

How Basic are Behavioral Biases?

Evidence from Capuchin-Monkey Trading Behavior

Keith Chen, Yale SOM

*Joint work with
Laurie Santos, Daeyeol Lee, & Venkat Lakshminarayanan*

Nobody ever saw a dog make a fair and deliberate exchange of one bone for another with another dog. Nobody ever saw one animal by its gestures and natural cries signify to another, this is mine, that yours; I am willing to give this for that.

(Adam Smith, Wealth of Nations)

Broad Agenda

1. Experimental Results: capuchins respond to **prices**, but are also **reference-dependent, loss-averse, and display diminishing sensitivity and the endowment effect.**

Why Capuchins?

- distinguish **Universal** vs. **Innate** behaviors
- Positive and normative implications

For this to make sense, need to believe:

2. Believe **Innateness**, (not the result of capuchin culture)
3. Believe **Homologous**, not analogous evolution

Together suggests that prospect-theory may arise from basic and evolutionarily ancient mechanisms.

Subjects:



Tufted Capuchin: an extractive forager

Lorises,
Lemurs



Old-World
monkeys



Humans



65

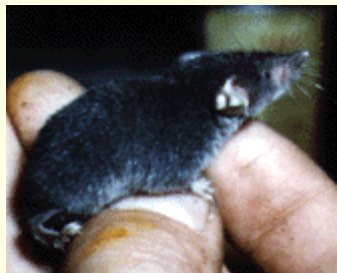
63

40

25

18

6 mybp



New-World
monkeys

Capuchins

Tamarins



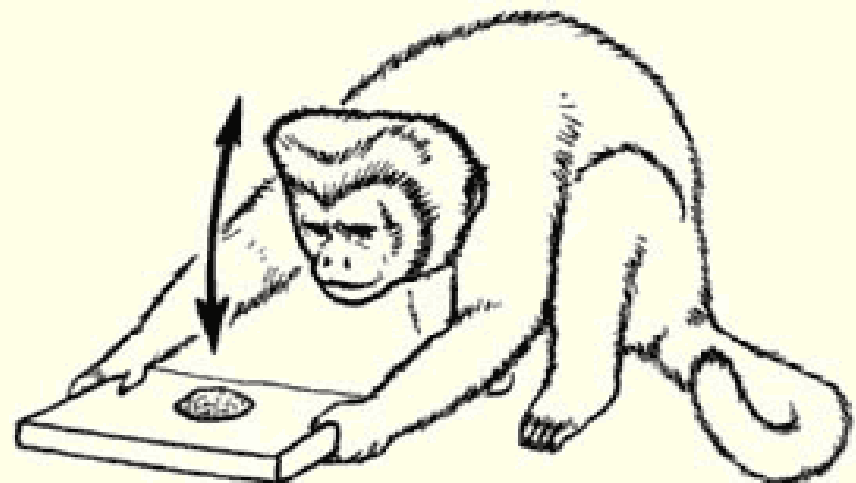
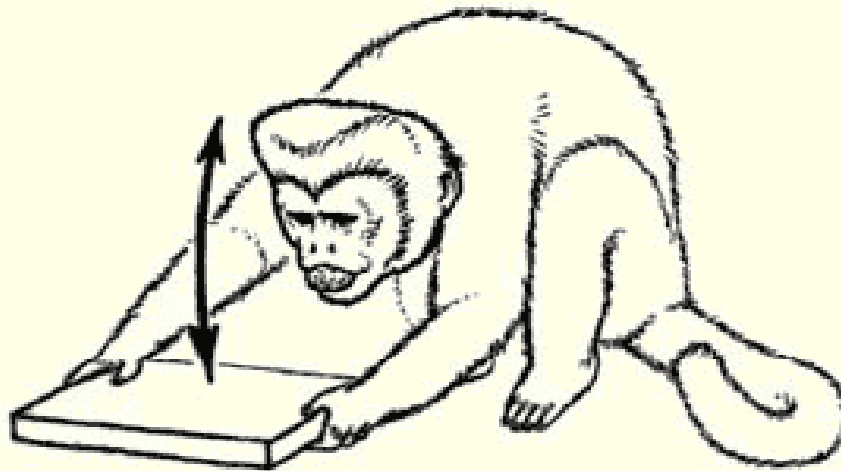
Chimpanzee



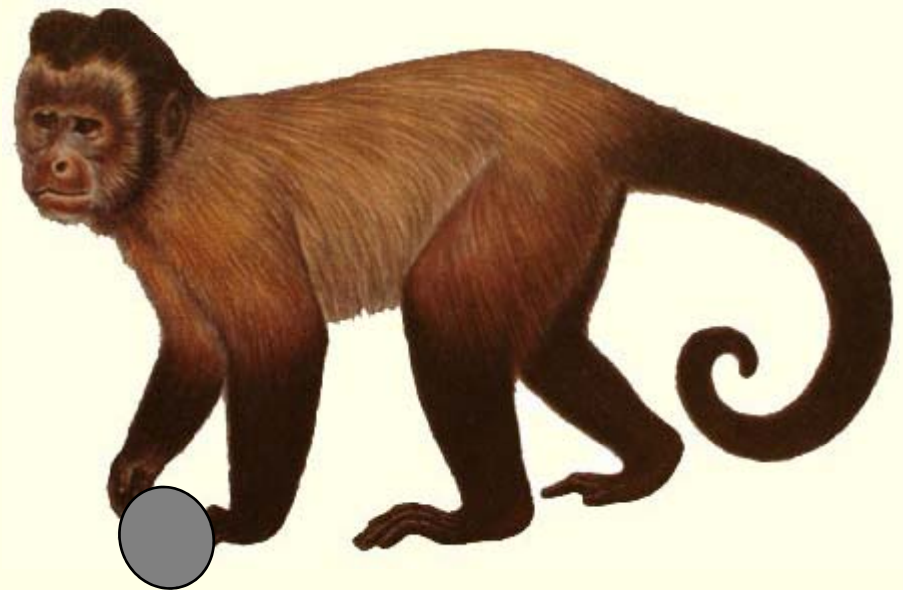
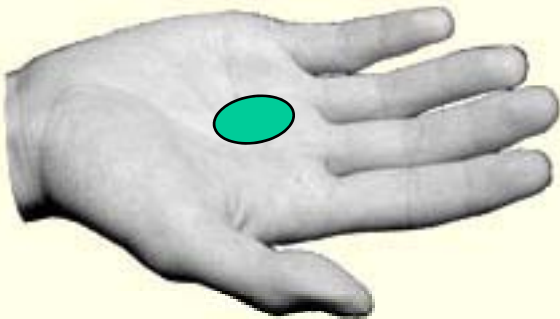
Apes

$\Delta \approx 1.5\%$

Capuchin (Non)Learning



Capuchin Purchasing: Riskless



Capuchin Purchasing Behavior

Trained Capuchin monkeys to know that “tokens” can be traded for different foods at different prices with different RAs.

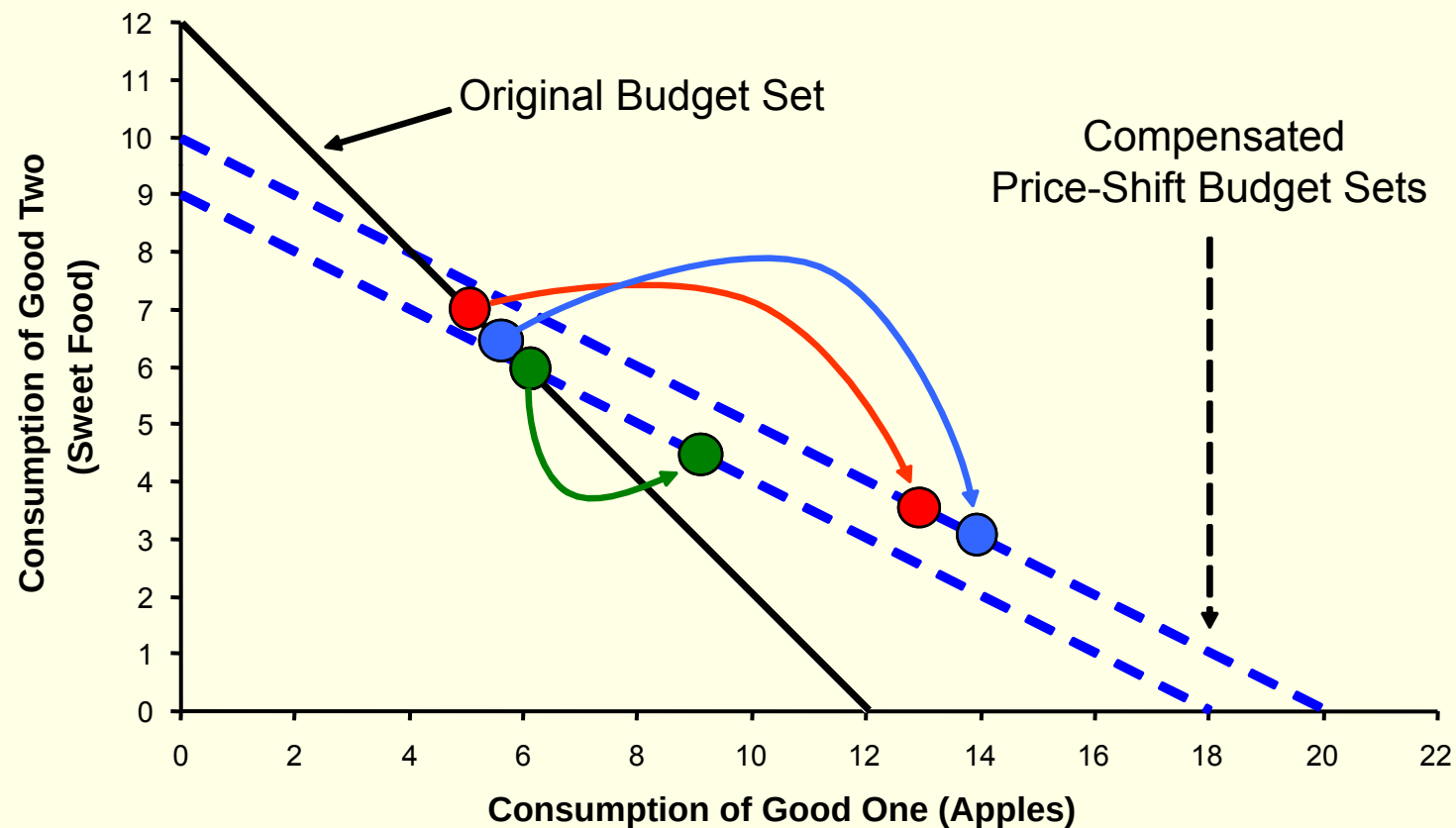
- Closely mirrors the work of Kagel, Battalio, and Green
- Three Steps:
 - Searched for foods for which each actor consumed a relatively interior bundle.
 - A baseline read of what bundle each subject likes
 - A compensated halving of one good's price
- The Use of Fiat Money:
 - Basic tests of Rational Preferences
 - Recognition of Common Value

Capuchin Purchasing Behavior



Is Capuchin Purchasing Rational?

