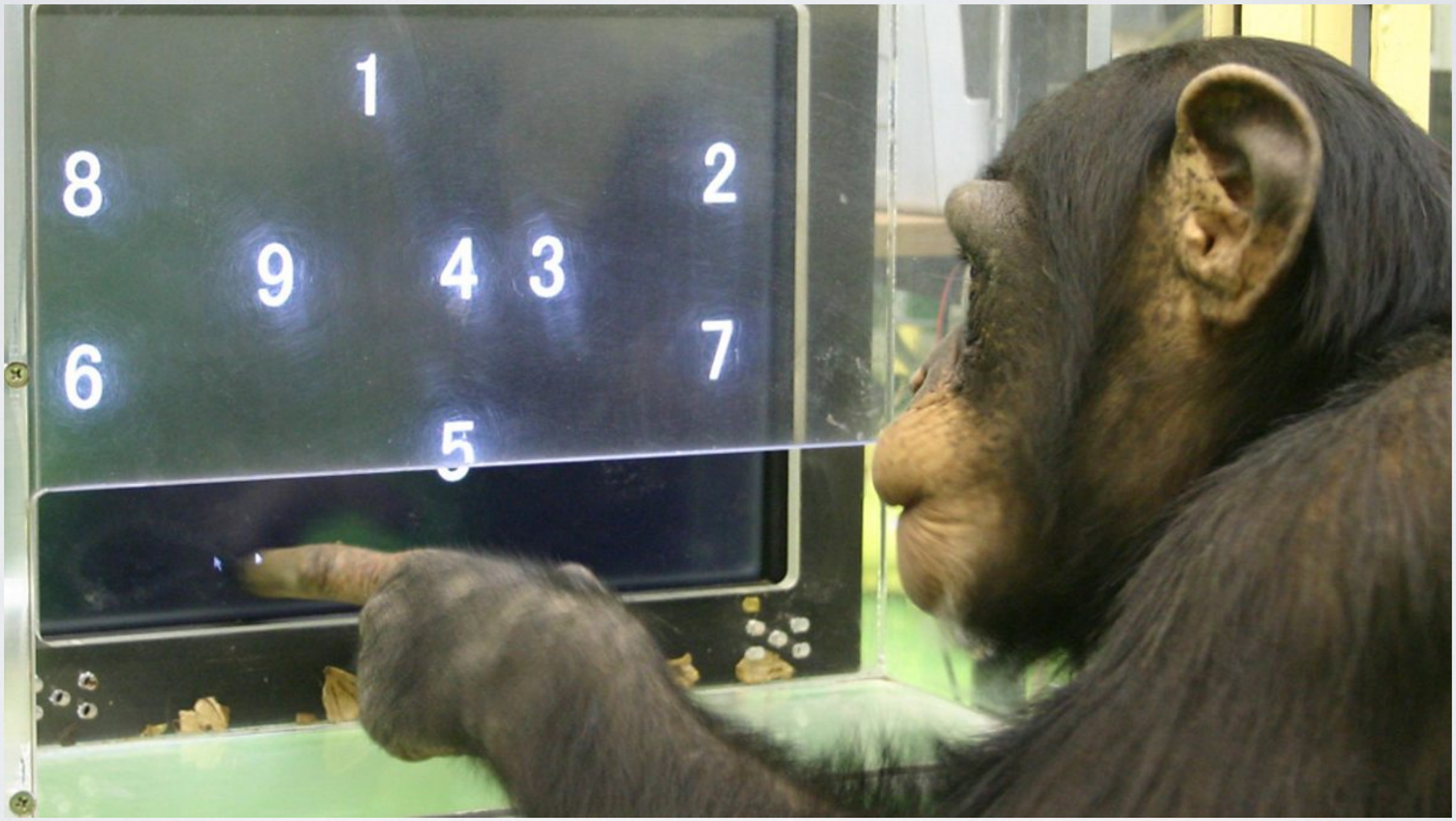
PRIMATE COGNITION:
INSIGHTS FROM THE LAB



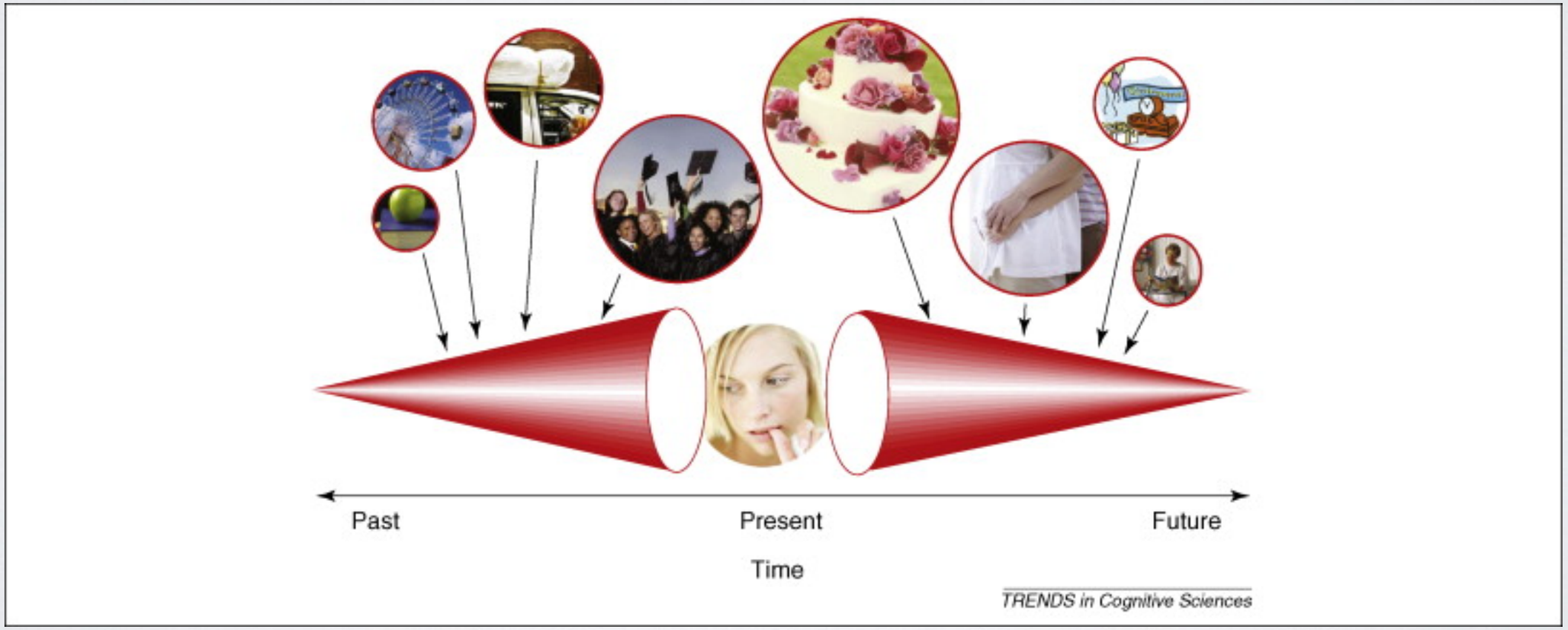
15 Oct 2020

TODAY

- Mental time travel
- Working memory
- Metacognition
- Numeracy

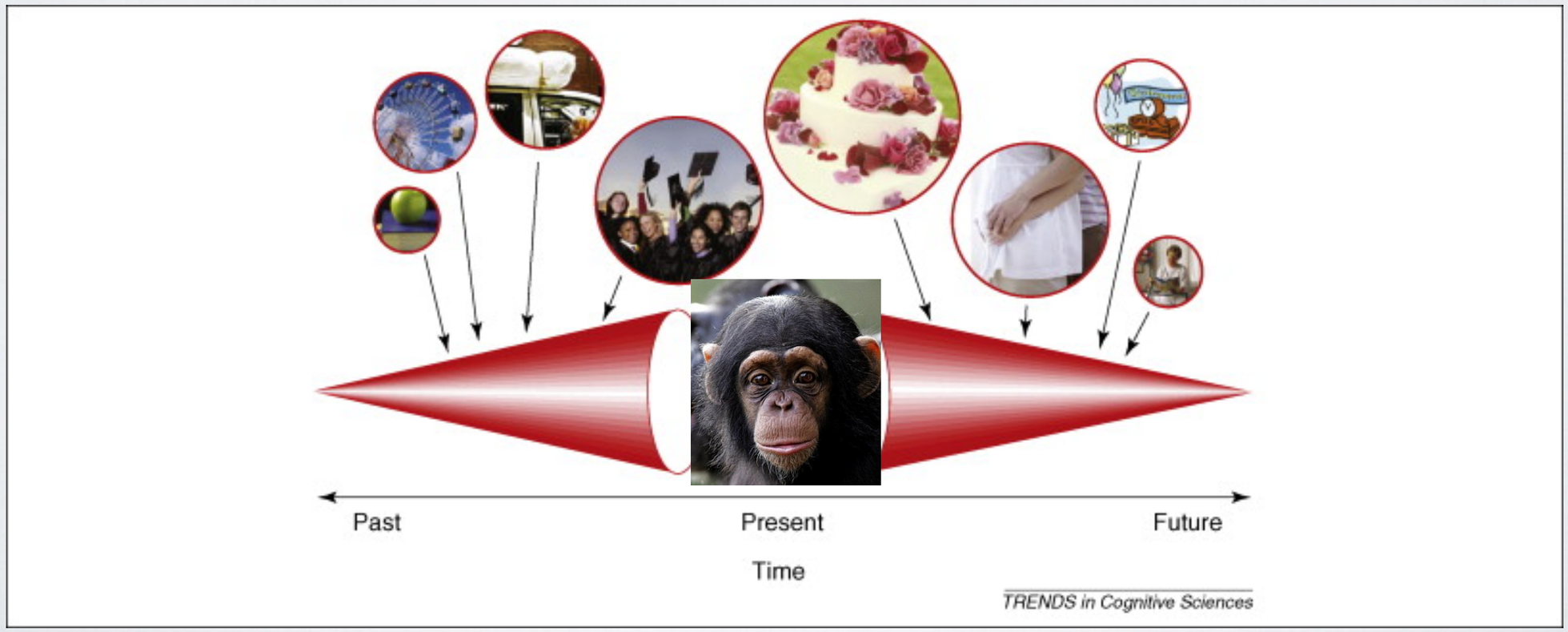
MENTAL TIME TRAVEL

- The ability to mentally transport oneself into the past and future



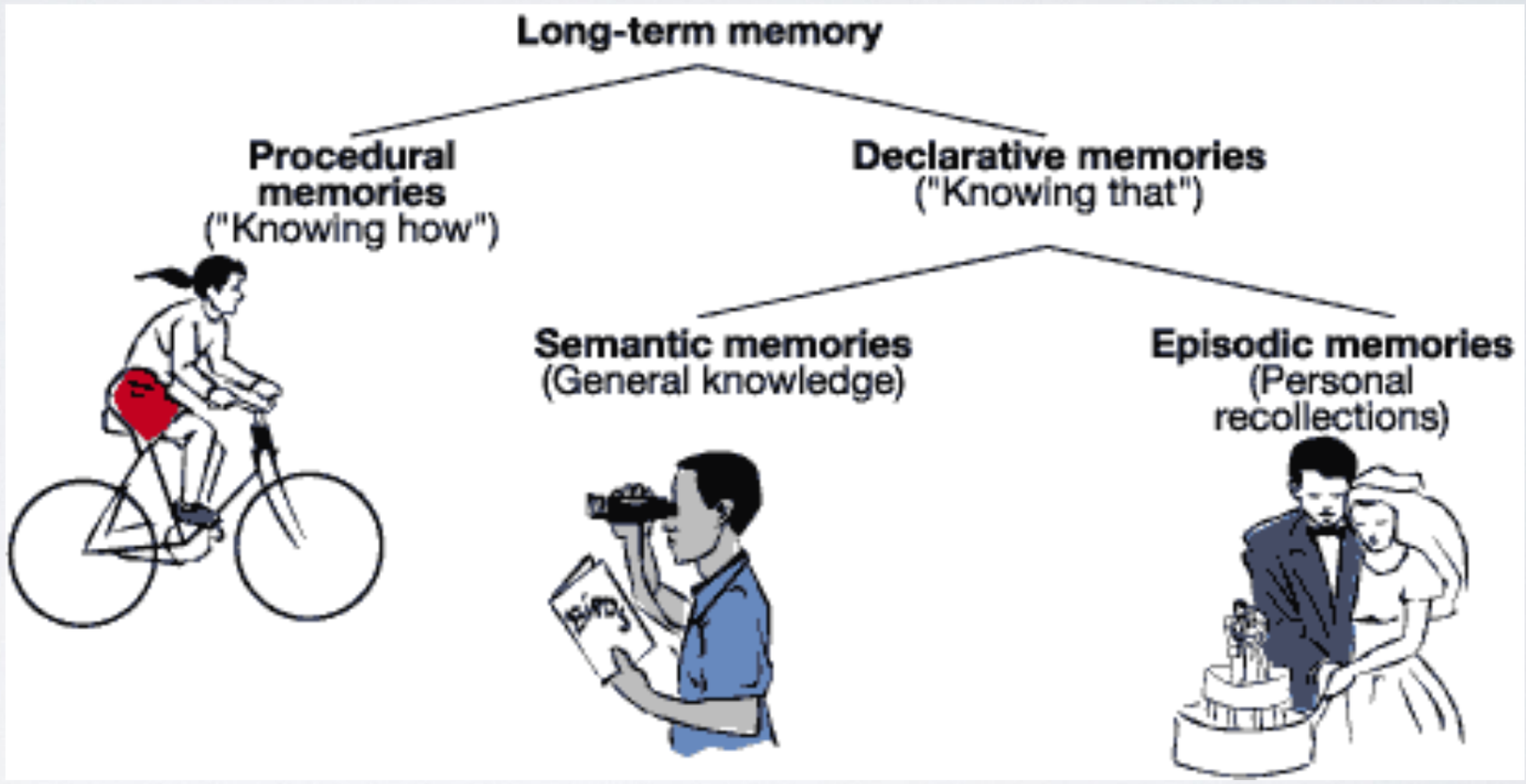
MENTAL TIME TRAVEL

- Can primates relive their memories?
- Can primates plan for the future planning ?



