

The Peak-End Rule Revisited: Peak-First in Rhesus Macaques

677.10

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Introduction

According to prospect theory⁷, an individual's subjective value always increases with objective value. Therefore, individuals should always tend toward (subjective) utility maximization.

Do and colleagues³ show that the order in receiving pleasurable rewards can be subjectively very different. For example, adults and children subjectively rate receiving a larger reward by itself significantly higher than receiving a more valued reward followed by a lesser valued reward.

These and other findings^{1,2,6,8,10,11} suggest that maximizing utility at the end is sometimes more important than overall utility. Hence, a peak-end rule may underlie valuation of alternatives.

To our knowledge, no study has tested for a peak-end rule in monkeys. In the current study, we investigated whether rhesus macaques (*Macaca mulatta*) would also exhibit a peak-end preference.

Behavioral methods

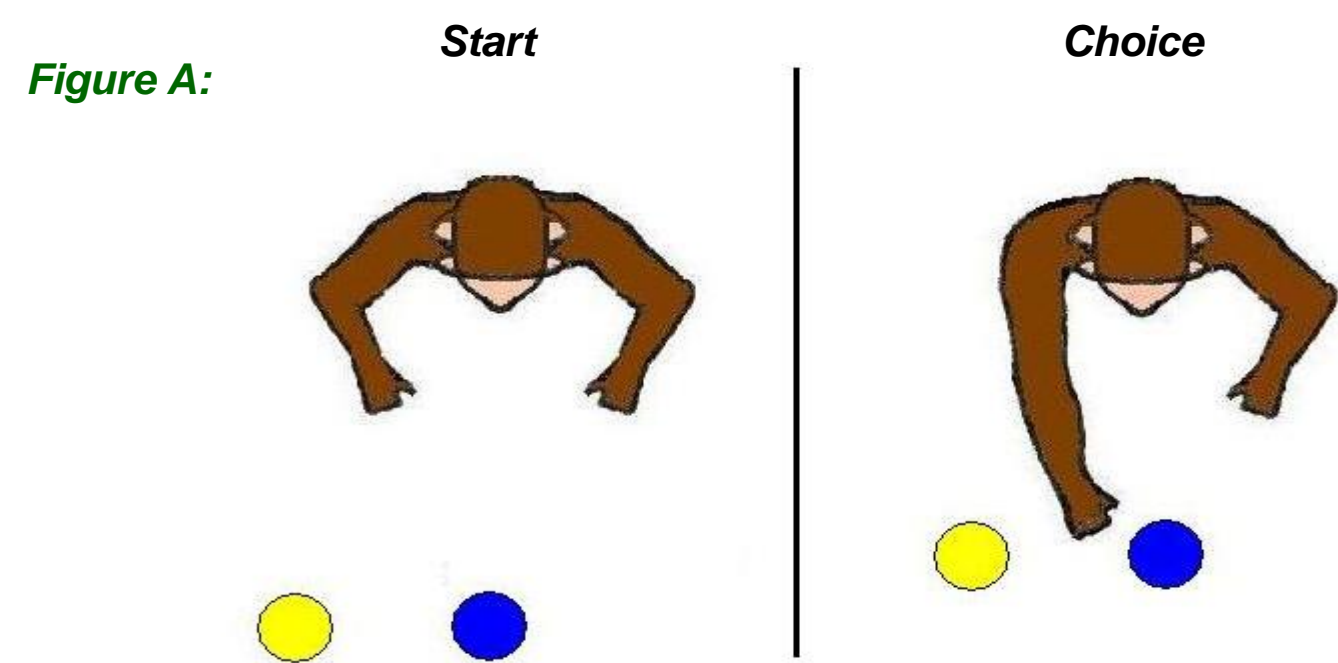
Subjects were 3 male rhesus macaque monkeys, denoted as monkeys T, P, and H.

Each monkey sat comfortably in a custom-made primate chair, with its left arm comfortably restrained and the right arm free to reach.

Monkeys were tested one session per day. Each session consisted of 10 familiarization trials and 30 experimental trials. Three significant ($p \leq 0.05$, two-tailed Binomial tests) or 10 non-significant sessions were required for each monkey before moving on to the next experiment.

All experiments used a two-alternative choice procedure (see Figure A). Choices were made between two different colored canisters, with each canister containing different food items received in different orders as described below (Tables 1-5).

Familiarization trials allowed the monkeys to learn the colored canister contingencies (Tables 1-5).



