# Models of Reference Dependent Preferences

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Behavioral Economics G6943
Autumn 2022

# Modelling Reference Dependence

- Likely that there are many different causes of reference dependence
  - As we discussed in the introduction
- Broadly speaking two classes of models

1. Preference-based reference dependence
   - Reference points affect preferences which affect choices
2. 'Rational' reference dependence
   - Reference dependence as a rational response to costs
     - Effort costs
     - Attention Costs

- Focus on the former, say a little about the latter

# Loss Aversion

- In 1979 Kahneman and Tversky introduced the idea of 'Loss Aversion'
- Basic idea: Losses loom larger than gains
  - Utility calculated on changes, not levels
  - The magnitude of the utility loss associated with losing $x$ is greater than the utility gain associated with gaining $x$
- Initially applied to risky choice
- Later also applied to riskless choice [Tversky and Kahneman 1991]
- Can explain
  - Endowment effect
  - Increased risk aversion for lotteries involving gains and losses
  - Status quo bias

# A Simple Loss Aversion Model

- World consists of different dimensions
  - e.g cash and mugs
- Will be asked to choose between alternatives that provide different amount of each dimension

$$\begin{pmatrix} x_c \\ x_m \end{pmatrix}$$

- Has a reference point for each dimension

$$\begin{pmatrix} r_c \\ r_m \end{pmatrix}$$

- **Key Point: Utility depends on changes, not on levels**

# A Simple Loss Aversion Model

- Utility of an alternative comes from comparison of output to reference point along each dimension

$$\begin{pmatrix} x_c \\ x_m \end{pmatrix}, \begin{pmatrix} r_c \\ r_m \end{pmatrix}$$

- Utility for gains relative to $r$ given by a utility function $u$

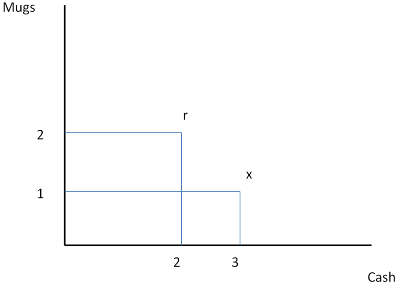
$$\begin{aligned} u_c(x_c) - u_c(r_c) \text{ if } x_c &> r_c \\ u_m(x_m) - u(r_m) \text{ if } x_m &> r_m \end{aligned}$$

- Utility of losses relative to $r$ given buy $u$ of the equivalent gain multiplied by $-\lambda$ with $\lambda > 1$

$$\begin{aligned} \lambda\left(u_c(x_c) - u_c(r_c)\right) \text{ if } x_c &< r_c \\ \lambda\left(u_m(x_m) - u(r_m)\right) \text{ if } x_m &< r_m \end{aligned}$$

- For simplicity assume that utilities are linear: $u_c(x_c) = x_c$, $u_m(x_m) = u_m x_m$

# A Simple Loss Aversion Model




- $x$ is a gain of \$1 and loss of 1 mug relative to $r$
- Utility of $x$

$$1 - \lambda u_m$$

# Loss Aversion and the Endowment Effect

- How can loss aversion explain the Endowment Effect (i.e. WTP/WTA gap)?
- Willingness to pay:
  - Let $(r_c, r_m)$ be the reference point with no mug
  - How much would they be willing to pay for the mug?
  - i.e. what is the $z$ such that

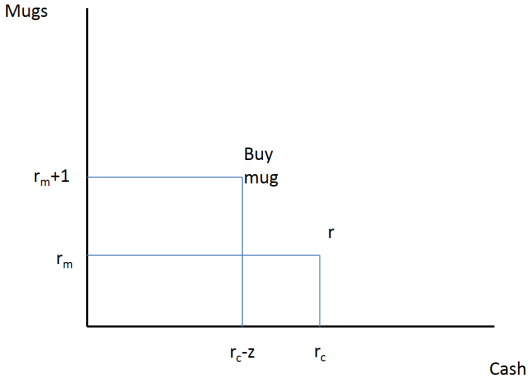
$$0 = U\left(\begin{array}{c} r_c \\ r_m \end{array}, \begin{array}{c} r_c \\ r_m \end{array}\right) = U\left(\begin{array}{c} r_c - z \\ r_m + 1 \end{array}, \begin{array}{c} r_c \\ r_m \end{array}\right)$$

- Utility of buying a mug given by

$$U\left(\begin{array}{c} r_c - z \\ r_m + 1 \end{array}, \begin{array}{c} r_c \\ r_m \end{array}\right) = u_m - \lambda z$$

