal Granula Cortex and Behavior*. Edited by J. M. Warren and K. Akert. McGraw-Hill, 1964. © McGraw-Hill. All rights reserved. This content is excluded from our Creative Commons license. For more information, see <http://ocw.mit.edu/fairuse>.





Frontal Lobes & Problem Solving

Card Sorting

- perseveration (motor parallel)
- role of inhibition in selection of actions
- mental flexibility

utilization behavior & ventromedial lesions –
Lhermitte

hammer, nail, picture – patient hangs picture

hypodermic needle, turns around, lowers pants –
patient injects himself

Frontal Lobes & Problem Solving

Estimation

Facts: (Shallice & Evans, 1978)

How long is a man's spine?

How fast does race horse gallop (8/60 mph)

What is the largest object normally found in the house?

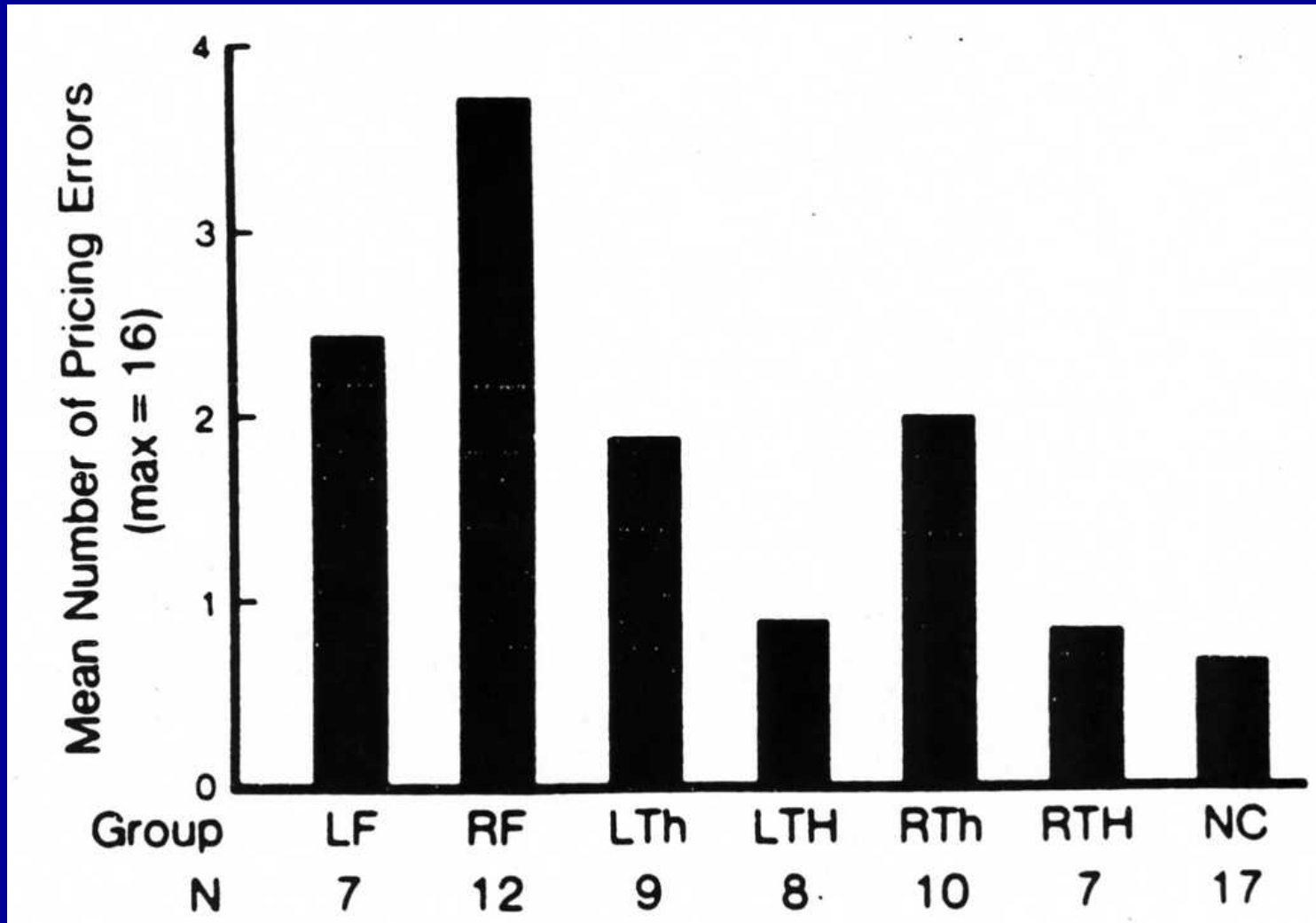
How many camels are there in the Netherlands?

