

# Gambling pigeons: Primary rewards are not all that matter

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Marcia Spetch, University of Alberta

Collaborators:

Matthew Brown, University of Alberta

Roger Dunn, San Diego State University

Elliot Ludvig, University of Warwick ([poster](#))

Christopher Madan, Boston College ([poster](#))

Margaret McDevitt, McDaniel College

Neil McMillan, University of Alberta

Jeffrey Pisklak, University of Alberta



# My goal

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1. Humans are not unique in making “irrational” choices.
2. Irrational choices may reflect basic learning and memory processes.



\$20 for sure



**OR**



50% Chance of \$40

Which option would you pick?



\$20 for sure



OR



50% Chance of \$40

Most people play it safe



Lose \$20 for sure



OR



50% Chance lose \$40

Now, which option would you pick?



Lose \$20 for sure



OR



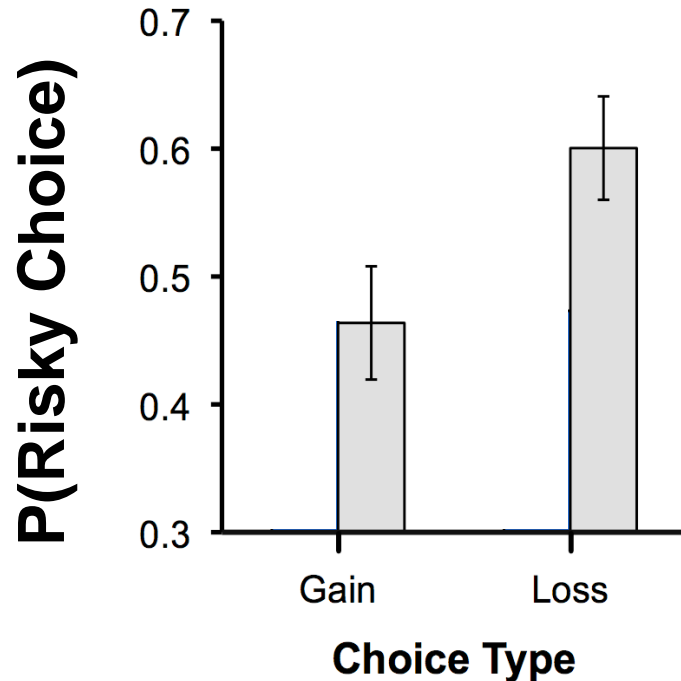
50% Chance lose \$40



Most people take the chance

People are more risk seeking for losses than for gains.

“Reflection Effect” Kahneman & Tversky, 1979



Same result when given repeated described choices

N=56

Ludvig & Spetch, 2011

# What if outcomes are instead learned by reinforcement?

Ludvig & Spetch, 2011









# Some doors lead to losses

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**- 20**



# Some doors are risky (outcome varies)

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- 40





- 0

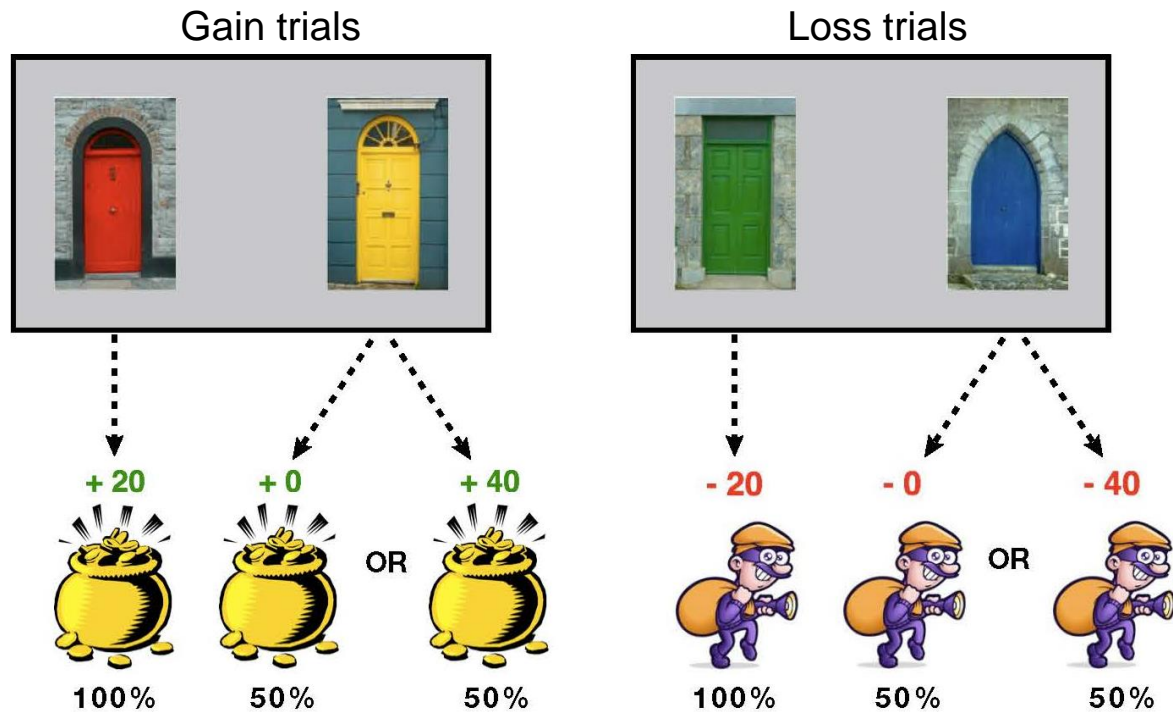




Some trials only give one door to ensure exposure to all contingencies

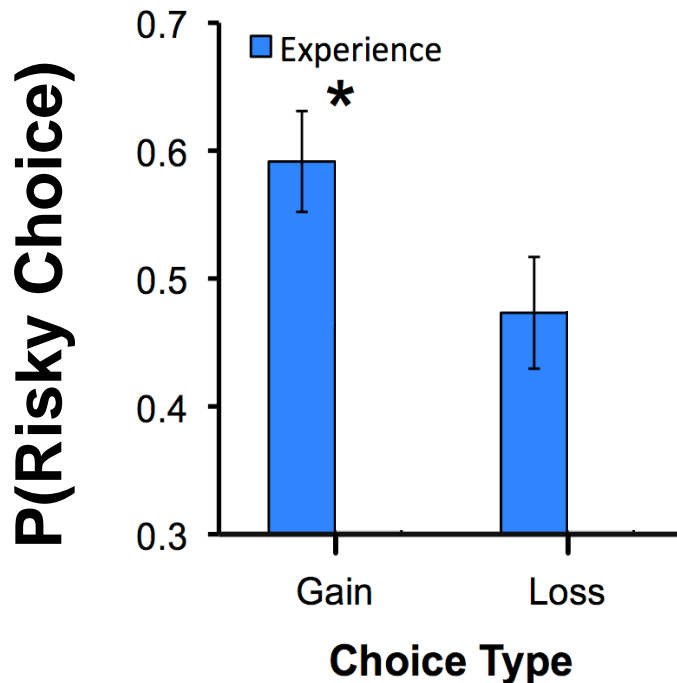


# After learning, people choose between fixed and risky doors



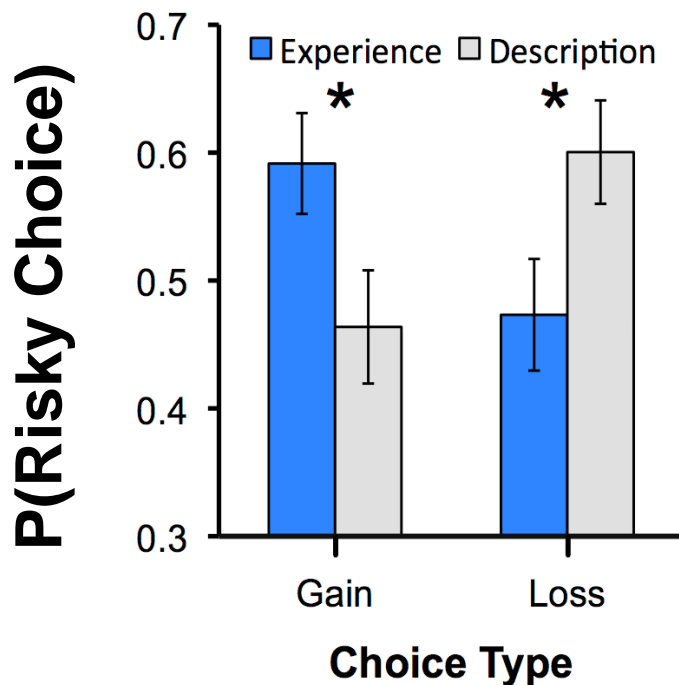
Do people still show different risk preferences for gains and losses?

Yes... but preference is biased in the *opposite* way



Experienced choices: Gamble more on gain trials!

Ludvig & Spetch, 2011



Experienced choices: Gamble more on gain trials!

Described choices: Gambled more on loss trials

N=56 Same people, same session

Ludvig & Spetch, 2011

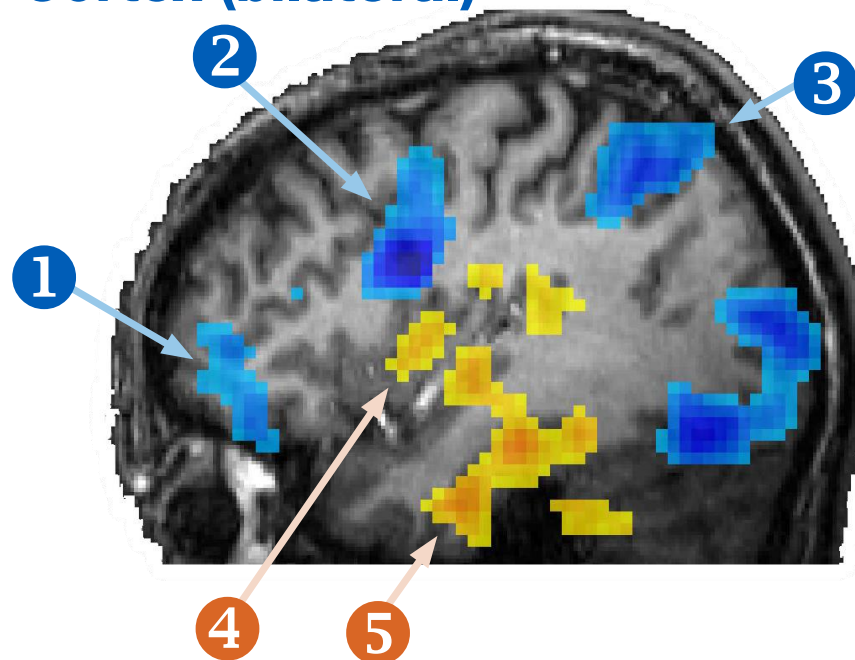
# Described and experience-based decisions engage different brain regions

Description > Experience

- ① OFC (bilateral)
- ② vIPFC (bilateral)
- ③ Superior Parietal Cortex (bilateral)

Experience > Description

- ④ Insula (bilateral)
- ⑤ Parahippocampal Cortex & Hippocampus (left)



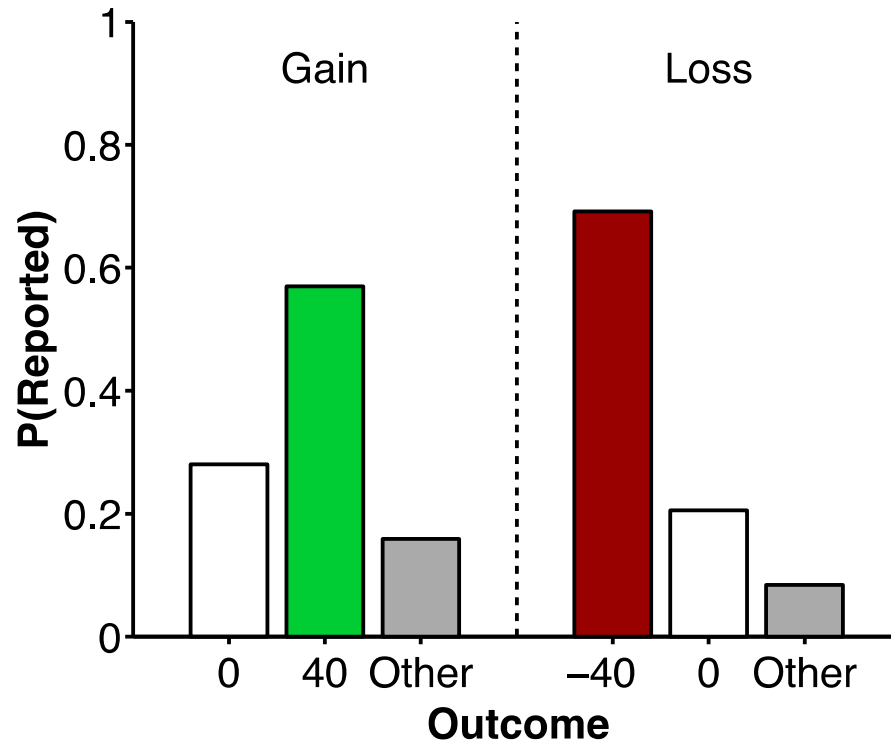
*Madan, Ludvig, Brown, Spetch,  
in prep (poster)*

*Why* are people more risk seeking for gains than for losses in experience-based choice?