- Break even buying price given by $z = \frac{u_m}{\lambda}$

# A Simple Loss Aversion Model




- Buying is a loss of $z and gain of 1 mug relative to $r$
- Utility of buying

$$u_m - \lambda z$$

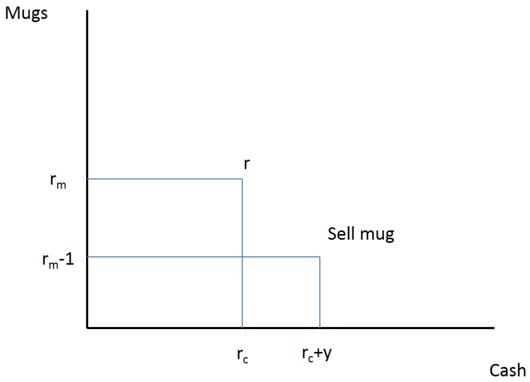
- Willingness to accept:
  - Let $(r_c, r_m)$ be the reference point with mug
  - How much would they be willing to sell your mug for?
  - i.e. what is the $y$ such that

$$0 = U\left(\begin{array}{cc} r_c & r_c \\ r_m & r_m \end{array}\right) = U\left(\begin{array}{cc} r_c + y & r_c \\ r_m - 1 & r_m \end{array}\right)$$

- Utility of selling a mug given by

$$U\left(\begin{array}{cc} r_c + y & r_c \\ r_m - 1 & r_m \end{array}\right) = -\lambda u_m + y$$

- Break even selling price given by $y = \lambda u_m(1)$




- Selling is a gain of \$y and loss of 1 mug relative to $r$
- Utility of selling

$$-\lambda u_m + y$$

# Loss Aversion and the Endowment Effect

- Willingness to pay

$$z = \frac{u_m}{\lambda}$$

- Willingness to accept

$$y = \lambda u_m$$

- WTP/WTA ratio

$$\frac{z}{y} = \frac{1}{\lambda^2}$$

- Less that 1 for $\lambda > 1$

- Tversky and Kahneman [1991] provide an axiomatization of this model

Axiom 1: Cancellation if, for some reference point

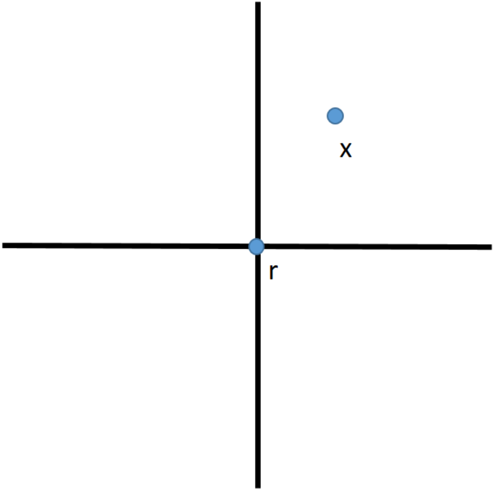
$$\begin{pmatrix} x_1 \\ z_2 \end{pmatrix} \succeq \begin{pmatrix} z_1 \\ y_2 \end{pmatrix} \text{ and } \begin{pmatrix} z_1 \\ x_2 \end{pmatrix} \succeq \begin{pmatrix} y_1 \\ z_2 \end{pmatrix}$$

then

$$\begin{pmatrix} x_1 \\ x_2 \end{pmatrix} \succeq \begin{pmatrix} y_1 \\ y_2 \end{pmatrix}$$

- (guarantees additivity)

- Define the 'quadrant' that $x$ is in relative to $r$



Axiom 2: Sign Dependence Let options $x$ and $y$ and reference points $s$ and $r$ be such that

1. $x$ and $y$ are in the same quadrant with respect to $r$ and with respect to $s$
2. $s$ and $r$ are in the same quadrant with respect to $x$ and with respect to $y$

Then $x \succeq y$ when $r$ is the status quo $\Longleftrightarrow$ $x \succeq y$ when $s$ is the status quo

- Guarantees that only the 'sign' matters

Axiom 3: Preference Interlocking Say that, for some reference point $r$, we saw that

$$\begin{pmatrix} x_1 \\ x_2 \end{pmatrix} \sim \begin{pmatrix} w_1 \\ w_2 \end{pmatrix} \text{ and } \begin{pmatrix} z_1 \\ x_2 \end{pmatrix} \sim \begin{pmatrix} y_1 \\ w_2 \end{pmatrix}$$

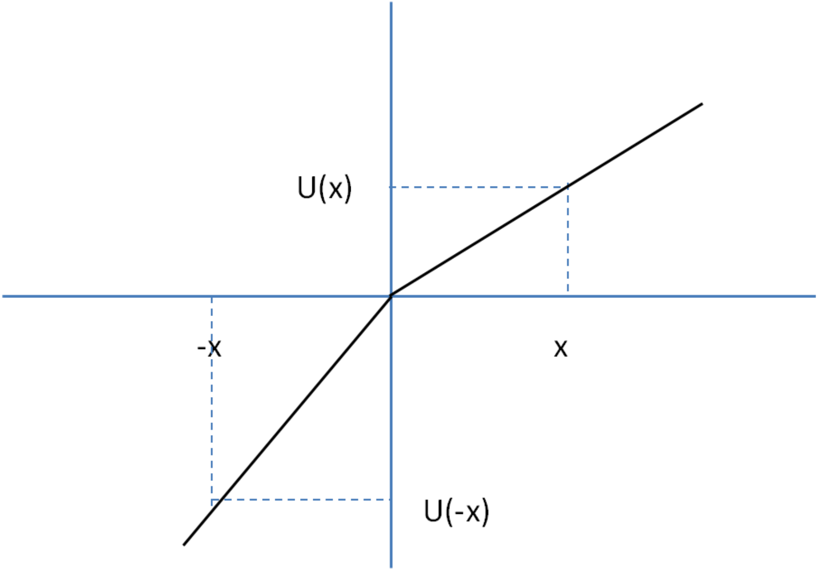
And, for another reference point $s$ (that puts everything in the same quadrant, but maybe a different quadrant to $r$)

