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NEFI NEW ENERGY FOR INDUSTRY

Visualizing Interaction Effects for Combinatorial Cost-Benefit Analysis

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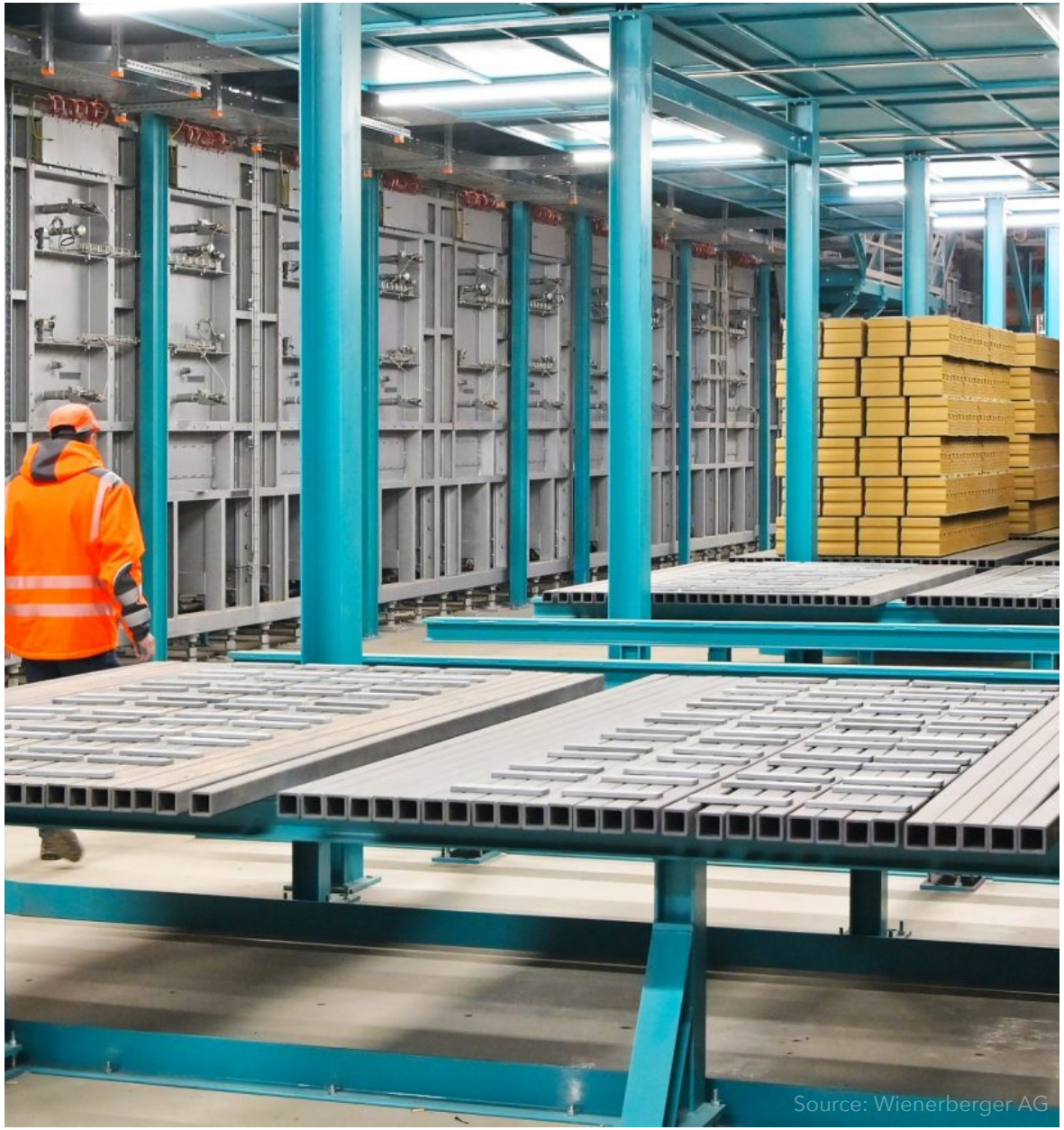
EuroVis 2025 Short Papers