TYPES OF LONG-TERM MEMORY

- Procedural
- Semantic
- Episodic (mental time travel)



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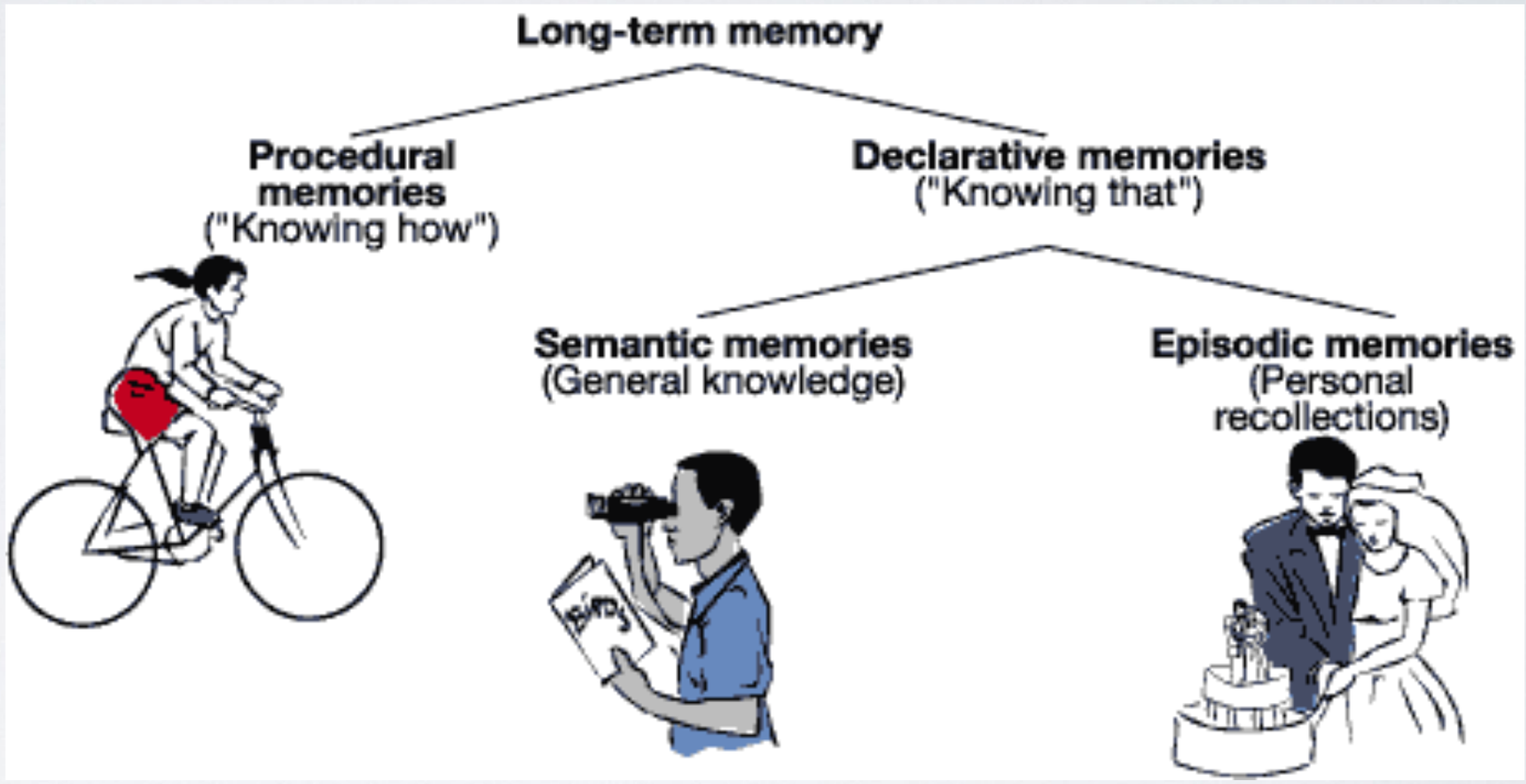


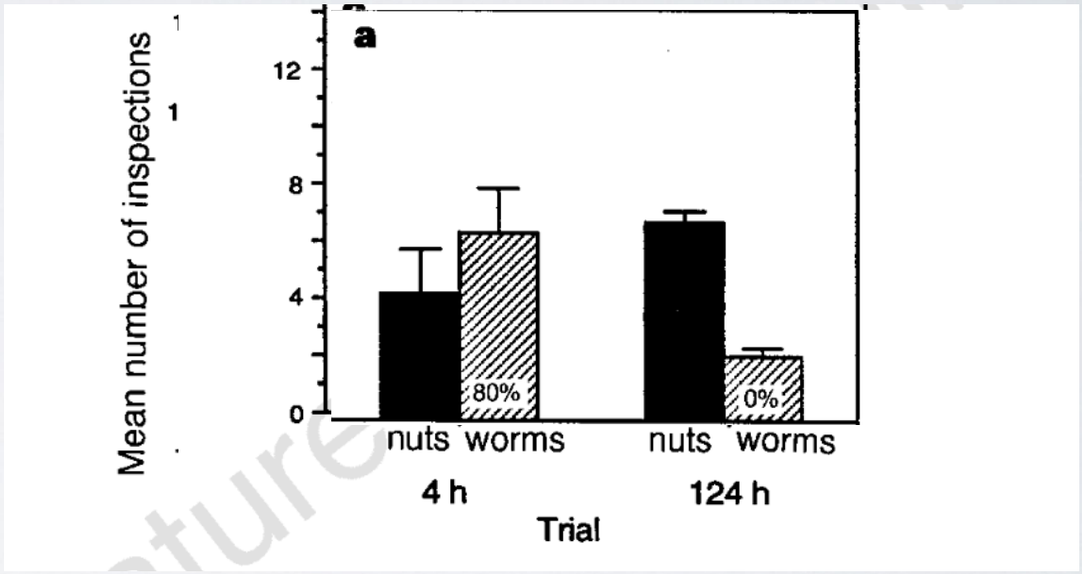
How to test whether primates the ability to mentally travel back into the past and forward into the future?

Without relying on introspection or language, design a study/experiment to test whether an individual's memories are episodic/autonoetic?

Design another experiment to test whether an individual is capable of mentally projecting herself into the future.

INTERROGATION AND DECONSTRUCTION OF MEMORIES

- Scrub jays remember what, when, and where they cached foods.
- Searched appropriately based on properties of the food



WHAT-WHERE-WHEN MEMORIES IN CHIMPANZEES

- Tested in similar paradigm to scrub jays
- Preferred reward (frozen juice) was retrievable after 5 mins, but unretrievable after an hour

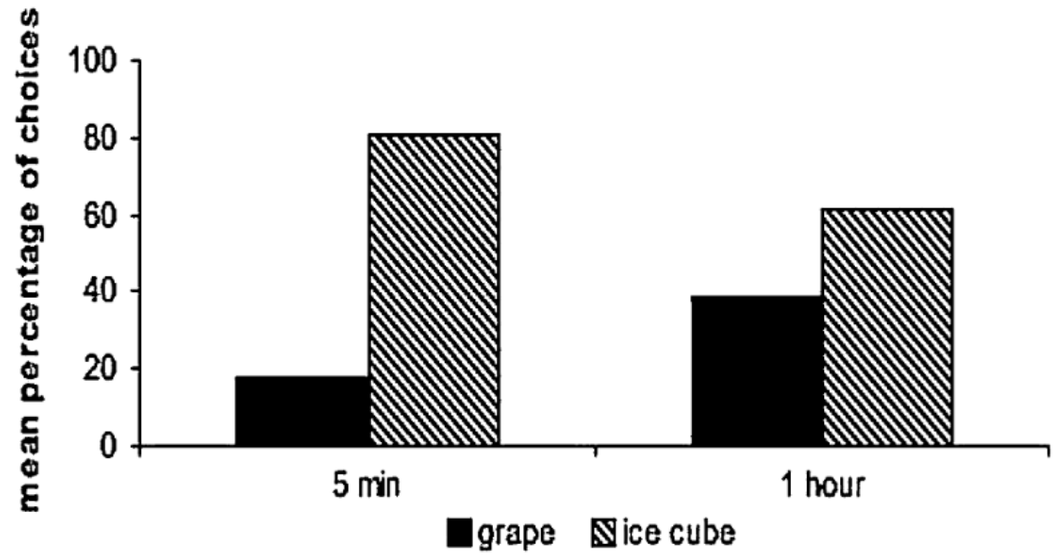


Fig. 2 Mean percentage of choices of frozen juice and grape in the 5-min and 1-h trials

Ordas et al. 2013

WHAT-WHO MEMORIES IN GORILLA

- King was able to recall what he ate and who gave it to him

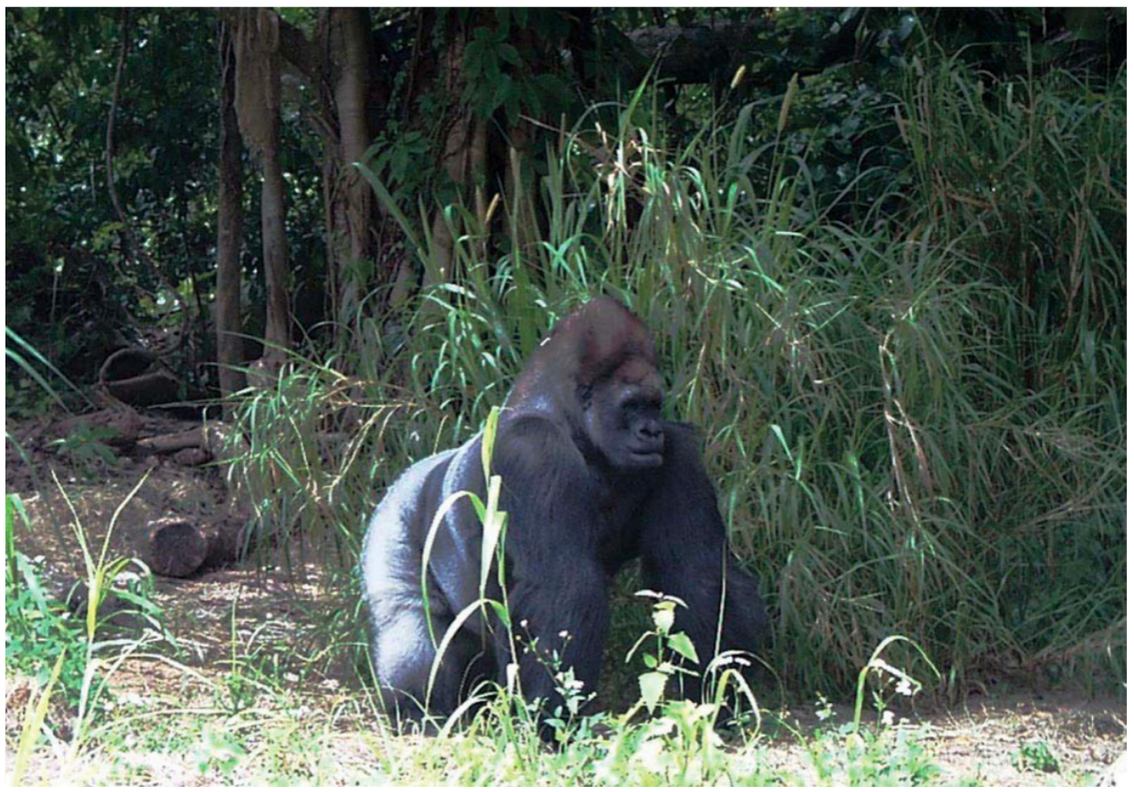


Fig. 1. King, the western lowland gorilla, in his outdoor habitat.

Table 1
King's percent correct (Schwartz et al., 2002)

	Percent correct			
	5-min RI		24-h RI	
	"What"	"Who"	"What"	"Who"
Experiment 1	70%		82%	
Experiment 2	55%	82%	73%	87%

20% is chance baseline for "what" questions; 50% is chance baseline for "who" questions.