$$\begin{pmatrix} x_1 \\ \bar{x}_2 \end{pmatrix} \sim \begin{pmatrix} w_1 \\ \bar{w}_2 \end{pmatrix} \Rightarrow$$
$$\begin{pmatrix} z_1 \\ \bar{x}_2 \end{pmatrix} \sim \begin{pmatrix} y_1 \\ \bar{w}_2 \end{pmatrix}$$

- Ensures that the same trade offs that work in the gain domain also work in the loss domain

# Loss Aversion in Risky Choice

- Loss aversion can also lead to increased risk aversion for lotteries that involve gains and losses
- Now there is only 1 dimension (money)
- Lotteries evaluated as gains/losses relative to some reference point
- See also Kosegi and Rabin [2007]
- Again, assume linear utility for money
  - Utility of winning $x$ is $x$
  - Utility of losing $x$ is -$\lambda x$


U(x)
-x
x
U(-x)

# Loss Aversion in Risky Choice

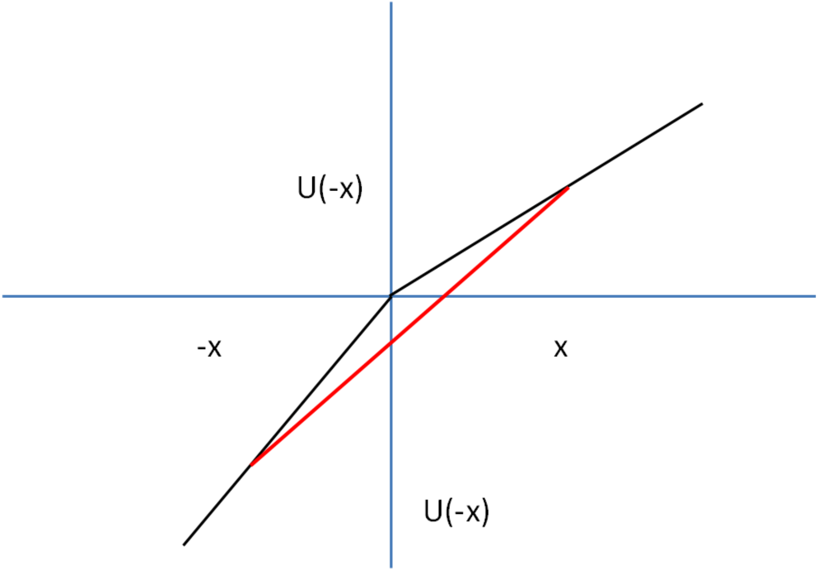
- What is the certainty equivalence of
  - 50% chance of gaining \$10
  - 50% chance of gaining \$0
- $x$ such that

$$\begin{aligned} u_c(x) &= 0.5 \times u_c(10) + 0.5 \times u_c(10) \\ x &= 0.5 \times 10 + 0.5 \times 0 \\ &= \$5 \end{aligned}$$

- What is the certainty equivalence of
  - 50% chance of gaining \$5
  - 50% chance of losing \$5
- $y$ such that

$$\begin{aligned} -\lambda u_c(-y) &= 0.5 \times u_c(5) + 0.5 \times (-\lambda))\, u_c(5) \\ -\lambda y &= 0.5 \times 5 - \lambda 0.5 \times 5 \\ y &= \frac{(1-\lambda)}{\lambda} < 0 \end{aligned}$$

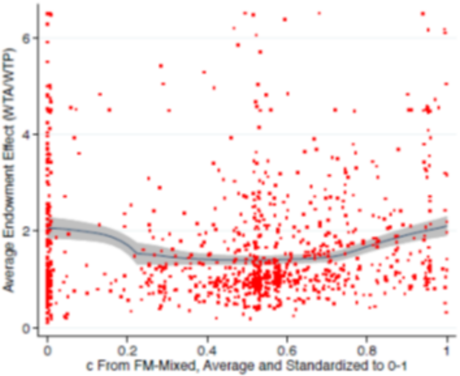
# Loss Aversion in Risky Choice



# A Unified Theory of Loss Aversion?

- We have claimed that loss aversion can explain
  - Increased Risk aversion for 'mixed' lotteries
  - Endowment Effect
- Though note somewhat different assumptions re reference points
- Is the same phenomena responsible for both behaviors?
- If so we would expect to find them correlated in the population
- Dean and Ortoleva [2014] estimate
  - $\lambda$
  - WTP/WTA gap

  In the same group of subjects
- Find a correlation of 0.63 (significant p=0.001)
  - See also Gachter et al [2007]
- However do not find such an effect in a recent larger study