Baseline and Compensated Price Shift:
Capuchins Obey GARP



Is Capuchin Purchasing Rational?

Baseline Experiment: Subjects given a budget of 12 disks, both goods have price 1.

	Actor 1: FL	Actor 2: NN	Actor 3: AG
Food used for good one:	Apples	Apples	Apples
Food used for good two:	Jello	Grapes	Jello
Percent of budget spent on good one:	47%	42%	51%
# of trials (the week following stability):	132	72	144
Compensated Price Shift:			
Good one's price 1 $\rightarrow$ 1/2, good two's price stays 1, and the budget shrinks.			
New budget of disks:	10	10	9
Percent of budget spent on good one:	69%	64%	50%
Good 1 before $\rightarrow$ after price shift:	5.6 $\rightarrow$ 13.8	5.0 $\rightarrow$ 12.8	6.1 $\rightarrow$ 9.0
# of trials (the week following stability):	140	100	216
Choices respond to price shift, p-value:	0.001	0.004	0.966
Change in choice satisfies GARP:	0.0001	0.0001	0.0001

Non-Standard Capuchin Choice

Prospect theoretic preferences:

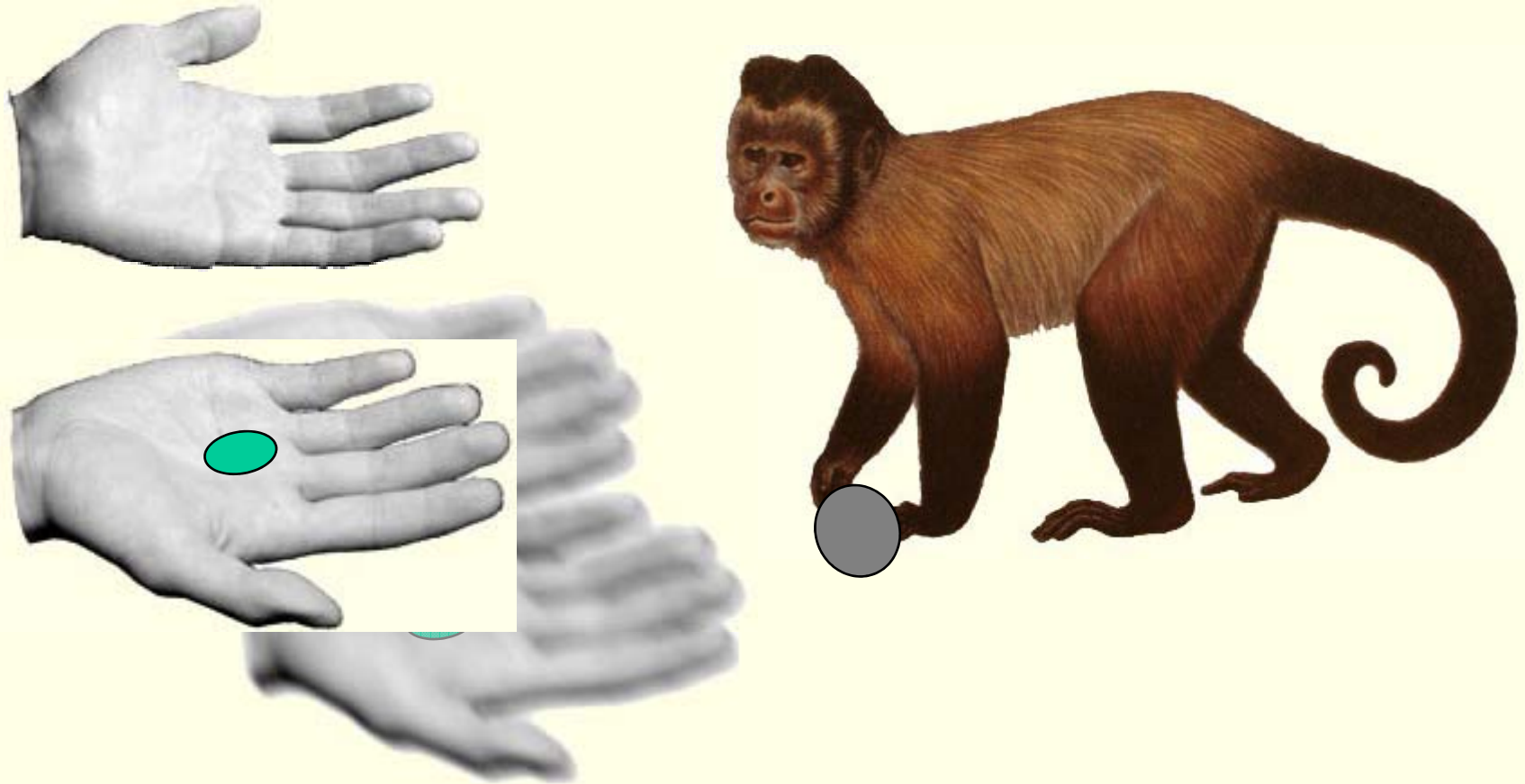
Reference Effects: Weigh gains and losses not levels

Loss Aversion: Weigh losses > gains

Diminishing Sensitivity: risk preferences “reflect”.

- Individual investors (*Odean 1998*)
- House sellers (*Genesove & Mayer 2001*)
- Consumer asymmetric elasticities (*Hardie et al 1993*)

Capuchin Purchasing: Gambles



Experiment One

Experiment 1

First Question:

Do capuchins like a strictly better gamble?

E1 shows 1 and gives 1, E2 shows 2, then gives 1 or 2 (w. prob. $\frac{1}{2}$).

Subject (name):	1: FL	2: HG	3: JM	4: MD	5: NN
Percent of trials E1 chosen:	10%	18%	12%	22%	5%
Sessions till stable:	7	6	7	6	11

Experiment Two

Second Question:

Do capuchins care about gains and losses?

E1 shows 1 and E2 shows 2, then both give 1 or 2 (w. prob. $\frac{1}{2}$).

Subject (name):	1: FL	2: HG	3: JM	4: MD	5: NN
Percent of trials E1 chosen:	68%	70%	70%	70%	78%
Sessions till stable:	11	9	9	9	13

Experiment Three

Third Question:

Do capuchins reference even in the absence of risk?

E1 shows 1 and E2 shows 2, then both give 1.

Subject (name):	1: FL	2: HG	3: JM	4: MD	5: NN
Percent of trials E1 chosen:	73%	75%	80%	82%	87%
Choice % > exp. 2, p-value:	0.27	0.27	0.10	0.07	0.11
Pooled, choice % p-value:	p<0.023, two-sided p-test.				
Sessions till stable:	9	10	10	8	10

E1 shows 1 and E2 shows 2, then both give 1 or 2 (w. prob. $\frac{1}{2}$).

Subject (name):	1: FL	2: HG	3: JM	4: MD	5: NN
Percent of trials E1 chosen:	68%	70%	70%	70%	78%
Sessions till stable:	11	9	9	9	13

Combining Experiments

All Experiments

Fourth Question:

Do capuchins display "Loss-Aversion"?

Experiment:	One		Two		Three	
Experimenter:	E1	E2	E1	E2	E1	E2
Gamble offered:	(1,1,1)	(2,1,2)	(1,1,2)	(2,1,2)	(1,1,1)	(2,1,1)
Gains:	0	0	1/2 ← 0	0	0	0
Losses:	0 ← 1/2	1/2	0 ← 1/2	1/2	0 ← 1	1
Expected Value:	1 → 1 1/2	1 1/2	1 1/2	1 1/2	1	1
% of trials chosen:	13%	87%	71%	29%	79%	21%

p < 0.023

$$U(G) = \alpha(\text{Losses}) + \beta(\text{Gains}) + \gamma(\text{Exp. Value}) + \varepsilon$$

$$\Pr(G1|\{G1,G2\}) = \Phi(\alpha \cdot \Delta\text{Losses} + \beta \cdot \Delta\text{Gains} + \gamma \cdot \Delta\text{EV})$$

Combining Experiments

Estimation

Fourth Question:

Do capuchins display “Loss-Aversion”?

Experiment:	Probit		Logit	
Experimenter:	Coef.	Std. Err.	Coef.	Std. Err.
Δ Losses (α):	-0.818	0.084	-1.345	0.146
Δ Gains (β):	0.308	0.058	0.478	0.096
Δ EV (γ):	3.040	0.313	5.089	0.146
# of observations:	900		900	

all standard errors computed clustering by subject.

$$\Pr(G1|\{G1,G2\}) = \Phi(\alpha \cdot \Delta\text{Losses} + \beta \cdot \Delta\text{Gains} + \gamma \cdot \Delta\text{EV})$$

Combining Experiments

Estimating Ratio

Fourth Question:

Do capuchins display “Loss-Aversion”?

<i>Experiment:</i>	<i>Probit</i>		<i>Logit</i>	
Experimenter:	Coef.	Std. Err.	Coef.	Std. Err.
Coef. of loss-aversion $-\alpha / \beta$:	2.654	0.551	2.813	0.642
Test if $-\alpha / \beta = 1$:	$p < 0.003$		$p < 0.005$	
Test if $-\alpha / \beta = 2.5$:	$p < 0.780$		$p < 0.625$	
# of observations:	900		900	

all standard errors computed clustering by subject.

$$\Pr(G1|\{G1,G2\}) = \Phi(\alpha \cdot \Delta\text{Losses} + \beta \cdot \Delta\text{Gains} + \gamma \cdot \Delta\text{EV})$$

The Reflection Effect

Experiment 2

Kahneman & Tversky (1981)

Imagine that the US is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. Two alternative programs to combat the disease have been proposed. Assume that the exact scientific estimates of the consequences of the programs are as follows.

Program A: If Program A is adopted, 200 people will be saved [72%].

Program B: If Program B is adopted, there is 1/3 probability that 600 people will be saved, and 2/3 probability that no people will be saved [28%].

Program C: If Program C is adopted 400 people will die [22%].