- Based on learning and memory
- Memories overweight the extremes

# Extremes are overweighted in memory

First outcome to come to mind for risky door:



People also overestimate how often they got the extreme outcomes.

*Madan Ludvig, Spetch, 2014*

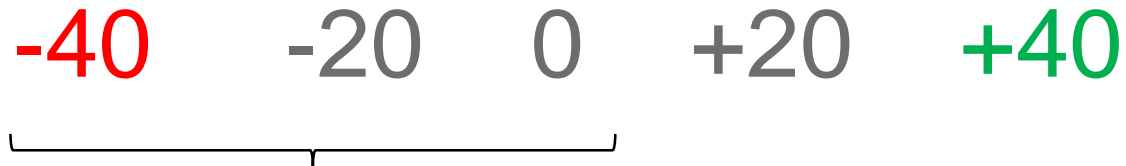
# *Why* are people more risk seeking for gains than for losses in experience-based choice?

- Based on learning and memory
- Memories overweight the extremes
- Avoid worst outcome and seek best outcome
- Decision context determines which outcomes are the extremes (worst and the best)



# Consider a loss choice: -20 vs 0/-40

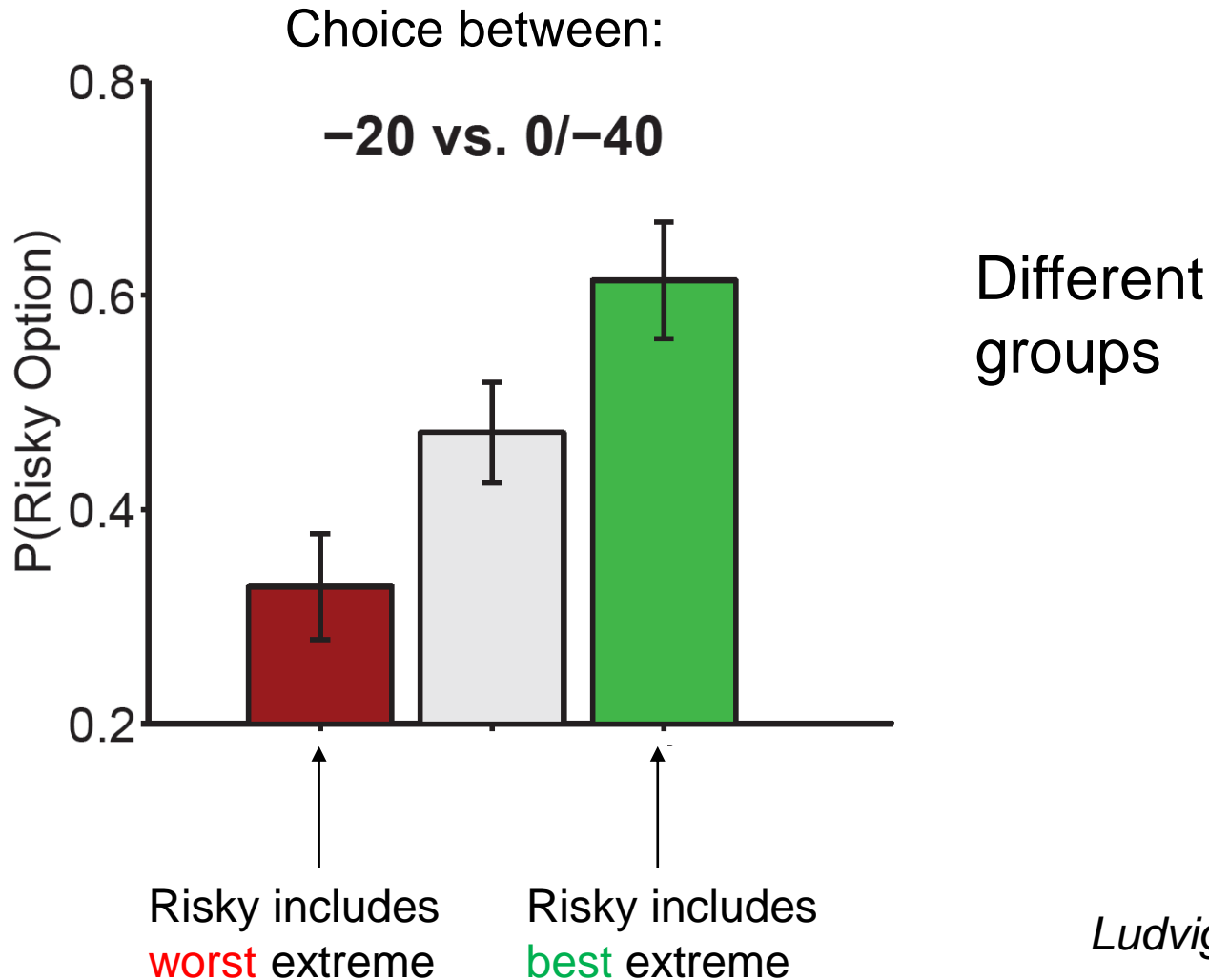
If gain and loss trials mixed, then the risky 0/-40 option includes the **worst** possible outcome:



But in an all loss context, the same risky choice now includes the **best** possible outcome.



# Decision context matters



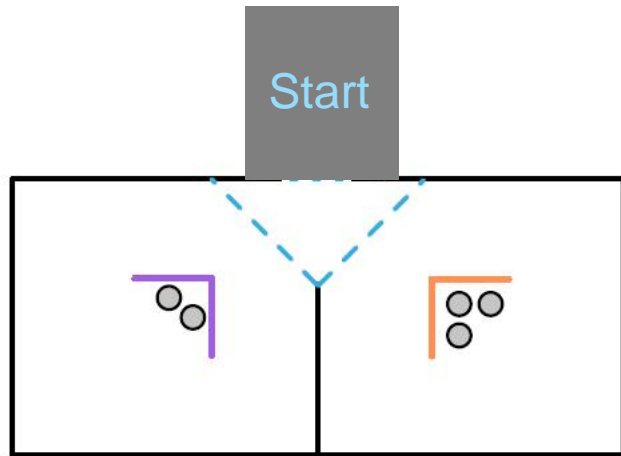
*Ludvig Madan Spetch, 2014*

# Is this bias unique to humans?

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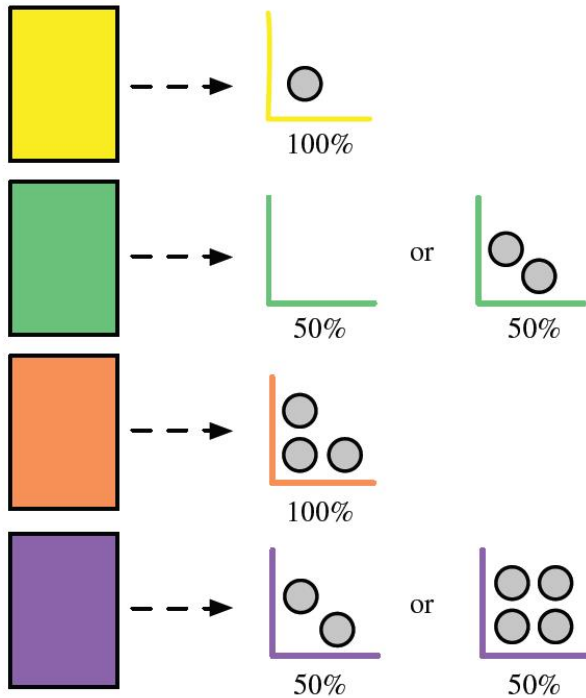
# Pigeon version of the door task



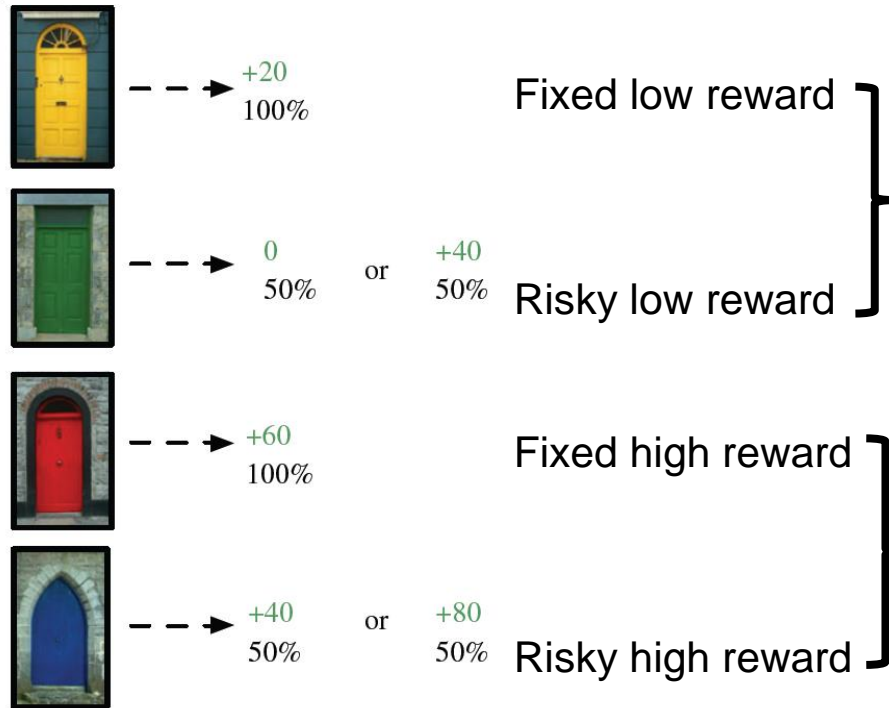
Used *relative* losses and gains:

