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Behavioral Issues in Multiple Criteria Decision Making

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My own background

- Interactive decision support: Multiple objective programming methods (interactive): theory, methods, applications – Zionts & Wallenius method, MS 1976; Korhonen & Wallenius, NRLQ 1988 (Pareto Race)
- We noticed early on that we had better chances of supporting DMs if our methods and models were behaviorally realistic:
  - Starting in late 1980's have been partially active in behavioral decision research
  - For many years I also taught a behavioral decision theory course for PhD students at Helsinki School of Economics (since 2010 Aalto University School of Business)

Outline of today's lecture

- Background: behavioral decision theory
- Doing behavioral decision research: conducting experiments with human subjects

Research Studies:

1. Choice behavior and prospect theory: cycles, premature stopping and path dependence
2. Robustness of linear value functions
3. The concept of importance and criterion weights
4. Tradeoff vs. win-win questions: two ways of approaching MCDM problems

Background

Father of behavioral decision theory: Ward Edwards (1927-2005)

- Published two papers on behavioral decision theory
  - *Psychological Review, 1954:* introduced the expected utility model, and asked: do people behave this way?
  - *Annual Review of Psychology, 1961:* established the field of behavioral decision making; studied how people make choices and how to improve them.
  - *Engineering Economist, 1971:* SMART (Simple Multi-attribute Rating Technique) – liked utility theory, but thought it was too difficult to use in practice.

Other major contributors

- Herbert Simon (1916-2001), Nobel Prize in Economics, 1978: 1955 paper on bounded or limited rationality (humans are not utility maximizers, but 'satisficers'; they set aspiration levels)

Other major contributors: Amos Tversky (1937-1996) and Daniel Kahneman (1934-, Nobel Laureate 2002)

Tversky and Kahneman collaborated for some 30 years and published many seminal papers in the 1970's and beyond.

- Biases and heuristics (anchoring, availability, representativeness)
- Framing (how questions are framed matter; lives lost, lives saved)
- Context matters (currently available alternatives, previously seen alternatives
- Prospect Theory (descriptive choice theory under uncertainty)

