Reward and probability: characterizing decision-making in situations with risk.

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Background
•How do humans make choices involving reward?
•Available tools (Iowa Gambling Task[1], Balloon Analogue Risk Task[2]) involve an element of learning and do not allow decomposition of decision factors.
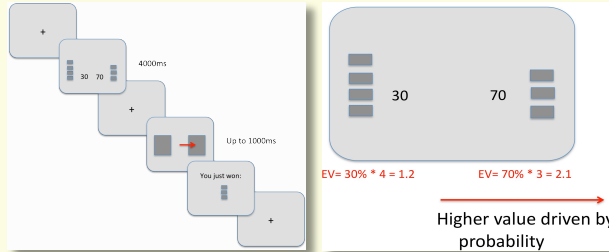
Objectives
Design a simple test of **decision-making under risk to**:
1. Measure discriminative threshold for value
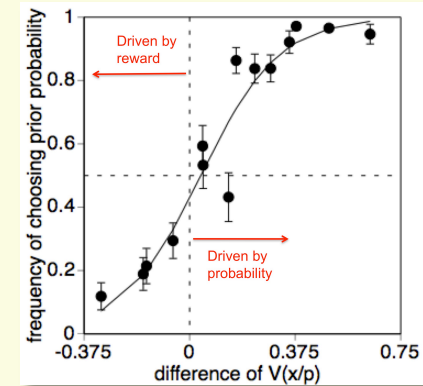2. Characterize decisional biases

Strategy
• Subjects face with two choices ('**prospects**'), one with larger reward, but the other with greater probability.
• **Expected value (EV)** = reward X probability
• By varying the relative EV of one prospect vs. the other, we can determine how sensitive a subject is to small differences in EV and if they tend to favour reward size over probability or vice versa.

Prospect theory
•Subjects decide using *perceived magnitude* and *perceived probability*, which are non-linear functions of objective magnitude and probability.

A. Reward magnitude: v(x)
• Concave curve
• Gradual decrease in value of increments. i.e. difference between $4 and $5 less than that between $1 and $2.
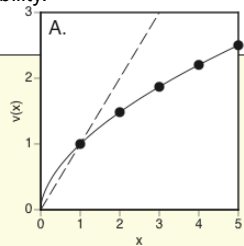
B. Probability: w(p)
•S-shaped function
  •Overweight low probabilities
  •Underweight high probabilities

EV= 30% * 4 = 1.2   EV= 70% * 3 = 2.1

Higher value driven by probability

Experimental Design
•20 healthy subjects
•Subjects choose (saccade) between two prospects.
•4 seconds to decide.
•$0.20 per token won
•170 trials; 14 combinations of probability and magnitude
•Difference in EV between prospects varied from 3-23%
•Payment made for accumulated winnings ($36.40-56.20)
•Control tasks: one prospect having both larger reward AND greater probability, or one aspect equal in both prospects.

Results as function of objective Expected Value
•Discriminative threshold = 10.8% difference in EV
•Choice bias: subjects willing to forego 9.4% in EV to choose side with greater probability **" risk premium"**

References: 1. Bechara et al. Cognition (1994) vol. 50 (1-3) pp. 7-15, 2. Lejuez et al. J Exp Psychol Appl (2002) vol. 8 (2) pp. 75-84, 3. Savage, L. (1954). *The foundation of statistics*. New York: John Wiley. 4. Hsu et al. (2009) vol. 29 (7) pp. 2231, 5. Kahneman and Tversky.. Econometrica (1979) vol. 47 (2) pp. 263-292
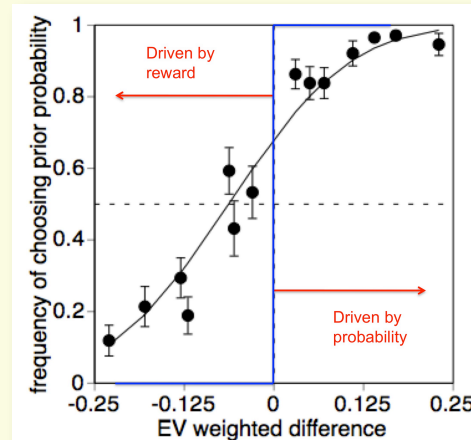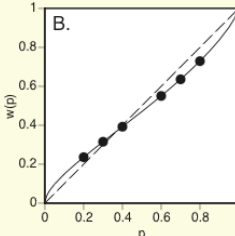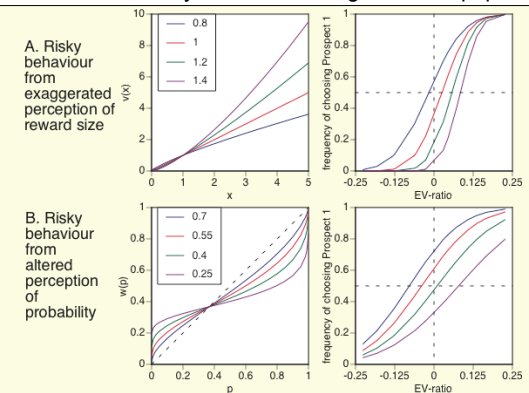
Results in prospect theory terms
•Calculate *perceived* value (V(x/p) from parameters from an independent study of healthy subjects [4].
•Curve now passes close to '0' difference between prospects
• Prospect Theory explains the **risk premium:** the outcome of non-linearities in subjective perception of reward magnitude and probability

Conclusions
• simple test of decision-making under risk, devoid of learning, with robust measures of sensitivity and bias
• Mean discriminative threshold for expected value is 10.8%.
• A systematic 9.4% decisional bias indicating risk aversion, explained by prospect theory.
•could be used to study decision-making in clinical populations

A. Risky behaviour from exaggerated perception of reward size

B. Risky behaviour from altered perception of probability