*Ludvig et al., 2014*

## Pigeons



## People



Fixed low reward

Risky low reward

Fixed high reward

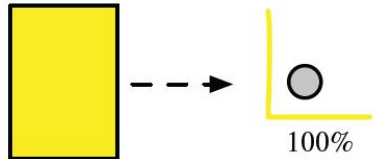
Risky high reward

Relative losses

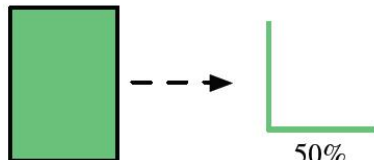
Relative gains

# Pigeons

# People

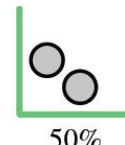


100%

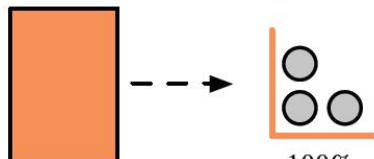


50%

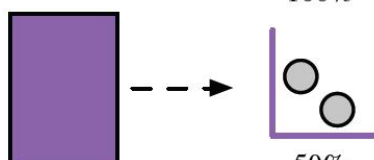
or



50%

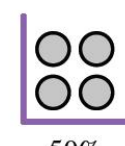


100%



50%

or



50%



+20  
100%

Fixed low reward



0  
50%

or  
+40  
50%

Risky low reward

Relative losses



+60  
100%

Fixed high reward



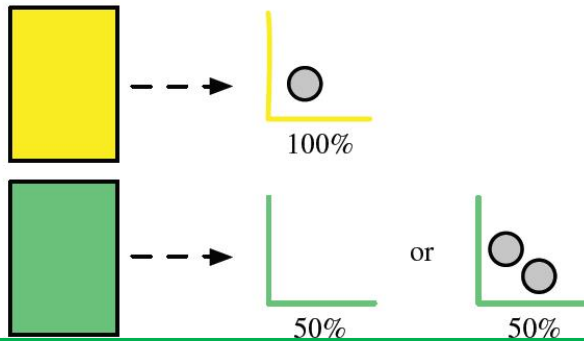
+40  
50%

or  
+80  
50%

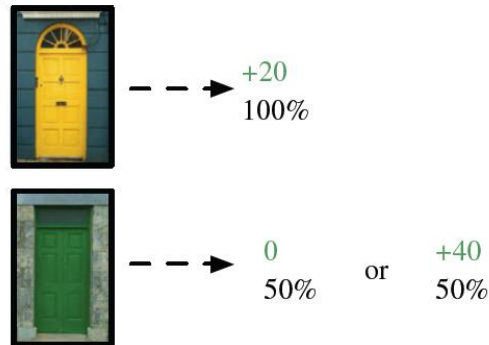
Risky high reward

Relative gains

## Pigeons



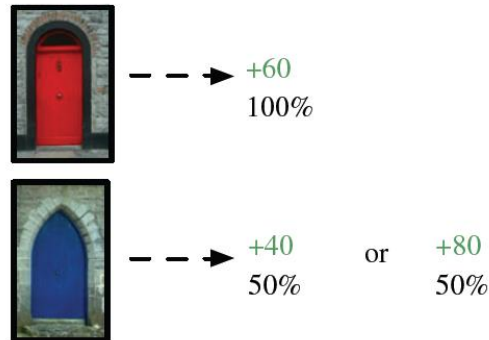
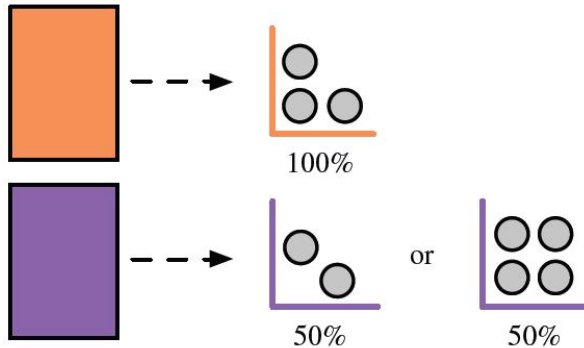
## People



Fixed low reward

Risky low reward

Relative losses

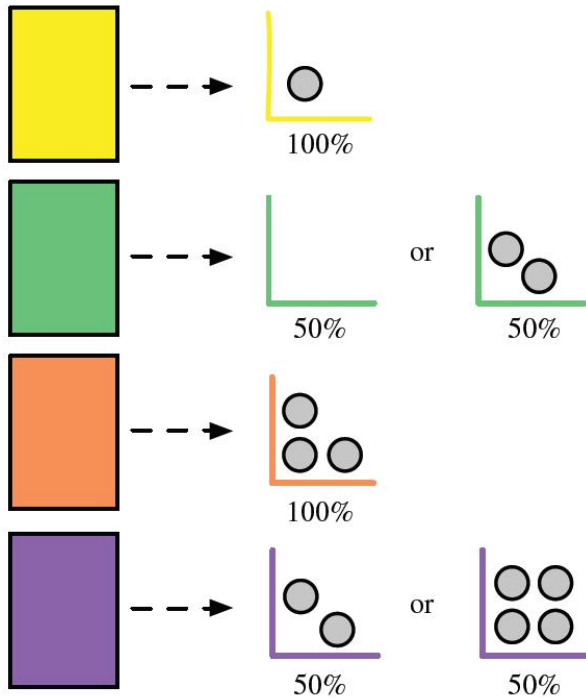


Fixed high reward

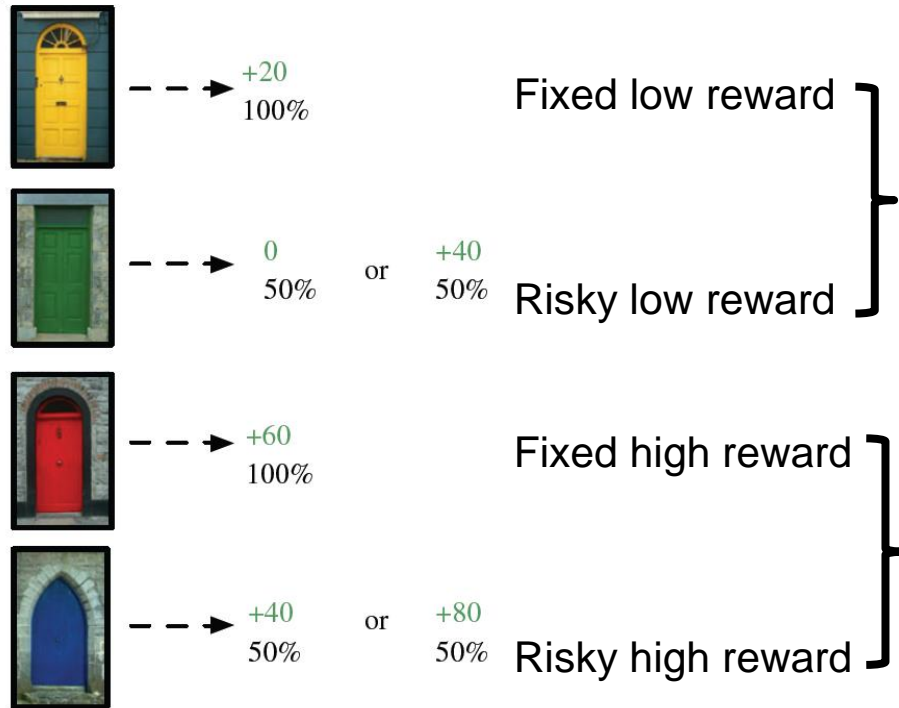
Risky high reward

Relative gains

# Pigeons



# People



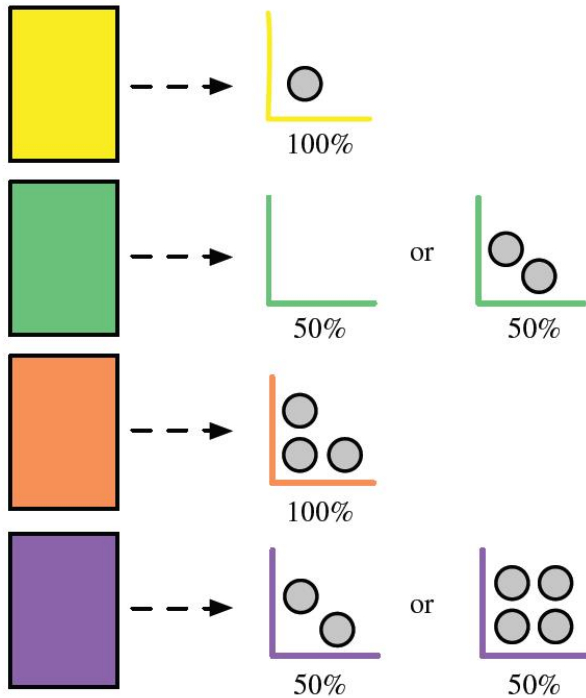
Learn?