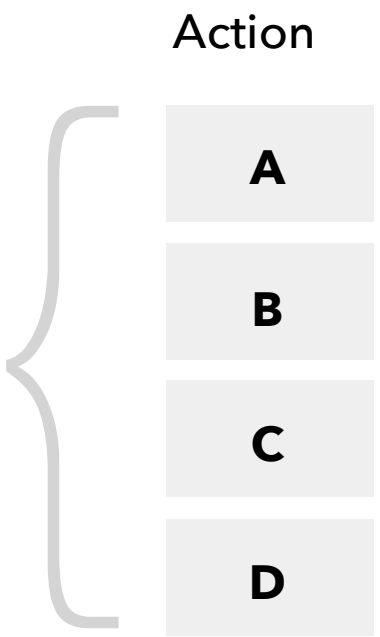
EUROVIS 2025 LUXEMBOURG



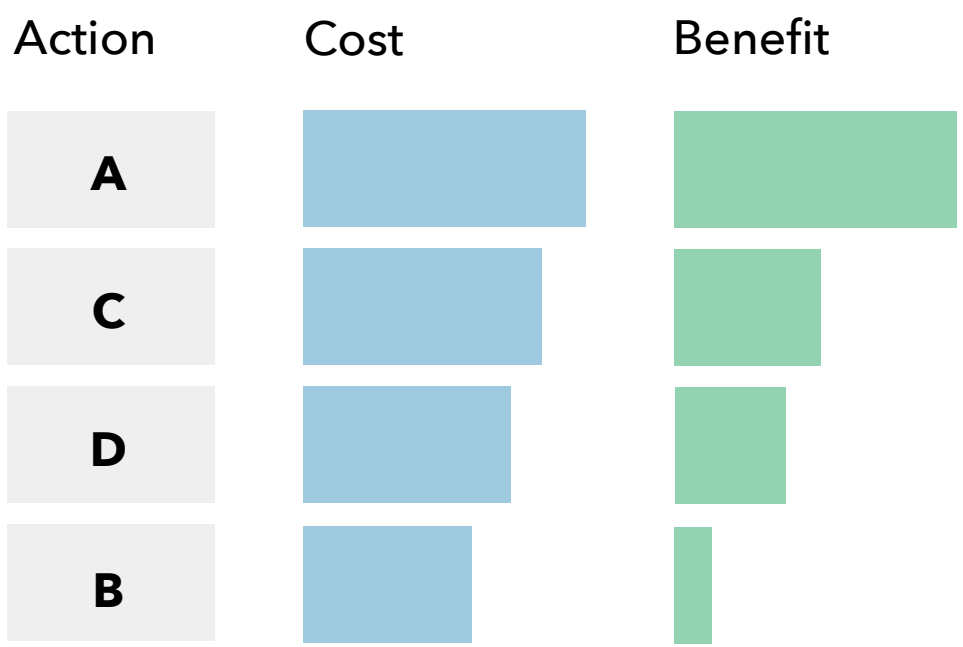
Motivation

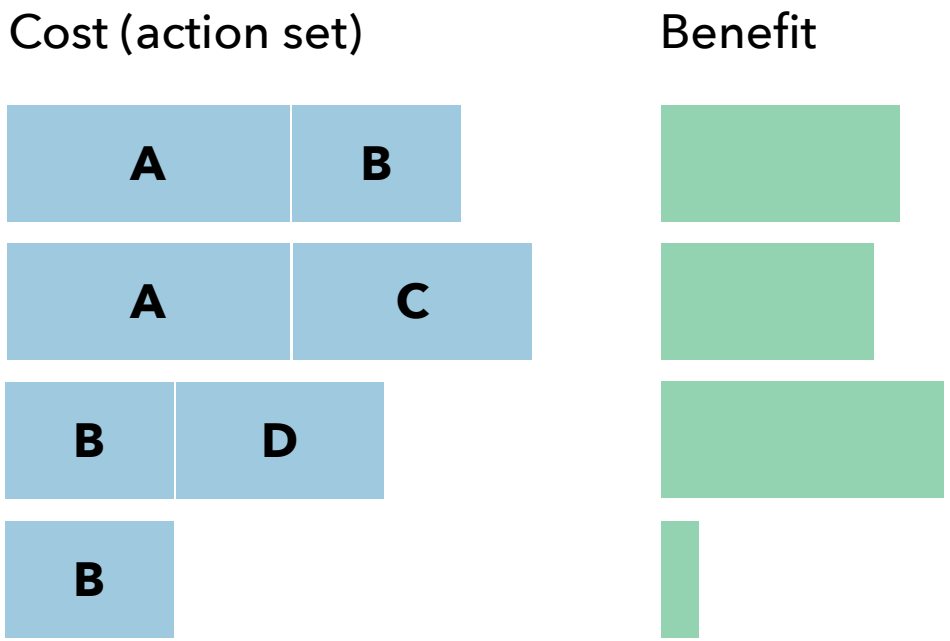
- Collaboration with an industrial manufacturer
- Reduce carbon emissions
- Domain experts: simulate outcomes, provide recommendations
- Decision-makers: techno-economic optimizations