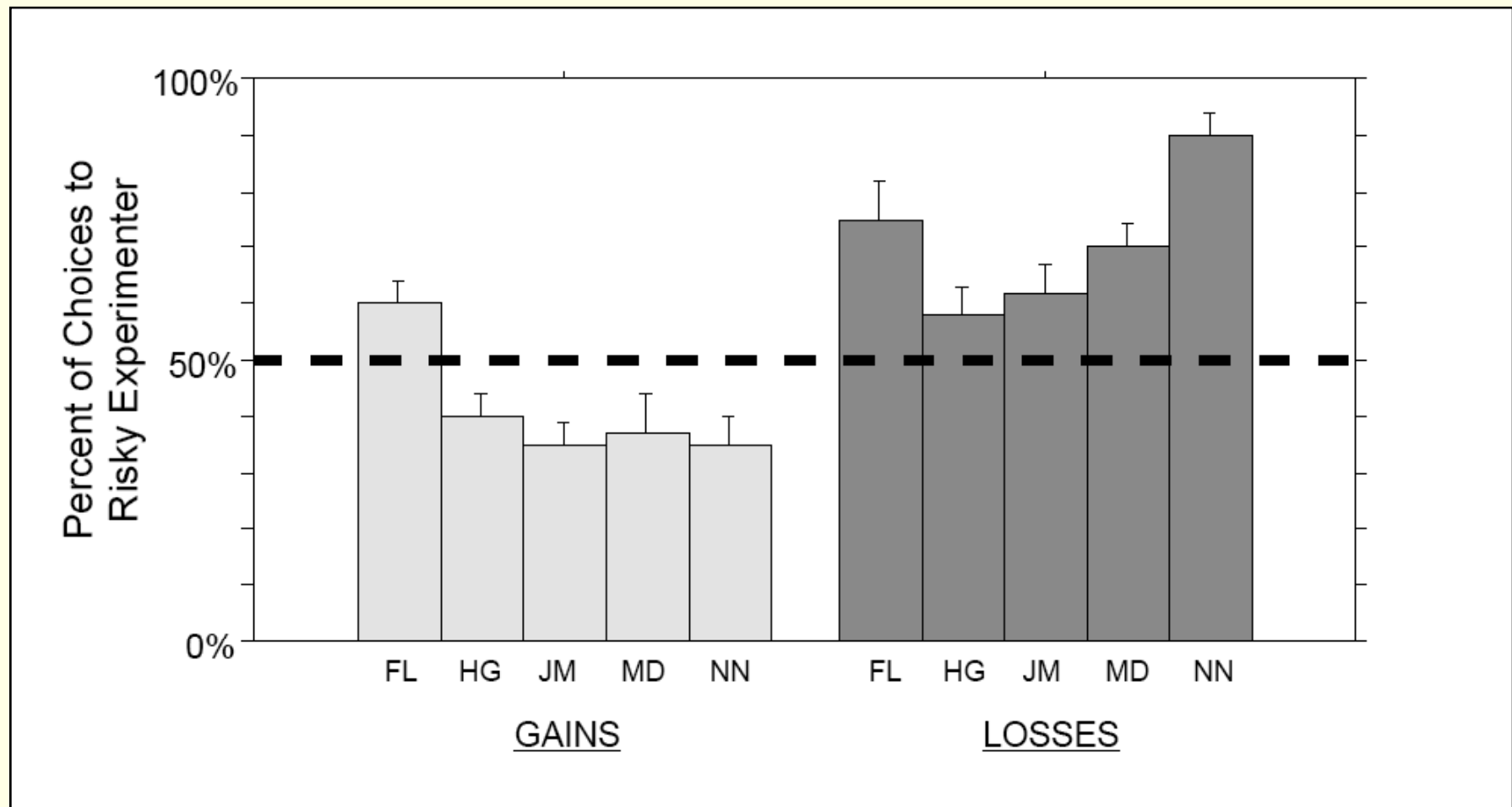
Program D: If Program D is adopted there is 1/3 probability that nobody will die, and 2/3 probability that 600 people will die [78%].

Experiment Four

Experiment 2

Question:

Do capuchins display the reflection effect?



You now own the object in your possession. [You do not own the object that you see in the possession of some of your neighbors.] You have the option of selling it [buying one] if a price, which will be determined later, is acceptable to you. For each of the possible prices below indicate whether you wish to: (1) Sell your object and receive this price [Pay this price and receive an object to take home with you] or (2) Keep your object and take it home with you. [Not buy an object at this price.] For each price indicate your decision by marking an X in the appropriate column.

At a price of \$.25... ☐ I will sell [buy] ☐ I will not sell [buy]

At a price of \$.50... ☐ I will sell [buy] ☐ I will not sell [buy]

At a price of \$.75... ☐ I will sell [buy] ☐ I will not sell [buy]

<so on until>...

At a price of \$8.75... ☐ I will sell [buy] ☐ I will not sell [buy]

RESULTS OF EXPERIMENT 1				
INDUCED-VALUE MARKETS				
Trial	Actual Trades	Expected Trades	Price	Expected Price
1	12	11	3.75	3.75
2	11	11	4.75	4.75
3	10	11	4.25	4.25
CONSUMPTION GOODS MARKETS				
Trial	Trades	Price	Median Buyer Reservation Price	Median Seller Reservation Price
Mugs (Expected Trades = 11)				
4	4	4.25	2.75	5.25
5	1	4.75	2.25	5.25
6	2	4.50	2.25	5.25
7	2	4.25	2.25	5.25
Pens (Expected Trades = 11)				
8	4	1.25	.75	2.50
9	5	1.25	.75	1.75
10	4	1.25	.75	2.25
11	5	1.25	.75	1.75

Kahneman, Knetsch, Thaler (1990)

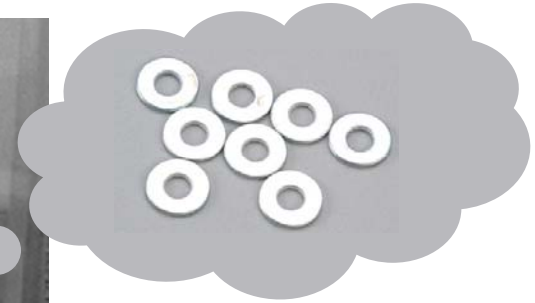
THE ENDOWMENT EFFECT IN CAPUCHINS:

Does ownership influence value for monkeys?

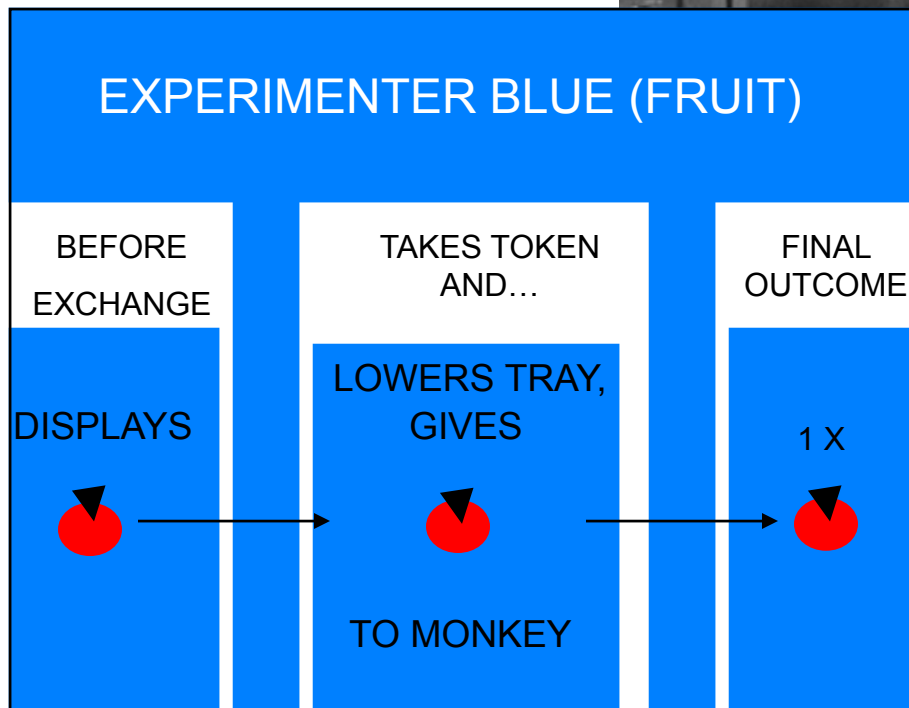
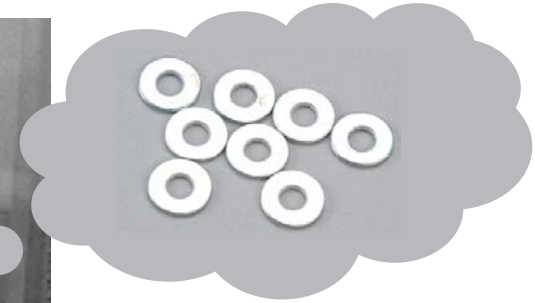
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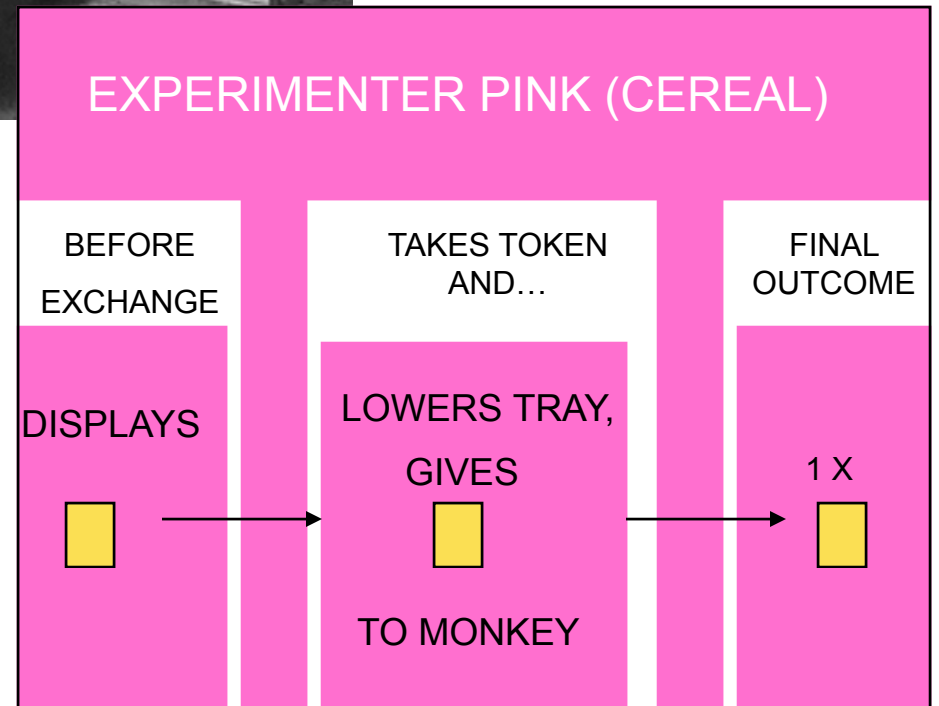
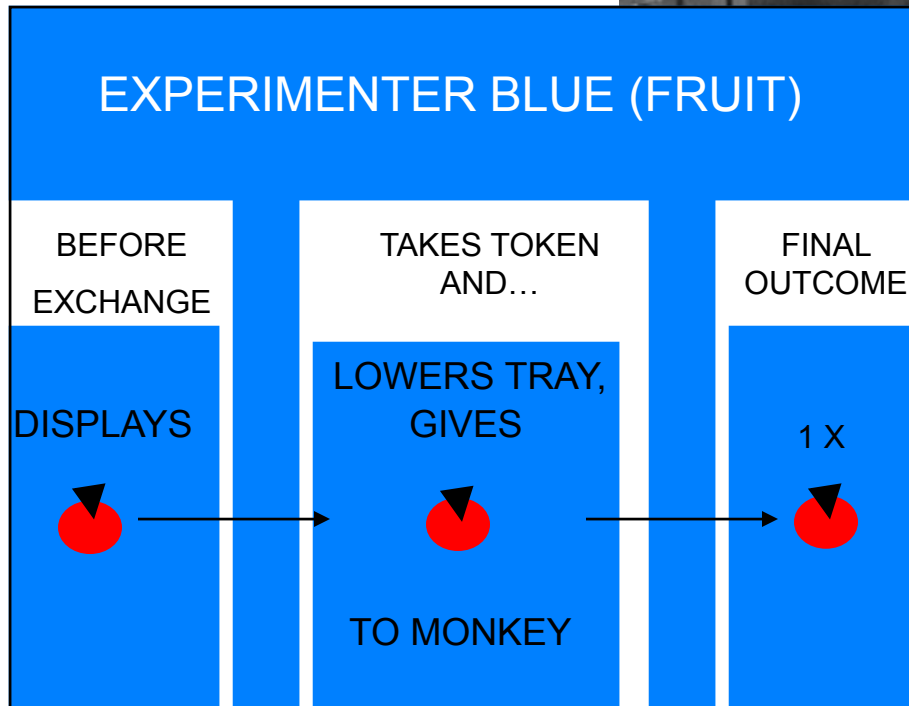
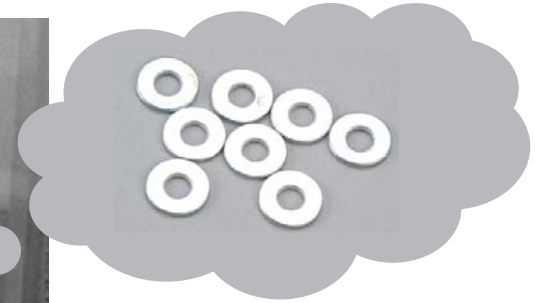
Expt 1: Equivalence Test