Relative losses

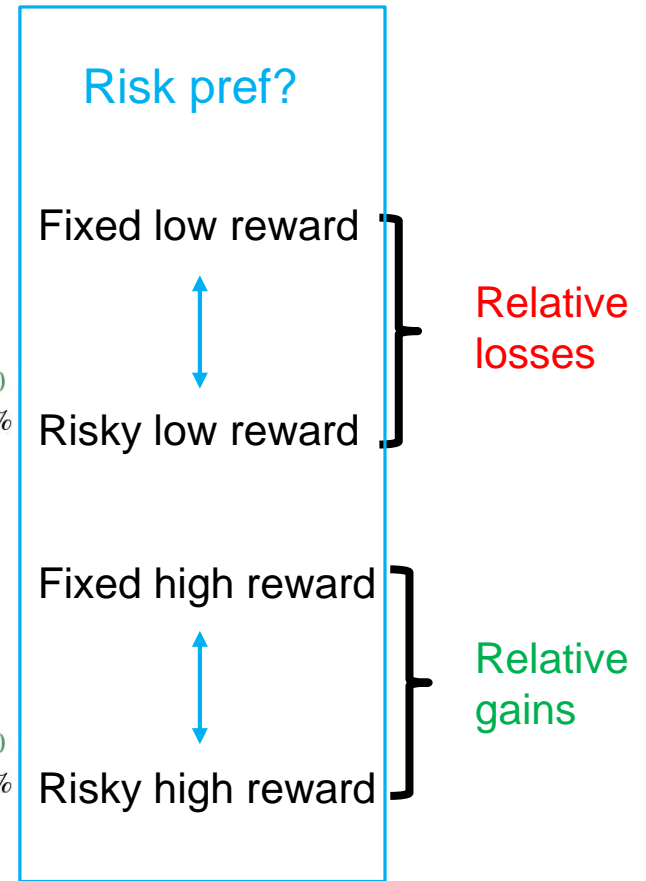
Relative gains



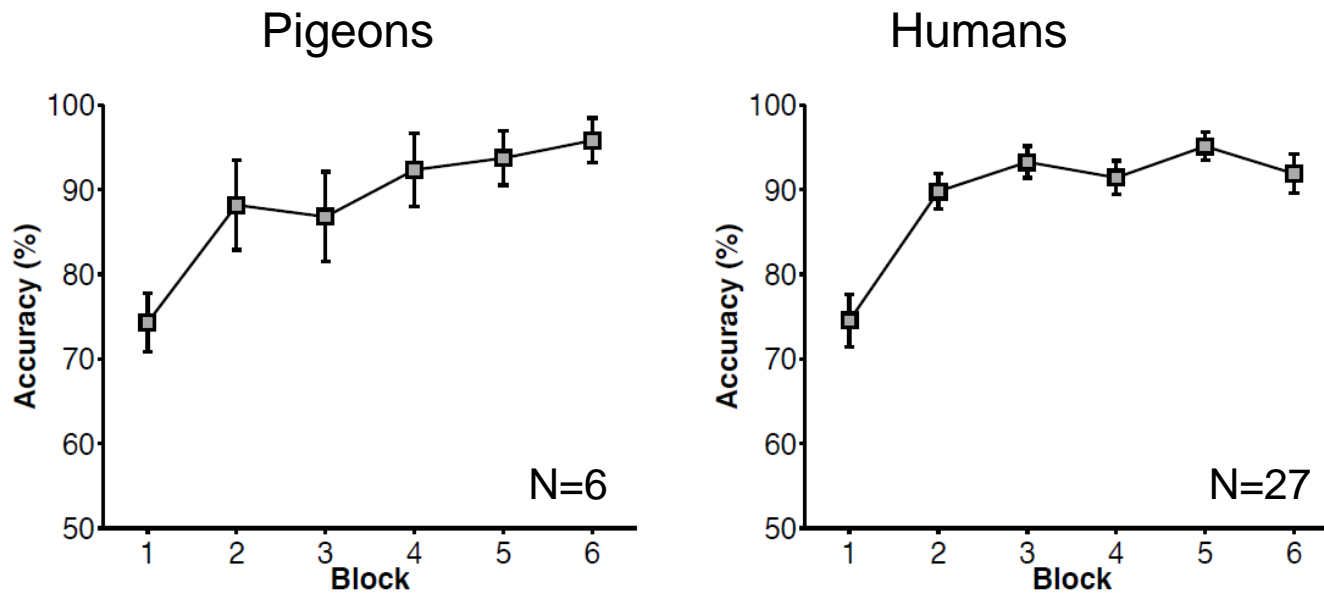
## Pigeons



## People

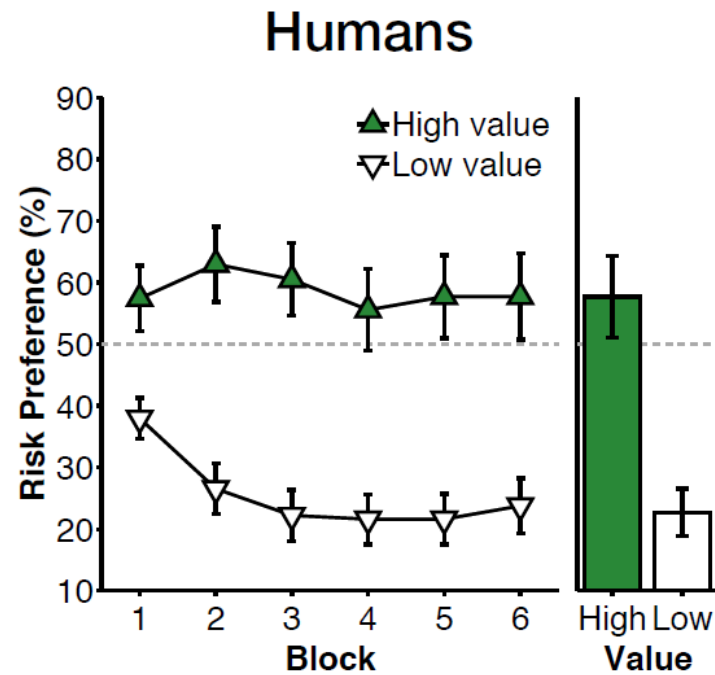
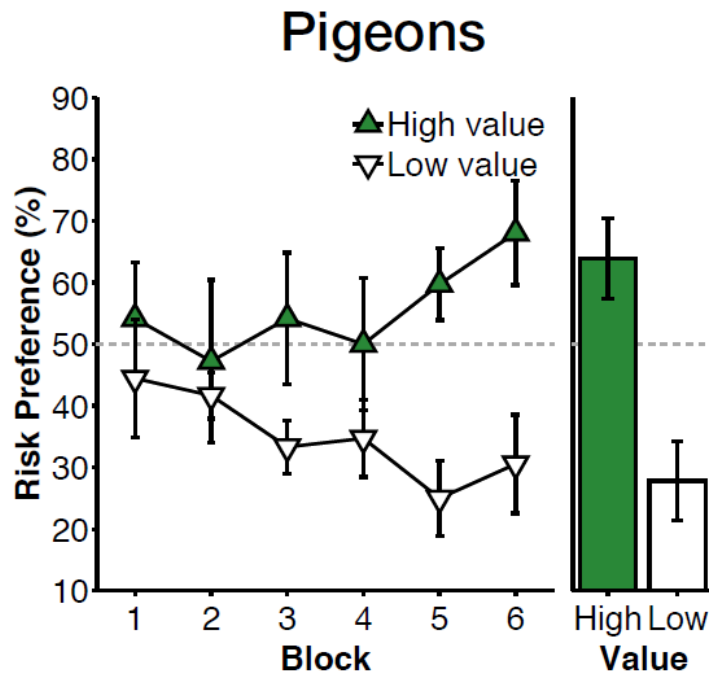


# Pigeons and people readily learned to choose high-value over low-value options



Blocks of 12 choices

Pigeons, like people, were riskier for high-value choices than for low-value choices



# So...

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- Similar bias in pigeons and humans
- Monkeys also develop risk seeking for gains (e.g. Hayden & Platt, 2007)
- For humans, bias depends on decision context and memory for extremes

# But, what if biases are “costly”?

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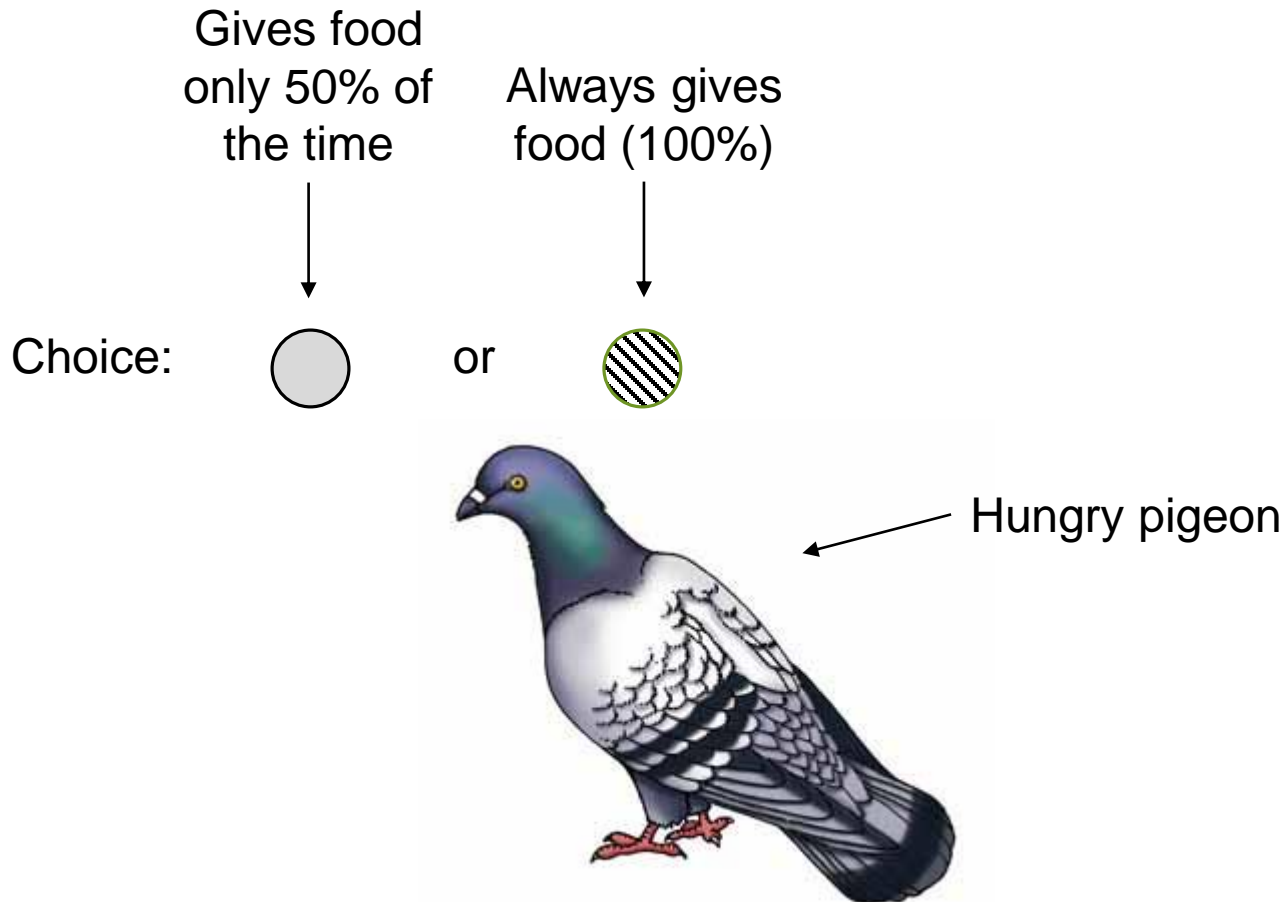
With equal expected value, bias has no cost.

Sometimes people seek risk ***despite*** large cost – e.g., problem gamblers.

Do animals also show costly irrational choices?

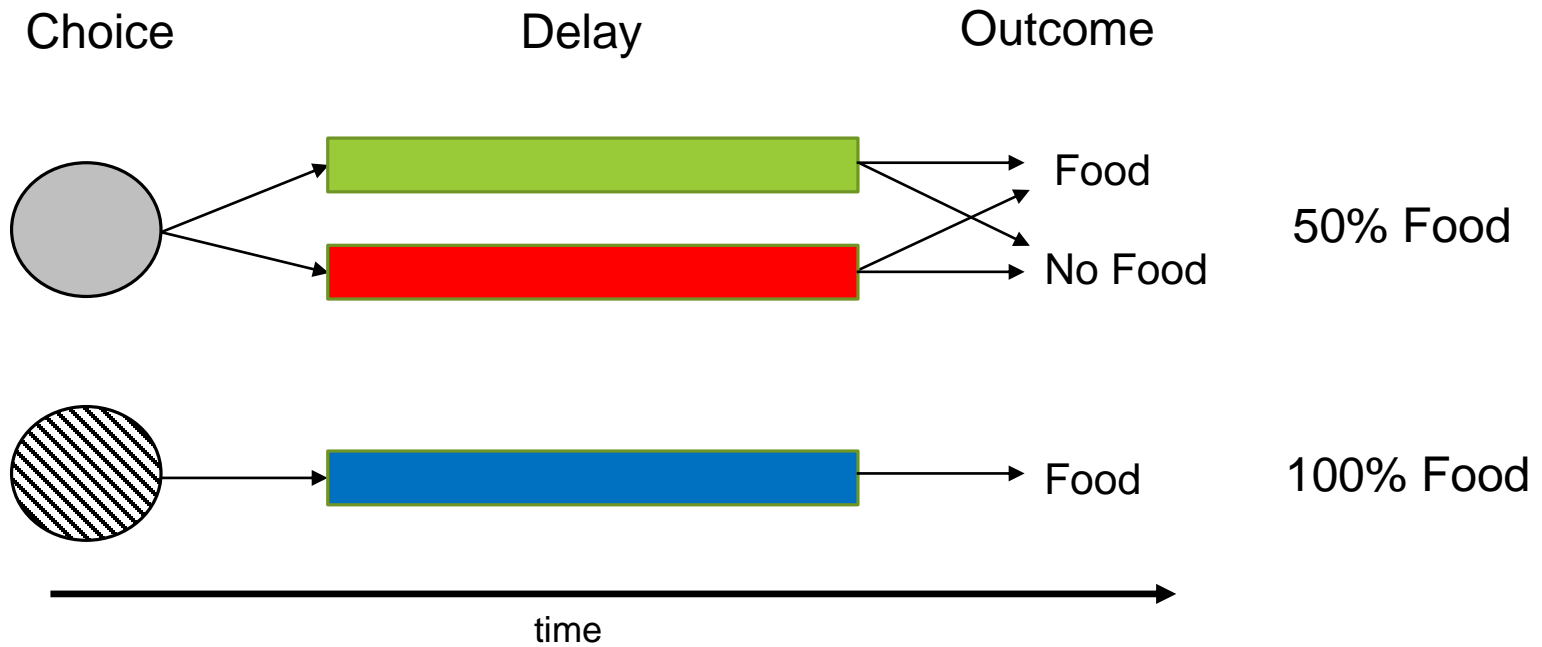
# Choice between 50% and 100% reinforcement