Potential actions

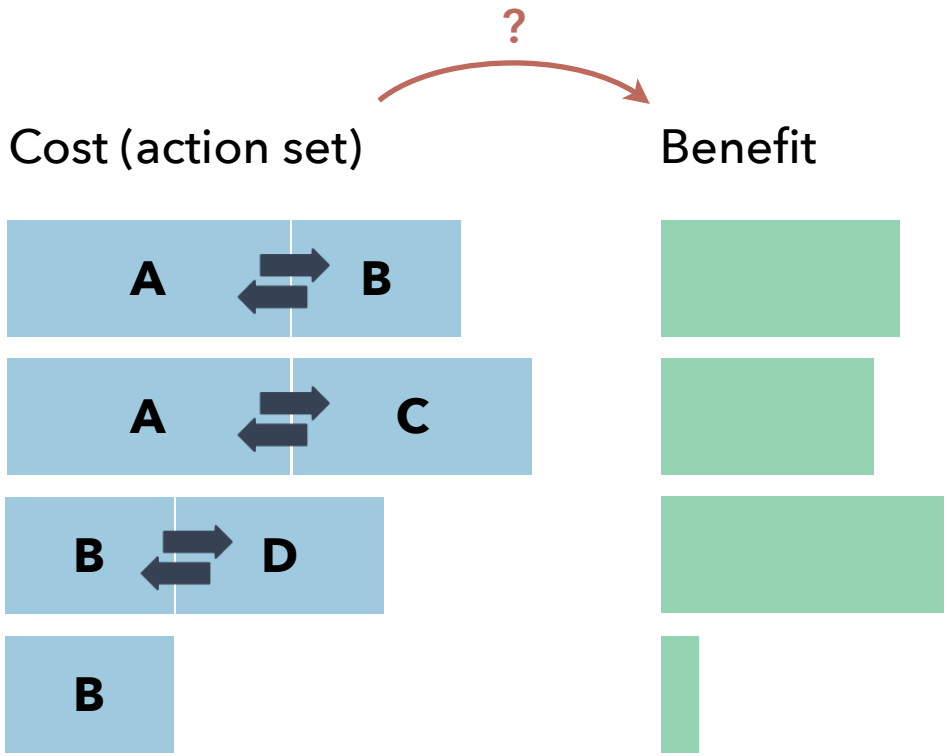


Potential actions


Action
Cost
Benefit
A
C
D
B


Cost (action set)
Benefit
A
B
A
C
B
D
B

Challenge: **Combinatorial Effects**



Research Questions

1. **Which visualization techniques are suitable for the analysis of interaction effects?**
2. **What challenges and design implications arise when visualizing interaction effects?**

… in the context of combinatorial cost-benefit analysis

Tasks

1. **Detect** interaction effect
2. **Characterize** interaction type
3. **Estimate** interaction strength
4. **Compare** sets that may inhibit interaction effects

Tasks

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2. **Characterize** interaction type
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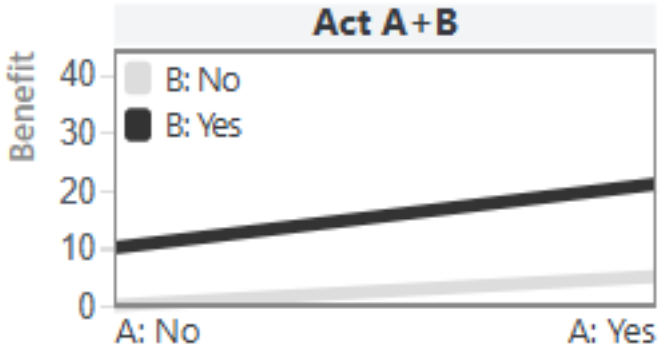
Data