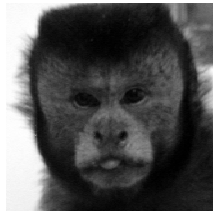
Expt 1: Equivalence Test



Expt 1: Equivalence Test



Results: Endowment Effect Baseline



**Tokens
Traded for
Cereal**

6

5

7

7

5

**Tokens
Traded for
Fruit**

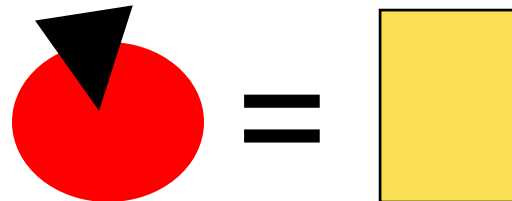
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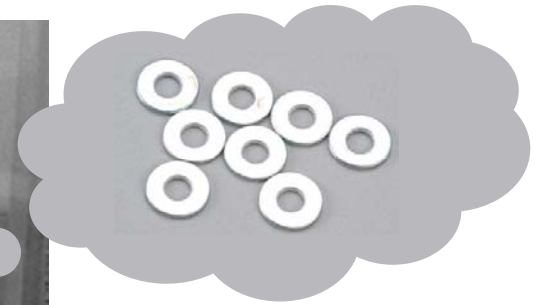
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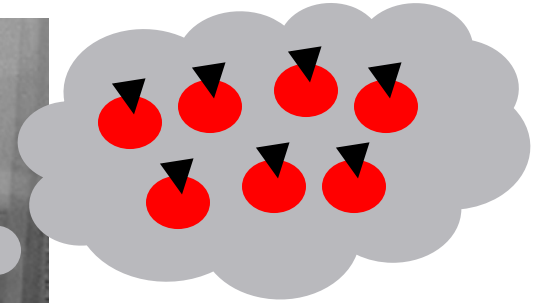
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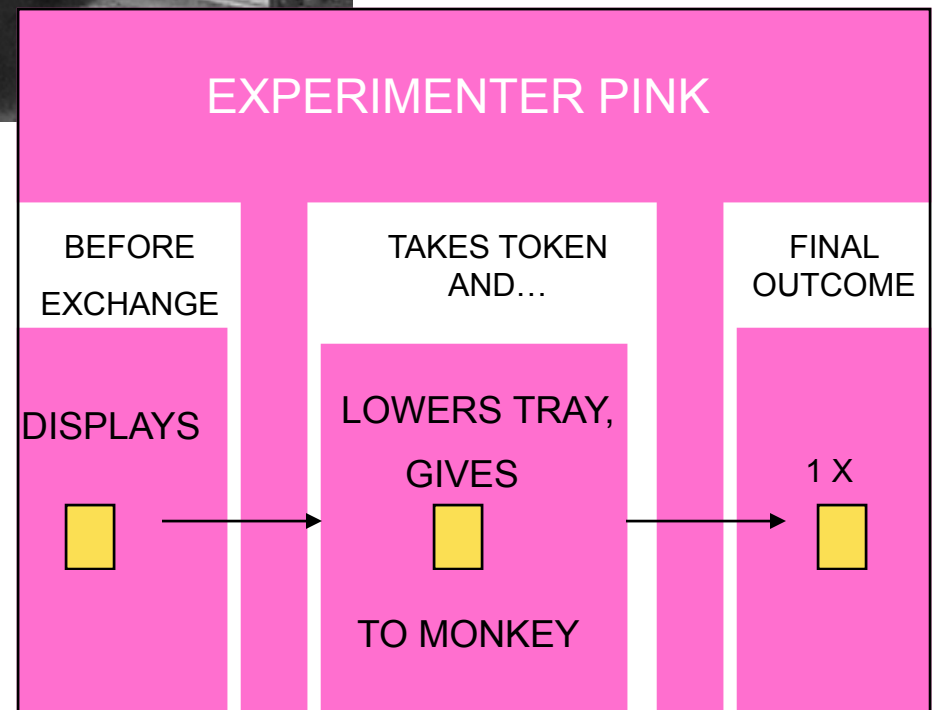
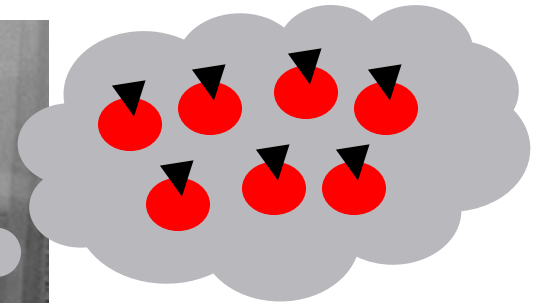
Expt 2: Endowment Effect



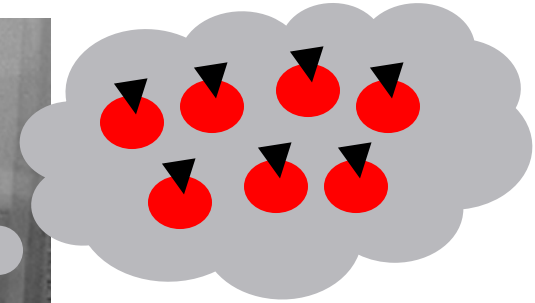
Expt 2: Endowment Effect



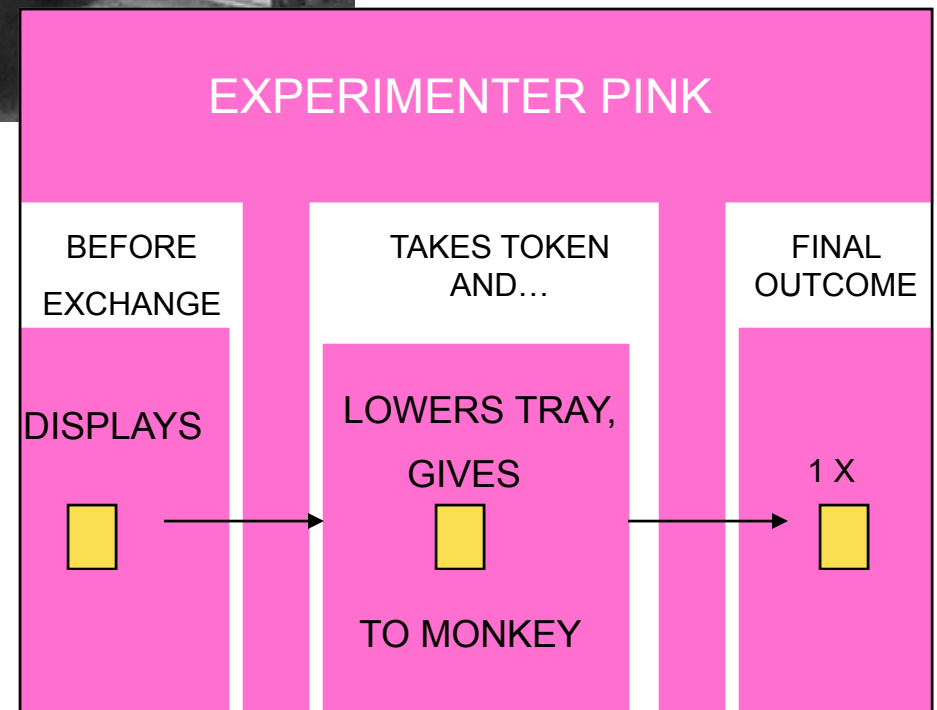
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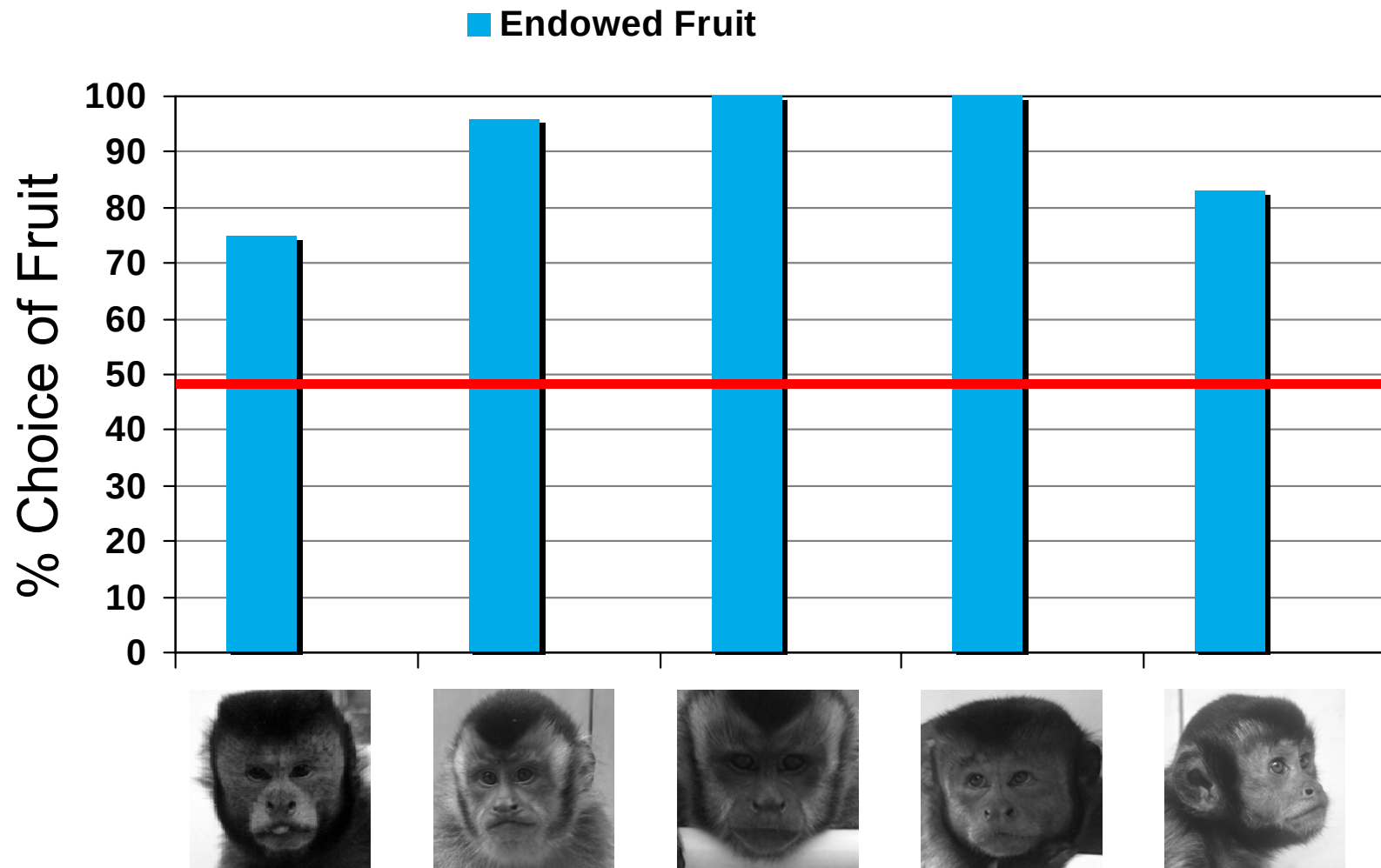
Expt 2: Endowment Effect