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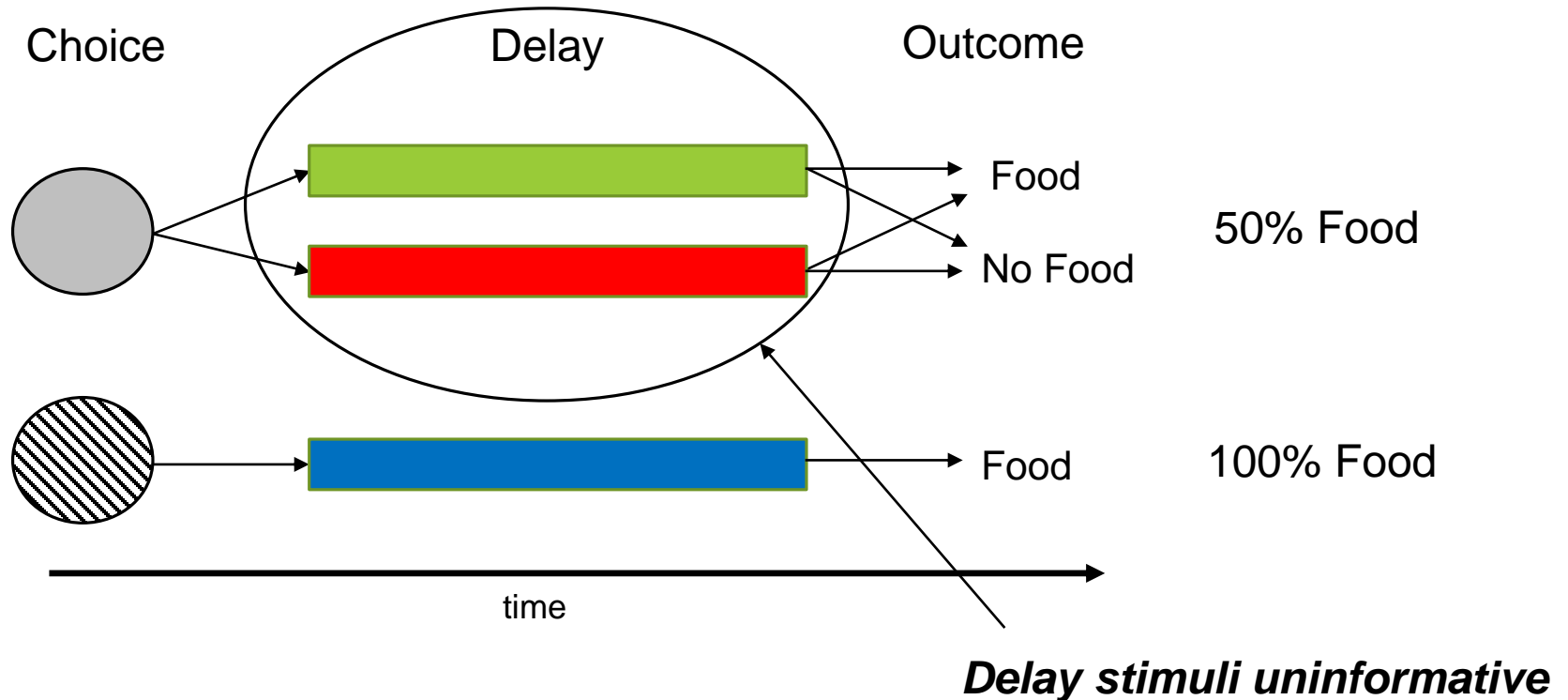
# Choice between 50% and 100% reinforcement

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# Choice between 50% and 100% reinforcement

## Unsignaled Procedure:





# Procedure

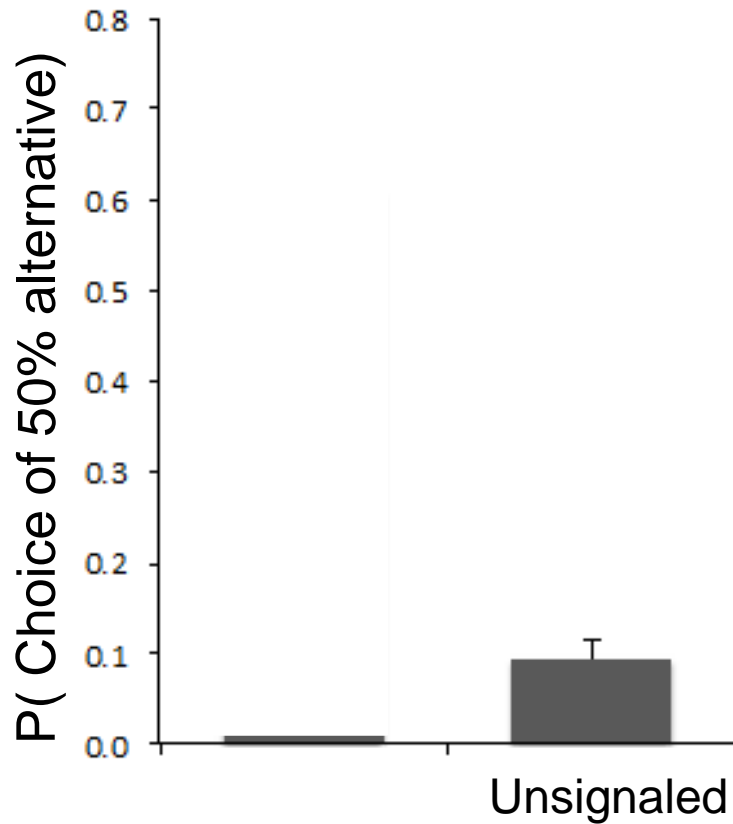
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Mixture of:

Single option trials – learn the outcomes

Choice trials – assess preference

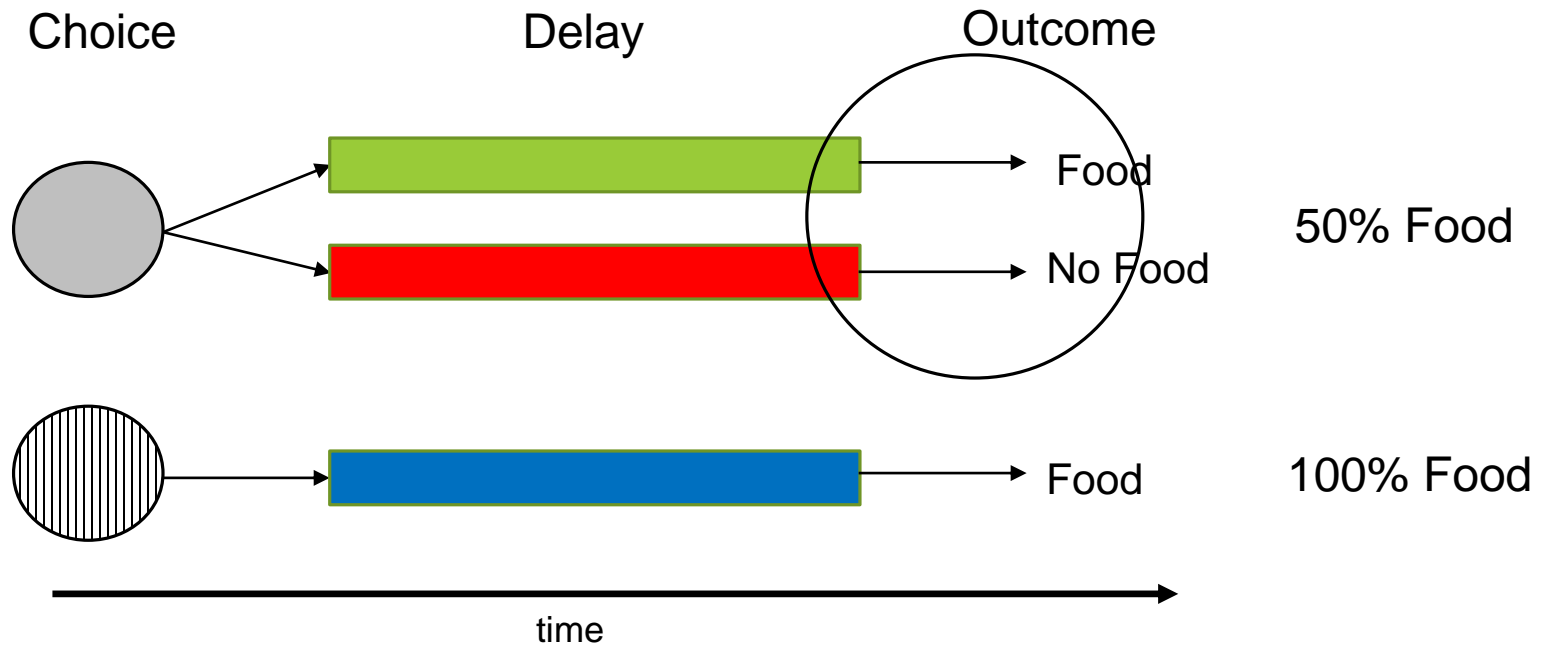
# Pigeons respond sensibly on unsignaled procedure



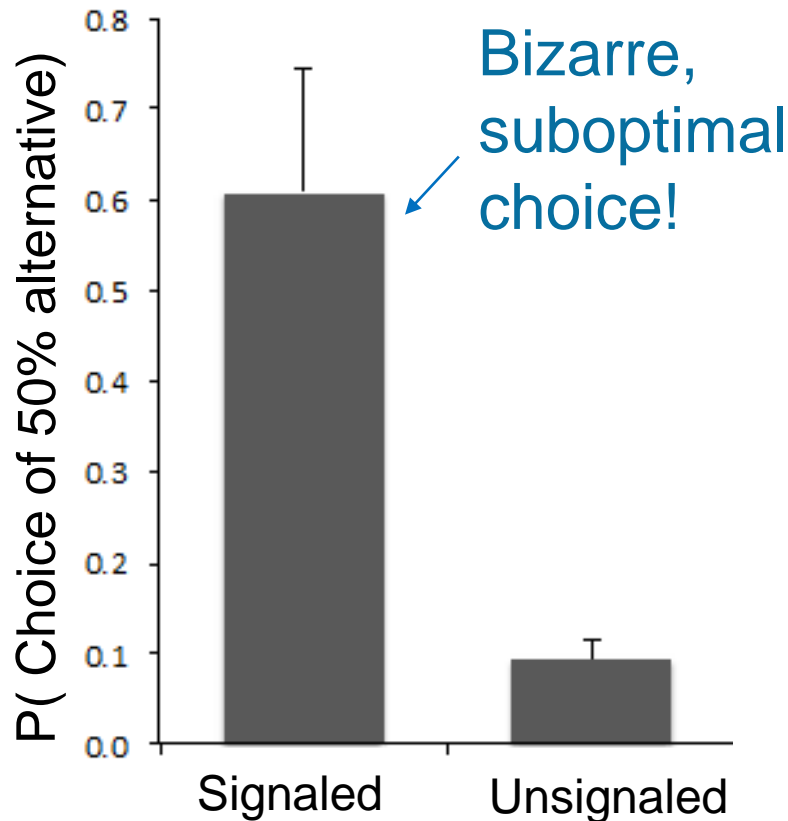
Dunn & Spetch, 1990

# But small change in procedure...

**Signaled** Procedure: Outcome on 50% option *is* signaled during delay



# Signals during delay lead pigeons to make bad choices!

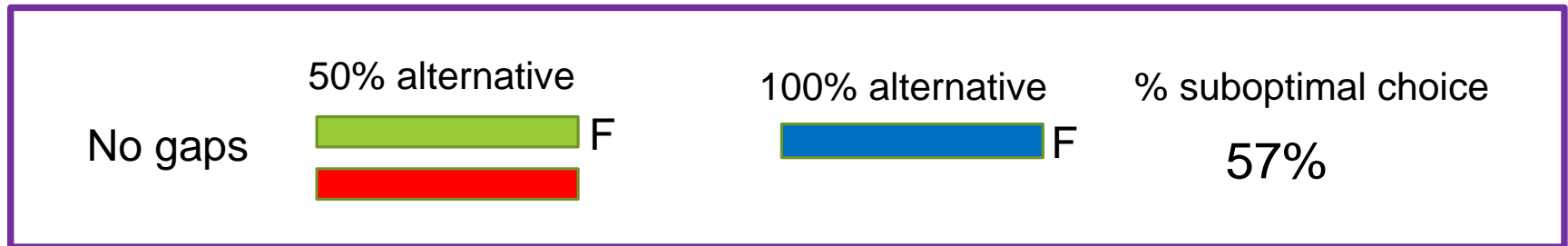


Note: any choice of the 50% option is costly – gives only half as much food!