SEQUENCE OF EVENTS

- Fed three different foods over 15 minutes.
- Recall for food order tested
- 90% accurate for most recent food; 50% for next most recent; 60% for most distant

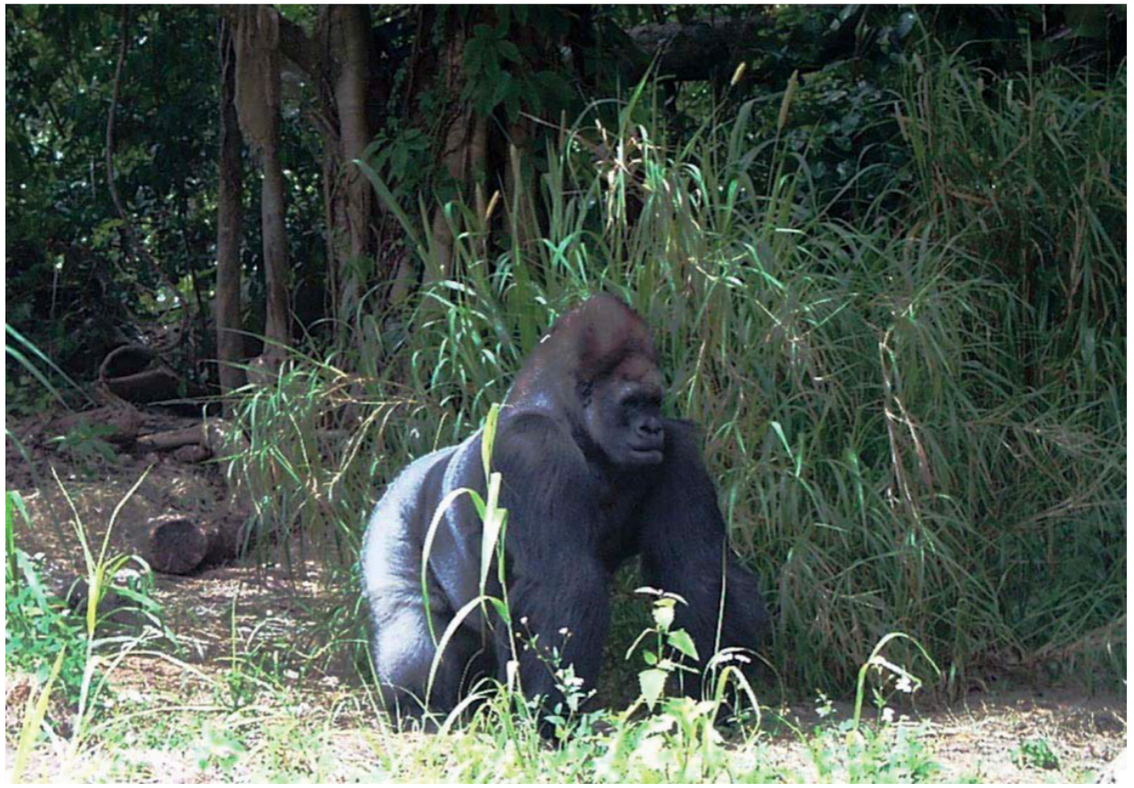
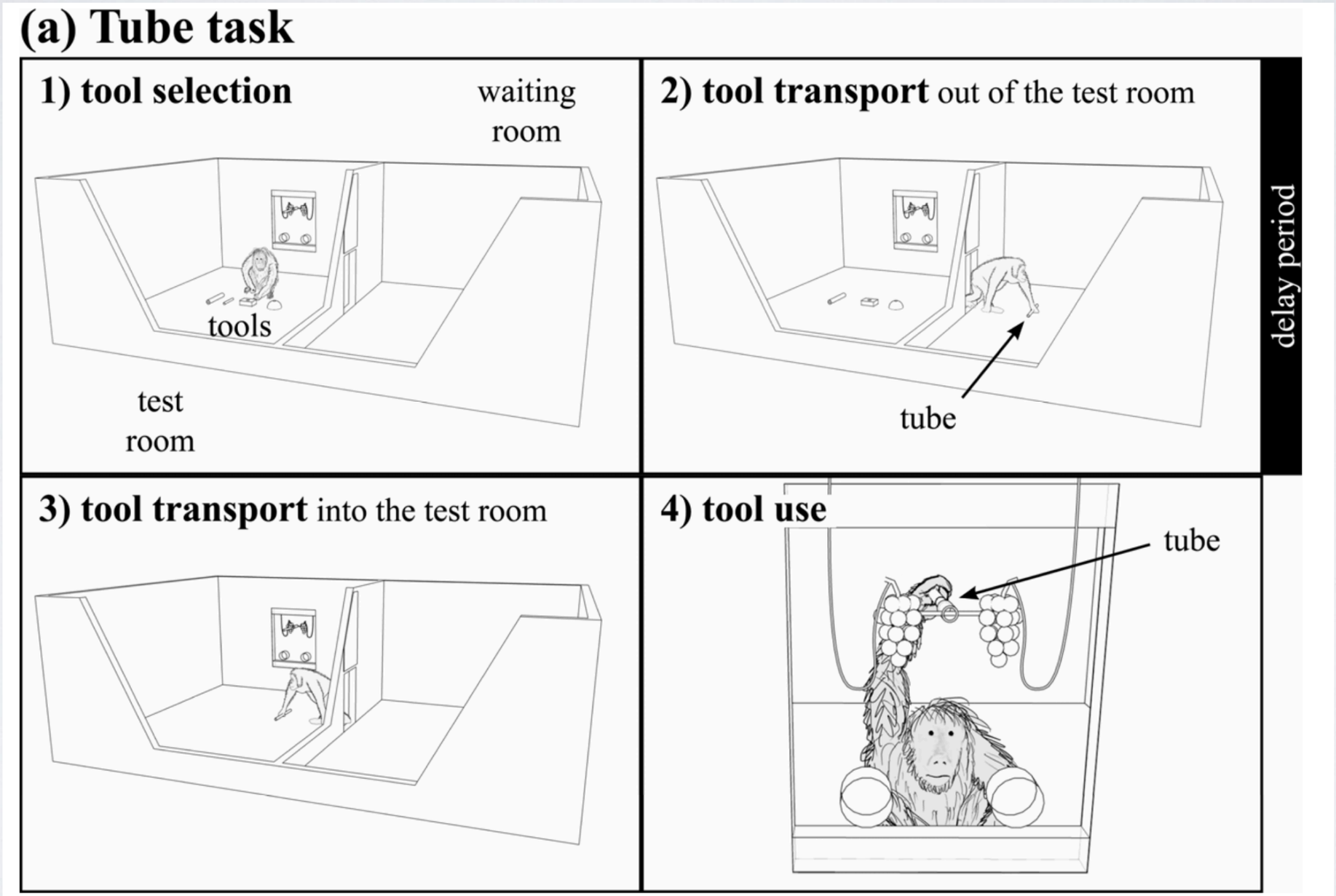


Fig. 1. King, the western lowland gorilla, in his outdoor habitat.

FUTURE PLANNING

- The spoon test

CAN APES PASS THE SPOON TEST?



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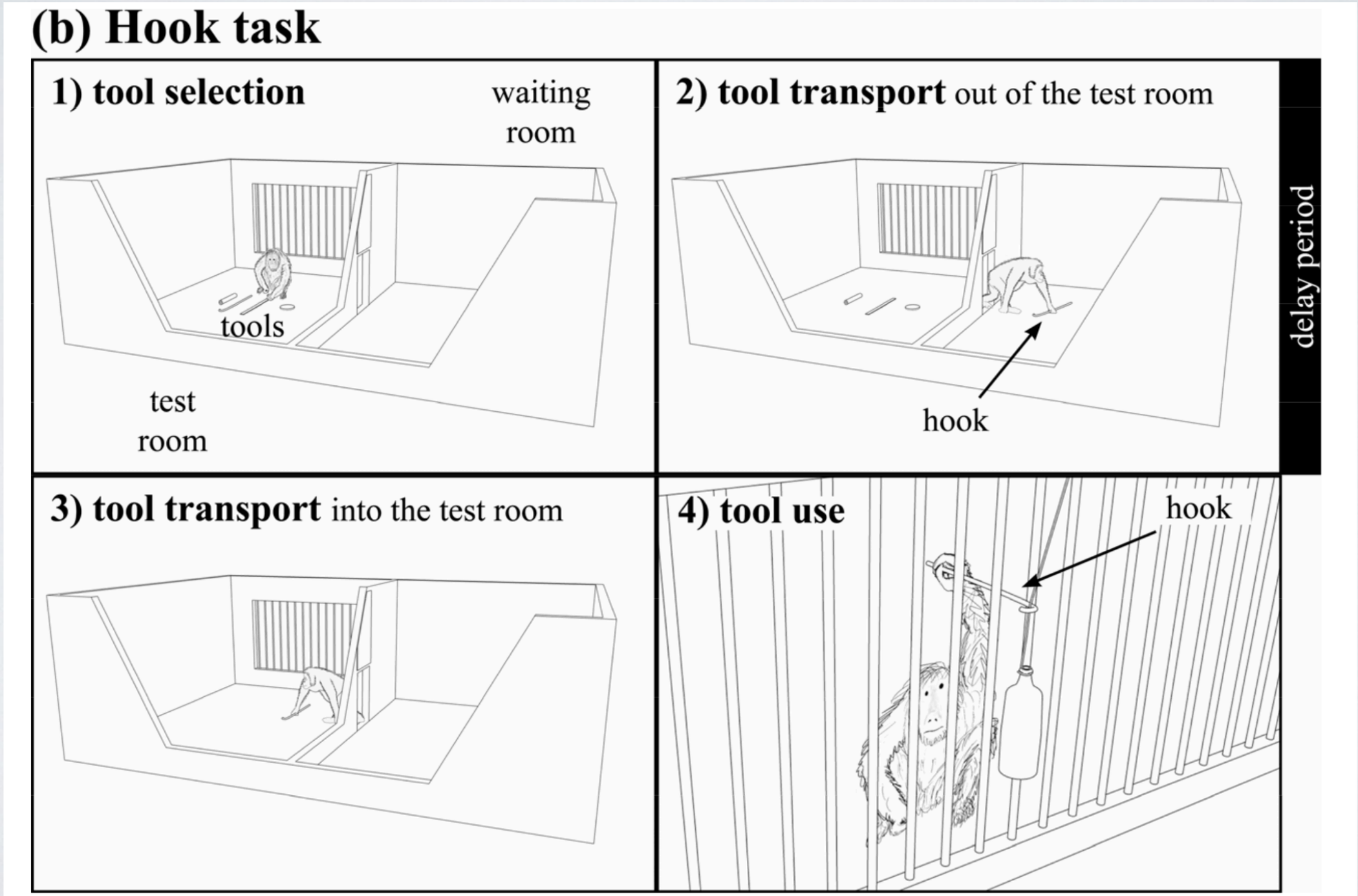


CAN APES PASS THE SPOON TEST?

- Experiment 1: 1-hour delay
- Experiment 2: 14-hour delay
- Experiment 3: Apparatus not visible
- Experiment 4: No use for tools, but reward structure identical

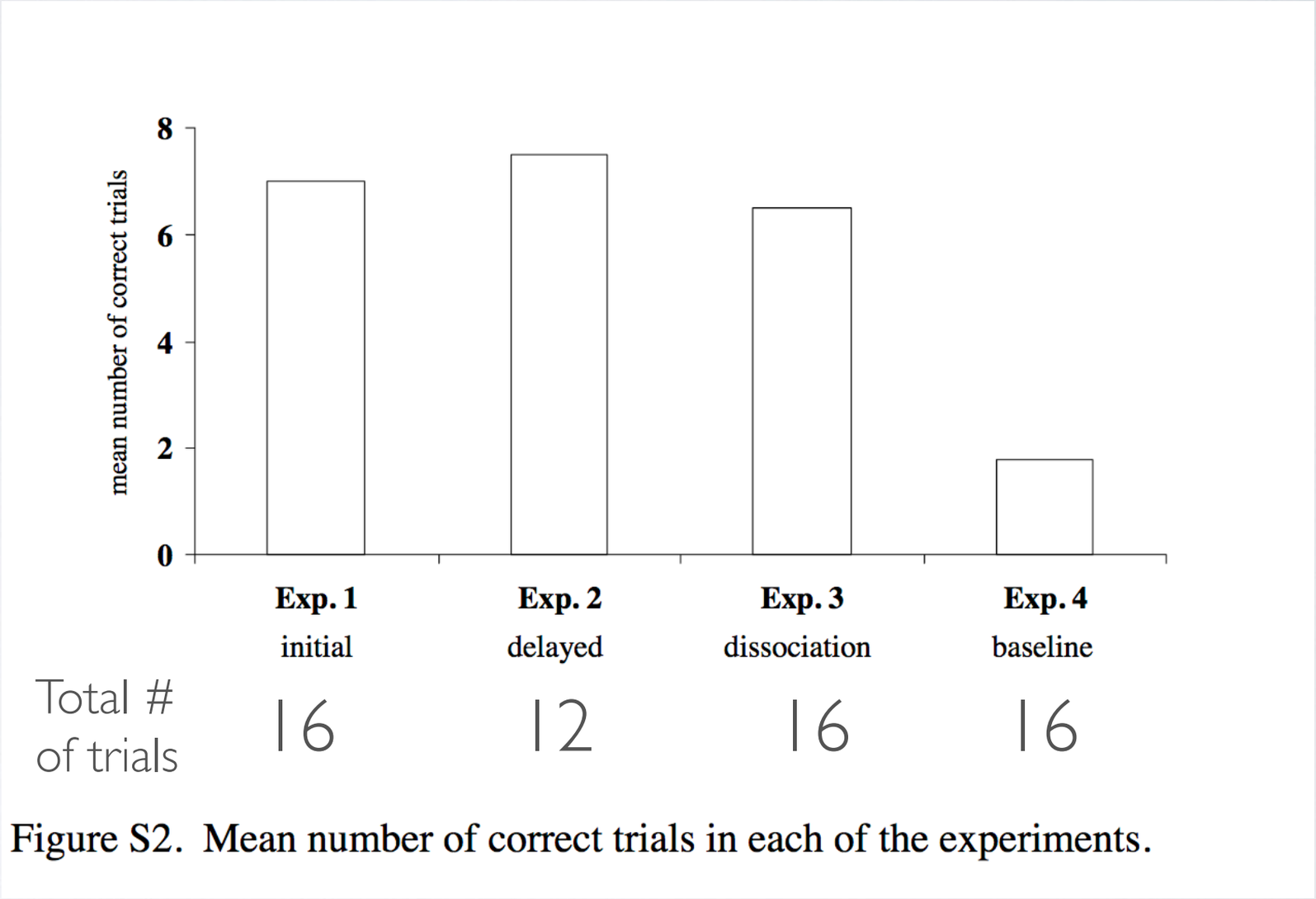


Figure S2. Mean number of correct trials in each of the experiments.