Richard Thaler (1945-), recipient of 2017 Nobel Prize

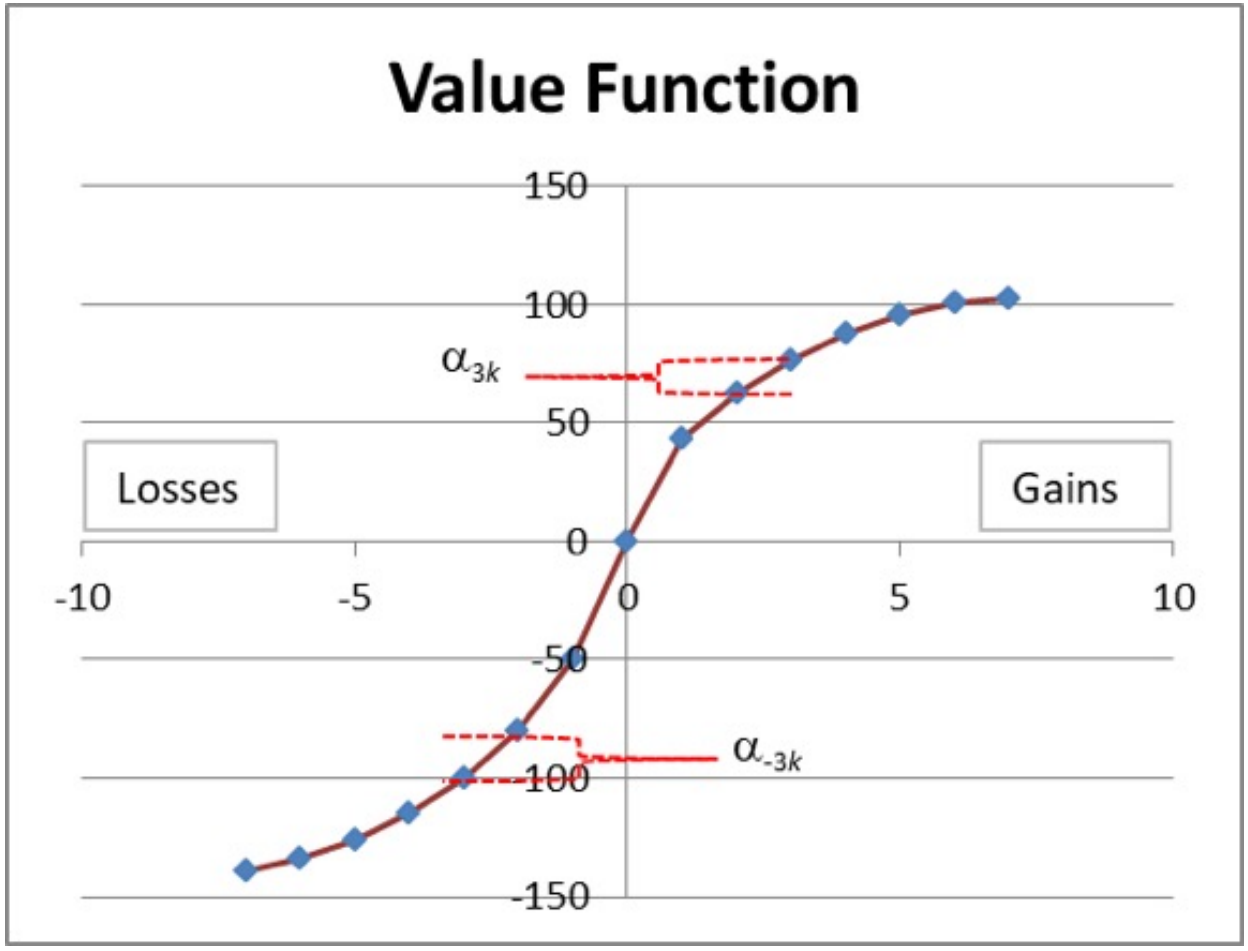
- Thaler, building upon the work of Tversky and Kahneman, developed, among other things mental accounting.
  - A person may use different monthly budgets for grocery shopping and eating out at restaurants, for example, and constrain one kind of purchase when its budget has run out while not constraining the other kind of purchase, even though both expenditures draw on the same resource (income).

Kahneman and Tversky: Prospect Theory, Econometrica 1979

Descriptive choice theory explains many anomalies of expected utility theory.

- Probabilities are replaced with decision weights.
- Humans overweigh small probabilities.
- Humans make choices with respect to a reference point, not in absolute terms (changes with respect to a reference point are coded as gains or losses).
- Humans are risk averse for gains, risk takers for losses.
  - Their value functions are concave for gains and convex for losses, however they are steeper for losses of the same magnitude than gains (humans react more strongly to negative than to positive stimuli).

Prospect theory value function



What reference point to use?

Tversky and Kahneman are rather vague about this in their paper… prospect theory was originally developed as a descriptive model, how humans make choices.

- Expected state? Expectation management …
- Promised state? Example: management-union labor contract negotiations
- Currently best available alternative?

Conducting Experiments in our Field 1/4

Where to recruit subjects?

Students or managers? How many?

- Psychology students are good, because they need to participate in experiments.
- Minimum number …. ?

Which problems to use? Discrete evaluation problems or continuous design problems?

- Choices between product baskets? Utilitarian products vs. hedonistic products?
- Something the subjects can relate to

Conducting Experiments 2/4

What performance measures to use?

- Subjective measures?
- Dominance?

Watch out for order effects:

- Do not test your methods, theories in the same order!

How to motivate the subjects? Important!

- How would you motivate your subjects?
- Let them keep one of their preferred choices (randomize).
- The more valuable the reward is, the easier it is to recruit subjects.

Depending on your university policy, you may need permission from your university's ethics committee.

Conducting Experiments 3/4

Be explicit of the goal/purpose (research question) of your experiment:

- Testing methods?
- Developing choice theories?

Do you need explicit hypotheses or does it suffice with a research question? If yes, how precise do the hypotheses need to be?

Practical advice: conduct a small-scale pilot study before the actual experiment.

How to analyze the results? Talk to an empirical statistician …

Open Science in Psychology 4/4

- An intense discussion on how to design, analyze and publish results from experiments (Simmons et al., *Psychological Science*, 2011, Vol. 22.
- The failures of replicating many studies highlights the problems … which analyses have truly been decided apriori?