The monkey is given the choice of two colored canisters:

- Start:** Colored canisters are held out of reach of the monkey and centered around the monkey's right arm.
- Choice:** The canisters are brought forward and monkey reaches toward desired canister.
- Reward:** (Not shown) the monkey is given the food rewards associated with color selected (Tables 1-5).

Results

Experiment 1

Table 1:

| Monkey | Canister Colors/Contingency | |
|--------|-----------------------------|--------|
| | A → [] | A → B |
| P | Blue | Yellow |
| H | Yellow | Blue |
| T | Yellow | Blue |

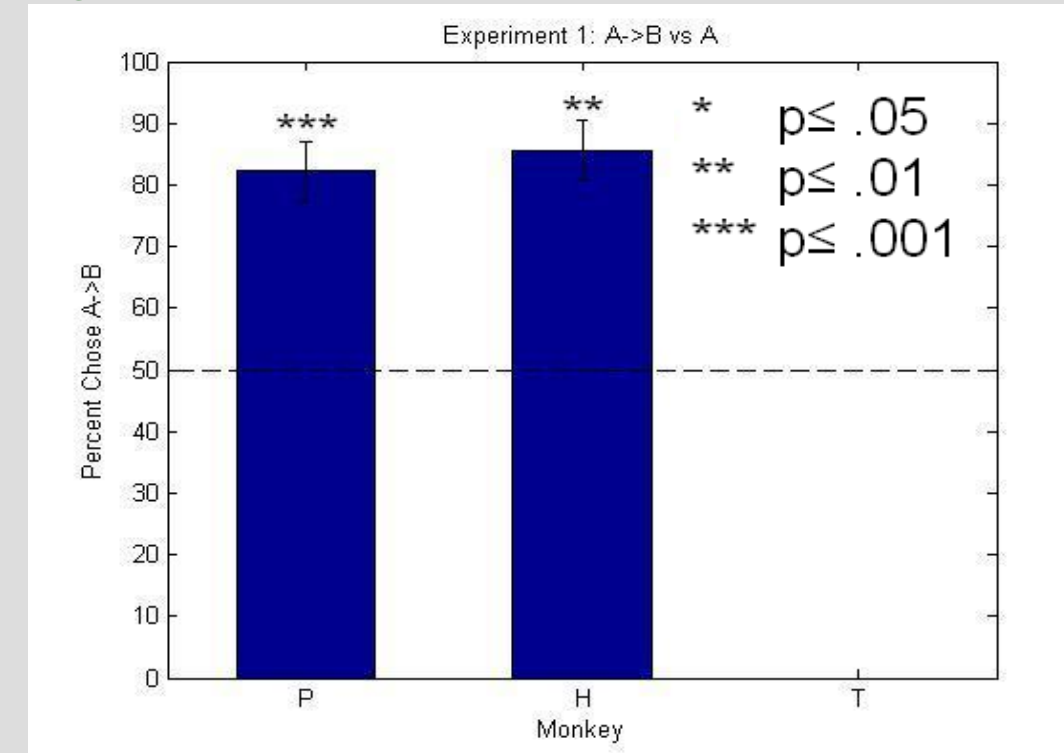
PURPOSE: To test Do and colleagues' finding (that $A > A \rightarrow B$) in rhesus macaques. Do monkeys prefer the superior item alone or do they maximize overall utility?

2/3 monkeys (P and H) preferred receiving grape followed by vegetable over grape alone

One monkey (T) did not reach significance

Thus, 2 monkeys maximized overall utility, and no peak-end effect was found

Figure 1:



A = grape, B = half vegetable, A > B
 Mean and standard error from 3 significant sessions/monkey
 P-values from Binomial test (against 50%) for first significant session /monkey
 * $p \leq .05$ (two-tailed), ** $p \leq .01$ (two-tailed), *** $p \leq .001$ (two-tailed)

Experiment 2

Table 2:

| Monkey | Canister Colors/Contingency | |
|--------|-----------------------------|---------|
| | B → A | [] → A |
| P | Purple | Green |
| H | Green | Purple |
| T | Black | Gray |