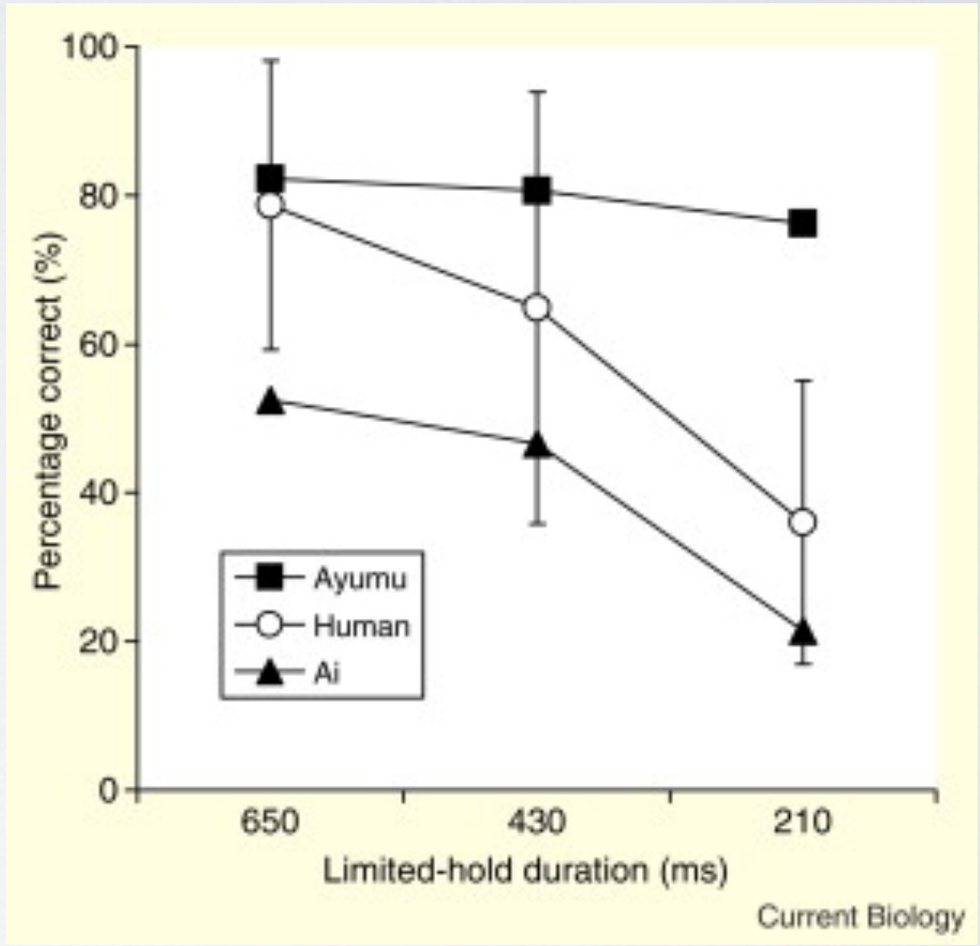
CAN APES PASS THE SPOON TEST?

- Yes-ish
- Why isn't performance at 100% ?

WORKING MEMORY

WORKING MEMORY

- Chimps beat humans!
- Young chimps (and humans) perform best



METACOGNITION

- Awareness and understanding of one's own mental states (intentions, motivations, desires, knowledge)
- Theory of one's own Mind

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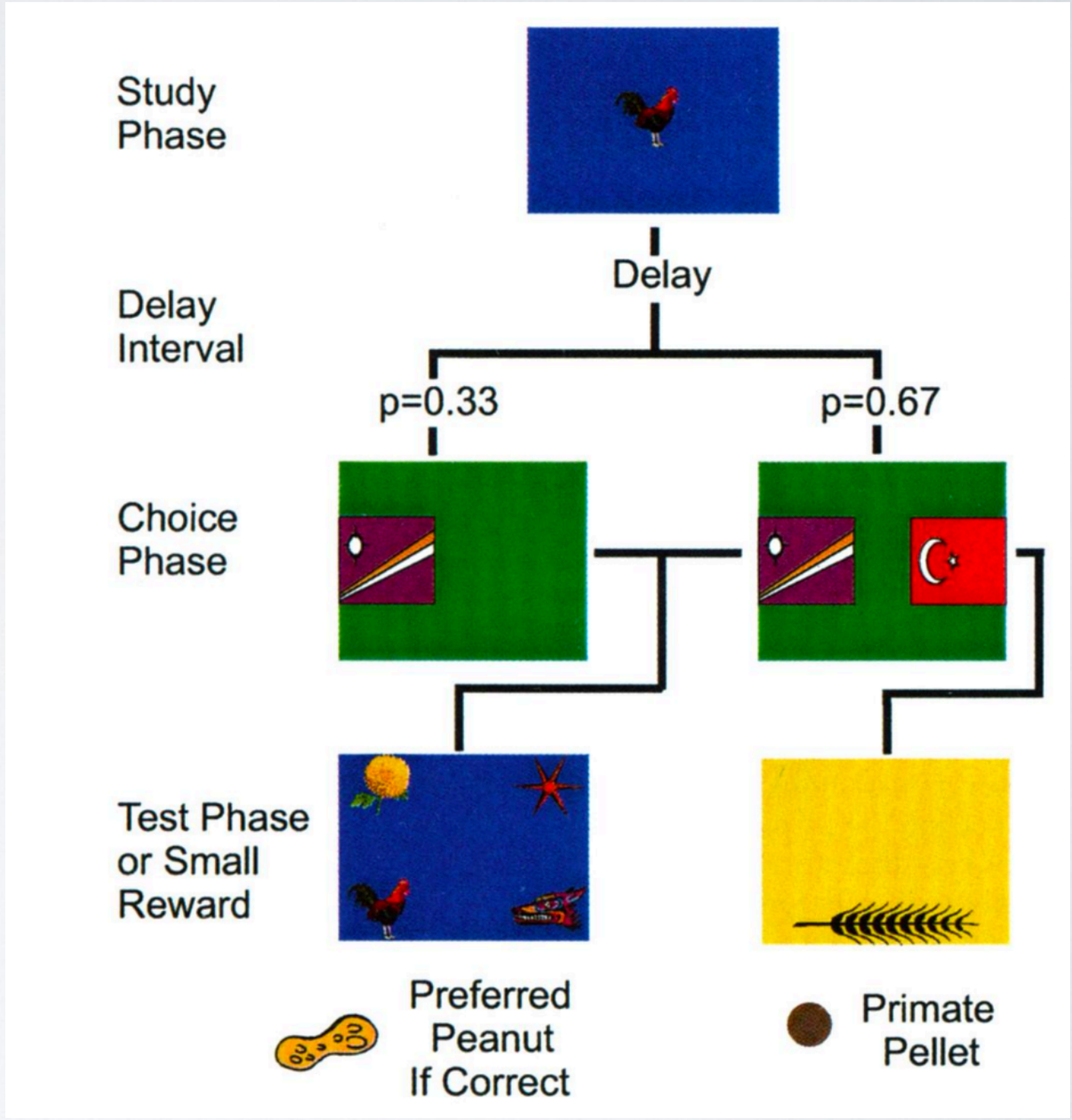
Are monkeys aware of their own knowledge?

METACOGNITION 1:
DO I REMEMBER WHAT I JUST SAW?

- Subjects shown an image in study phase
- ~30 second delay
- 2/3 of trials subjects choose or decline to take a recall test
- 1/3 of trials subjects are forced to take the recall test

- If right in recall test, subjects get a peanut. If wrong, nothing
- If subjects decline recall test, they get a less-preferred food



Hampton 2001

METACOGNITION 1:
DO I REMEMBER WHAT I JUST SAW?

- Dark bars=freely chosen recall tests
- Light bars=forced recall tests
- Subjects slightly more accurate when choosing to take recall test
- Suggests that they are more likely to decline test when they might get it wrong

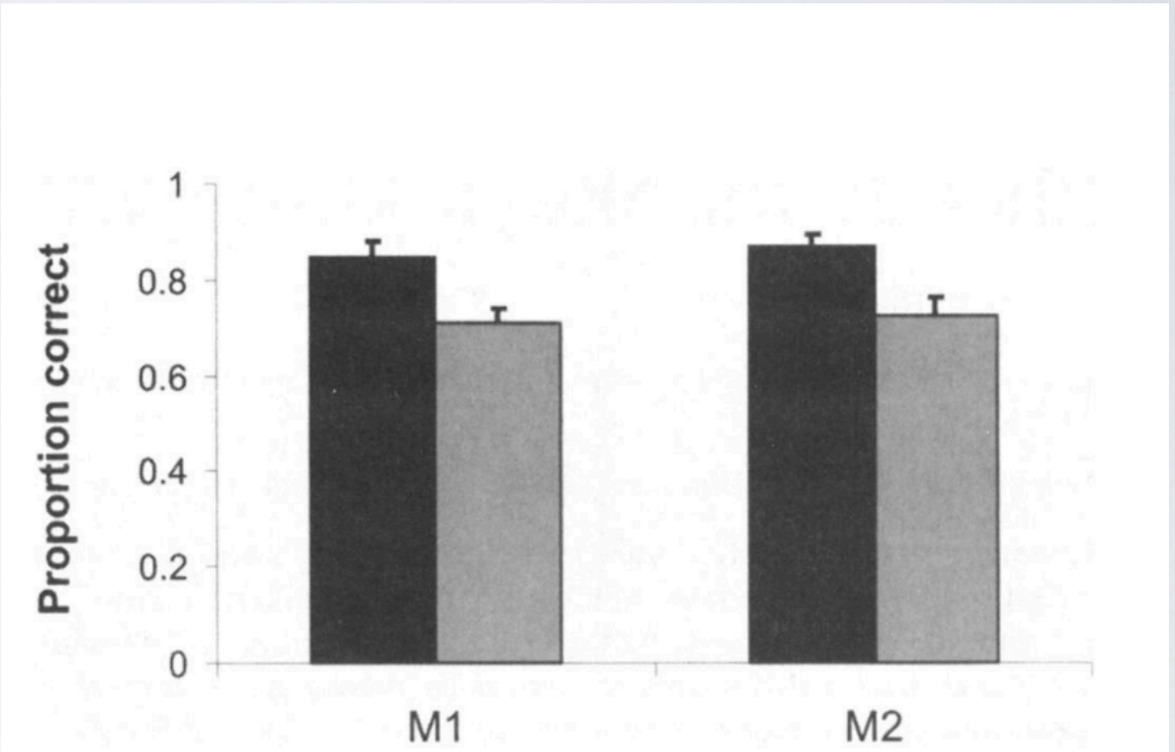
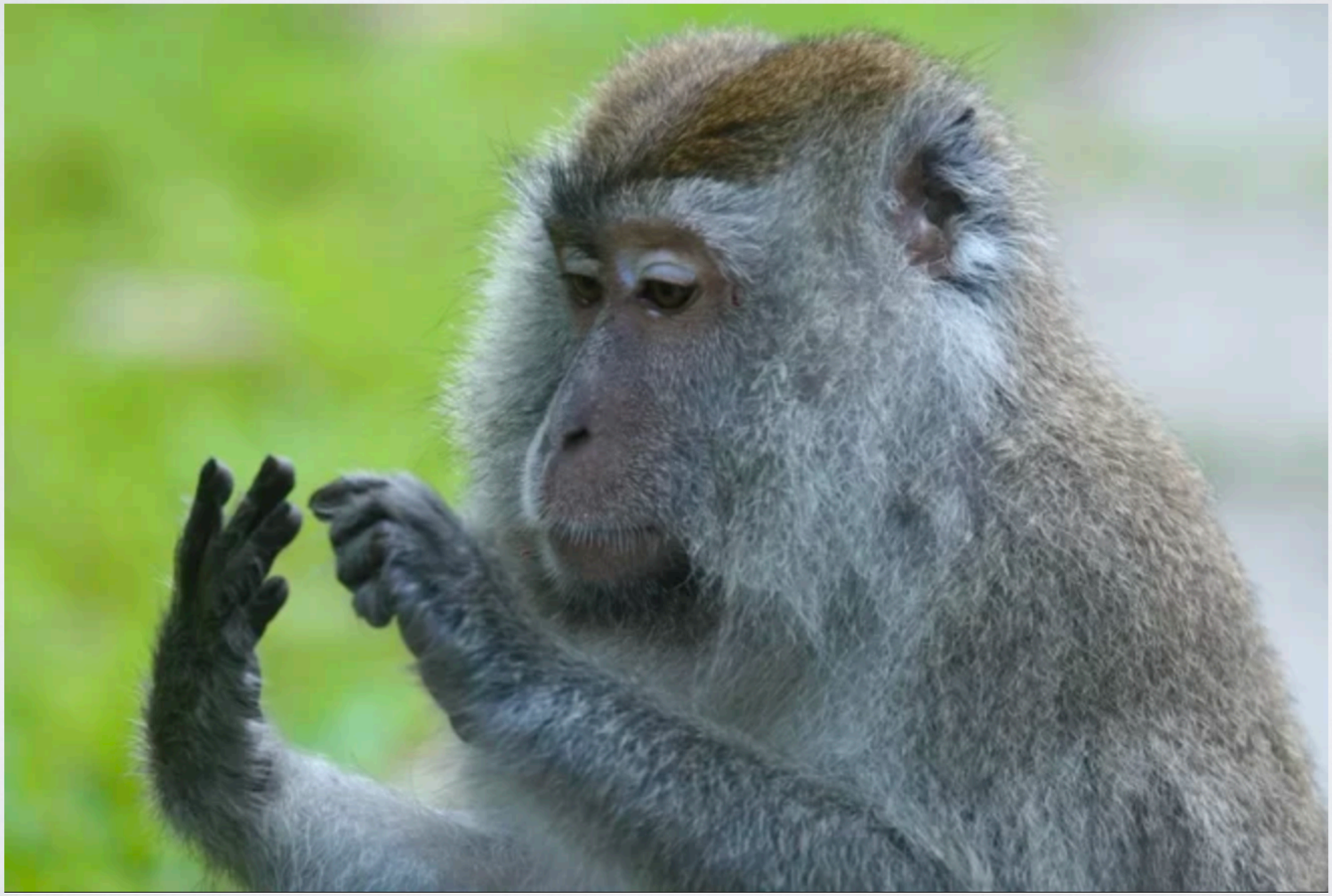