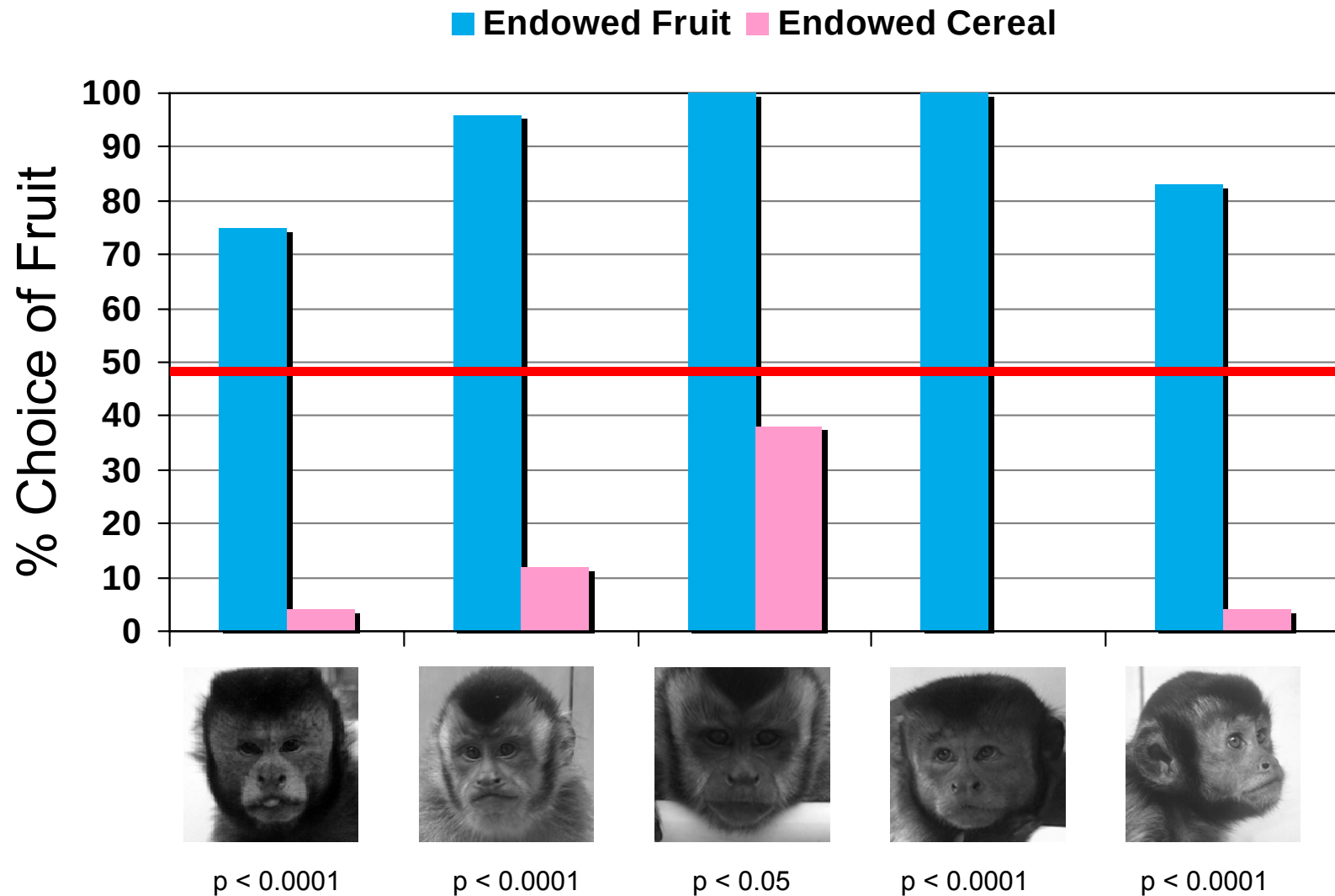
EQUIVALENT GOOD ➤

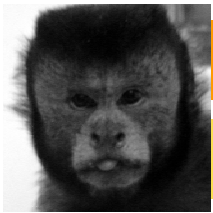
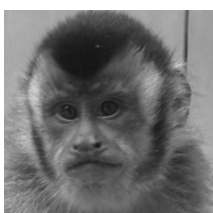


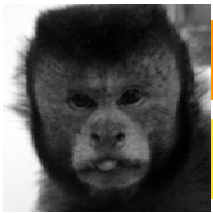
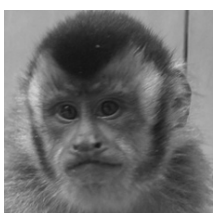
Expt 2: Endowment Effect



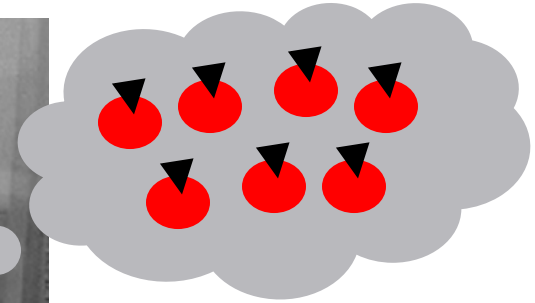
Expt 2: Endowment Effect



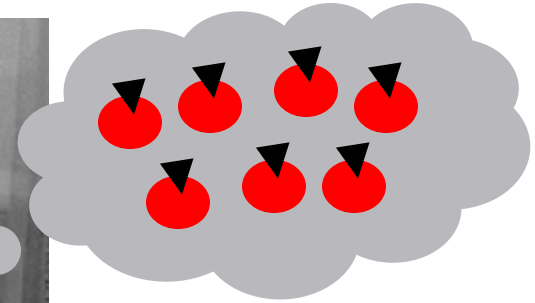
	Endow With	Trade For	Eaten	Traded
	Fruit	Cereal	18	6
	Cereal	Fruit	23	1
	Fruit	Cereal	24	0
	Cereal	Fruit	24	0
	Fruit	Cereal	20	4
	Cereal	Fruit	23	1
	Fruit	Cereal	23	1
	Cereal	Fruit	21	3
	Fruit	Cereal	15	9
	Cereal	Fruit	24	0

	Endow With	Trade For	Eaten	Traded
	Fruit	Cereal	18	6
	Cereal	Fruit	23	1
	Fruit	Cereal	24	0
	Cereal	Fruit	24	0
	Fruit	Cereal	20	4
	Cereal	Fruit	23	1
	Fruit	Cereal	23	1
	Cereal	Fruit	21	3
	Fruit	Cereal	15	9
	Cereal	Fruit	24	0
			215	25

Expt 3: Endowment Effect Control

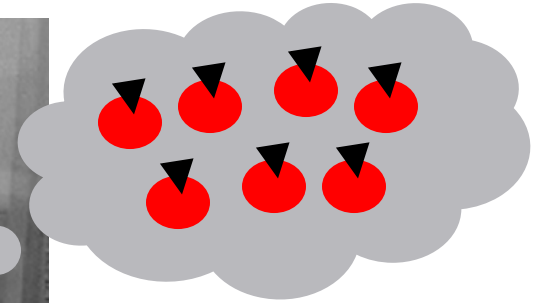


Expt 3: Endowment Effect Control



MUCH BETTER GOOD

Expt 3: Endowment Effect Control

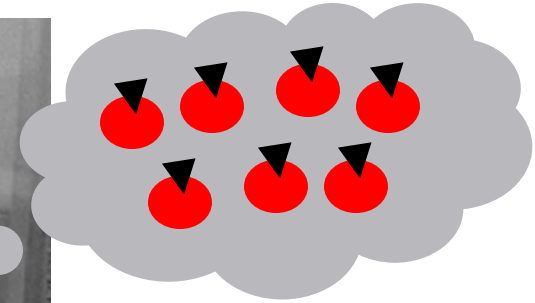


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MUCH BETTER GOOD

Expt 3: Endowment Effect Control



EXPERIMENTER PINK

BEFORE
EXCHANGE

DISPLAYS



TAKES TOKEN
AND...