Dunn & Spetch, 1990

# Suboptimal choice depends on contiguity between choice and signals on the 50% option

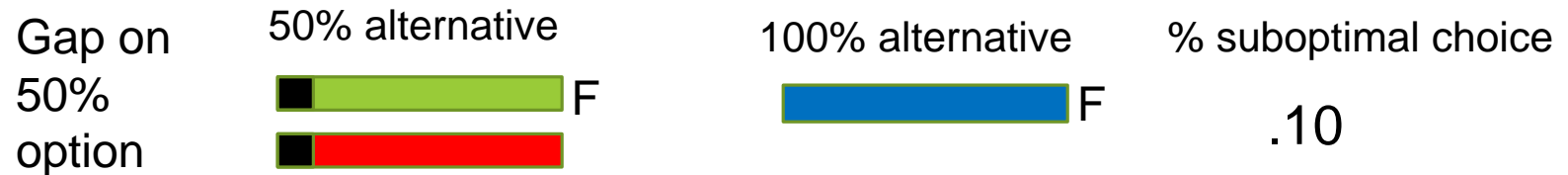
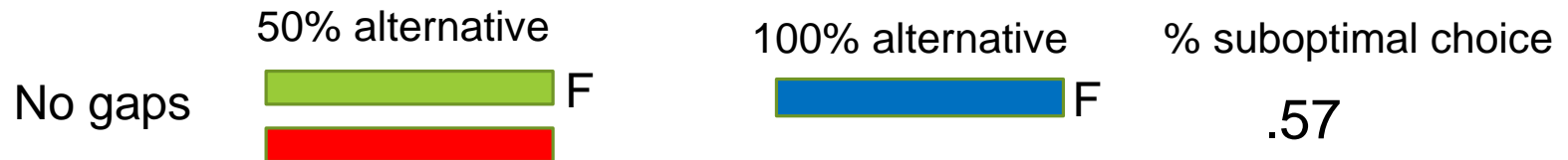
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McDevitt et al., 1997

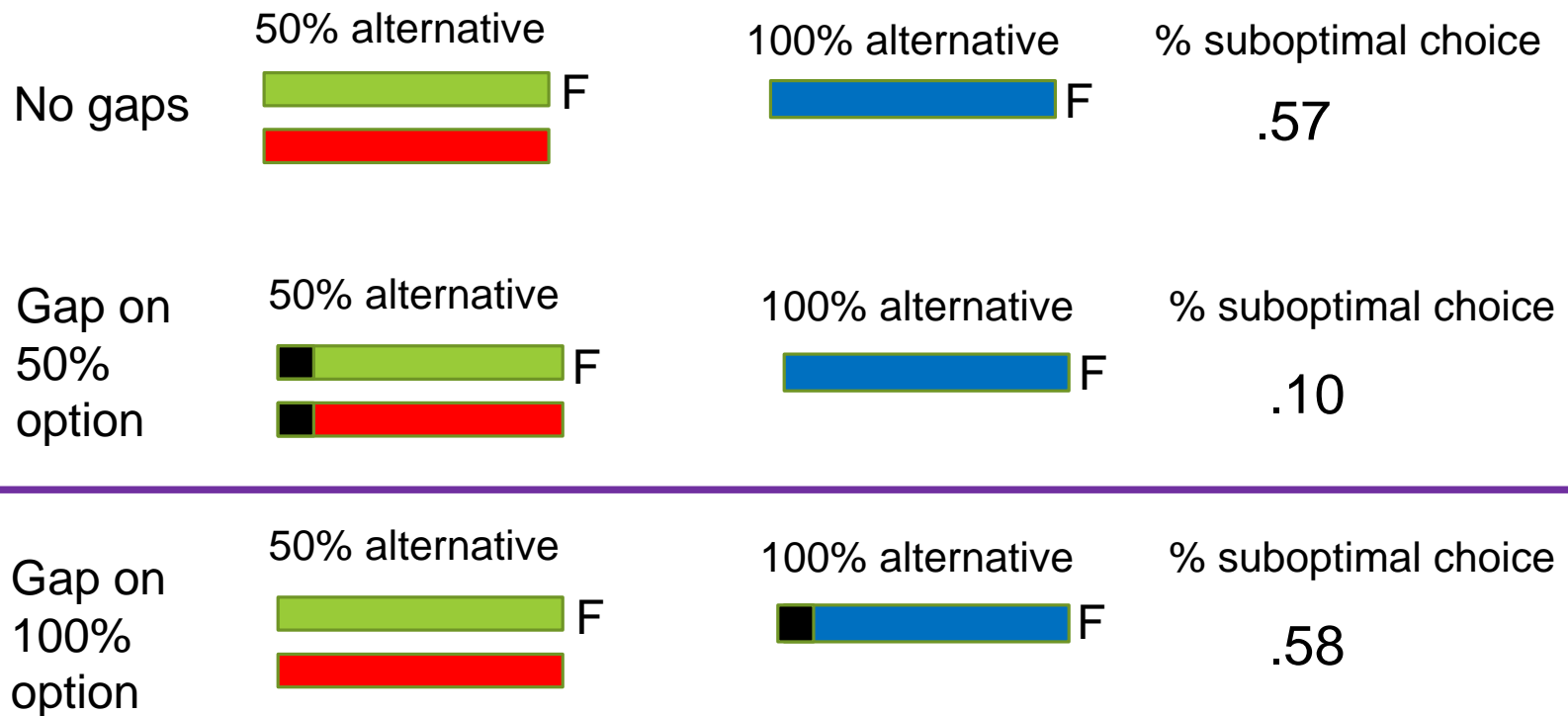
# Suboptimal choice depends on contiguity between choice and signals on the 50% option

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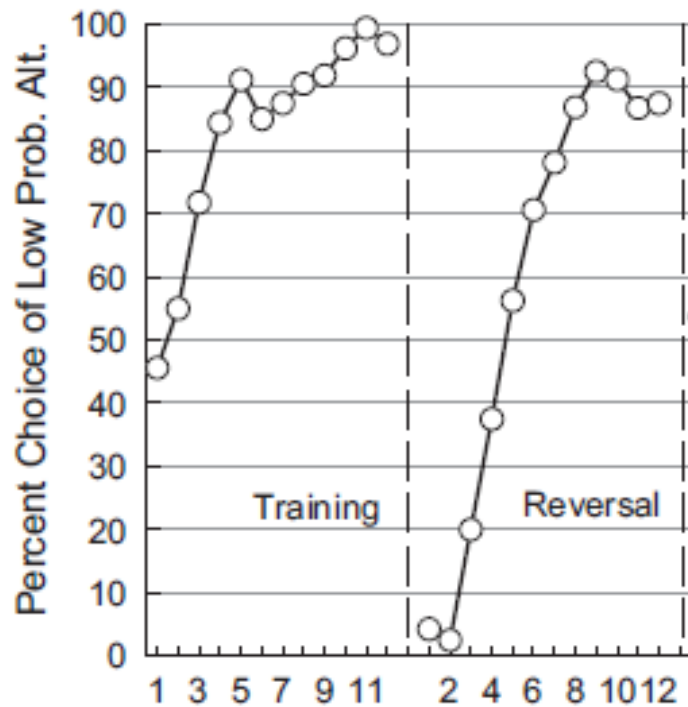
McDevitt et al., 1997