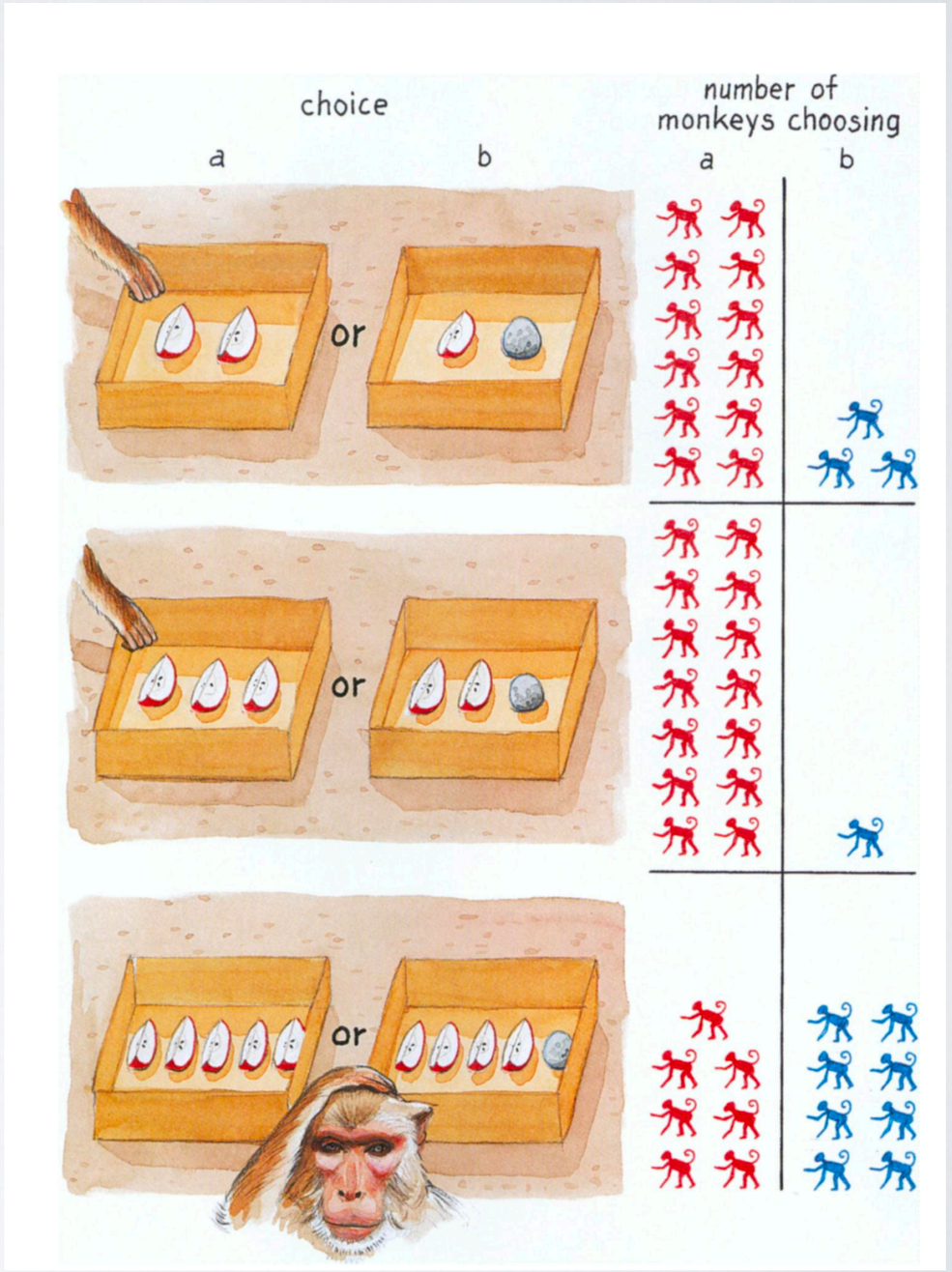
Fig. 2. Accuracy on freely chosen and forced tests. Dark bars represent accuracy on tests the monkeys chose to take. Light bars represent performance on trials where the animals were not given the choice of declining tests. Scores for the two monkeys are the means of 10 daily sessions. Error bars are standard errors. Subjects would be correct 25% of the time if guessing.

WHAT DO PRIMATES UNDERSTAND ABOUT NUMBERS?



WHAT DO PRIMATES UNDERSTAND ABOUT NUMBERS?

- Monkeys presented choice between two amounts of food



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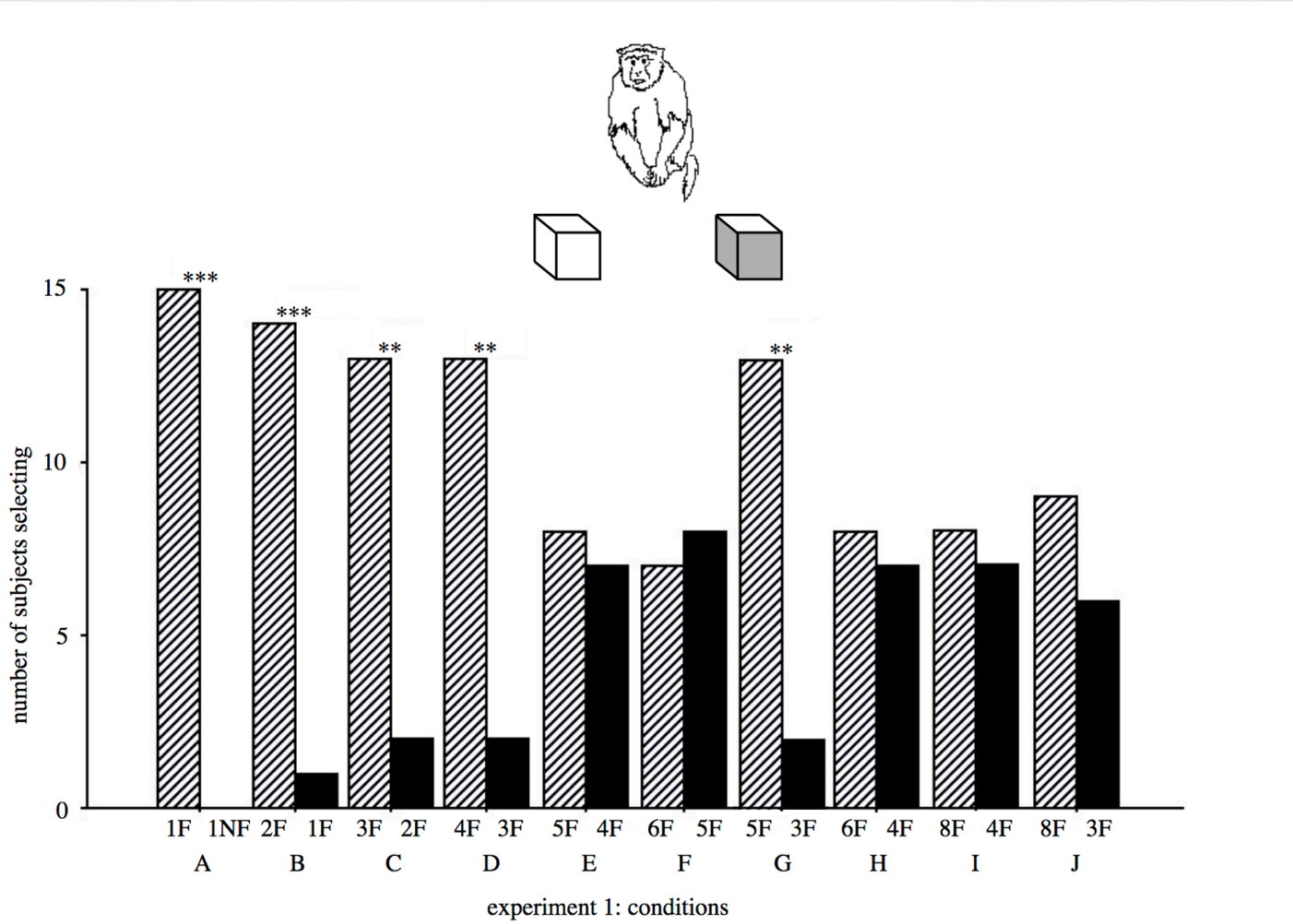

Figure 1. The results from experiment 1. Fifteen subjects were run in each condition in experiment 1 and the *y*-axis plots the number of subjects picking the larger (striped bars) over the smaller number (black bars) of apple slices. Statistical significance was tested with a one-tailed sign test, with significance set at the $p < 0.05$ level. Condition A involved the presentation of one slice of apple (one-eighth of an apple; F = food) versus one rock (NF = non-food). All other conditions in experiment 1 involved the presentation of different food quantities, some sets differing by only one apple slice (conditions A–F), while others differed by as much as two or more times the quantity in the other box (conditions G–J). All quantities were presented sequentially.
$^{***}p < 0.001$, $^{**}p < 0.004$.

Hauser et al. (2000)

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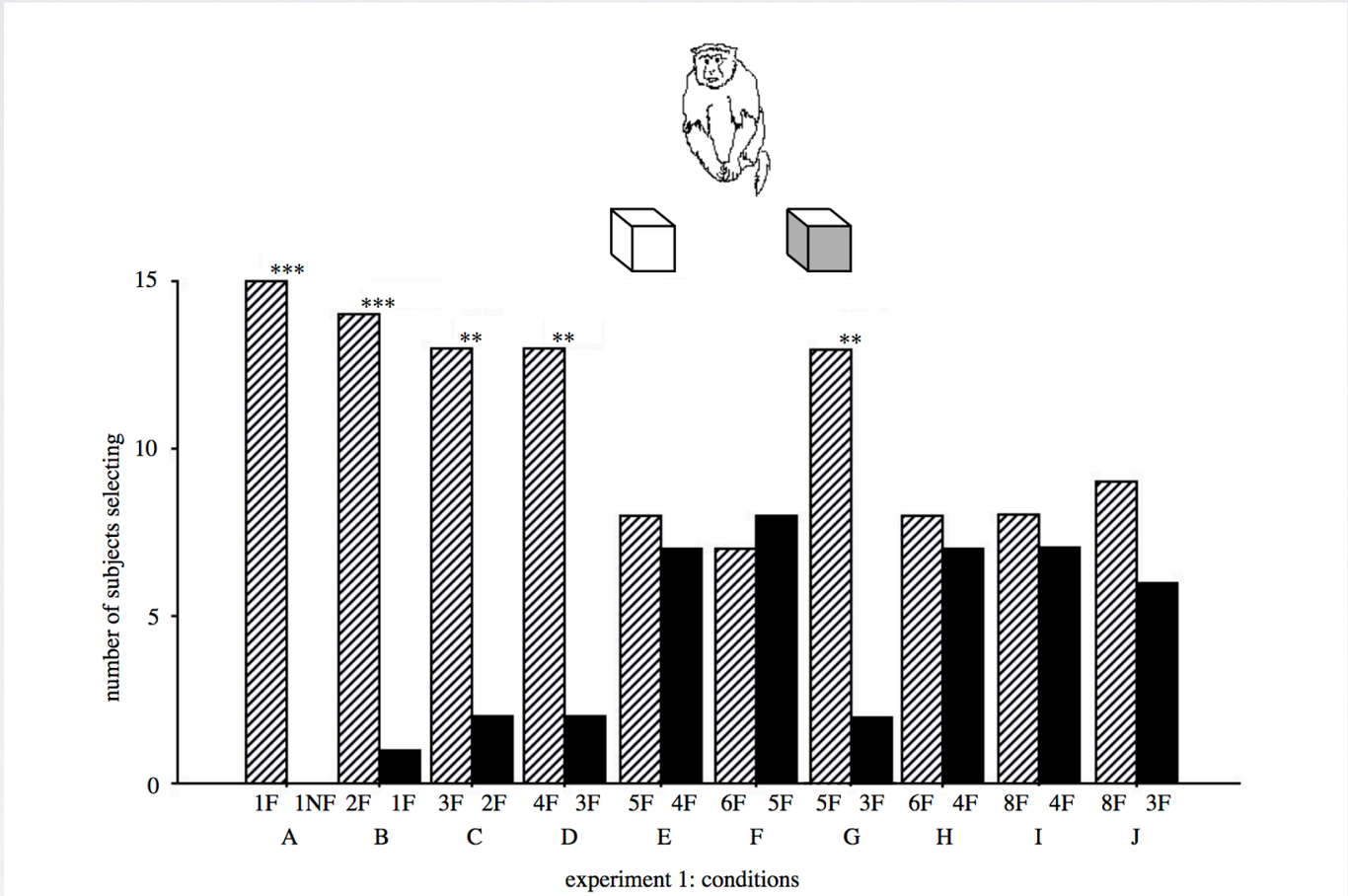

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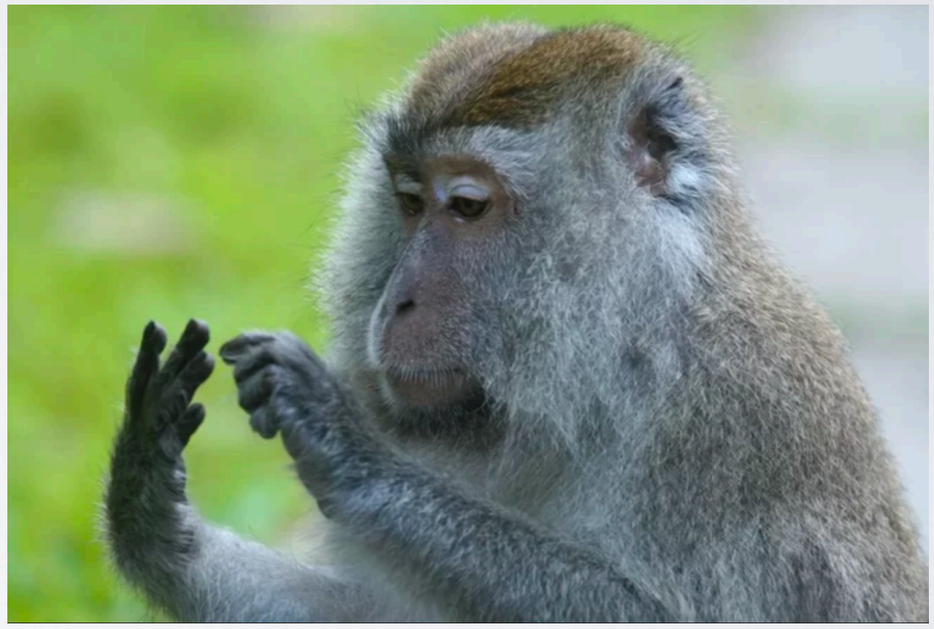
Hauser et al. (2000)