LOWERS TRAY,
GIVES

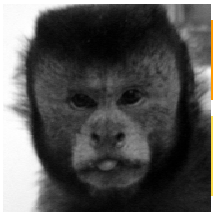
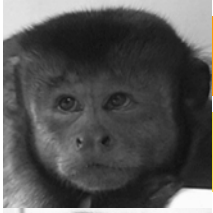
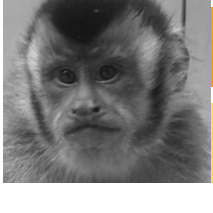
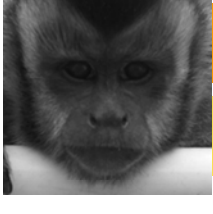


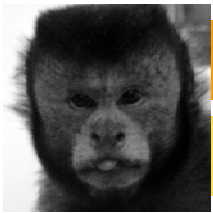
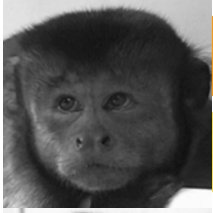
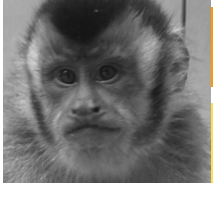
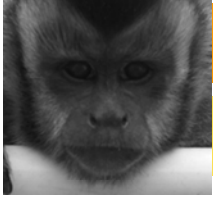
FINAL
OUTCOME

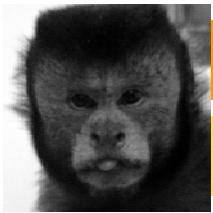
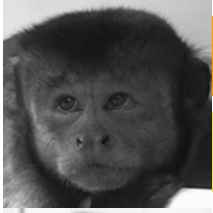
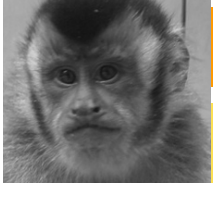
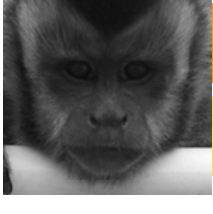
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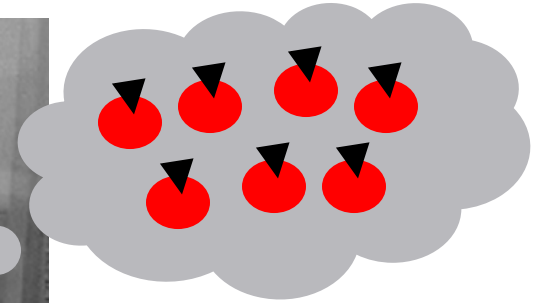
MUCH BETTER GOOD ➤

	Endow With	Trade For	Eaten	Traded
	Fruit	Fluff-Roll-Up		
	Cereal	Fluff-Roll-Up		
	Fruit	Fluff-Roll-Up		
	Cereal	Fluff-Roll-Up		
	Fruit	Fluff-Roll-Up		
	Cereal	Fluff-Roll-Up		
	Fruit	Fluff-Roll-Up		
	Cereal	Fluff-Roll-Up		
	Fruit	Fluff-Roll-Up		
	Cereal	Fluff-Roll-Up		

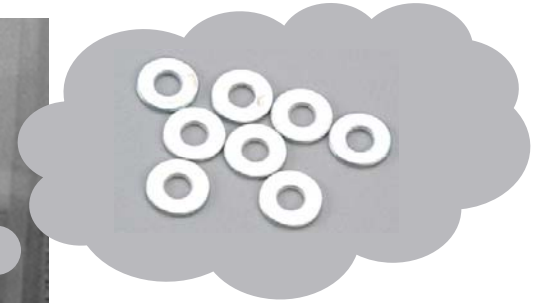
	Endow With	Trade For	Eaten	Traded
	Fruit	Fluff-Roll-Up	0	24
	Cereal	Fluff-Roll-Up	5	19
	Fruit	Fluff-Roll-Up	0	24
	Cereal	Fluff-Roll-Up	0	24
	Fruit	Fluff-Roll-Up	2	20
	Cereal	Fluff-Roll-Up	0	24
	Fruit	Fluff-Roll-Up	2	22
	Cereal	Fluff-Roll-Up	10	14
	Fruit	Fluff-Roll-Up	6	18
	Cereal	Fluff-Roll-Up	7	17

	Endow With	Trade For	Eaten	Traded
	Fruit	Fluff-Roll-Up	0	24
	Cereal	Fluff-Roll-Up	5	19
	Fruit	Fluff-Roll-Up	0	24
	Cereal	Fluff-Roll-Up	0	24
	Fruit	Fluff-Roll-Up	2	20
	Cereal	Fluff-Roll-Up	0	24
	Fruit	Fluff-Roll-Up	2	22
	Cereal	Fluff-Roll-Up	10	14
	Fruit	Fluff-Roll-Up	6	18
	Cereal	Fluff-Roll-Up	7	17
			32	208

Expt 4: Transaction Cost Control

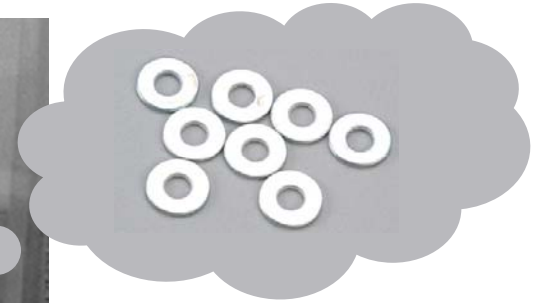


Expt 4: Transaction Cost Control



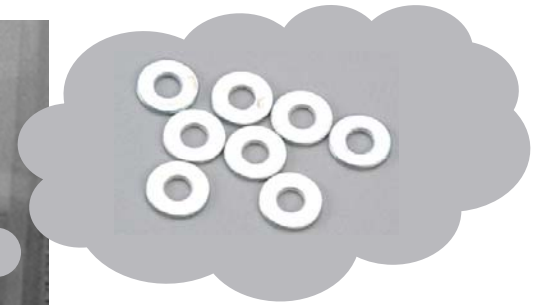
SMALLEST POSSIBLE GOOD

Expt 4: Transaction Cost Control



SMALLEST POSSIBLE GOOD

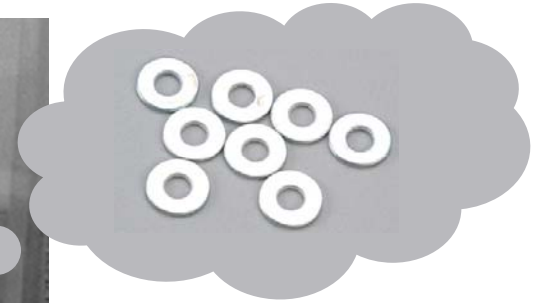
Expt 4: Transaction Cost Control



= 1 oat

SMALLEST POSSIBLE GOOD

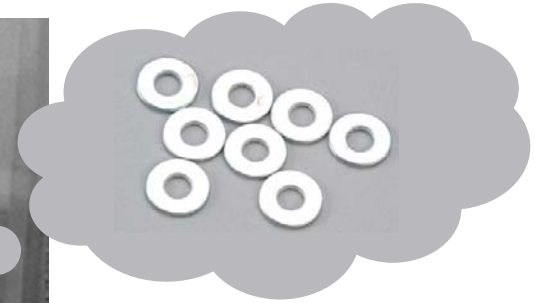
Expt 4: Transaction Cost Control



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SMALLEST POSSIBLE GOOD

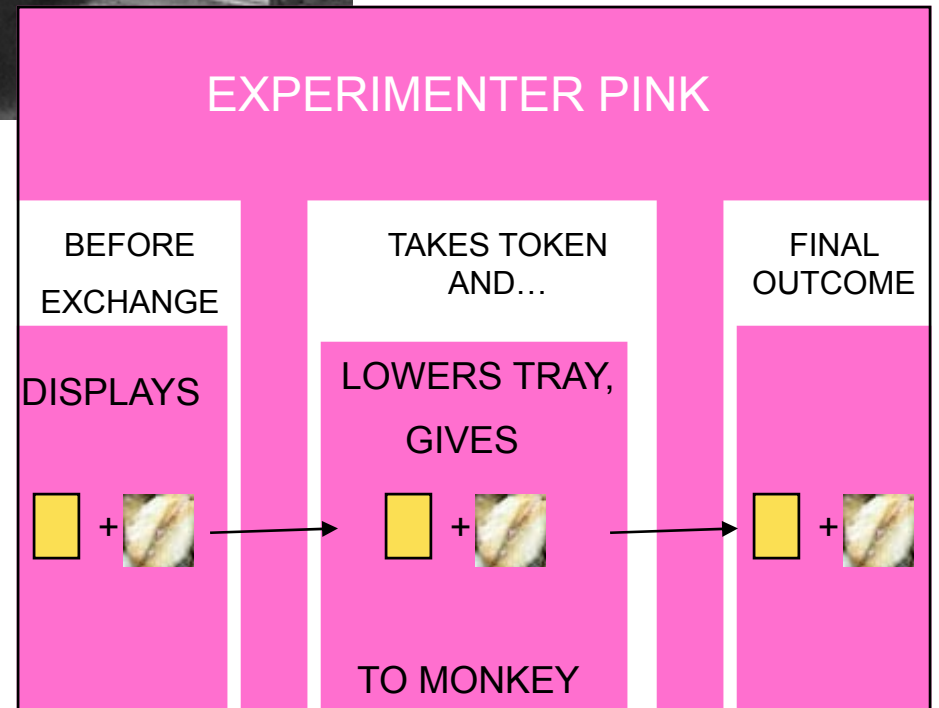
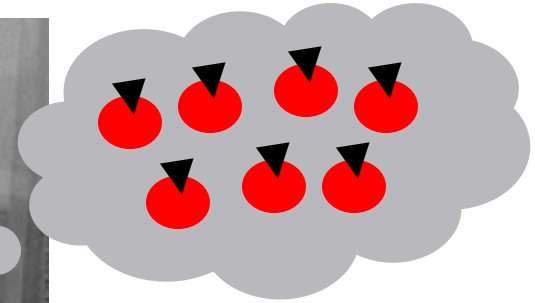
Expt 4: Transaction Cost Control