- **Binary actions**
- **Max. 3 actions per set**
- **Costs are independent**

Review of Visualization Techniques

Interaction plots

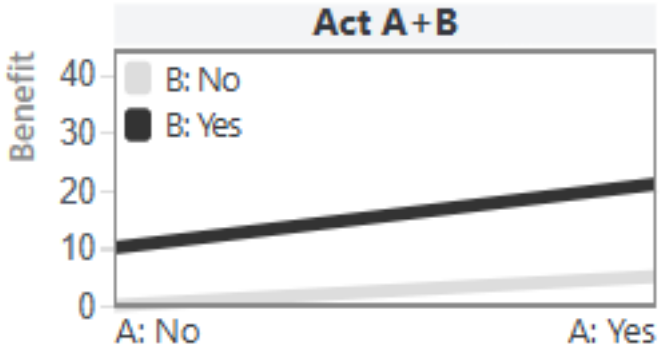
Two-way interaction



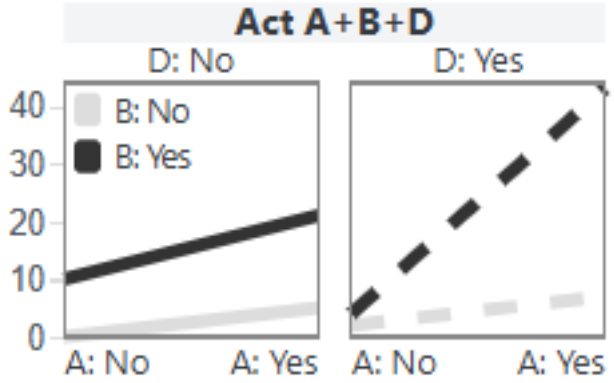
Review of Visualization Techniques

Interaction plots

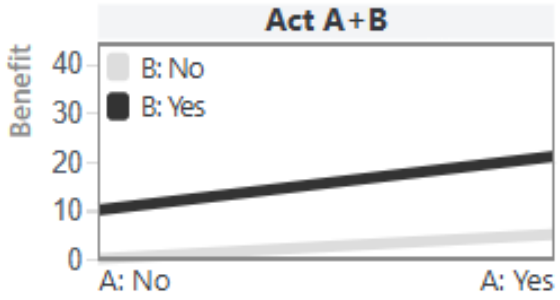