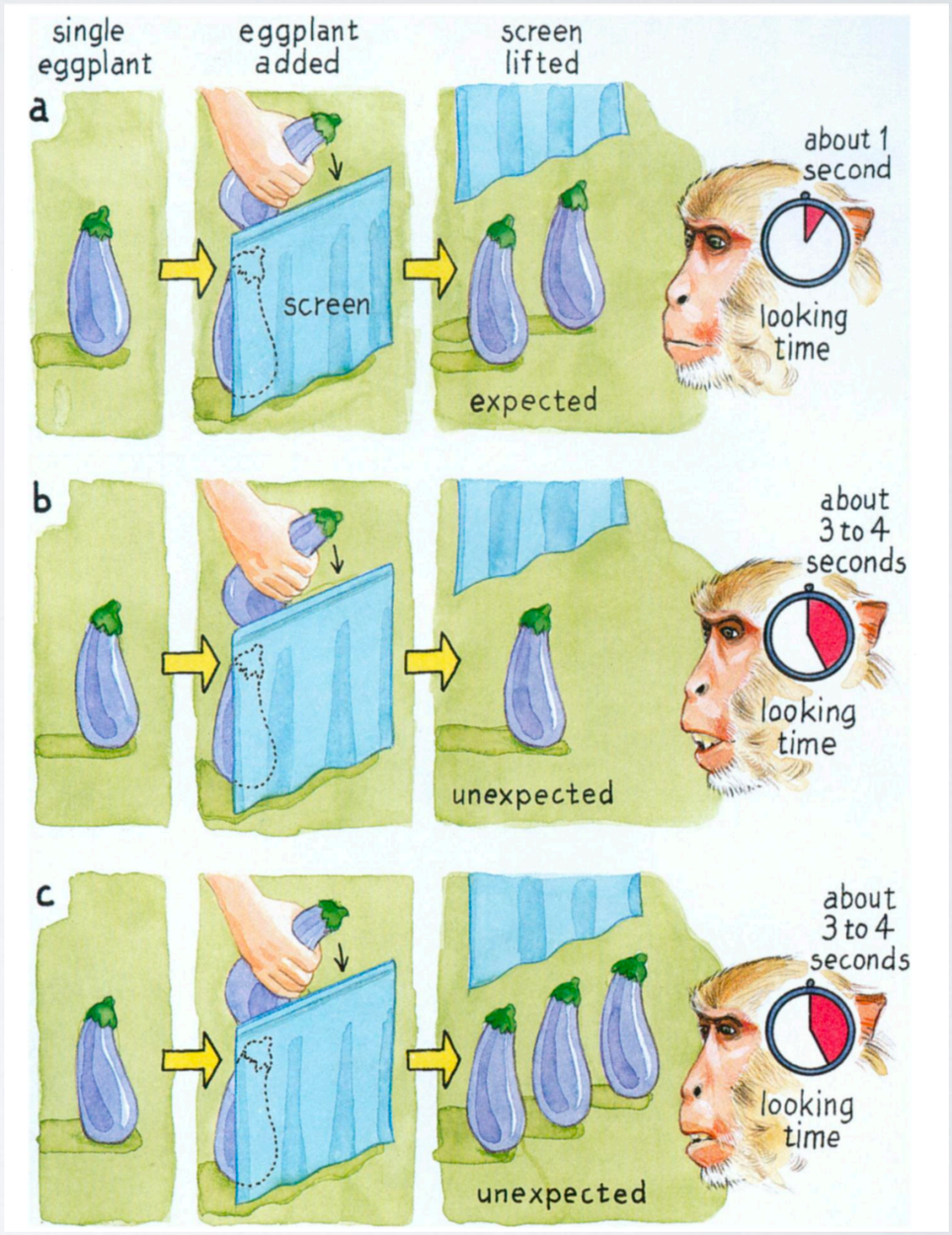
Interpretation of these results?

WHAT DO PRIMATES UNDERSTAND ABOUT NUMBERS?

- Precise number concept
- Approximate number system
- Mixing food and numbers?



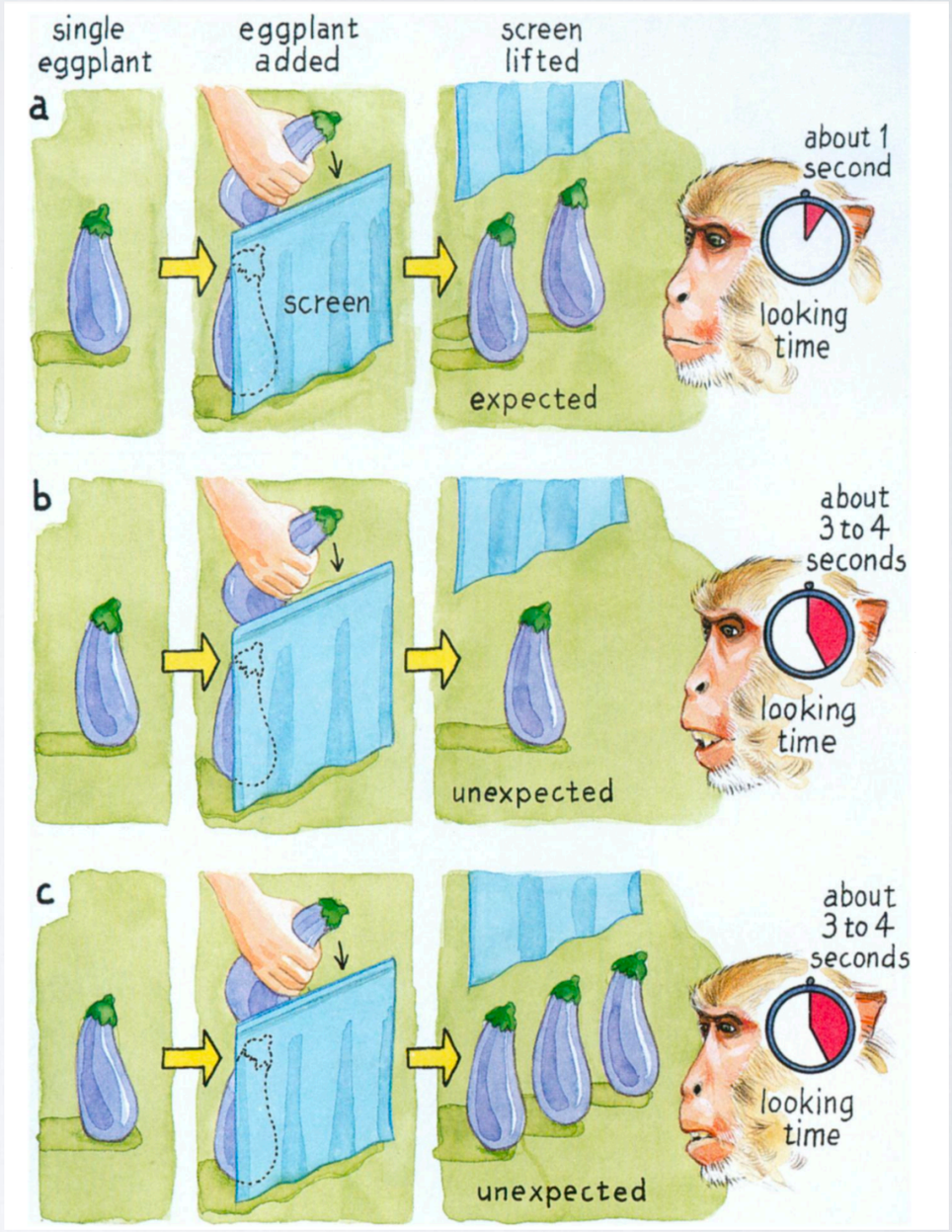
PRECISE UNDERSTANDING OF NUMBERS



PRECISE UNDERSTANDING OF NUMBERS

- 2+1=3 vs 2 vs 4 👍
- 2+1=3 vs 4 vs 5 👎

Seem to have a precise representation of numbers up to 3 (maybe 4)



HOW MANY STARS ARE THERE?

HOW MANY STARS ARE THERE?

HOW MANY STARS ARE THERE?

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HOW MANY STARS ARE THERE?

SUBITIZATION

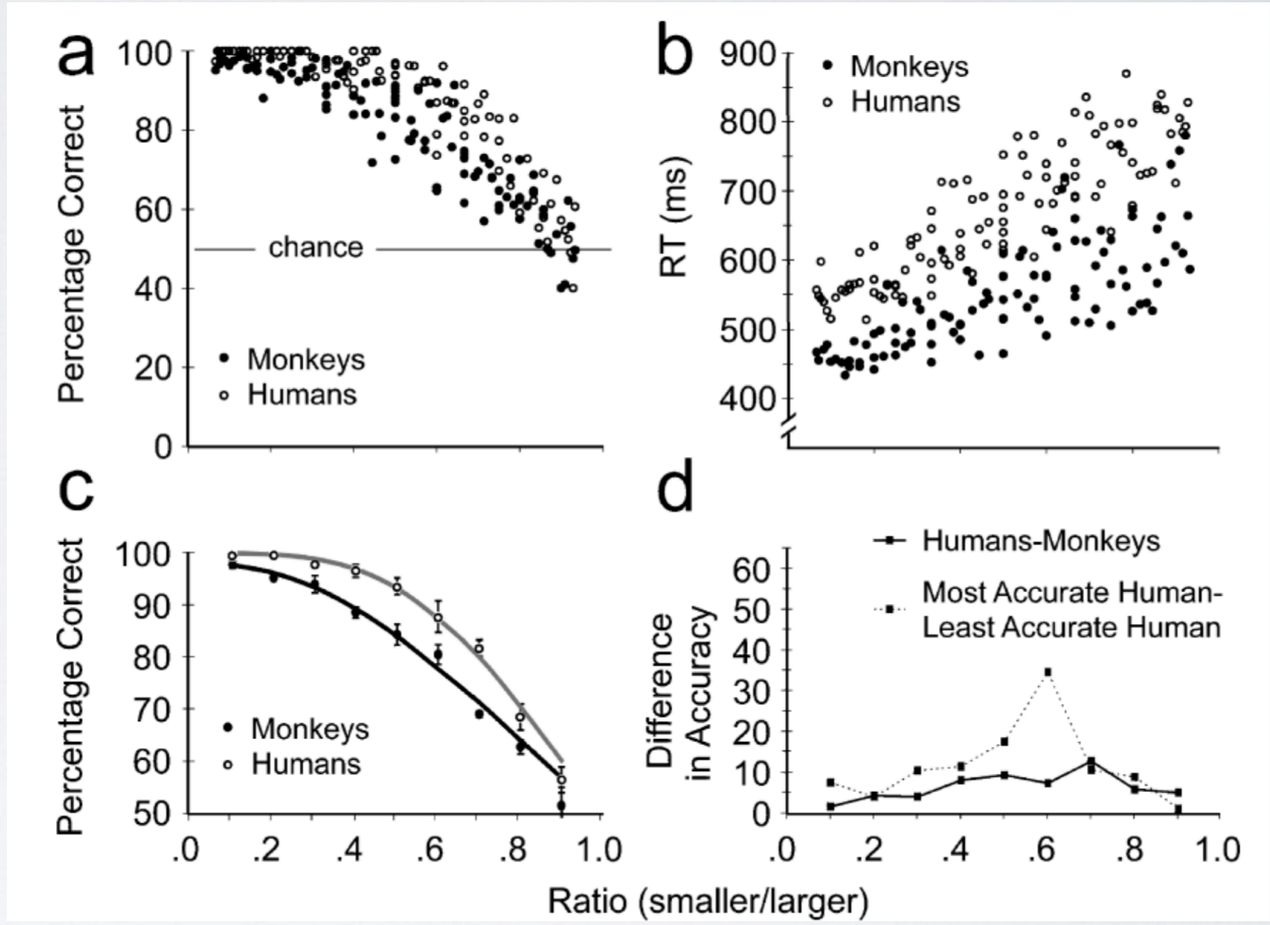
- Rapid, precise, accurate judgments of amounts up to 3 or 4
- May account for primates precise understanding of small numbers
- Similar across all primates