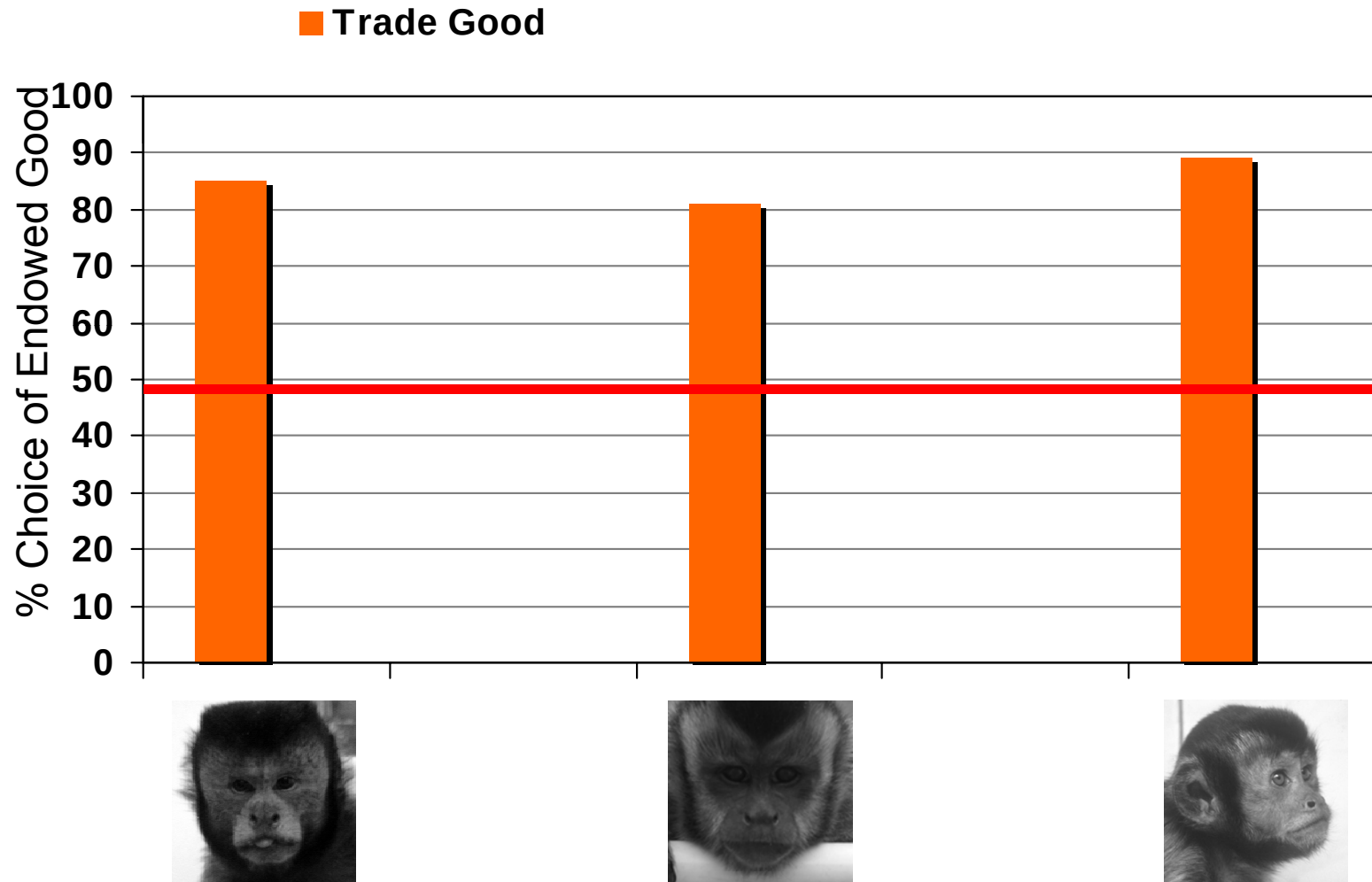
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SMALLEST POSSIBLE GOOD

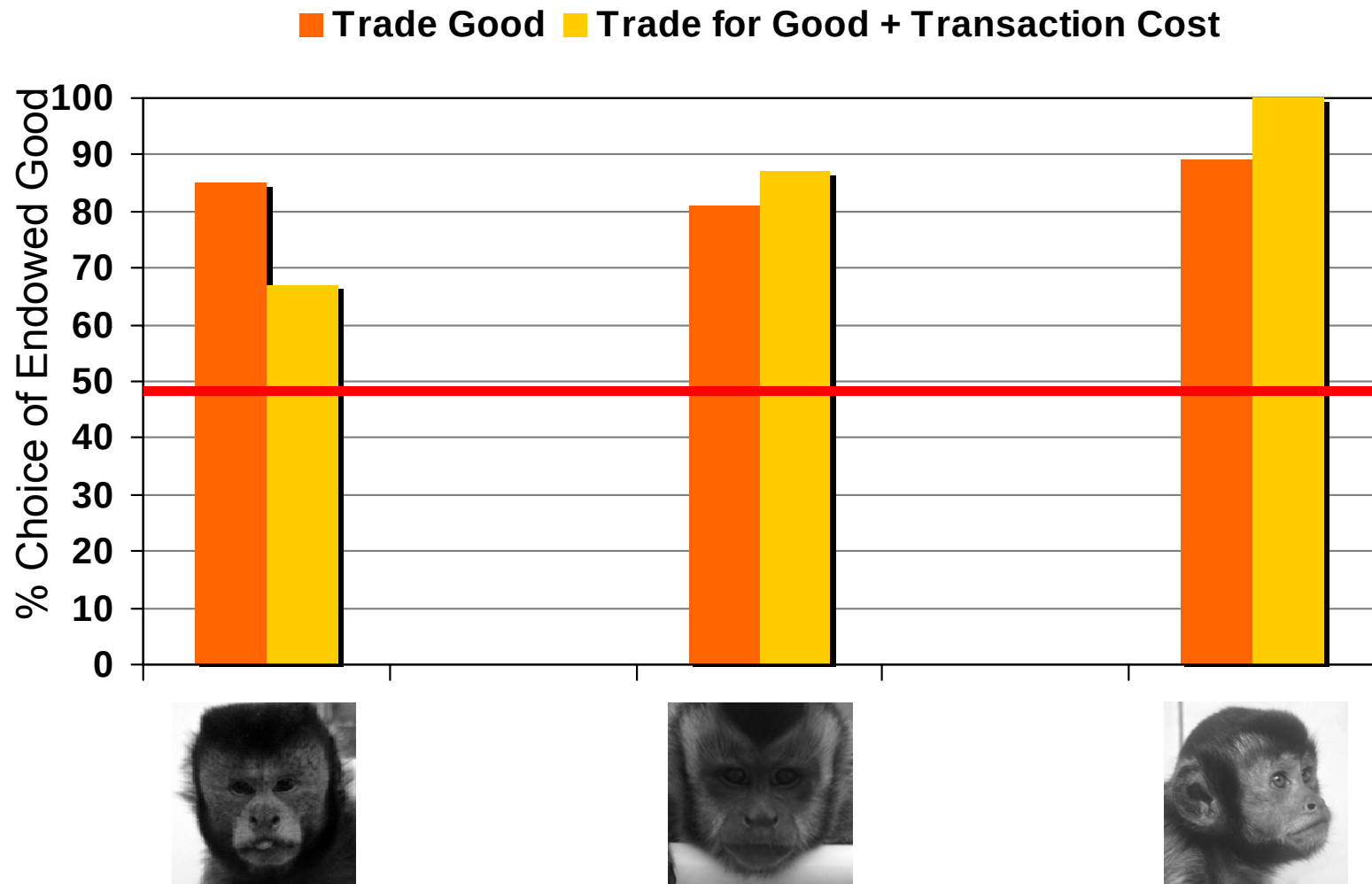
Expt 4: Transaction Cost Control



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Expt 4: Transaction Cost Control