Two-way interaction

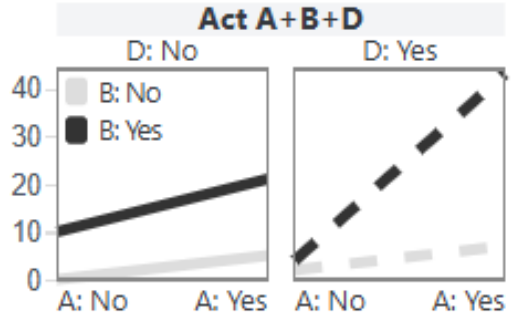


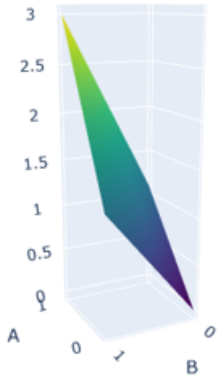
Three-way interaction

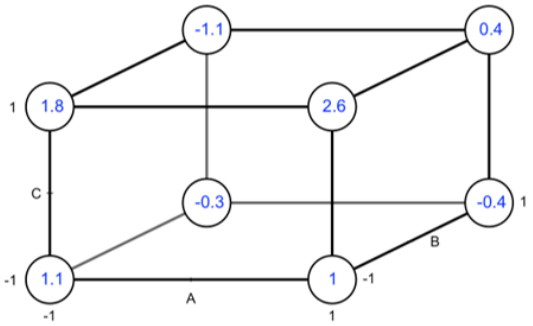


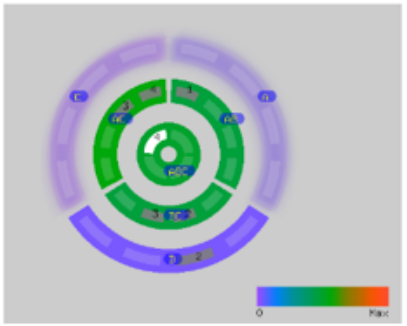
Review of Visualization Techniques

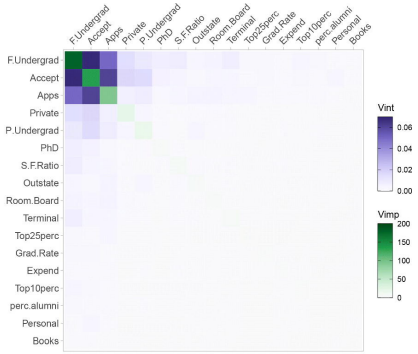




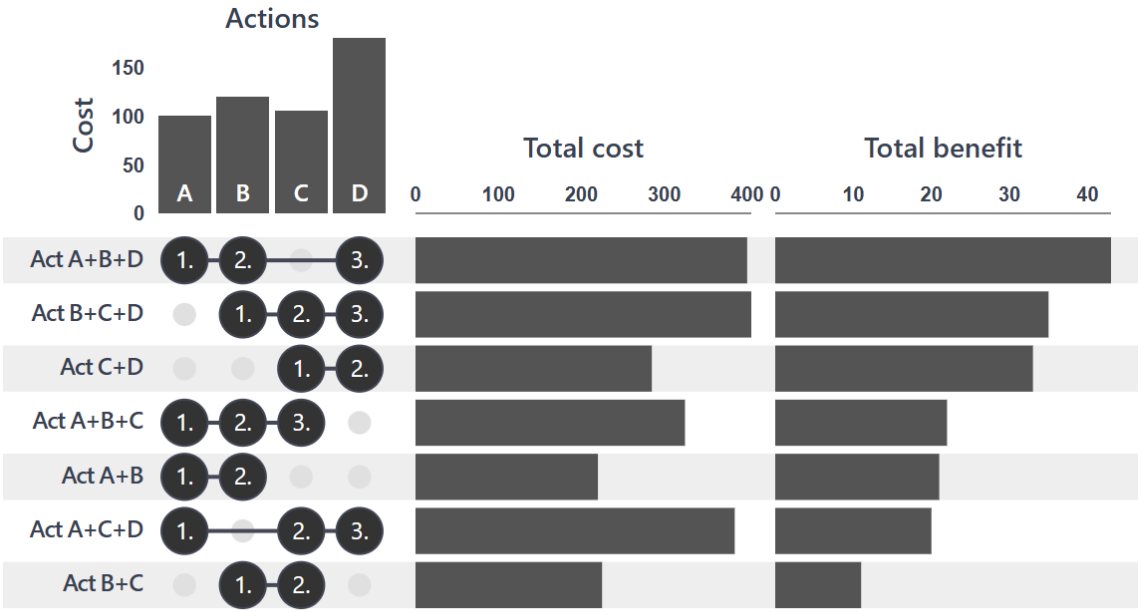