APPROXIMATE NUMBER SYSTEM

- Numerical understanding based on comparison of magnitudes

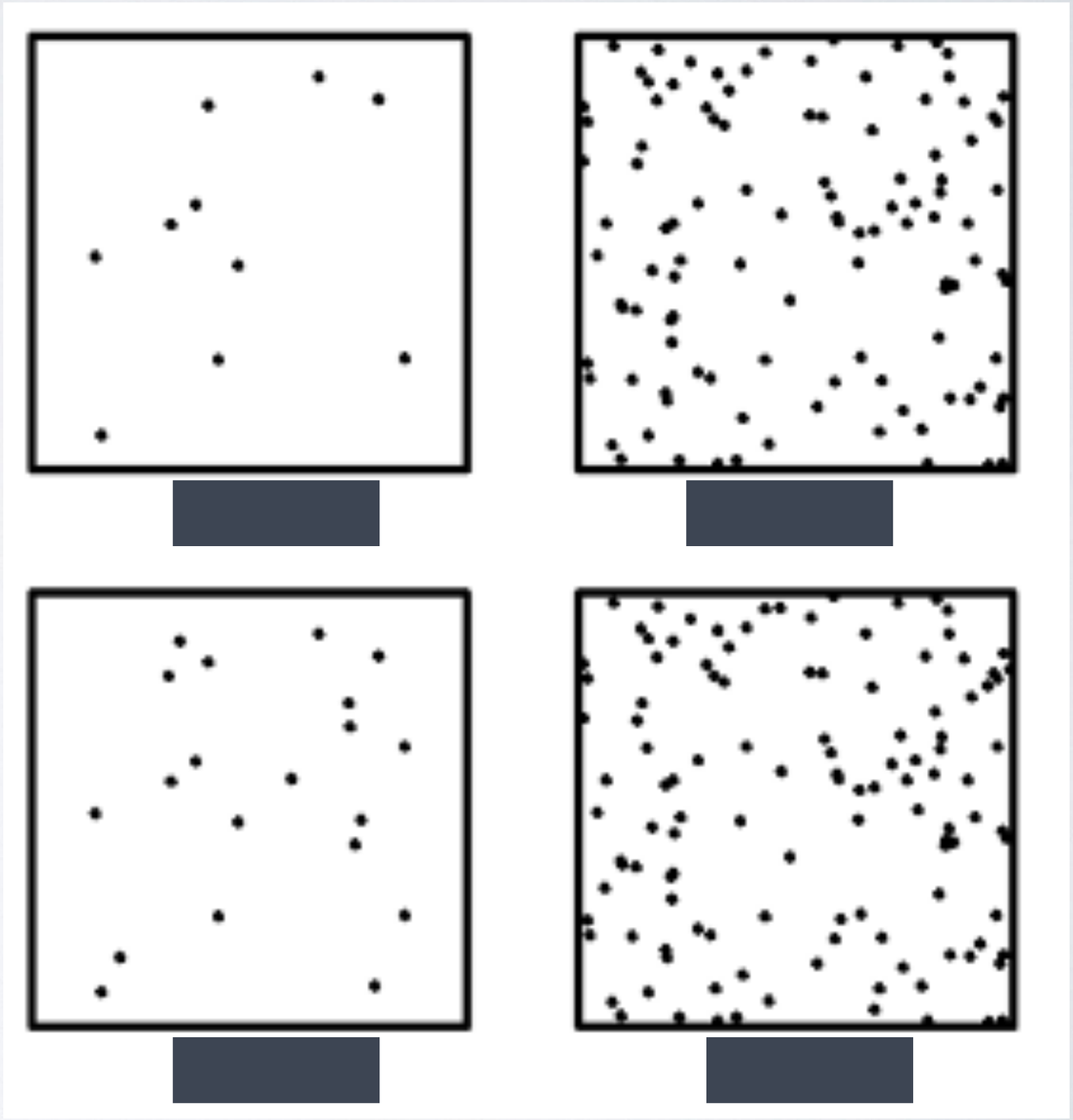
APPROXIMATE NUMBER SYSTEM

- Humans and monkeys seem to have same approximate number system
- Accuracy declines as ratio between quantities approaches 1



Cantlon and Brannon 2006

WEBER'S LAW



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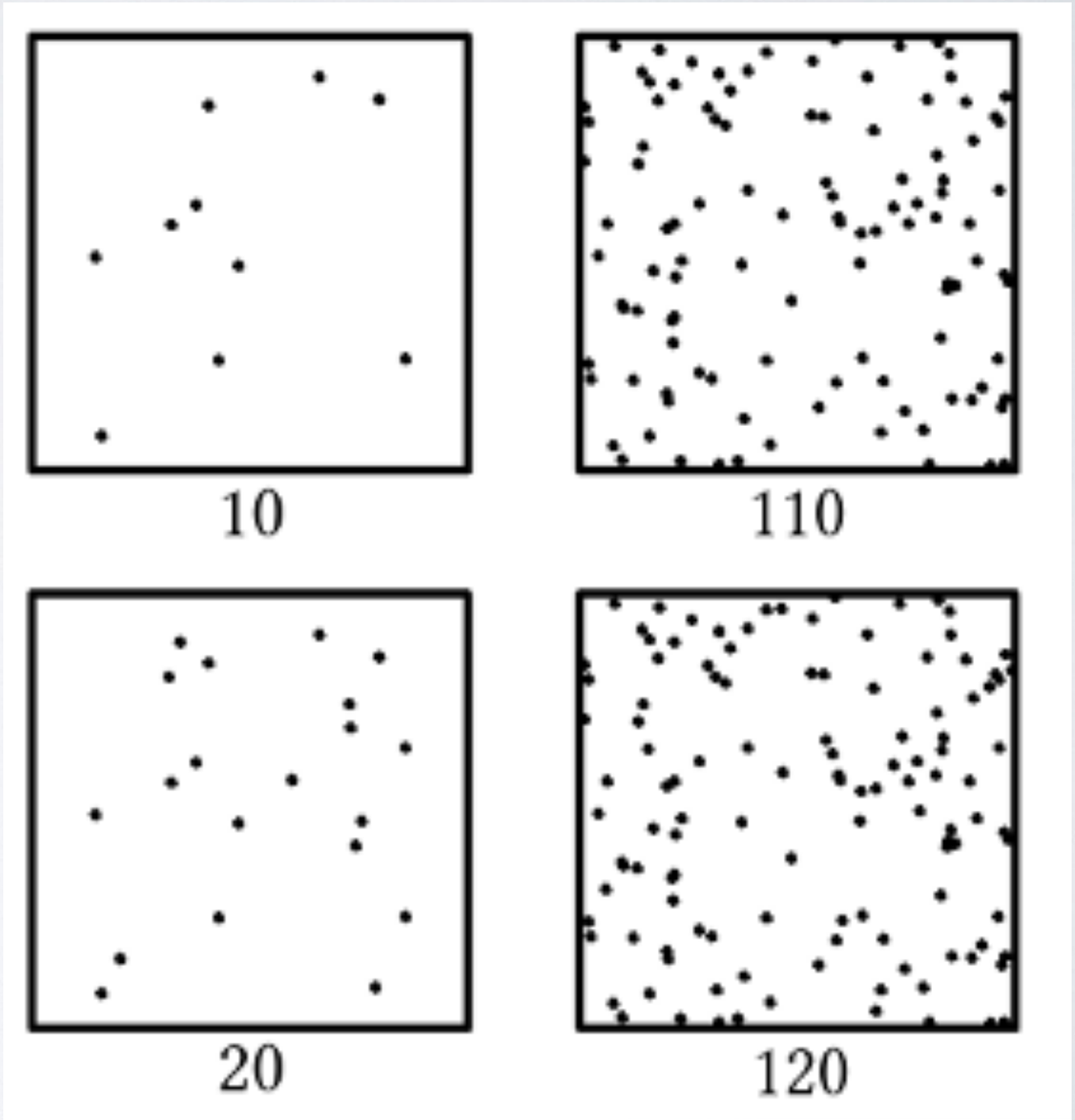
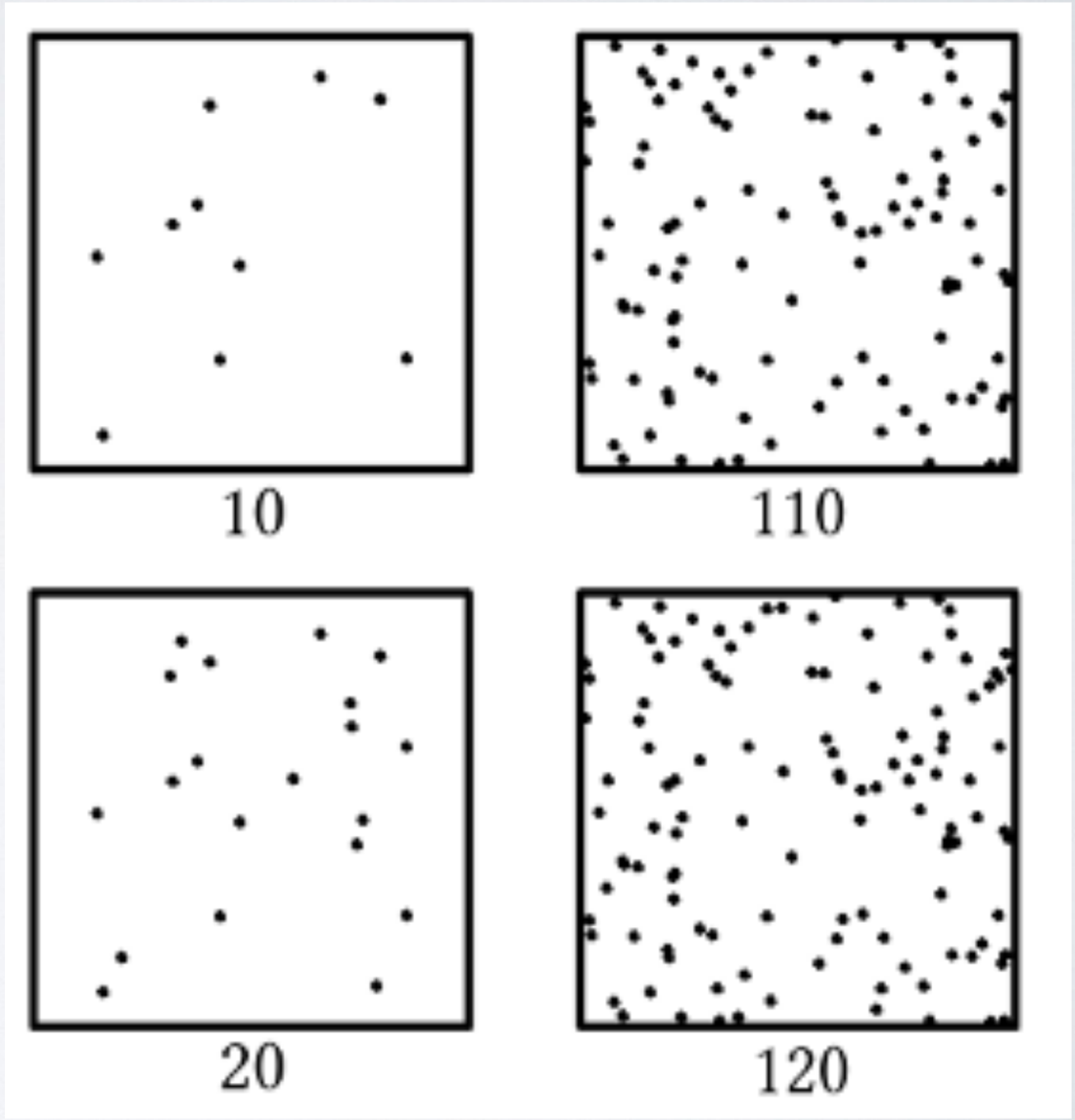


WEBER'S LAW

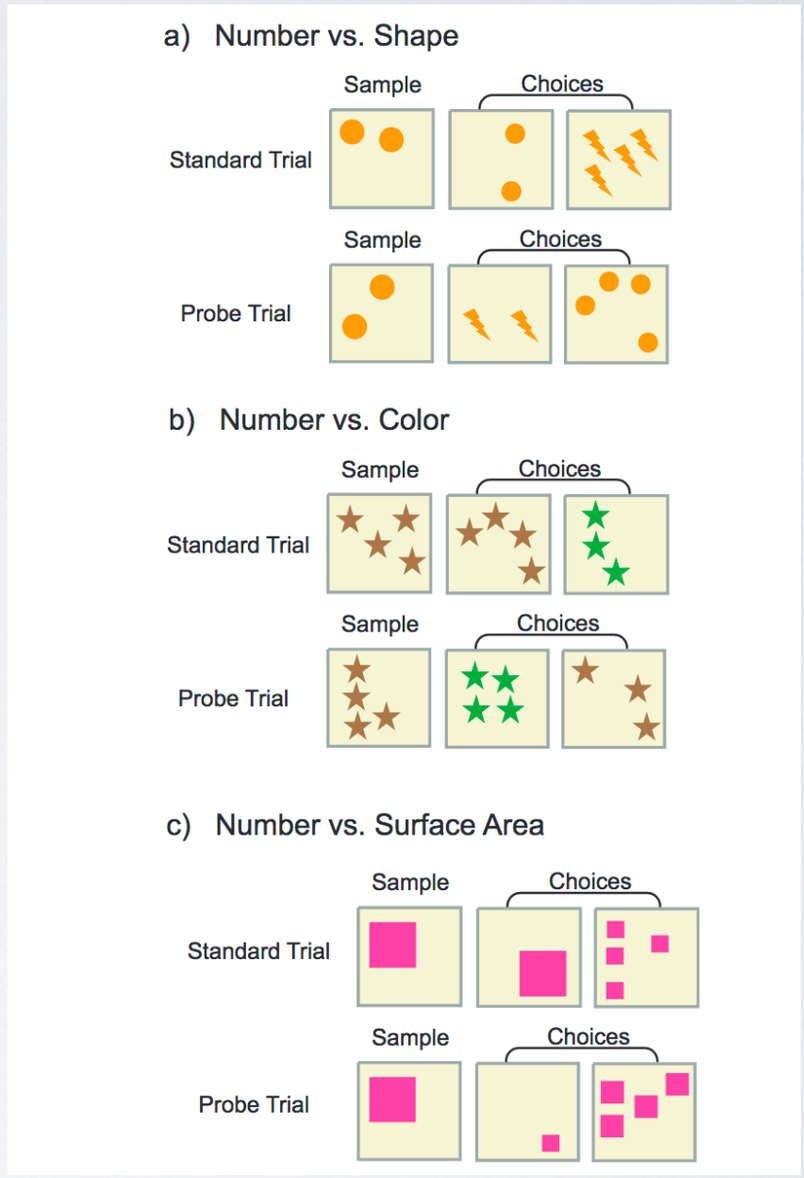
- "Simple differential sensitivity is inversely proportional to the size of the components of the difference; relative differential sensitivity remains the same regardless of size."