This has led to an inflation of false-positives, since hypotheses have been manipulated after seeing the data.

- Your hypotheses should come from the literature/prevailing theory, they should not arise from your data
- Example of false-positive: the medical diagnostic test says you have a certain disease, even though you do not have it.

Many psychology journals now require that you post your hypotheses and other details of your experiment prior to the experiment on a public website.

Choice Behavior and Prospect Theory: 1/6 Cycles, Premature Stopping and Path Dependence

- Pekka Korhonen, Herbert Moskowitz and Jyrki Wallenius: Annals of Operations Research Vol. 23, 1990, pp. 161-179.

- Also published in: The Rocky Road to Publishing in the Management and Decision Sciences and Beyond, Springer Briefs, 2013
  - Documented the entire story of the finally published article from the first draft, to submissions to journals … 100 page story).

Choice Behavior and Prospect Theory 2/6

- Ran some experiments with student subjects using a software system (VIMDA, 1988) developed by one of us.
  - Choosing between washing machines & homes
- Found some behavioral anomalies and inconsistencies:
  - Cycles
  - Premature stopping
- First we were puzzled, what's going on?
- Explanation: Prospect Theory (Kahneman and Tversky, *Econometrica* 1979) or more precisely the deterministic version of it.

Choice Behavior and Prospect Theory 3/6

Applying Prospect Theory to a Deterministic MCDM Setting:

- People make choices with respect to a reference point (current solution) – people react to change.
- Their value functions are concave for gains, convex for losses (steeper for losses = loss aversion).

Choice Behavior and Prospect Theory 4/6

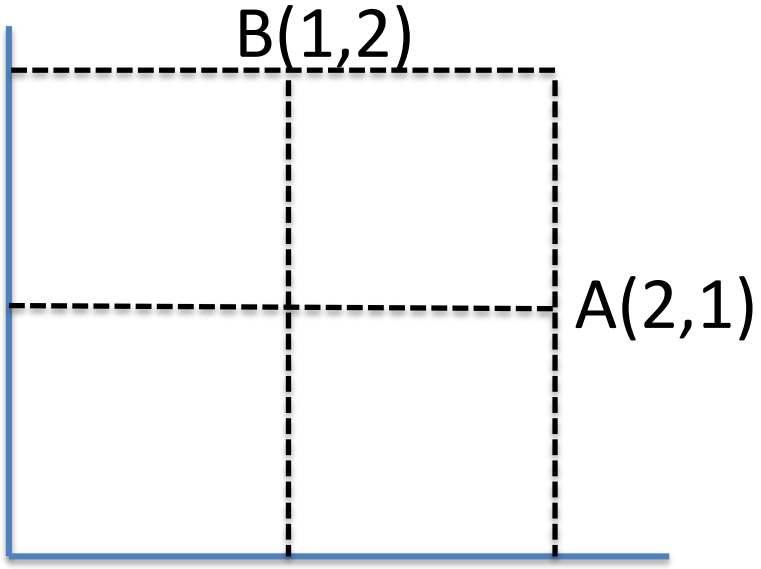
This theory would explain all the observed anomalies in our study – and some more.

- Cyclic behavior
- Premature stopping (explaining why interactive man-machine algorithms converge/stop so quickly)
- Path dependence (which has been ignored in the optimization literature)

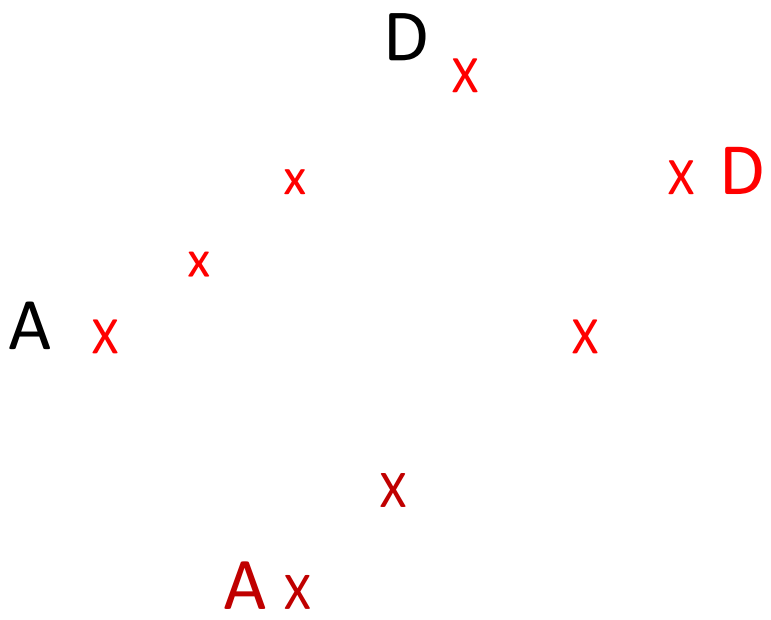
Show how!