- Figure from Chapman et al [2022]
- See also Fehr and Kubler [2022]

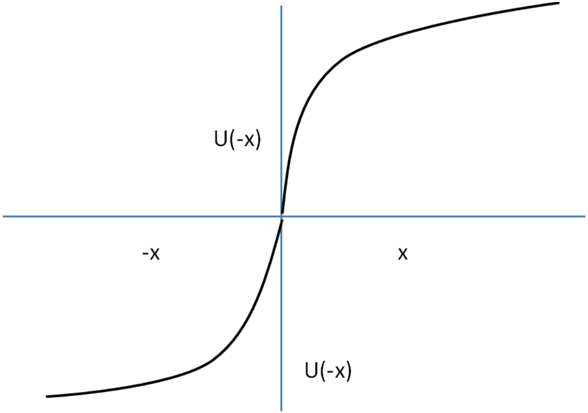
Table 4: ORIV Correlations between WTA, WTP, and Other Risk Measures, Study 2

| | | | Fixed Lottery | | | | | Variable Lottery | |
|---|---|---|---|---|---|---|---|---|---|
| | | WTA | Urn | Gain | Mixed | Loss | WTP | FM | 2L |
| Fixed Lottery | Urn | −0.66*** (.042) | | | | | 0.07 (.067) | | |
| | Gain | −0.66*** (.051) | 0.65*** (.051) | | | | 0.04 (.070) | | |
| | Mixed | −0.58*** (.054) | 0.51*** (.053) | 0.60*** (.049) | | | 0.19*** (.069) | | |
| | Loss | −0.27*** (.076) | 0.26*** (.067) | 0.39*** (.070) | 0.65*** (.056) | | 0.30*** (.077) | | |
| Variable Lottery | FM | −0.03 (.070) | 0.05 (.066) | 0.09 (.069) | −0.14* (.069) | −0.19*** (.075) | −0.45*** (.041) | | |
| | 2L | 0.12* (.071) | −0.17*** (.063) | −0.13* (.071) | −0.21*** (.073) | −0.15* (.078) | −0.28*** (.061) | 0.41*** (.061) | |
| Qualitative | | −0.24*** (.062) | 0.18*** (.058) | 0.18*** (.077) | 0.17*** (.070) | −0.05 (.089) | −0.15*** (.064) | 0.15*** (.062) | 0.13* (.065) |

Notes: ***, **, * denote statistical significance at the 1%, 5%, and 10% level. Each cell in the table is an ORIV correlation with bootstrapped standard errors from 10,000 simulations in parentheses. All measures except WTA and WTP are (re-)coded so that higher values correspond to more risk aversion.

- Prospect Theory: Kahneman and Tversky [1979]
- 'Workhorse Model' of choice under risk
- Combines
  - Loss Aversion
  - Cumulative Probability Weighting
  - Diminishing Sensitivity

# Loss Aversion in Risky Choice




- Diminishing sensitivity:
  - Differences harder to distinguish as you move away from reference point (similar to perceptual psychology)
  - Leads to risk aversion for gains, risk loving for losses
- Looks like many other perceptual phenomena

# Loss Aversion in Risky Choice

- Let $p$ be a lottery with (relative) prizes

$$x_1 > x_2..x_k > 0 > x_{k+1} > .. > x_n$$

- $p_i$ probability of winning prize $x_i$
- Utility of lottery $p$ given by

$$\begin{aligned}
&\pi(p_1)u(x_1) \\
&+ (\pi(p_2) - \pi(p_1))\, u(x_1) \\
&+ ... \\
&+ (\pi(p_1 + .. + p_k) - \pi(p_1 + .. + p_{k-1}))\, u(x_k) \\
&- (\pi(p_1 + .. + p_{k+1}) - \pi(p_1 + .. + p_k))\, \lambda u(-x_{k+1}) \\
&- ... \\
&- (\pi(p_1 + .. + p_n) - \pi(p_1 + .. + p_{n-1}))\, \lambda u(-x_n)
\end{aligned}$$

- Kahneman and Tversky start with a model of behavior, and then derive axioms
- Arguably, model is compelling, axioms not so much
- An alternative approach is taken by Masatlioglou and Ok [2005]
- Start with some axioms, and see what model obtains

# Primitives

- $X$: finite set of alternatives
- $\diamond$: Placeholder for no status quo
- $\mathcal{D}$ : set of decision problems $\{A, x\}$ where $A \subset X$ and $x \in A \cup \diamond$
  - Note the enrichment of the data set
- $C : \mathcal{D} \rightrightarrows X$ : choice correspondence

# Axioms

**Axiom 1: Status Quo Conditional Consistency** For any $x \in X \cup \diamond$, $C(A, x)$ obeys WARP

**Axiom 2: Dominance** If $y = C(A, x)$ for some $A \subset B$ and $y \in C(B, \diamond)$ then $y \in C(B, x)$

**Axiom 3: Status Quo Irrelevance** If $y \in C(A, x)$ and for every $\{x\} \neq T \subset A, x \notin C(T, x)$ then $y \in C(A, \diamond)$