Prices: (Smith & Milner, 1984)

Prices of objects

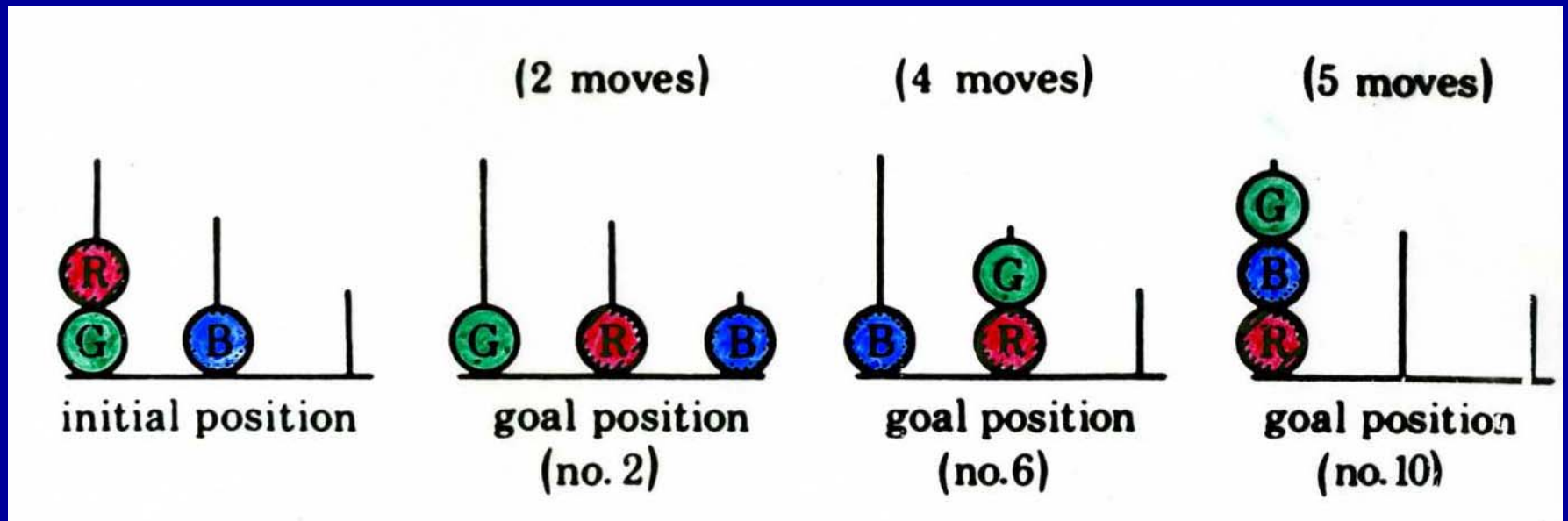
Tower of London (Shallice, 1981)

Pricing Estimation



Smith, M. L., and B. Milner. "Differential effects of frontal-lobe lesions on cognitive estimation and spatial memory." *Neuropsychologia* 22, no. 6 (1984): 697-705.
Courtesy of Elsevier, Inc., <http://www.sciencedirect.com>. Used with permission.

