Gambling pigeons: Primary rewards are not all that matter

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My goal

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?
Most people play it safe

$20 for sure

OR

50% Chance of $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
Some doors are risky (outcome varies)
Some trials only give one door to ensure exposure to all contingencies
After learning, people choose between fixed and risky doors

**Gain trials**
- $+20$
- $+0$
- $+40$

**Loss trials**
- $-20$
- $-0$
- $-40$

100% 50% 50% 100% 50% 50%

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:

\[-40 \quad -20 \quad 0 \quad +20 \quad +40\]

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

\[-80 \quad -60 \quad -40 \quad -20 \quad 0\]
Decision context matters

Choice between:

-20 vs. 0/-40

Different groups

Risky includes worst extreme
Risky includes best extreme

Ludvig Madan Spetch, 2014
Is this bias unique to humans?
Pigeon version of the door task

Used \textit{relative} losses and gains:

\textit{Ludvig et al., 2014}
Fixed low reward
Risky low reward
Fixed high reward
Risky high reward

Relative losses
Relative gains

Pigeons

People
<table>
<thead>
<tr>
<th>Pigeons</th>
<th>People</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="#" alt="Yellow Door" /></td>
<td><img src="#" alt="Fixed Low Reward" /></td>
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<tr>
<td><img src="#" alt="Green Door" /></td>
<td><img src="#" alt="Risky Low Reward" /></td>
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<tr>
<td><img src="#" alt="Orange Door" /></td>
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</tr>
<tr>
<td><img src="#" alt="Purple Door" /></td>
<td><img src="#" alt="Risky High Reward" /></td>
</tr>
</tbody>
</table>

Relative losses

- Fixed low reward
- Risky low reward

Relative gains

- Fixed high reward
- Risky high reward
Pigeons

- Fixed low reward
- Risky low reward

People

- Fixed low reward
- Risky low reward

Relative losses

- Fixed high reward
- Risky high reward

Relative gains
Pigeons

- **Fixed low reward**
  - 100%

- **Risky low reward**
  - 50%
  - 50%

- **Fixed high reward**
  - 100%

- **Risky high reward**
  - 50%
  - 50%

People

- **Fixed low reward**
  - +20
  - 100%

- **Risky low reward**
  - 0
  - 50%
  - +40
  - 50%

- **Fixed high reward**
  - +60
  - 100%

- **Risky high reward**
  - +40
  - 50%
  - +80
  - 50%

Learn?

Relative losses

Relative gains
Fixed low reward
Risky low reward
Fixed high reward
Risky high reward

Relative losses
Relative gains

Risk pref?
Fixed low reward
Risky low reward
Fixed high reward
Risky high reward

Pigeons
People
Pigeons and people readily learned to choose high-value over low-value options.
Pigeons, like people, were riskier for high-value choices than for low-value choices.
So...

- 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”?

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

- Gives food only 50% of the time
- Always gives food (100%)

Choice:  

- [ ] or

Hungry pigeon
Choice between 50% and 100% reinforcement

Choice | Delay | Outcome
--- | --- | ---
50% Food | No Food | 50% Food
100% Food | Food | 100% Food
Choice between 50% and 100% reinforcement

Unsignaled Procedure:

Delay stimuli uninformative
Procedure

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

- Choice
- Delay
- Outcome

- 50% Food
  - Food
  - No Food

- 100% Food
  - Food
Signals during delay lead pigeons to make bad choices!

Bizarre, suboptimal choice!

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

McDevitt et al., 1997
Suboptimal choice depends on contiguity between choice and signals on the 50% option.

<table>
<thead>
<tr>
<th>No gaps</th>
<th>50% alternative</th>
<th>100% alternative</th>
<th>% suboptimal choice</th>
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<tbody>
<tr>
<td></td>
<td>F</td>
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<td>.57</td>
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<tr>
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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 unsigned.

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

Stagner & Zentall, 2010
Other findings:

• 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

![Graph showing percentage choice of 50% reinforcement over sessions for high and low restriction groups. The graph indicates an increase in percentage choice for the high restriction group and a decrease for the low restriction group.](attachment:image.png)

- Hungrier
- Less Hungry
Gambling humans (Molet et al., 2012)

Suboptimal Choice

Expected Value = 2 Generals Killed

Expected Value = 3 Generals Killed
Students who gambled made more suboptimally choices (Molet et al., 2012)
SiGN Hypothesis: Choices reinforced by Signals for Good News (Ludvig et al poster)

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**

- **Choice**
- **Delay**
- **Outcome**

- Food stimulus on 50% option signals “good news”
- 100% stimulus is redundant

**Unsignaled Procedure**

- **Choice**
- **Delay**
- **Outcome**

- Stimuli on 50% option are uninformative
Behavioral choice data

B

MonkV

Choice of Information

100%

50%

0%

1 10 20 30 40 50

Session #

MonkZ

95% CI

1 10 20 30 40 50

Session #
Midbrain Dopamine Response
Bromberg-Martin & Hikosaka (2009)
Modelling Suboptimal Choice with RL?

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

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

- 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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Questions?