**Axiom 4: Status Quo Bias** If $x \neq y \in C(A, x)$, then $y = C(A, y)$

- These axioms are necessary and sufficient for two representations
- Model 1: There exists
  - Preference relation $\succeq$ on $X$
  - A completion $\trianglerighteq$ such that

$$\begin{aligned} C(A,\diamond) &= \{x \in A | x \trianglerighteq y \ \forall \ y \in A\} \\ C(A,x) &= x \text{ if } \nexists \ y \in A \text{ s.t } y \succ x \\ &= \{y \in A | y \trianglerighteq z \ \forall \ z \succ x\} \ \text{ otherwise} \end{aligned}$$

- Interpretation:
  - $\succeq$ represents 'easy' comparisons
  - If there is nothing 'obviously' better than the status quo, choose the status quo
  - Otherwise think more carefully about all the alternatives which are obviously better than the status quo

- An equivalent representation
- Model 2: there exists
  - $u : X \to \mathbb{R}^N$
  - A strictly increasing function $f : u(X) \to \mathbb{R}$ such that

$$
\begin{aligned}
C(A, \diamond) &= \arg\max_{x \in A} f(u(x)) \\
C(A, x) &= x \text{ if } U_u(A, x) \text{ is empty} \\
&= \arg\max_{x \in U_u(A,x)} f(u(x)) \text{ otherwise}
\end{aligned}
$$

Where $U_u(A, x) = \{y \in A | u(y) > u(x)\}$

## The Story So Far

- Models of reference dependence discussed so far are preference-based
- A status quo generates a set of preferences:

$$\succeq_s \text{ for all } s \in X \cup \Diamond$$

- Decision Maker chooses to maximize these preference

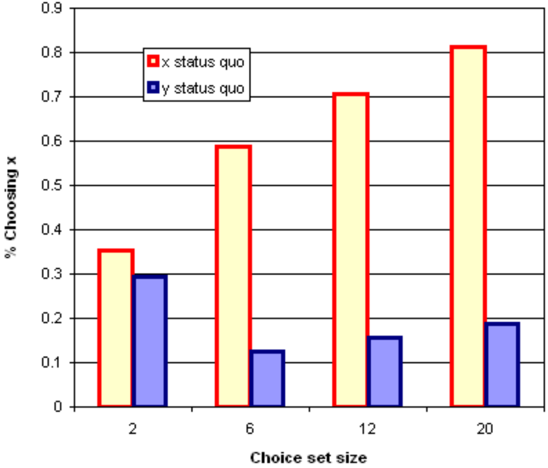
$$C(A, s) = \{z \in A | z \succeq_s y \text{ for all } y \in A\}$$

# Behavioral Implications of Preference-Based Models

- For a *fixed* status quo, DM maximizes a *fixed* set of preferences
- Looks like a 'standard' decision maker
- **Status Quo Conditional Consistency (SQCC):**
- *For any* $(A, s)$, $(B, s)$
  - *Independence of Irrelevant Alternatives: If* $x \in A \subset B$ *and* $x \in C(B, s)$ *then* $x \in C(A, s)$

# The Problem with Preference-Based Models

- This cannot capture **too much choice** effects
  - e.g. Iyengar and Lepper
  - People switch to choosing the status quo in larger choice sets
- Violates Independence of Irrelevant Alternatives for a fixed status quo
  - Status quo chosen in bigger choice set
  - Still available in smaller choice set
  - Yet not chosen in smaller choice set


0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
% Choosing x
x status quo
y status quo
2
6
12
20
Choice set size

# Decision Avoidance

- One possible solution: models of decision avoidance
  - Try to avoid hard choices
- ‘Easy’ choice:
  - Make an active decision to select an alternative
  - May move away from the status quo
- ‘Difficult’ choice
  - May avoid thinking about the decision
  - End up with the status quo
- May cause switching to the SQ in larger choice sets
  - If this leads to more difficult choices

# Models of Decision Avoidance

- What makes choice difficult?
- Conflict model
    - Difficulty in comparing two alternatives
- Information overload model
    - Ability to compare objects reduces with the size of the choice set

# The Conflict Model

- DM endowed with a possibly incomplete preference ordering
- In any given choice set
  - If one alternative is preferred to all others, the DM chooses it
  - If not, may avoid decision by choosing the status quo
- If no suitable status quo, uses other decision making mechanism
  - 'Think harder' about the problem
  - Complete their preference ordering

- **Formal Representation:**
- Let $\succeq$ be a transitive and reflexive (but not necessarily complete) preference relation

1. Choice is defined for any $\{Z, s\}$ by
   1. $C(Z,s) = \{x \in Z | x \succeq y \ \forall \ y \in Z\}$ if such set is non-empty
   2. otherwise $C(Z,s) = s$ if $s \in Z / T(Z)$
   3. otherwise $C(Z,s) = \{x \in Z | x \trianglerighteq y \ \forall \ y \in Z\}$