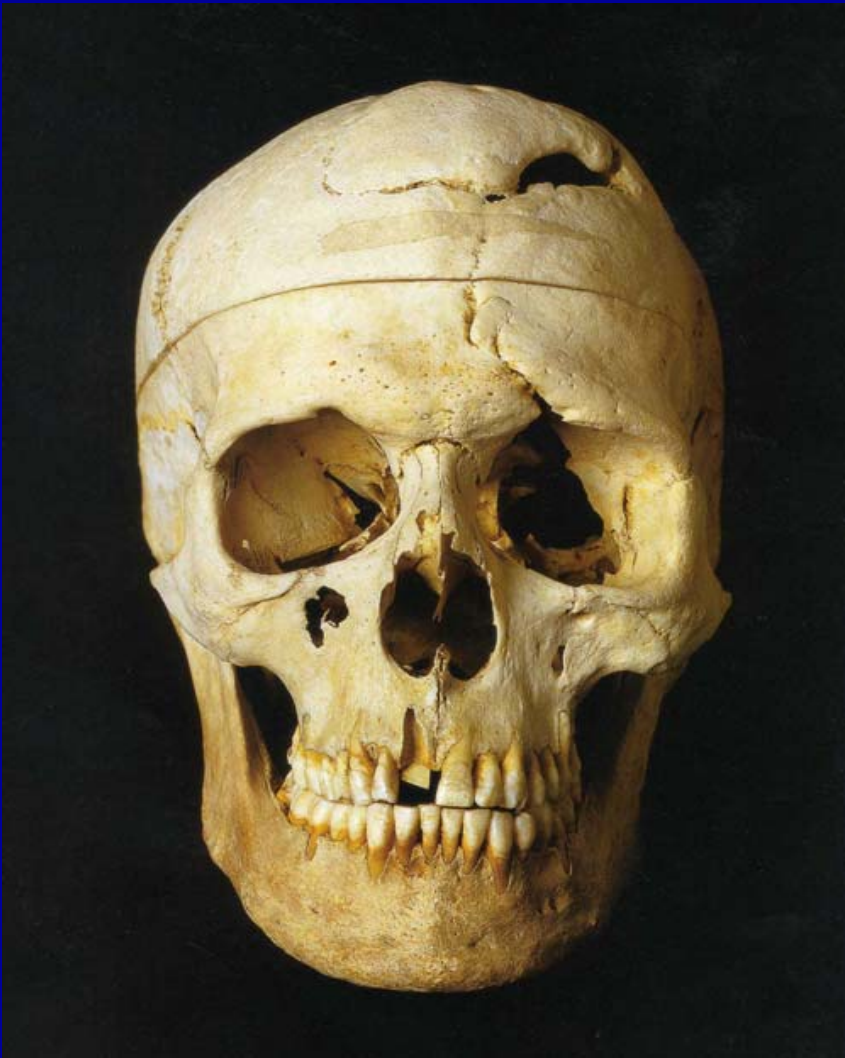
Tower of London



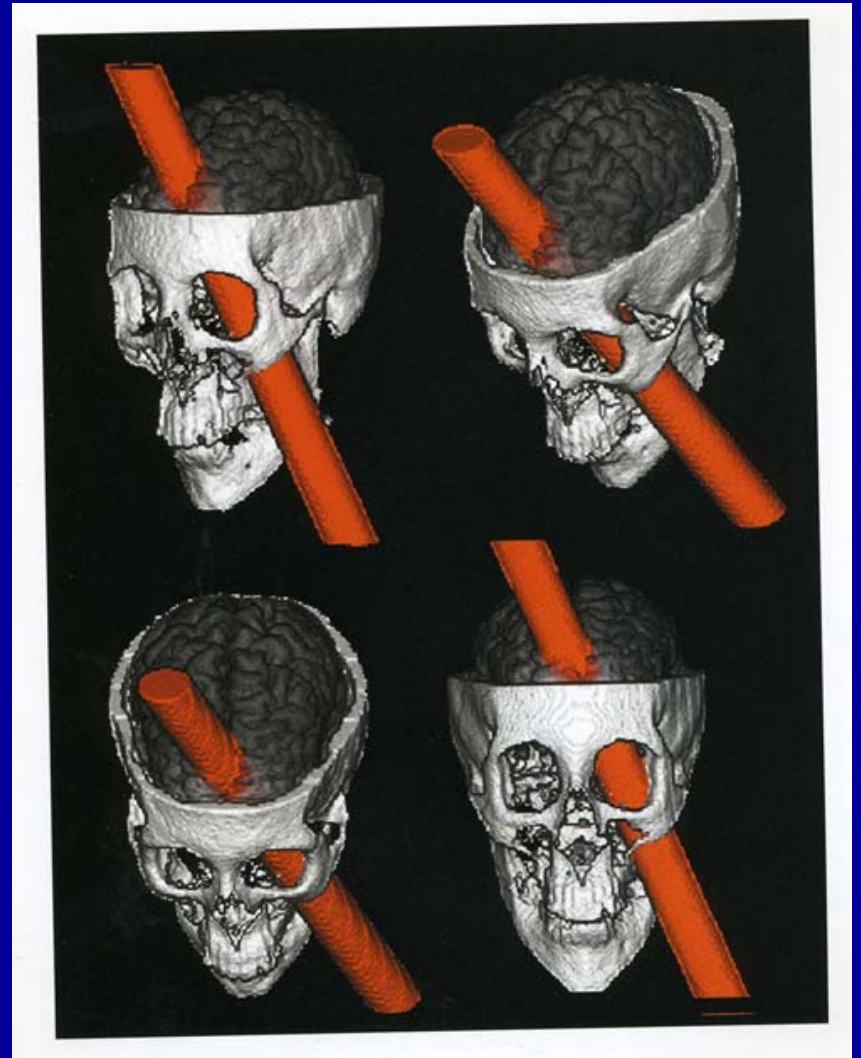
Shallice, T. "Specific impairments of planning."
Phil. Trans. R. Soc. Lond. B 298, no. 1089 (1982): 199-209.