# Suboptimal choice depends on contiguity between choice and signals on the 50% option



McDevitt et al., 1997

# Pigeons show *extreme* suboptimal preference for signaled over unsignaled.



Choice between:  
**signaled 20%** vs.  
**unsignaled 50%**  
food

Stagner & Zentall, 2010

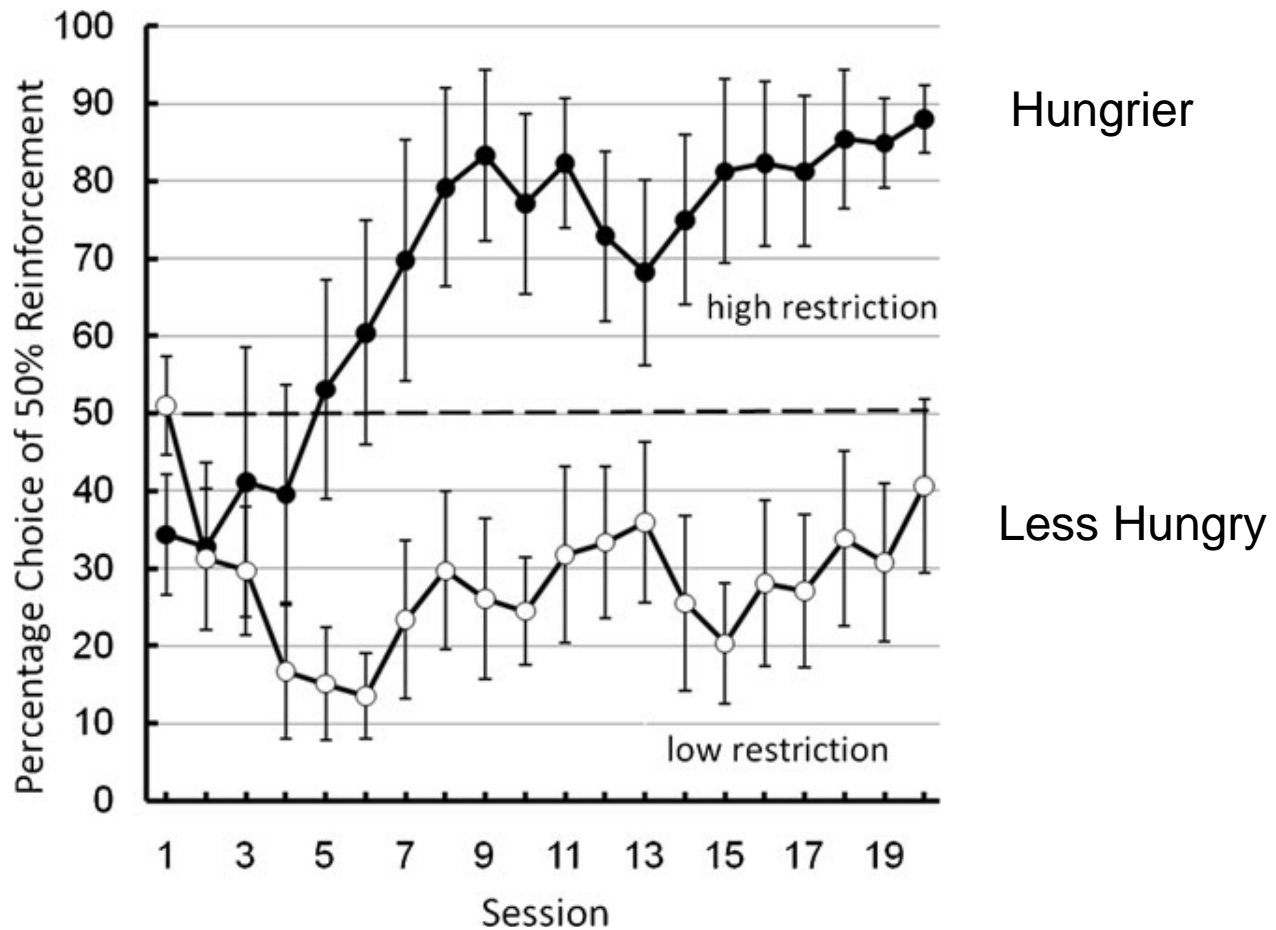


# Other findings:

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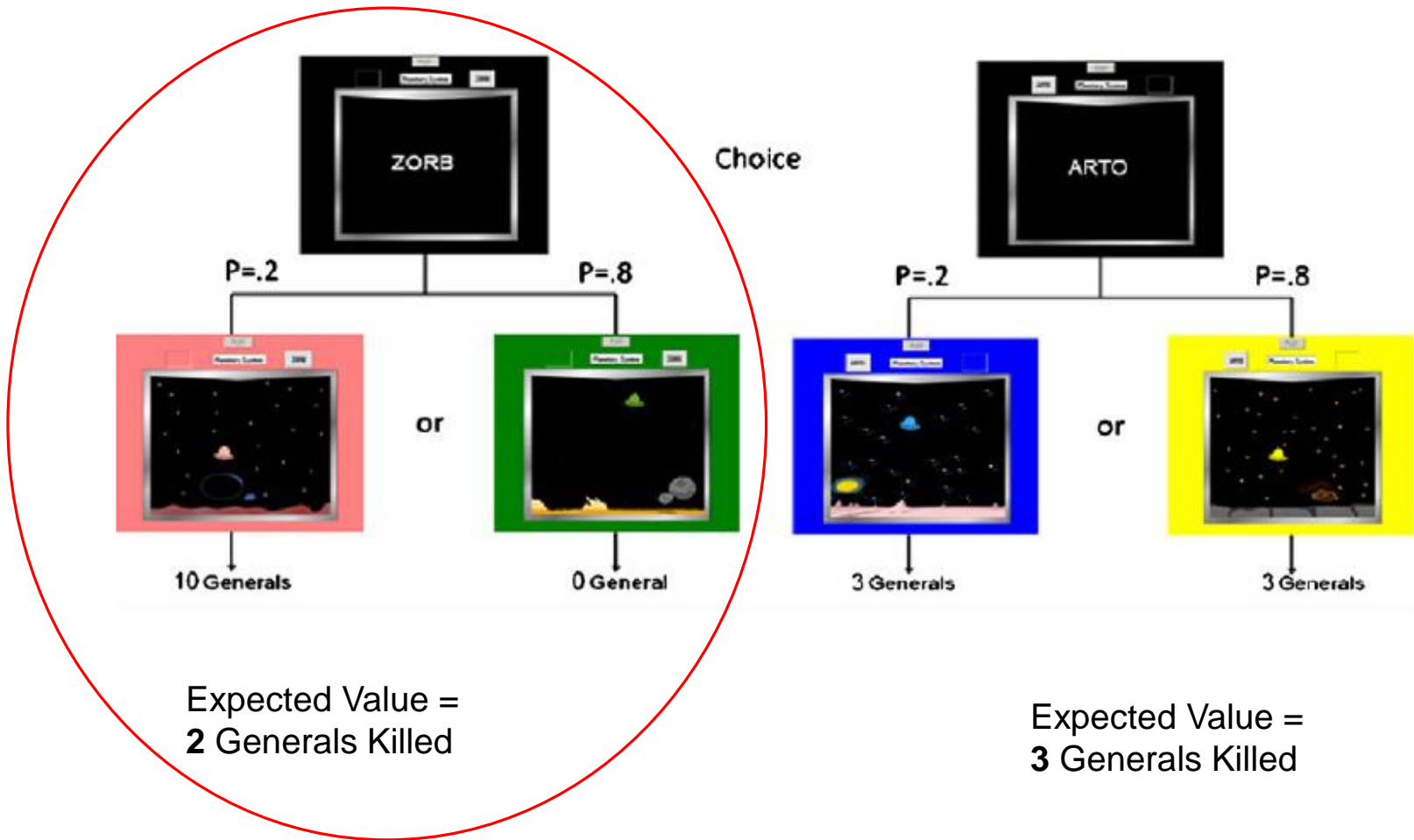
- Suboptimal choice increases with longer delays to food (Spetch et al., 1990)
- Suboptimal choice is correlated with impulsivity (Laude et al., 2014)
- Hungrier pigeons make more suboptimal choices (Laude et al., 2012)

# Laude et al., 2012

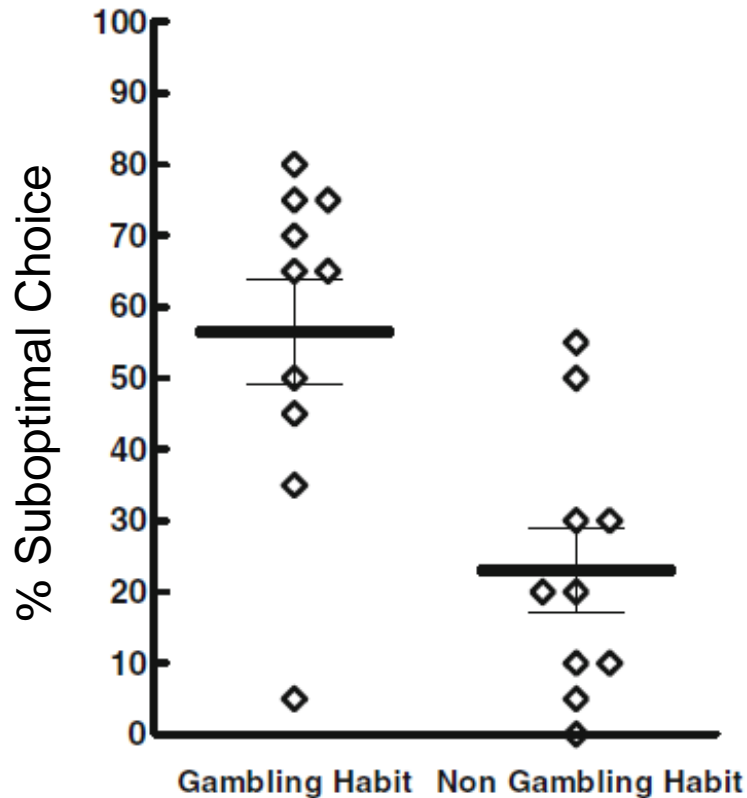


# Gambling humans (Molet et al., 2012)

## Suboptimal Choice



# Students who gambled made more suboptimally choices (Molet et al., 2012)



# SiGN Hypothesis: Choices reinforced by Signals for Good News (Ludvig et al poster)

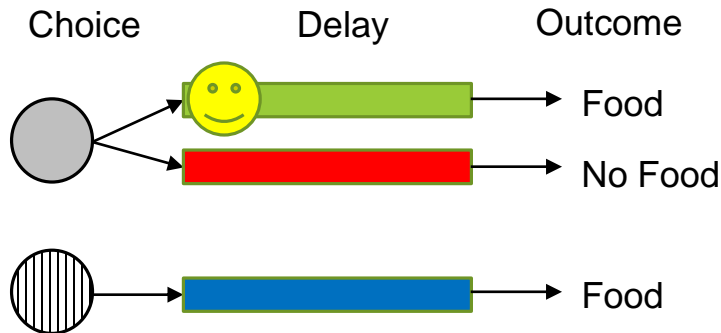
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1. Good news is rewarding when outcomes uncertain.
2. Signal on 100% option is redundant.
3. Good news exerts control when primary reward is delayed.
4. “Bad news” has little punishing effect

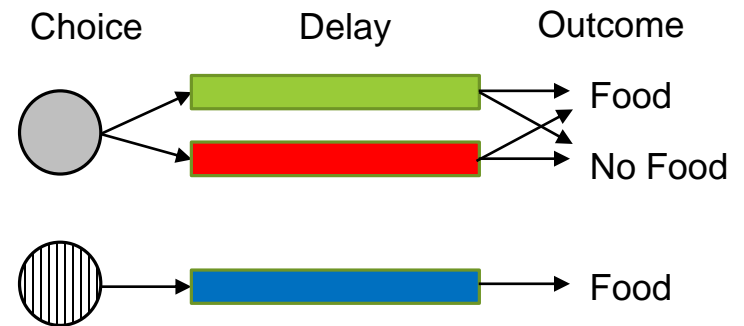
(Belke & Spetch., 1994; Laude et al., 2014; McDevitt et al., 1997; Pisklak et al., submitted; Stagner et al., 2011)

# Illustration of SiGN Hypothesis:

## Signaled Procedure



## Unsignaled Procedure



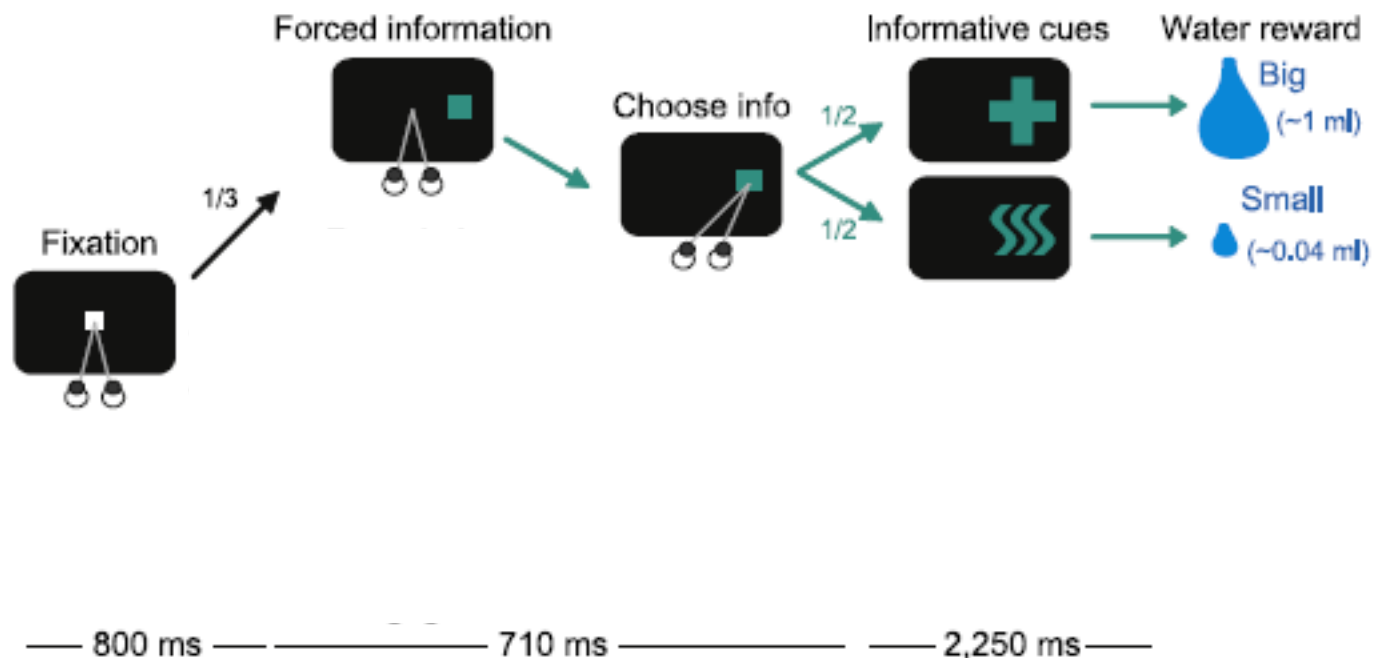
Food stimulus on 50% option  
signals “good news”

100% stimulus is redundant

Stimuli on 50% option are  
uninformative

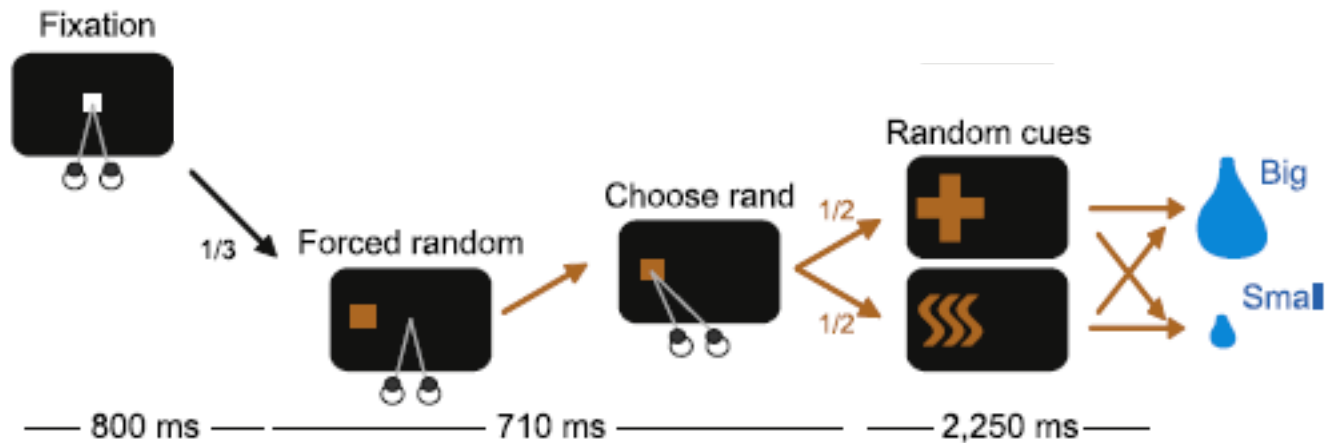
# Monkeys also choose signals.