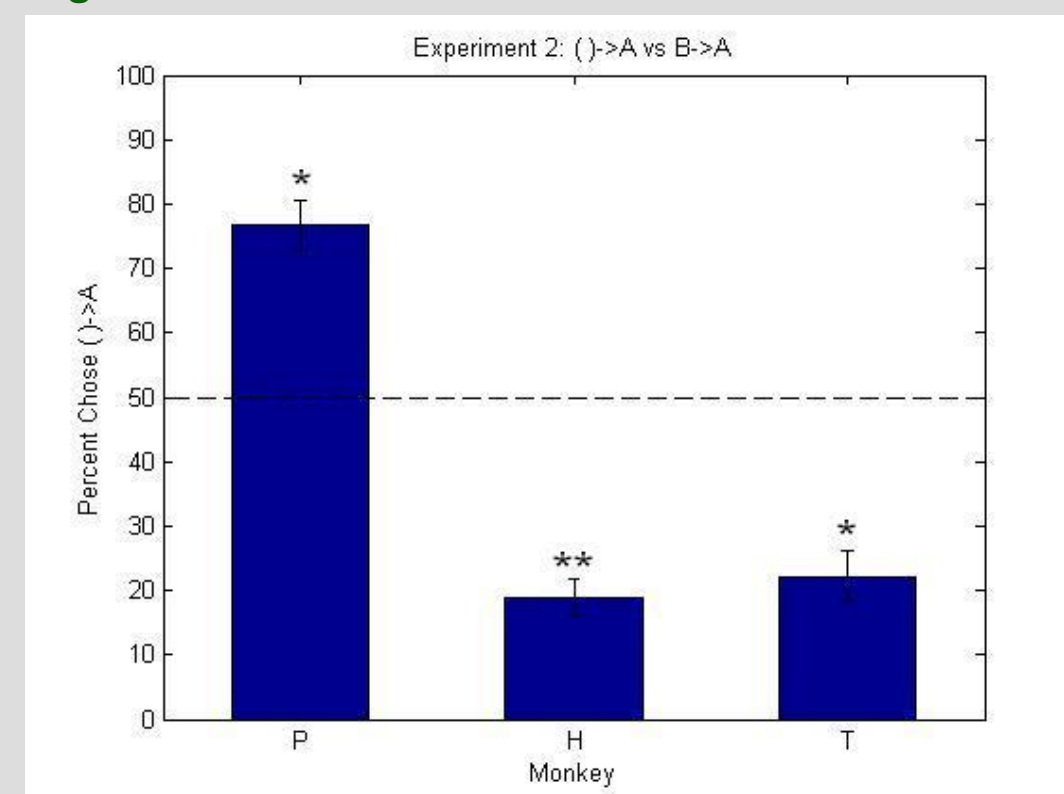
PURPOSE: To investigate whether monkeys prefer receiving a superior item alone over utility maximizing

2/3 monkeys (H and T) preferred receiving vegetable followed by grape over delay followed by grape

One monkey (P) preferred receiving a delay followed by a grape over vegetable followed by grape

Thus, 2 monkeys maximized overall utility, while the 3rd monkey's result (P) suggested a possible peak-first effect

Figure 2:



A = grape, B = half vegetable, A > B
 Mean and standard error from 3 significant sessions/monkey
 P-values from Binomial test (against 50%) for first significant session /monkey
 * $p \leq .05$ (two-tailed), ** $p \leq .01$ (two-tailed), *** $p \leq .001$ (two-tailed)

Experiment 3

Table 3:

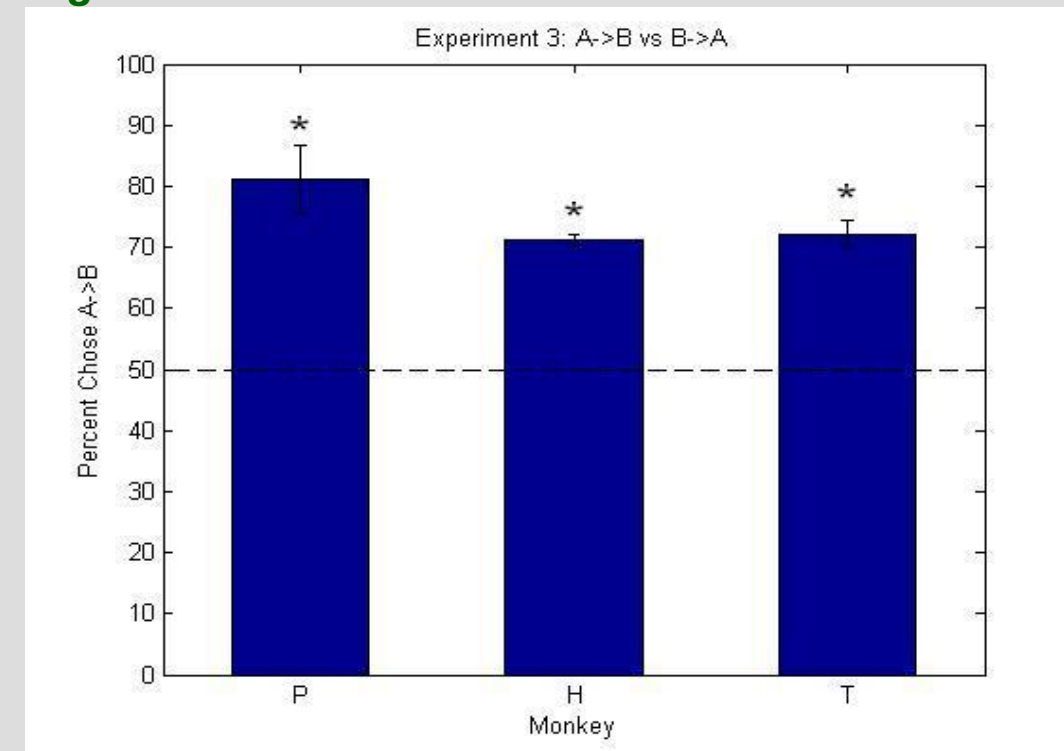
| Monkey | Canister Colors/Contingency | |
|--------|-----------------------------|--------|
| | B → A | A → B |
| P | Purple | Yellow |
| H | Green | Blue |
| T | Purple | Blue |