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Phineas Gage



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Orbitofrontal Lesions – Relation of Thoughts and Emotions

1. Phineas Gage

2. Orbitofrontal patients

- GSR is measure of autonomic response – related to sweat – emotional reactivity – used for lie detection
- no GSR in response to faces of family members vs. strangers (opposite of prosopagnosic patients)
- no GSR in response to emotional relative to neutral pictures
- disconnection between thought and emotion

Risk Taking

- low immediate rewards but positive long-term rewards vs. high immediate rewards but higher long-term loss (delayed gratification)
- two decks of cards – pick a card and win or lose \$\$\$\$
 - Pile A – win \$50/lose \$100
 - Pile B – win \$100/lose \$1250
- controls select Pile A over time
- orbitofrontal patients select Pile B
- GSR – goes up as somebody picks up a card – for controls, GSR was large when selecting from risky Pile B – no anticipatory GSR for patients – disconnection between thought and emotion
- same pattern for injuries at 15 months & 3 months when tested as adults

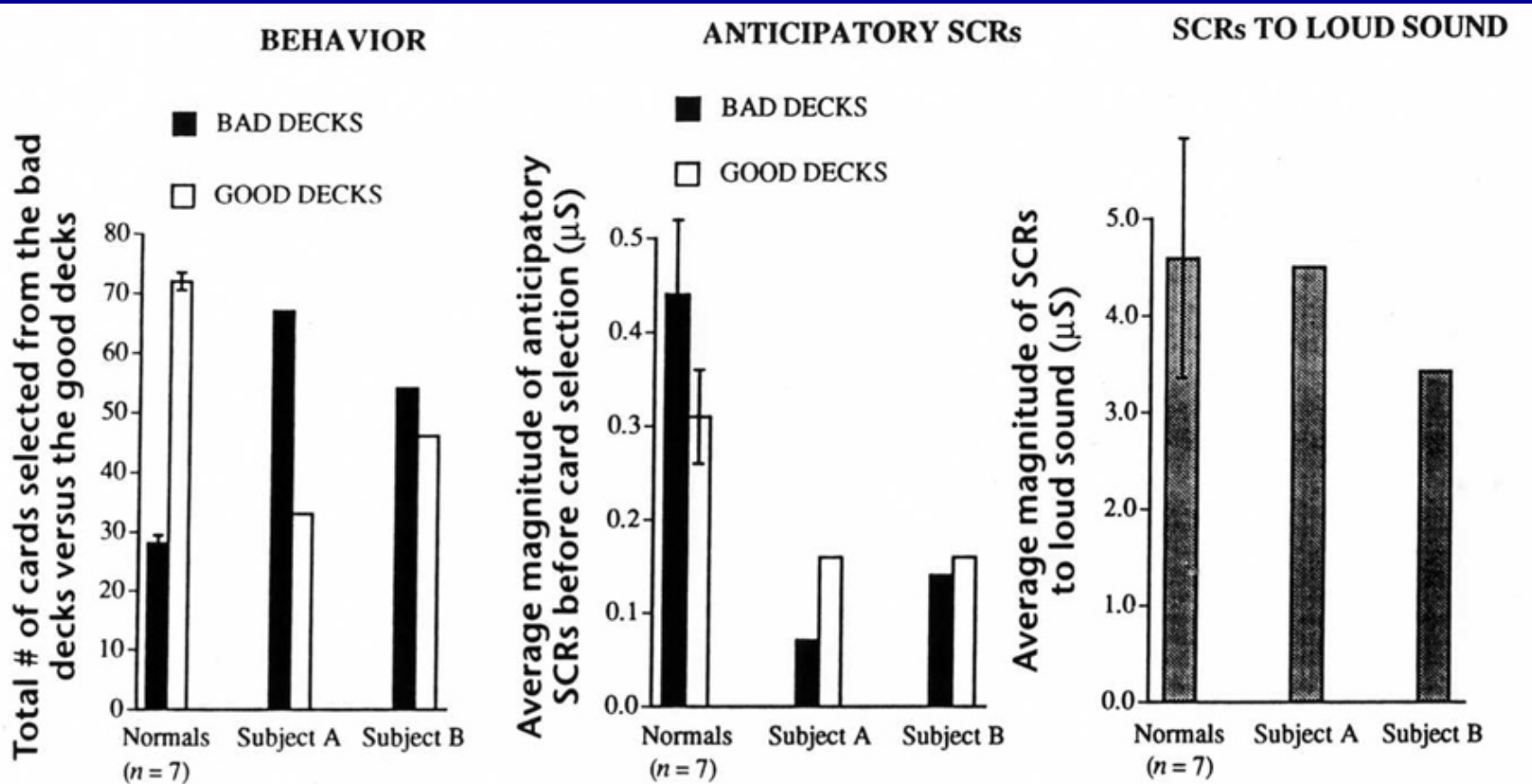


Fig. 2. Experimental decision-making and psychophysiology. (a) Responses on the gambling task. (b) Anticipatory skin conductance responses (SCRs). (c) SCRs to an unconditioned stimulus (sudden onset of 110-dB noise).

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