Bromberg-Martin & Hikosaka (2009).



# Monkeys also choose signals.

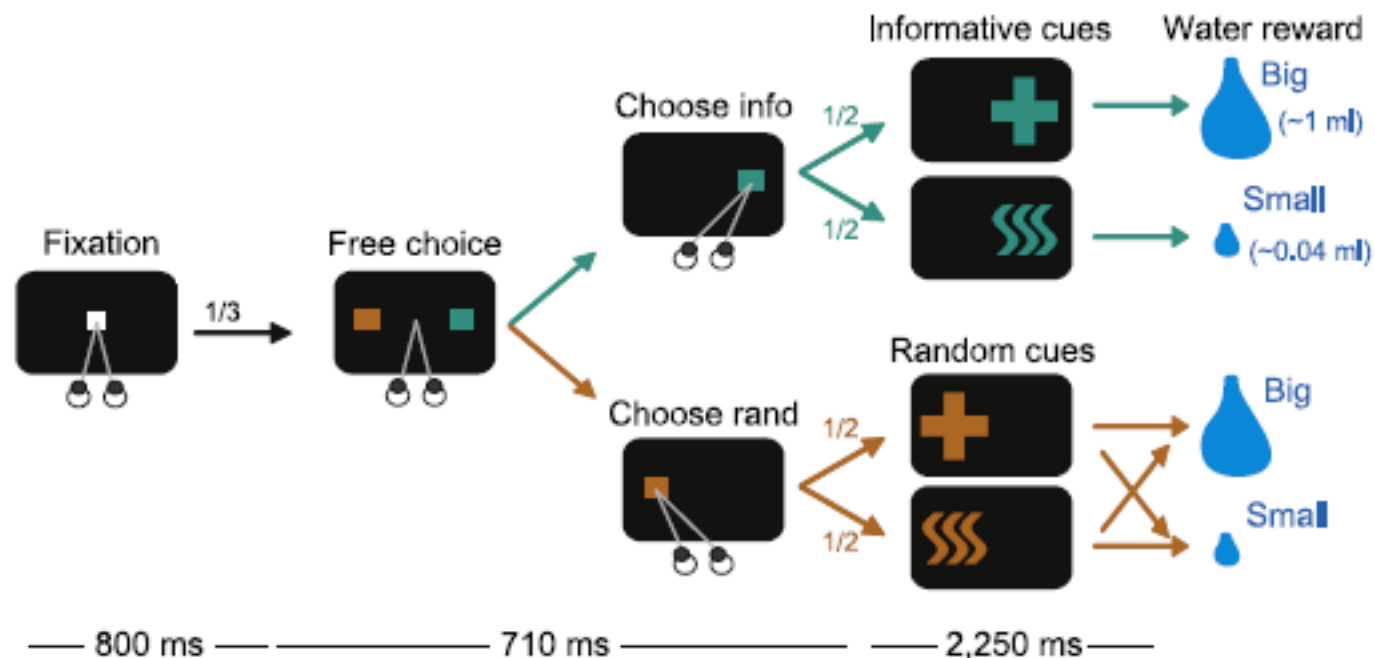
Bromberg-Martin & Hikosaka (2009).





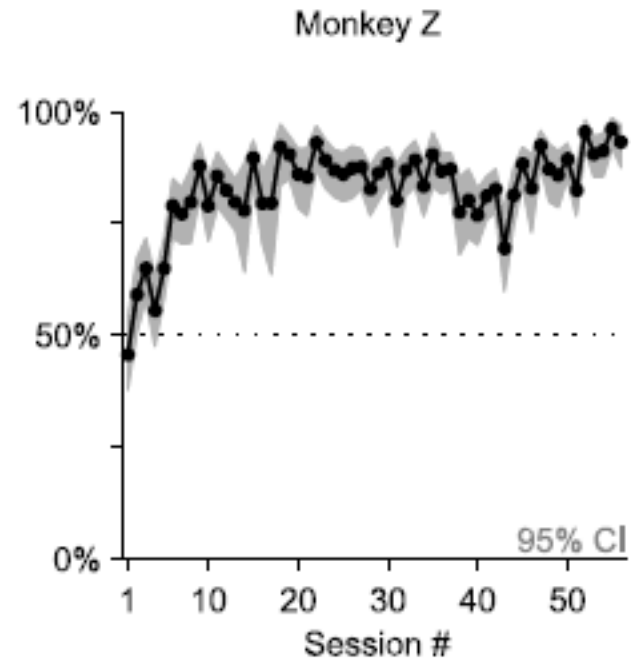
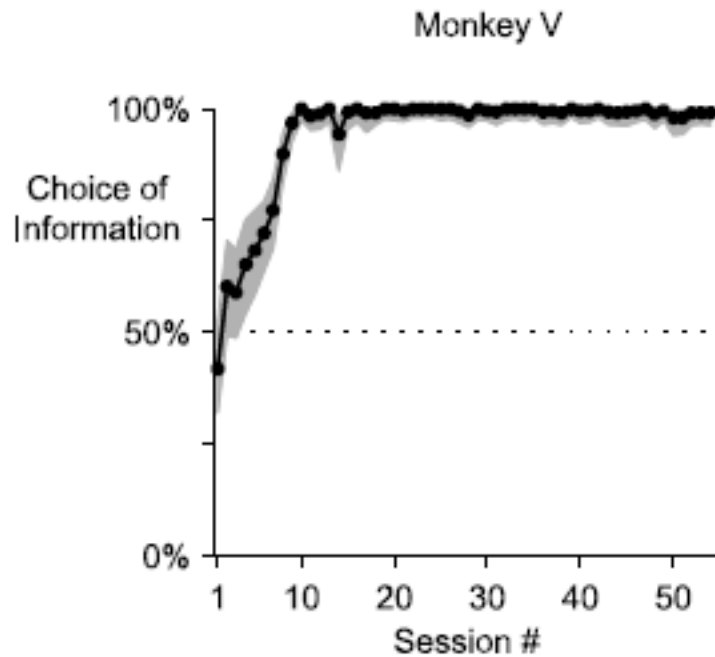
# Monkeys also choose signals.

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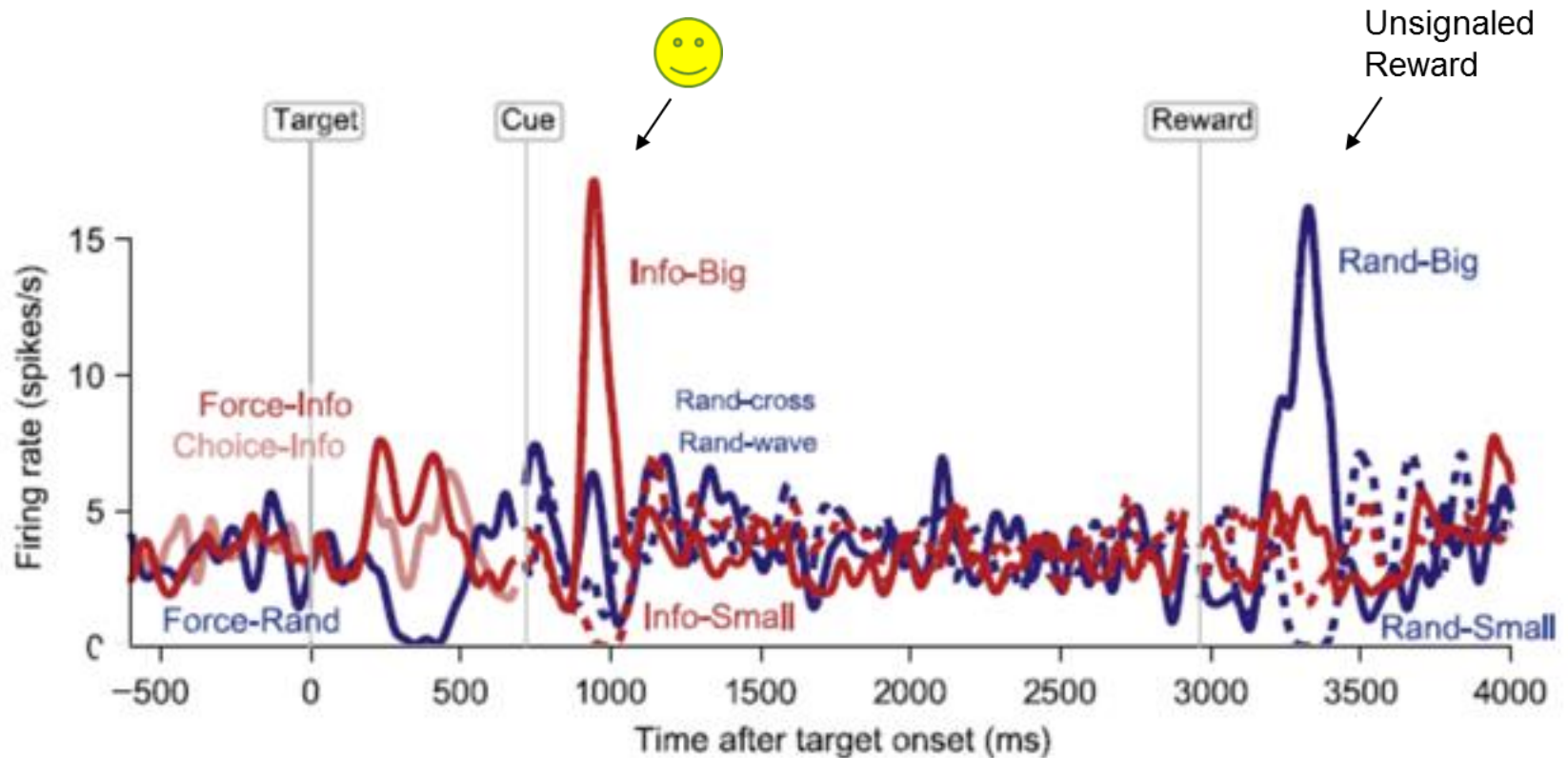
# Behavioral choice data Bromberg-Martin & Hikosaka (2009).

**B**



# Midbrain Dopamine Response

## Bromberg-Martin & Hikosaka (2009)



# Modelling Suboptimal Choice with RL?

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Beierholm & Dayan, 2010 – RL model simulated monkey data

- Does not predict suboptimal preference

Ludvig et al.(poster) – our first attempt to model with RL.  
Added “Good News bonus”

- Promising but more testing needed

# Conclusions

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Choice does not simply follow primary rewards

Irrational preferences can arise from:

- overweighting of extremes
- attraction to “good news”

Sometimes these choices are very costly

# Take home messages and speculations

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- Animal models useful



- Adaptive processes not always “tuned” to specifics

- Irrational choice (including gambling) may reflect “fatal attractions” that are adaptive in other contexts.



# Thanks to

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Research Assistants:

Josh Yong

Nuha Mahdi

Jason Long

Ariel Greiner

Pauline Kwong



## Questions?