# A Multi-Utility Representation

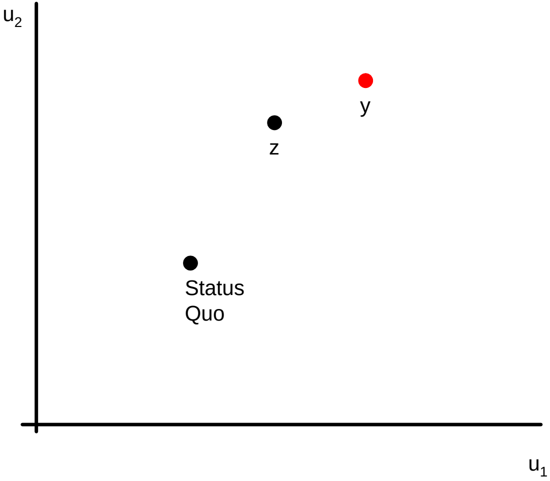
- Incomplete preference ordering $\succeq$ can be represented by a vector-valued utility function:

$$u(z) = \begin{pmatrix} u_1(z) \\ \vdots \\ u_n(z) \end{pmatrix}$$

- Such that

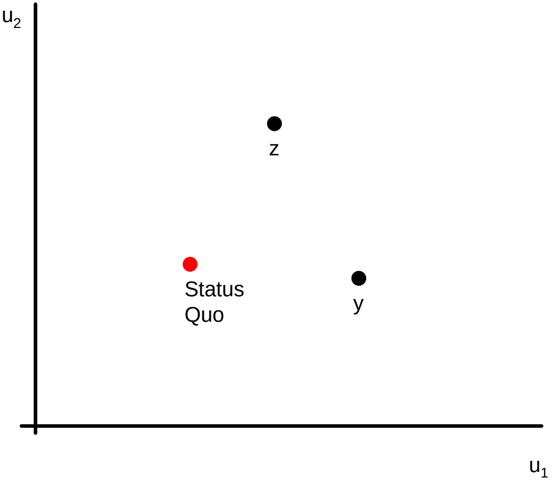
$$\begin{aligned} z &\succeq w \\ \text{if and only if } u_i(z) &\geq u_i(w) \; \forall \; i \in 1..n \end{aligned}$$

# A Multi-Utility Representation




- Choose $y$ as $y$ is best object along all dimensions

# A Multi-Utility Representation




- Choose status quo to avoid having to decide between $z$ and $y$

- Alternative hypothesis: Information Overload
  - Large choice sets are inherently more difficult than small choice sets
    - Iyengar and Lepper [2000]
  - DM can compare all available options on a bilateral basis,
  - May still find large choice set difficult

# Nested Preferences

- Modify Conflict model to allow for information overload
- Preferences may become less complete in large choice sets
- Replace fixed preference relation of Conflict model with nested preference relation
- **Nested Preferences:**
  - For every $Z$ a preference relation $\succeq_Z$
  - Such that, for every $W \subset Z$

$$x \succeq_Z y \Rightarrow x \succeq_W y$$

  - but not

$$x \succeq_Z y \Longleftarrow x \succeq_W y$$

# The Information Overload Model

- Modifies the Conflict Decision Avoidance Model....

1. Choice is defined for any $\{Z, s\}$ by
    1. $C(Z, s) = \{x \in Z | x \succeq_Z y \ \forall \ y \in Z\}$ if such set is non-empty
    2. otherwise $C(Z, s) = s$ if $s \in Z / T(Z)$
    3. otherwise $C(Z, s) = \{x \in Z | x \trianglerighteq y \ \forall \ y \in Z\}$

# Behavioral Implications of Decision Avoidance Models

- Information overload model and conflict model:
  - **A1:** Limited status quo dependence
  - **A2:** Weak status quo conditional consistency
- Conflict model only
  - **A3:** Expansion

# Limited Status Quo Dependence

- Choice can only depend on status quo in a limited way
- Making an object $x$ the status quo can lead people to switch their choices to $x$...
- ...but cannot lead them to choose another alternative $y$
- **A1: LSQD:** *In any choice set, choice must be either*
  - *The status quo*
  - *What is chosen when there is no status quo*
- Note - not implied by preference-based models

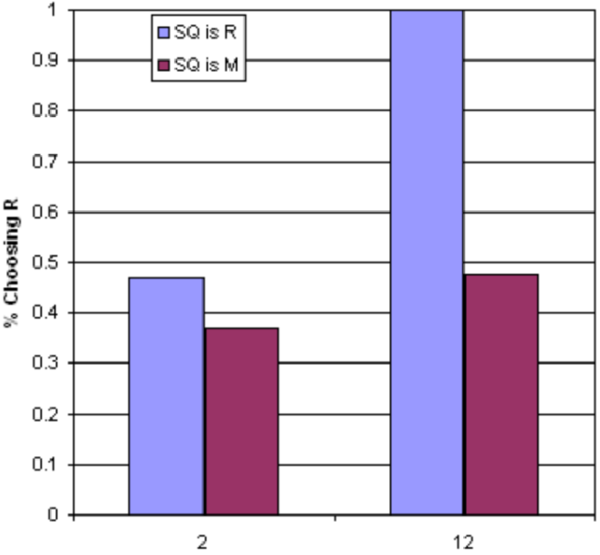
# Weak Status Quo Conditional Consistency