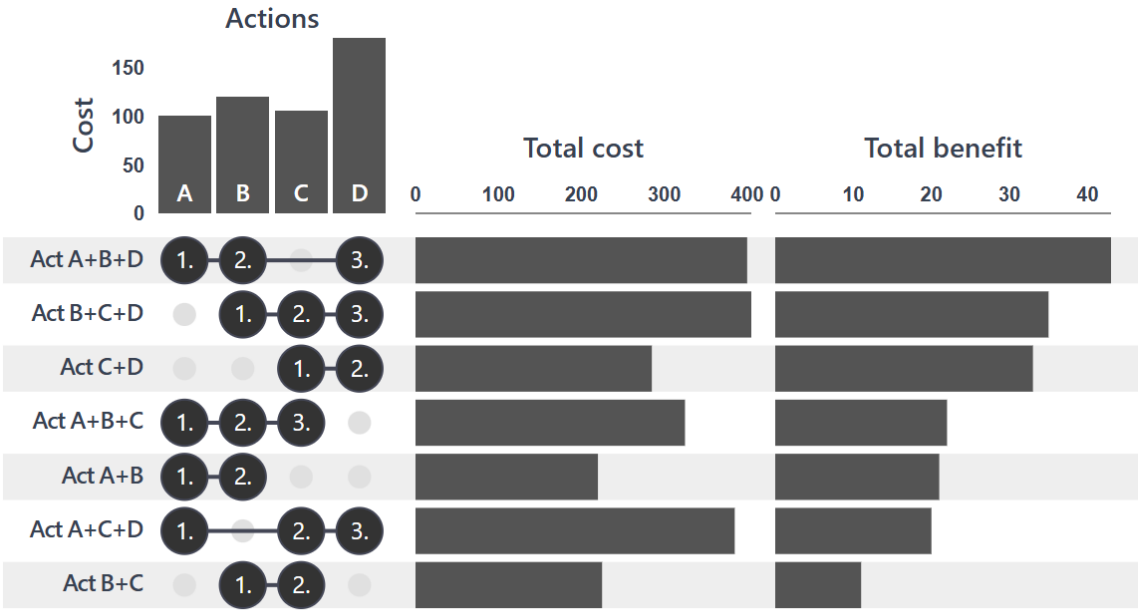


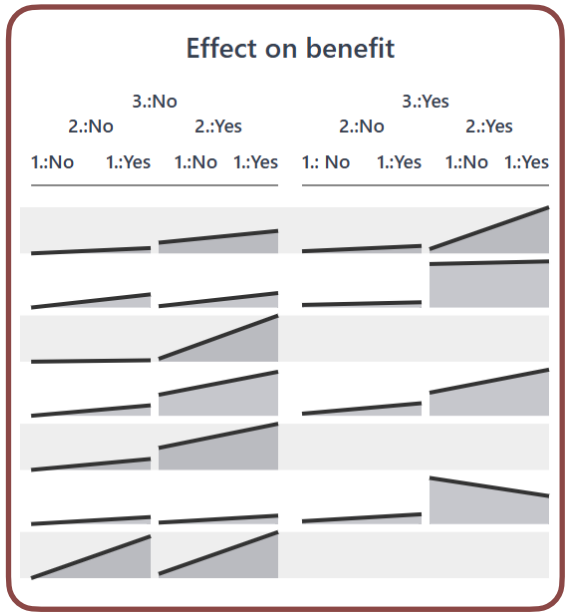
Multi-Attribute Set Rankings



← Action set

Multi-Attribute Set Rankings with **Interaction Effects**

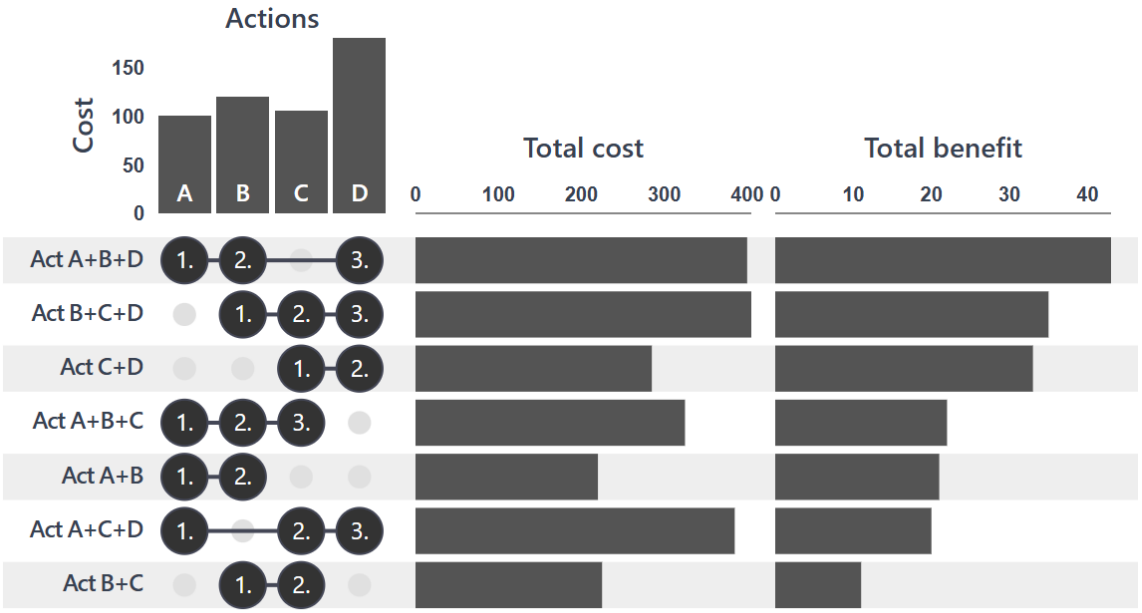


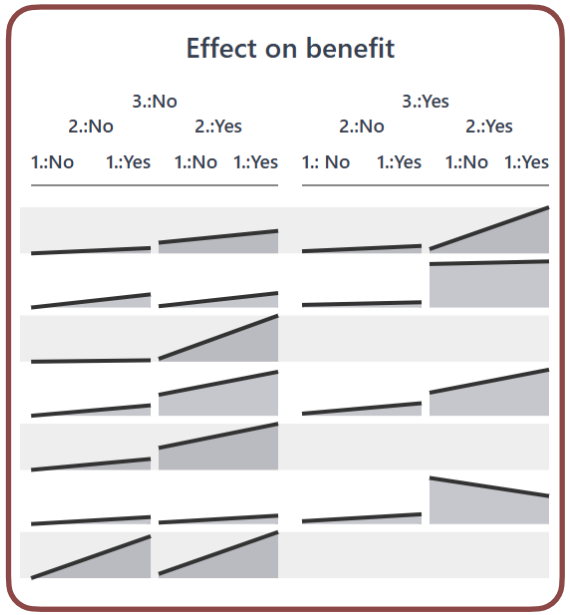


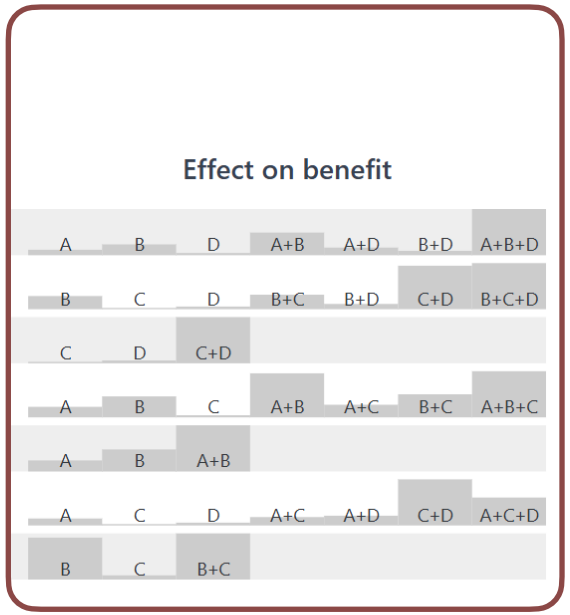
Variant 1

(juxtaposed areas)