Choice Behavior and Prospect Theory: Explaining classical inconsistencies 5/6

If B is the reference point, it is quite possible that the DM does not want to move to A. If A is the reference point … (axes describe the attribute values).



Choice Behavior and Prospect Theory: Path Dependence (multiple authors have studied this phenomenon) 6/6



Ds may lie on the efficient frontier.

Can a Linear Value Function Explain Choices? EJOR 219, 2012. 1/4

(Korhonen, Silvennoinen, Wallenius, Öörni)

- Old controversy: humans seem to violate a linear value function, yet many scholars/practitioners work with linear value functions and think they work alright?
- We revisited the old topic and found that humans are inconsistent with a linear value function (in a simple bi-criteria setting).

So what's the big deal?

Can a Linear Value Function … 2/4

- Subjects made 20 pairwise choices.
- Used the first 10 pairwise choices to estimate weights for a linear value function (using our max epsilon formulation*).
- Separated the subjects into two categories: those consistent with a linear value function, and those not.
- In **both** cases used the estimated weights to predict the following 10 pairwise choices.

Max epsilon formulation based on pairwise comparisons 3/4

Max ϵ subject to:

$$\sum_{j=1}^{p} \lambda_j x_{rj} - \epsilon \geq \sum_{j=1}^{p} \lambda_j x_{sj}, \text{ for all } (X_r, X_s)$$

$where\ X_r\ is\ preferred\ to\ X_s$

$$\sum_{j=1}^{p} \lambda_j = 1\,, \lambda_j > 0, \forall j = 1,2, \dots, p.$$

Getting an epsilon value over zero means that the subject has answered in a fashion consistent with a linear value function.

Note: even if epsilon is negative, the model anyway generates lambda weights.

Can a Linear Value Function … 4/4

- The predictability of a correct choice is high irrespective of whether the value function is linear (0.88) or not (0.81).
- We were not able to find a statistically significant difference between them.
- Interestingly if we remove 2 choices (the trouble makers), 85% of cases become consistent with a linear value function.
- The results seem to generalize to 4 criteria: new study.

Conclusion: if we do not have information about the form of the value function, it seems alright to work with a linear value function (robustness quality).

Judgments of importance revisited: What do they mean? ½

Tommi Pajala, Pekka Korhonen, and Jyrki Wallenius (forthcoming in *Journal of Operational Research Society*)

- Weights are commonly believed to reflect criterion importance – despite warnings
- In two experimental settings (with 2 and 4 criteria), we asked subjects to rank criteria in terms of importance (which they often do) – using AHP
- We also estimated weights based on pairwise comparisons
- Then we studied how well weights would reflect importance:
  - ➢ Not well!

Judgments of importance revisited 2/2

The median rank correlation between importance and weights was about 0.25 (new 4 attribute experiment)

If weights do not explain importance, what does?

- Need new models
- A promising model: impact (product of weight times range)

Some decision analysts refuse to make importance statements – however, politicians have no problem with them. The problem is that we do not fully understand what they mean.