PURPOSE: To determine whether monkeys prefer a superior item first or last (i.e. does order matter?)

All monkeys preferred receiving grape (A) followed by vegetable (B) against receiving vegetable (B) followed by grape (A)

Thus, all monkeys showed a preference for receiving the superior item first

Figure 3:



A = grape, B = half vegetable, A > B
 Mean and standard error from 3 significant sessions/monkey
 P-values from Binomial test (against 50%) for first significant session /monkey
 * $p \leq .05$ (two-tailed), ** $p \leq .01$ (two-tailed), *** $p \leq .001$ (two-tailed)

Experiment 4

Table 4:

| Monkey | Canister Colors/Contingency | |
|--------|---------------------------------|---------------------------------|
| | B ₂ → A ₂ | A ₂ → B ₂ |
| P | Brown | Pink |
| H | Orange & Blue Cross | Black & White Checkerboard |
| T | Orange & Blue Cross | Black & White Checkerboard |

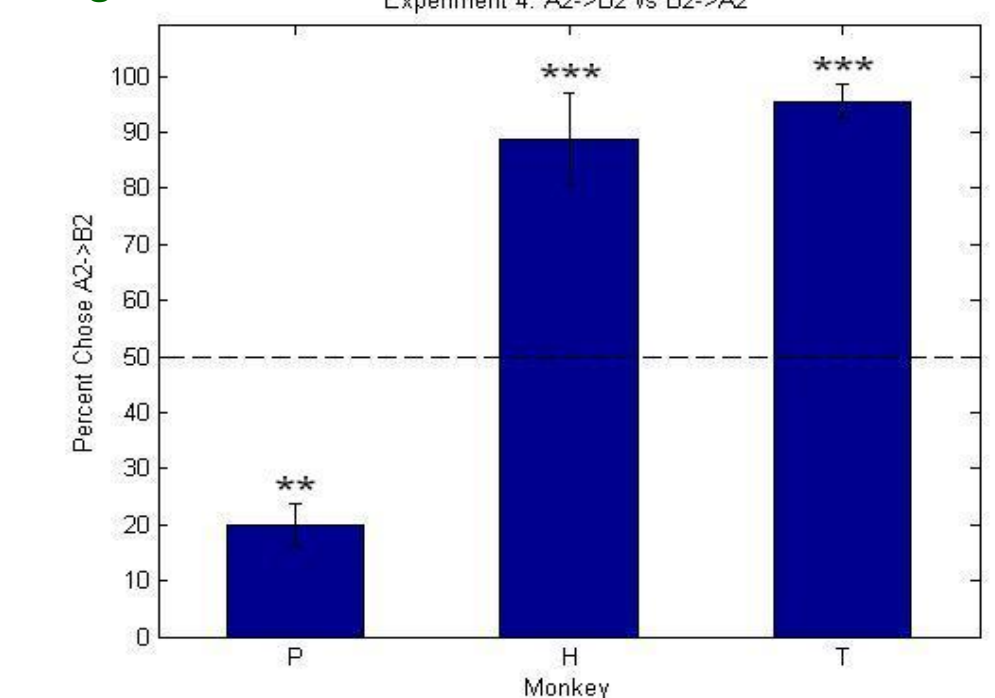
PURPOSE: To test if findings of Experiment 3 transfer to other food items