Multi-Attribute Set Rankings with **Interaction Effects**





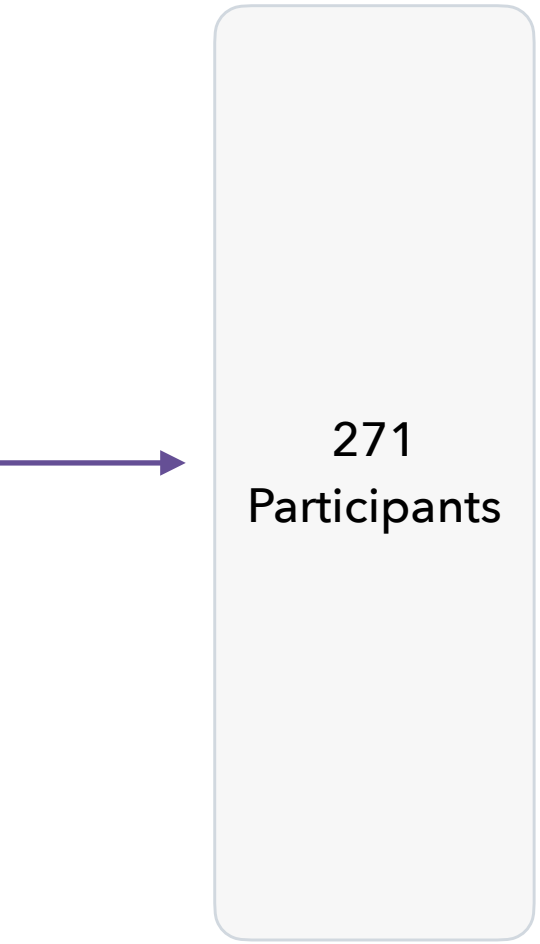


Variant 1
(juxtaposed areas)

Variant 2
(column charts)

Comparative Evaluation

Between-Subjects Evaluation



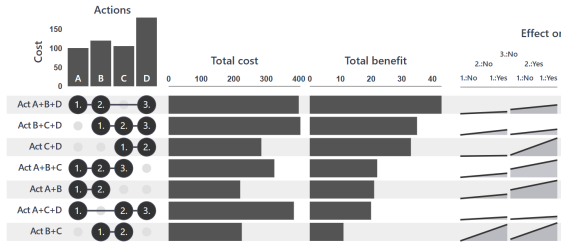
Between-Subjects Evaluation

4 Groups

271 Participants

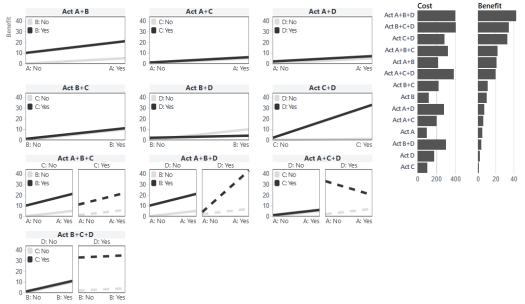
A

Multi-attribute set rankings (Variant 1: areas)



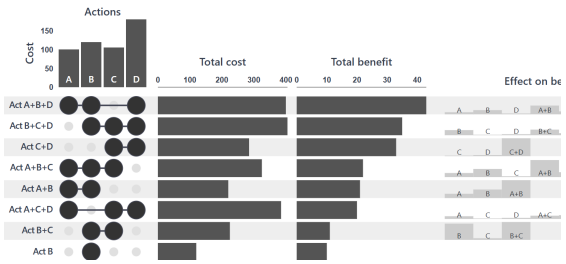
C

Interaction plots (small multiples)



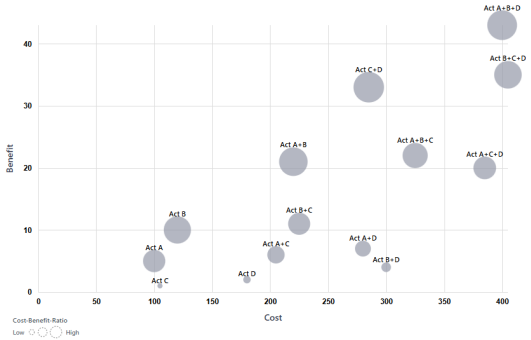
B

Multi-attribute set rankings (Variant 2: columns)