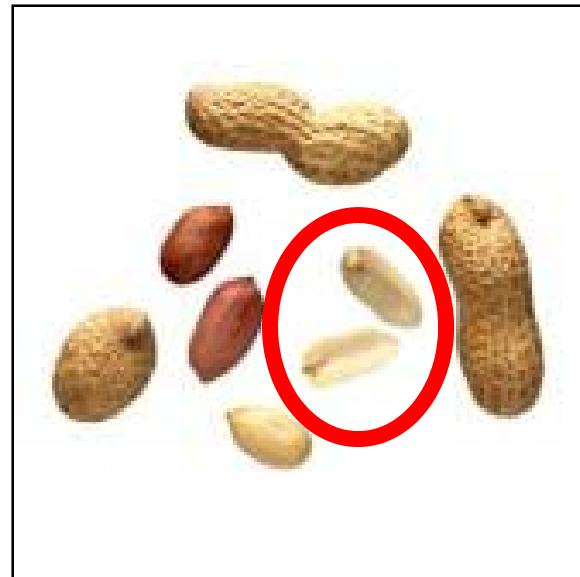
Expt 5: Timing Control



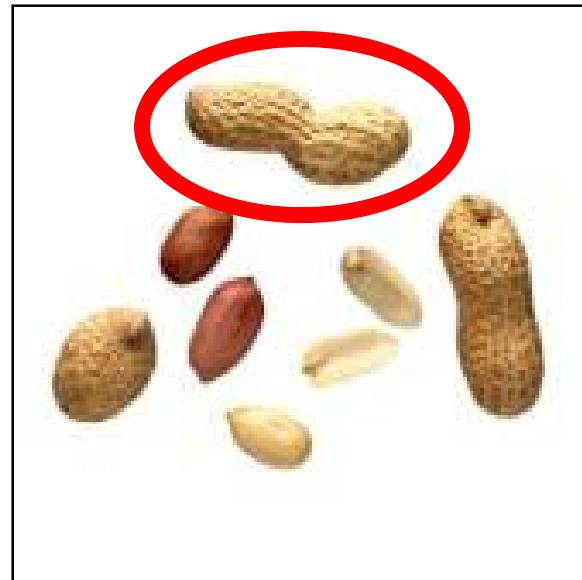
Expt 5: Timing Control



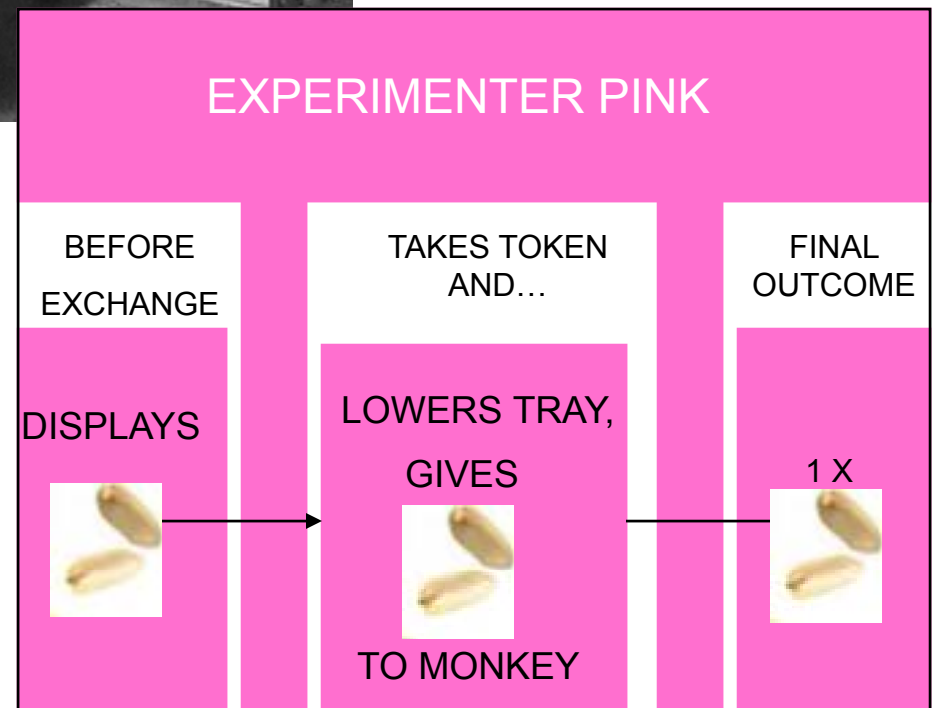
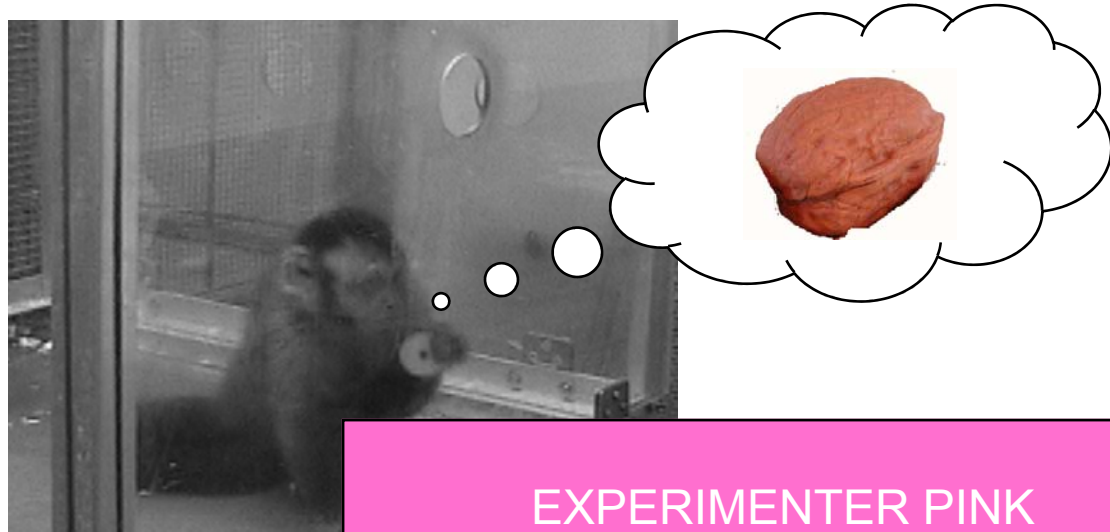
Expt 5: Timing Control



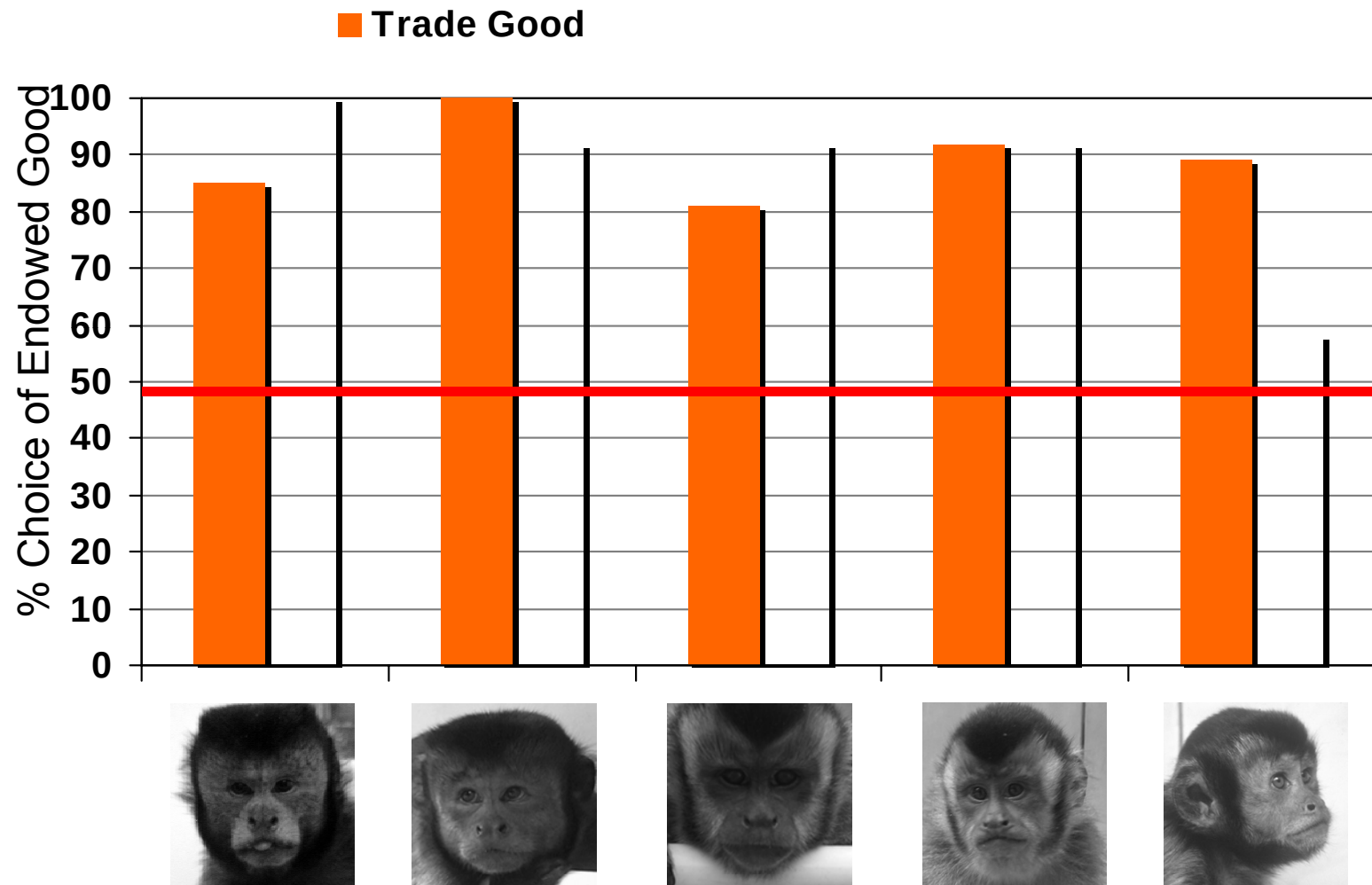
Expt 5: Timing Control



Expt 5: Timing Control

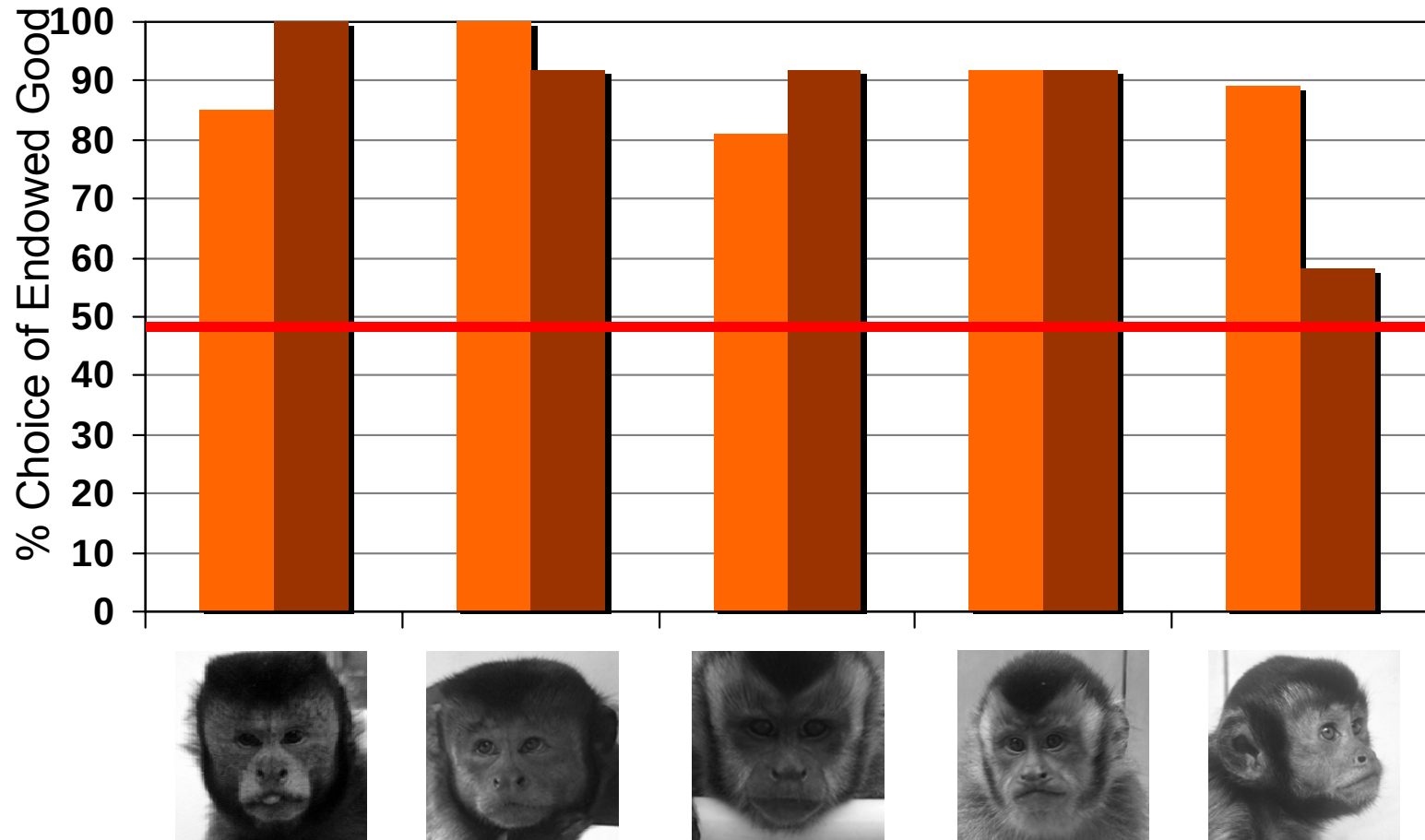


Expt 5: Timing Control



Expt 5: Timing Control

Trade Good Trade for Shorter Timed Good



Conclusions and Future Work

Evidence that:

- Price theory works quite well far afield
- Loss-aversion and reference-dependence most likely ancient and innate
 - Suggests these behaviors likely to persist and hold across contexts

Future work:

- Behavioral biases: endowment effect, self-control
- Investigate non-consequential probabilistic reasoning

Why Capuchins?

Universal vs. universal and ***Innate*** behaviors

Humans	Capuchins
have cultures, learn	limited learning, no culture
limited time in the lab	raised in the lab
very smart, rich language	not as smart, no language
large sample sizes	sample of 8, (current max)
incentives low-powered	highly motivated