2/3 monkeys (H and T) preferred receiving a marshmallow (A) followed by a cheerio (B) over receiving cheerio (B) followed by marshmallow (A)

One monkey (P) preferred receiving a cheerio (B) followed by a marshmallow (A) over marshmallow (A) followed by cheerio (B)

Thus, 2 monkeys replicated the Experiment 3 findings, whereas 1 did not. Overall, then, monkeys appear to prefer receiving the superior item first, but these findings depend on the relative differences of the food items

Figure 4:



A₂ = mini marshmallow, B₂ = cheerio, A₂ > B₂
 Mean and standard error from 3 significant sessions/monkey
 P-values from Binomial test (against 50%) for first significant session /monkey
 * $p \leq .05$ (two-tailed), ** $p \leq .01$ (two-tailed), *** $p \leq .001$ (two-tailed)

Experiment 5

Table 5:

| Monkey | Canister Colors/Contingency | |
|--------|-----------------------------|---------------------------|
| | B → A → [] | [] → A → B |
| P | Purple | Yellow |
| H | Green | Blue |
| T | Yellow | Striped (Green and White) |

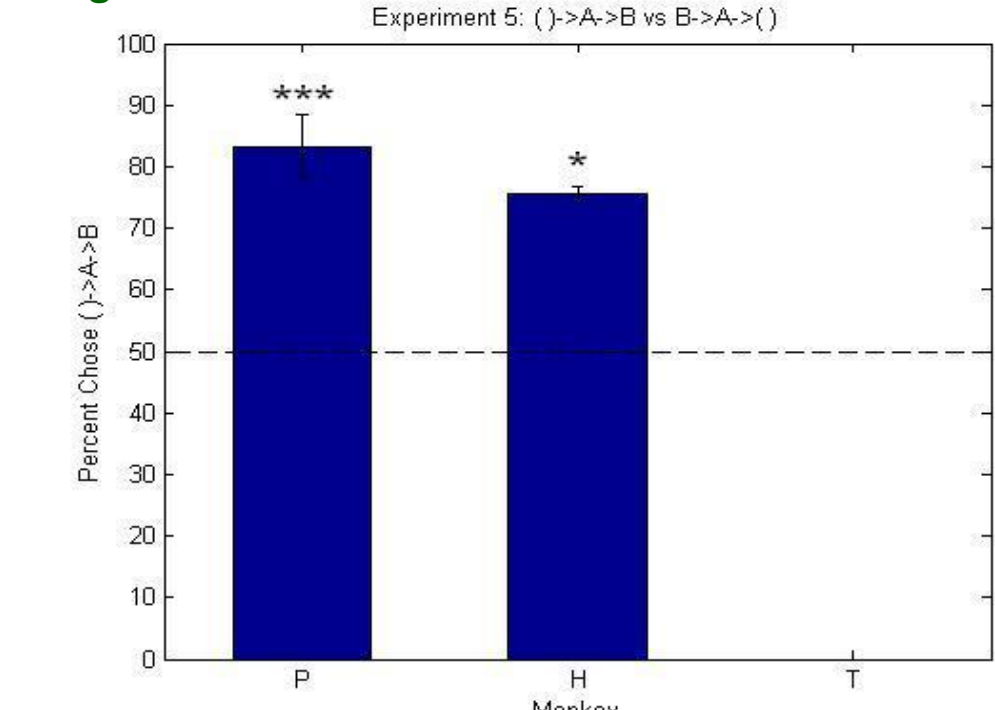
PURPOSE: To provide a stronger test of a peak-first preference

2/3 monkeys (P and H) preferred receiving a delay followed by a grape then vegetable over receiving a vegetable followed by a grape then delay

One monkey (T) did not reach significance

Thus, 2 monkeys again preferred receiving the superior item first, even when it was preceded by a delay

Figure 5:



A = grape, B = half vegetable, A > B
 Mean and standard error from 3 significant sessions/monkey
 P-values from Binomial test (against 50%) for first significant session /monkey
 * $p \leq .05$ (two-tailed), ** $p \leq .01$ (two-tailed), *** $p \leq .001$ (two-tailed)

Conclusions and future directions

- Instead of peak-end, we found a peak-first rule, whereby rhesus macaques prefer receiving the superior reward first, and maximizing thereafter.
- We have shown that the peak-end rule, in which humans rate outcomes that end well higher than those that end less well but offer cumulatively more, does not necessarily hold when participants have a choice and know both outcomes.
- In future studies, humans as well as other animal species will need to be tested under identical conditions to uncover potential similarities/differences in valuation and cognition across species.

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