D

Bubble chart

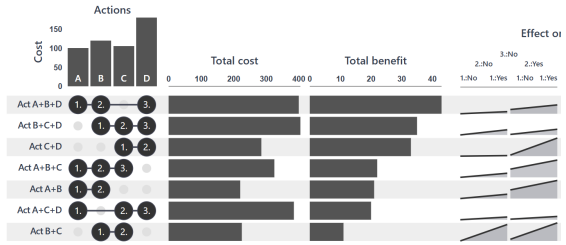


Between-Subjects Evaluation

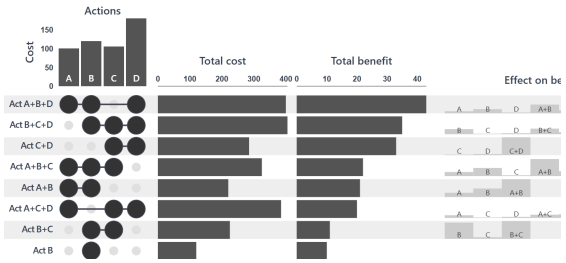
271 Participants

4 Groups

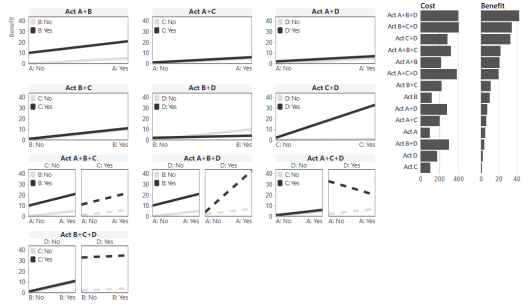
A Multi-attribute set rankings (Variant 1: areas)



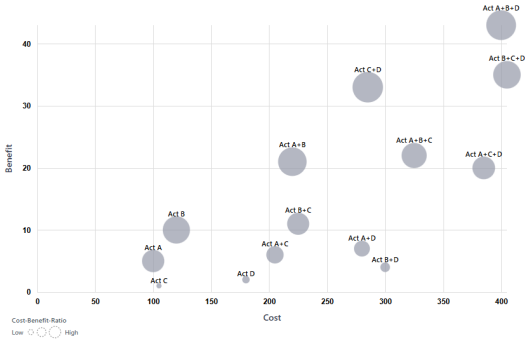
B Multi-attribute set rankings (Variant 2: columns)



C Interaction plots (small multiples)



D Bubble chart

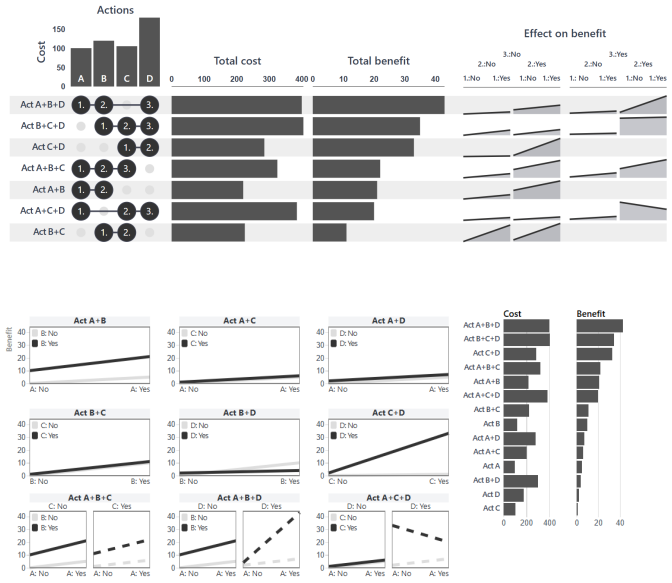


Assessed

- Performance
- Comprehension
- Duration
- Perceived load
- Visualization literacy

Results

- None of the techniques performed significantly better overall
- Multi-attribute rankings with interaction effects indicates the best balance of performance and usability
  (variant 1: juxtaposed areas)
- Interaction plots performed worst across all task metrics



Future Directions

- Comparing interaction effects across sets is highly-relevant
- Multi-attribute rankings scale well to many action sets
- Limitation: trade-off between realistic analysis scenario and manageable interaction complexity
- New approaches are needed for:
  larger sets, non-binary actions, effects on various attributes
- Timing of actions and dynamic effects are also important to consider

Visualizing Interaction Effects for Combinatorial Cost-Benefit Analysis

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michaeloppermann.com

- Review of visualization techniques
- Multi-attribute set rankings with small-scale visualizations
- Preliminary comparative evaluation (n=271)
- Future directions: scale # actions and # variable types; temporal dimension

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