Tradeoff vs win-win choices 1/4

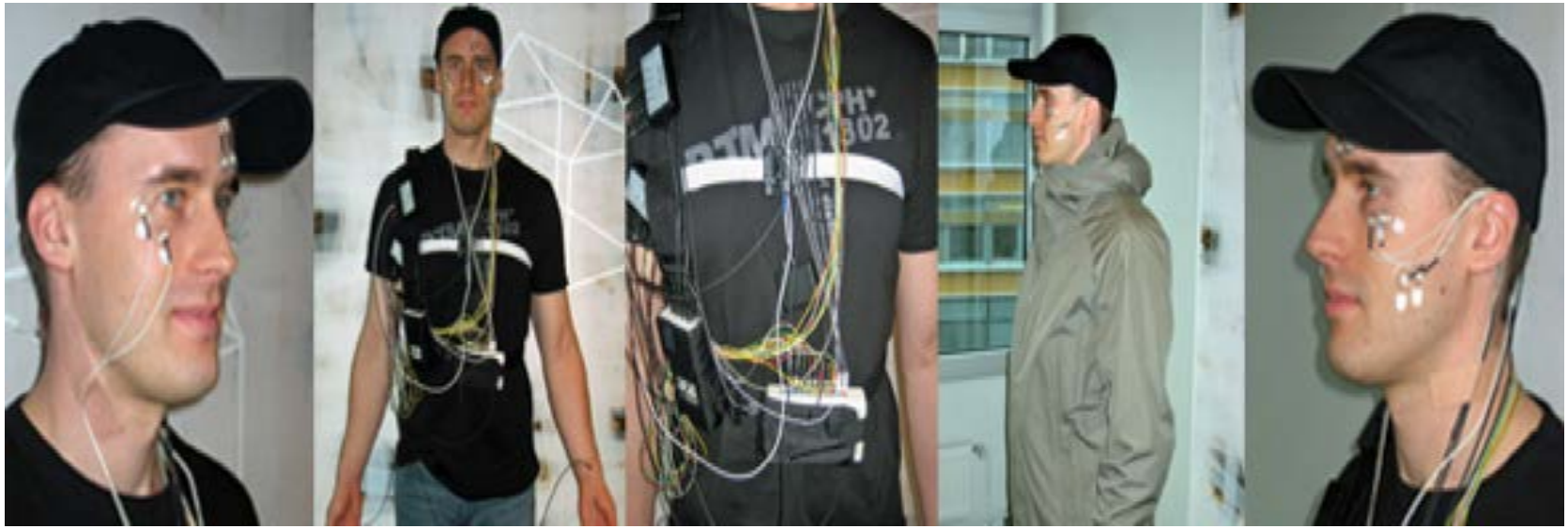
In *Journal of Economic Psychology*, 2016, we published a paper (Ravaja et al.), where we investigated the cognitive and emotional load of making tradeoff vs. win-win choices

Hooked the subjects to neuro-physiological instruments. Monitored the subjects':

- facial expressions
- skin reactions
- brain activity (electric hat) – option fMRI (hospital)

The instruments do not lie (kind of lie detectors …). Need to collaborate with a person who has experience in using such instruments and who can analyze the (large amounts of) data.

Neuro-physiological instruments: facial expressions 2/4



Monitoring brain activity: electric hat 3/4

Tradeoffs vs. win-win choices 4/4

Long story short: clear tradeoff aversion (from perspective of marketing literature not a new finding …) – cognitively and emotionally tradeoffs are harder than win-win choices.

Questions and implications:

- Tradeoff approach is common in MCDM (we work with efficient solutions, and moving from one efficient solution to another, implies a tradeoff).
- Win-win approach common in negotiations (interestingly: sometimes negotiators reject win-win solutions … the ultimatum game; who is familiar with it?).
- Which approach (tradeoff or win-win) does lead to better solutions? Jury is still out there … Both approaches have strengths and weaknesses …

Conclusion

- Have talked about some classic behavioral research and also presented several examples of behavioral research where I have been involved.
- Fascinating field, not new but gaining in importance, becoming more mainstream in OR/MS.
  - There is a EURO Working Group on Behavioral OR, with a track in EURO Conferences (chaired by Alberto Franco and Raimo Hämäläinen).
- There exist many beliefs and myths which are not necessarily true.
- Challenge them! Go run experiments!

Conclusion continued

- My personal view is pragmatic: the better understanding we have of how decisions are made, the better chances we have to successfully support decision makers.
  - ➢ Do you agree or disagree?
- Why do you think it has taken so long (since Simon's research from mid-50s) for behavioral decision research to become mainstream?
- Who is involved in behavioral decision research? Anybody conducted research with neuro-physiological instruments? Tell us!