- Ratios, not precise numbers, determine ability to discriminate two quantities



APPROXIMATE NUMBER SYSTEM

- Compare salience of number to other object properties (i.e., color and surface area)



Catlon and Brannon 2007

APPROXIMATE NUMBER SYSTEM

- Number salient when ratio manageable

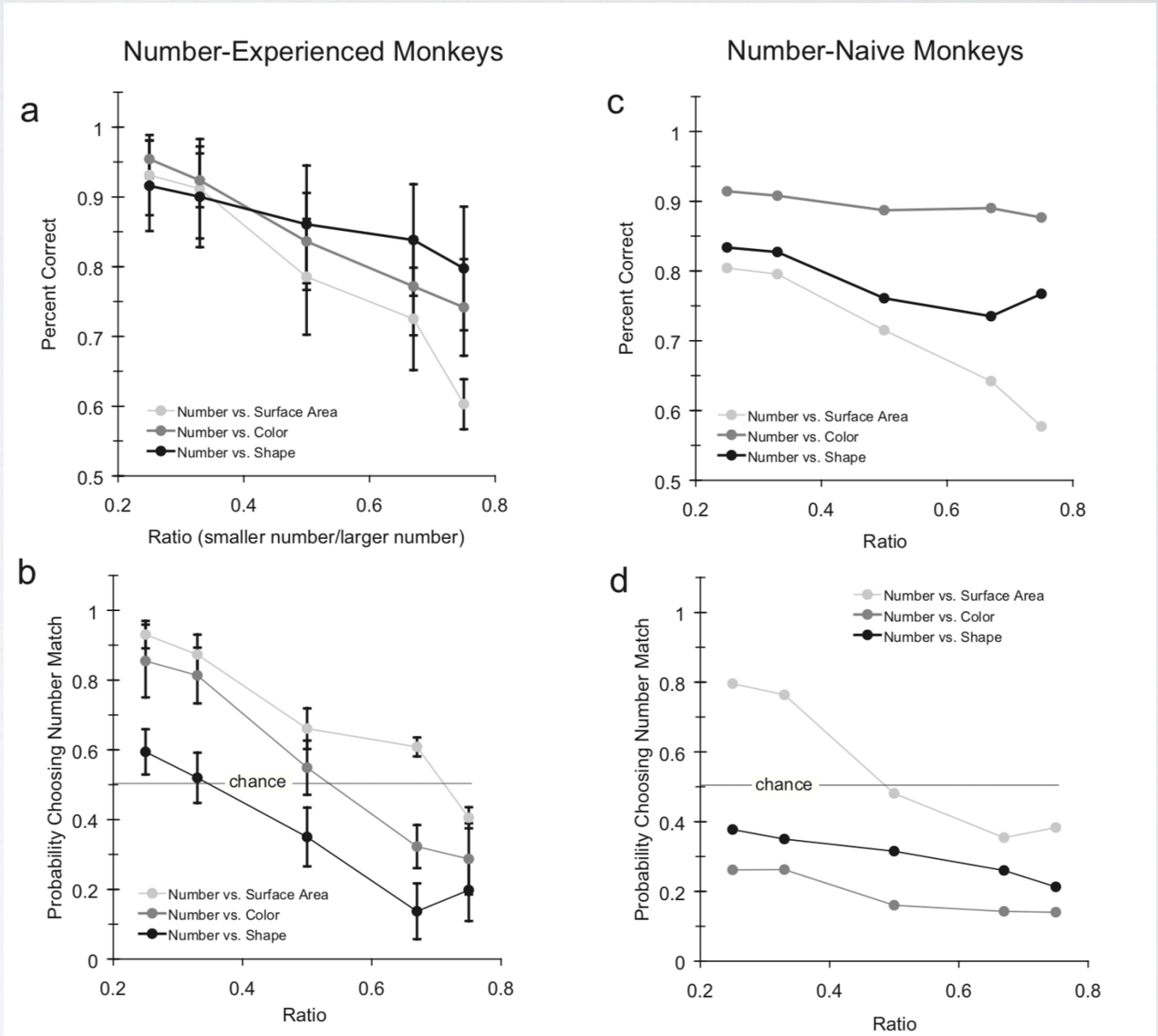


Figure 2. Performance of number-experienced monkeys on the three experimental conditions (number vs. shape, number vs. color, and number vs. surface area) during standard trials (a) and probe trials (b) as a function of the ratio between the numerical values of the two choice stimuli. On standard trials (a), accuracy for choosing the matching stimulus is plotted. For probe trials (b), the probability of choosing a numerical match is plotted (chance = .5). Standard error bars reflect variance between the three monkeys. Performance of number-naive monkey on the three experimental conditions (number vs. shape, number vs. color, and number vs. surface area) was a function of numerical ratio. On standard trials (c), accuracy for choosing the matching stimulus is plotted. For probe trials (d), the probability of choosing a numerical match is plotted (chance = .5).

Catlon and Brannon 2007

FOOD AND NUMBERS

- Do food rewards help or hinder numerical abilities?

FOOD AND NUMBERS

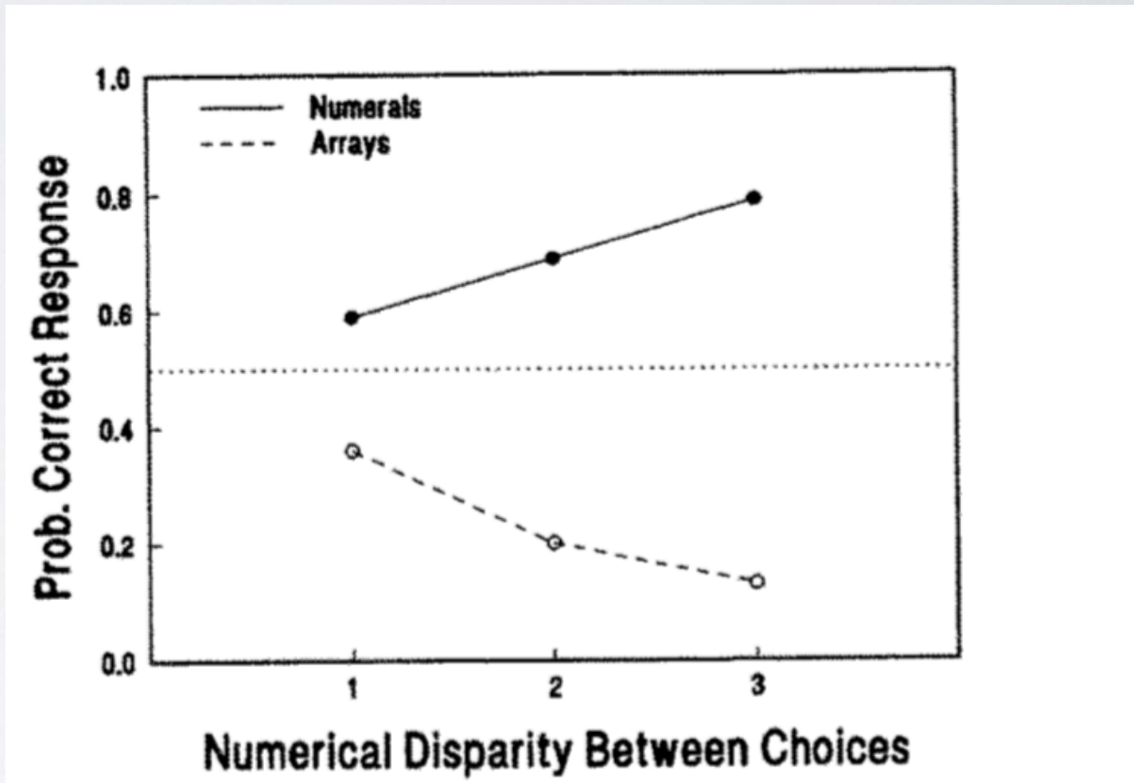
- Performance on comparison task with food is often bad
- Reverse-reward task impossible with food

FOOD AND NUMBERS

- Chimps cannot choose the smaller amount of food, even when it results in a larger reward

- When symbols used, they perform much better

REVERSE-REWARD TASK



FOOD AND NUMBERS

- Mere sight of food impairs cognitive function?
- Using the stimuli as the reward impairs cognitive function?

ARTICLE

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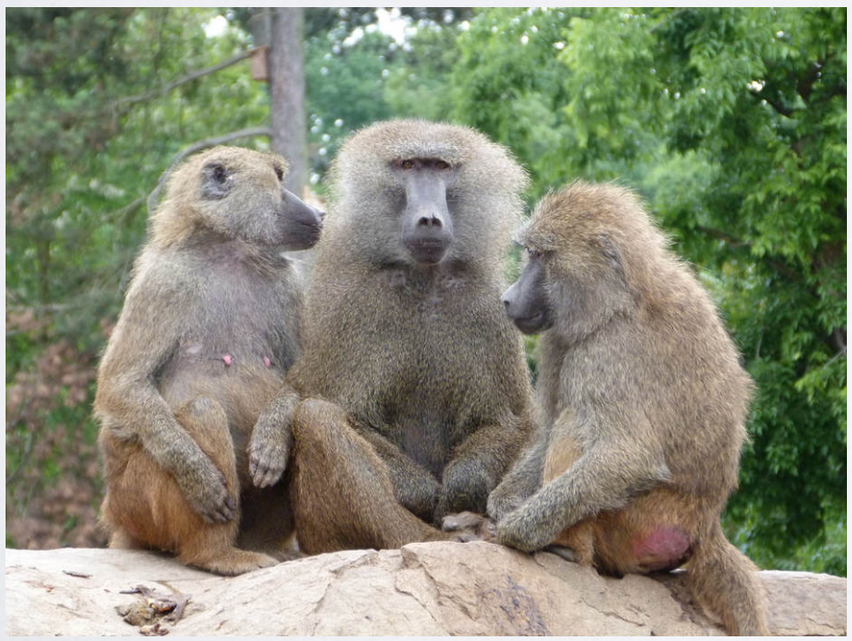
Representational format determines numerical competence in monkeys

Vanessa Schmitt[1,2] & Julia Fischer[1,2]

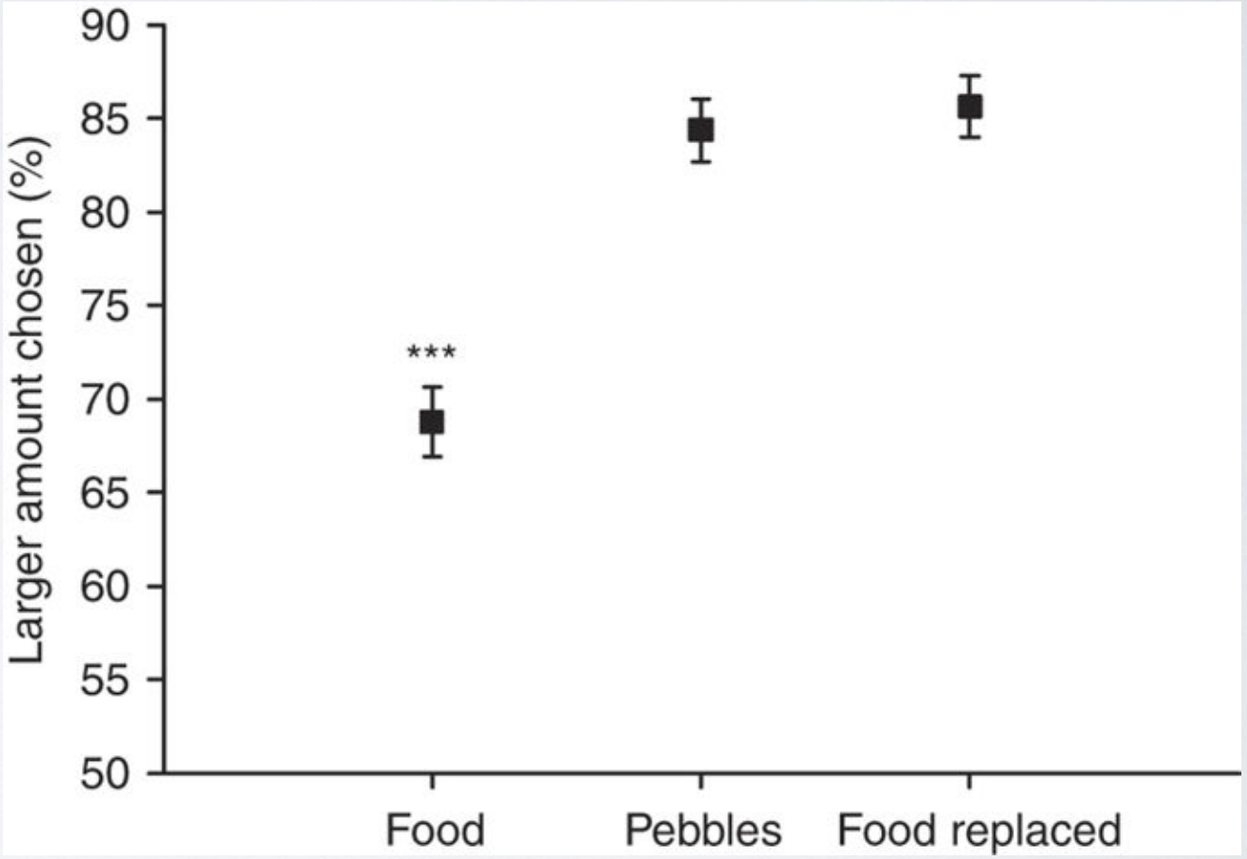


FOOD CONDITION

FOOD REPLACEMENT CONDITION

INHIBITORY CONTROL IN QUANTITY DISCRIMINATION

- Performance improved when the stimuli are not the reward
- EVEN when the stimuli are the same exact food, but just not the pieces that will be given to the monkey
- Inhibitory control depends on internal representation of stimuli, not just the properties of the stimuli



SUMMARY

- Dual representation is difficult (e.g., my mind vs your mind; present vs. future; food as stimuli vs food as food)

- Inhibitory control can interfere with measurement of cognitive tasks

QUESTIONS?