- Decision avoidance models allow for violations of SQCC, but only of a specific type
  - People may switch to choosing the status quo in larger choice sets
- **A2: Weak SQCC:** *For a fixed status quo*
  - *if $x$ is chosen in a larger choice set*
  - *must also be chosen in a subset*
  - *unless $x$ is the status quo*

- **A3: Expansion:** *Adding dominated options cannot lead people to switch to the status quo*
- Say $x$ is chosen in a choice set $Z$ when it is not the status quo
- Add option $y$ to the choice set that is *dominated* by some $w \in Z$
  - $w$ is chosen over $y$ even when $y$ is the status quo
- $x$ must still be chosen from the larger choice set

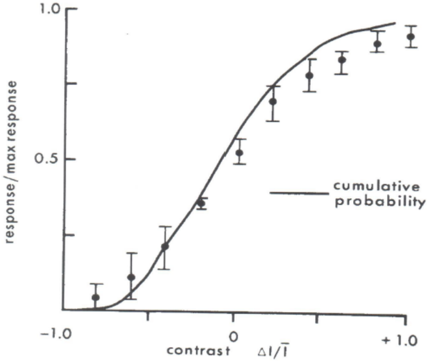
# Expansion

- Conflict model implies expansion
  - Adding dominated options does not make choice any more ‘difficult’
- Information overload model does not imply expansion
  - DM may ‘know’ their preferred option in smaller choice set
  - Adding dominated options to the choice set degrades preferences
  - Can no longer identify preferred option in the larger choice set


SQ is R
SQ is M
% Choosing R
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2
12

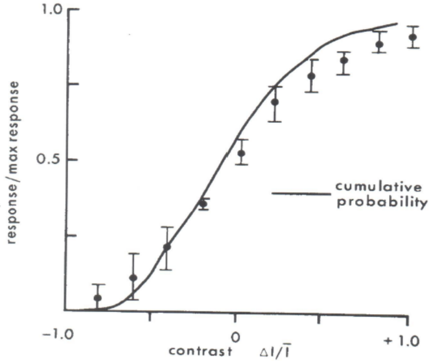
# Reference Points and Optimal Coding

- One possible interpretation of reference point effects is that they focus attention on particular parts of the problem
- Could this be a rational use of neural resources?
  - Focus attention where it is most useful
- If so, may be a role for reference points affecting valuation and therefore choice
  - Reference points tell us what is most likely to happen
  - and so where it is most likely to be useful to make fine judgements
- This hypothesis is explored in by Mike Woodord in depth




- Shows neural response to contrast differences in light sources (black dots)
- Also CDF of contrast differences in blowfly environment (line)

# A Detour Regarding Blowflys




- Sharpest distinction occurs between contrasts which are likely to occur
- i.e slope of line matches the 'slope' of the dots

- Blowflies seem to use neural resources to best differentiate between states that are most likely to occur
- Does this represent ‘optimal’ use of resources?
- Surprisingly not if costs are based on Shannon mutual information
- Why not?

- Remember Shannon Mutual Information costs can be written as

$$-\left[H(\Gamma) - E(H(\Gamma|\Omega))\right] =$$

$$\sum_{\gamma\in\Gamma(\pi)} P(\gamma)\ln P(\gamma) - \sum_{\omega}\mu(\omega)\left(\sum_{\gamma\in\Gamma(\pi)} \pi(\gamma|\omega)\ln \pi(\gamma|\omega)\right)$$

where

$$P(\gamma) = \sum_{\omega\in\Omega} \pi(\gamma|\omega)\mu(\omega)$$

- Changing the precision of a signal in a given state (i.e. $\pi(\gamma|\omega)$) changes info costs by

$$\left(\ln(P(\gamma)) + 1\right)\frac{\partial P(\gamma)}{\partial \pi(\gamma|\omega)} - \mu(\omega)\left(\ln(\pi(\gamma|s) + 1\right)$$

# The Effect of Priors

- But $\frac{\partial P(\gamma)}{\partial \pi(\gamma|\omega)} = \mu(\omega)$, so

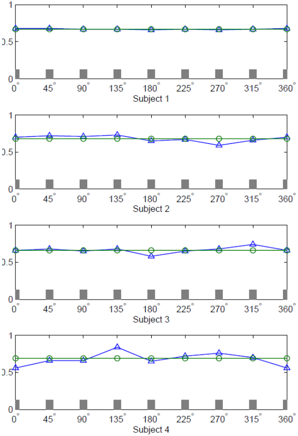
$$\mu(\omega)\left(\ln(P(\gamma)) - \ln(\pi(\gamma|s)\right)$$

- It is cheaper to get information about states that are less likely to occur
  - Intuition: you only pay the expected cost of information
  - Expected cost information about states that are unlikely to occur is low
- This offsets the lower value of gathering information about such states
  - In the Shannon model the two offset exactly
  - Prior probability of state should not matter for optimal coding

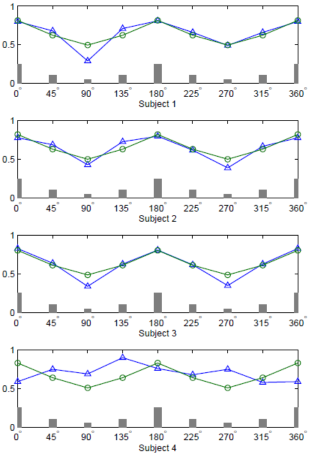
# The Effect of Priors

- Does this hold up in practice?
- Experiment: Shaw and Shaw [1977]
  - Subjects had to report which of three letters had flashed onto a screen
  - Letter could appear at one of 8 locations (points on a circle)
- Two treatments
  - All positions equally likely
  - 0 and 180 degrees more likely
- Shannon prediction: behavior the same in both cases

# Shaw and Shaw [1977]: Treatment 1



# Shaw and Shaw [1977]: Treatment 2



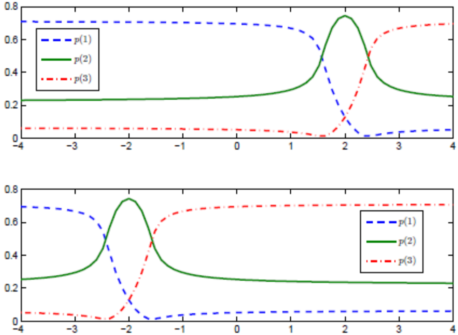
- This observation lead Woodford [2012] to consider an alternative cost function
  - Shannon Capacity
- Let

$$I_\mu(\Gamma, \Omega)$$

be the Mutual Information between signal and state under prior beliefs $\mu$
- Shannon Capacity is given by

$$\max_{\mu \in \Delta(\Omega)} I_\mu(\Gamma, \Omega)$$

- i.e. the maximal mutual information across all possible prior beliefs
- True priors no longer affect costs
- Signals on less likely states no cheaper than signals on more likely states



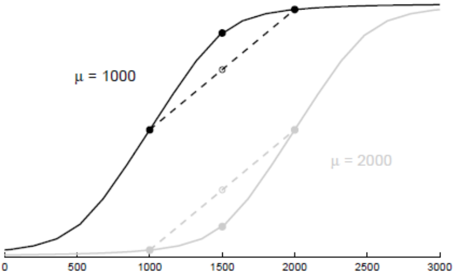

- Optimal behavior when objective is linear in squared error
- Upper panel prior is $N(2,1)$, lower panel prior is $N(-2,1)$

# Coding Values

- One can apply this model to economic choice
- Assume that DM have to encode the value of a given alternative
- Assume alternative is characterized along different dimensions
- Has a limited capacity to encode value along each dimension
- Chooses optimal encoding given costs, prior beliefs and the task at hand

- This model can explain diminishing sensitivity
    - But not, in an obvious way, loss aversion
    - Though see Villas-Boas, J. Miguel. "Towards an Information-Processing Theory of Loss Aversion." (2022).
- Remember, diminishing sensitivity predicts
    - Risk aversion for gains
    - Risk seeking for losses
- E.g.
    - Choice 1: start with 1000, choose between a gain of 500 for sure or a 50% chance of a gain of 1000
    - Choice 2: start with 2000, choose between a loss of 500 for sure or a 50% chance of a loss of 1000

- Assume that the change in the reference point changes the prior distribution over final outcomes
  - Choice 2 has a mean which is 1000 higher than choice 1
  - Assume that prior is normal
- In Choice 1 1000 most likely, then 1500, then 2000
  - 1000 most precisely encoded, then 1500 then 2000
  - More 'sensitive' to the change between 1000 and 1500 than between 1500 and 2000
  - Leads to risk aversion
- In Choice 2 2000 most likely, then 1500, then 1000
  - 2000 most precisely encoded, then 1500 then 1000
  - More 'sensitive' to the change between 2000 and 1500 than between 1500 and 1000
  - Leads to risk loving




- Plot of Mean Squared Normalized Value under the two different coding schemes

- This is part of a developing literatature looking at behavioral biases from a perceptual standpoint
  - Khaw, Mel Win, Ziang Li, and Michael Woodford. "**Cognitive imprecision and small-stakes risk aversion**." The review of economic studies 88.4 (2021): 1979-2013.
  - Gabaix, Xavier, and David Laibson. **Myopia and discounting**. No. w23254. National bureau of economic research, 2017.
  - Adriani, Fabrizio, and Silvia Sonderegger. "**Optimal similarity judgments in intertemporal choice (and beyond).**" Journal of Economic Theory 190 (2020): 105097.
  - Enke, Benjamin, and Thomas Graeber. **Cognitive uncertainty.** No. w26518. National Bureau of Economic Research, 2019.

# Reference Dependent Preferences

- Strong evidence that people evaluate options relative to some reference point
- Change in reference point can change preferences
  - Endowment Effect
  - Risk aversion
- One robust finding is loss aversion
  - Losses loom larger than gains
  - Can explain the endowment effect and increased risk aversion for mixed choice
- One open question is where reference points come from
- Prospect theory is a workhorse model of choice under risk
  - Loss Aversion
  - Probability Weighting
  - Diminishing Sensitivity