Comparing Alternative Goal Model Visualizations for Decision Making: an Exploratory Experiment

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Overview

- Quantitative Goal Model
- Alternative Visualizations
- Experimental Design
- Experimental Results
- Conclusions and Remarks

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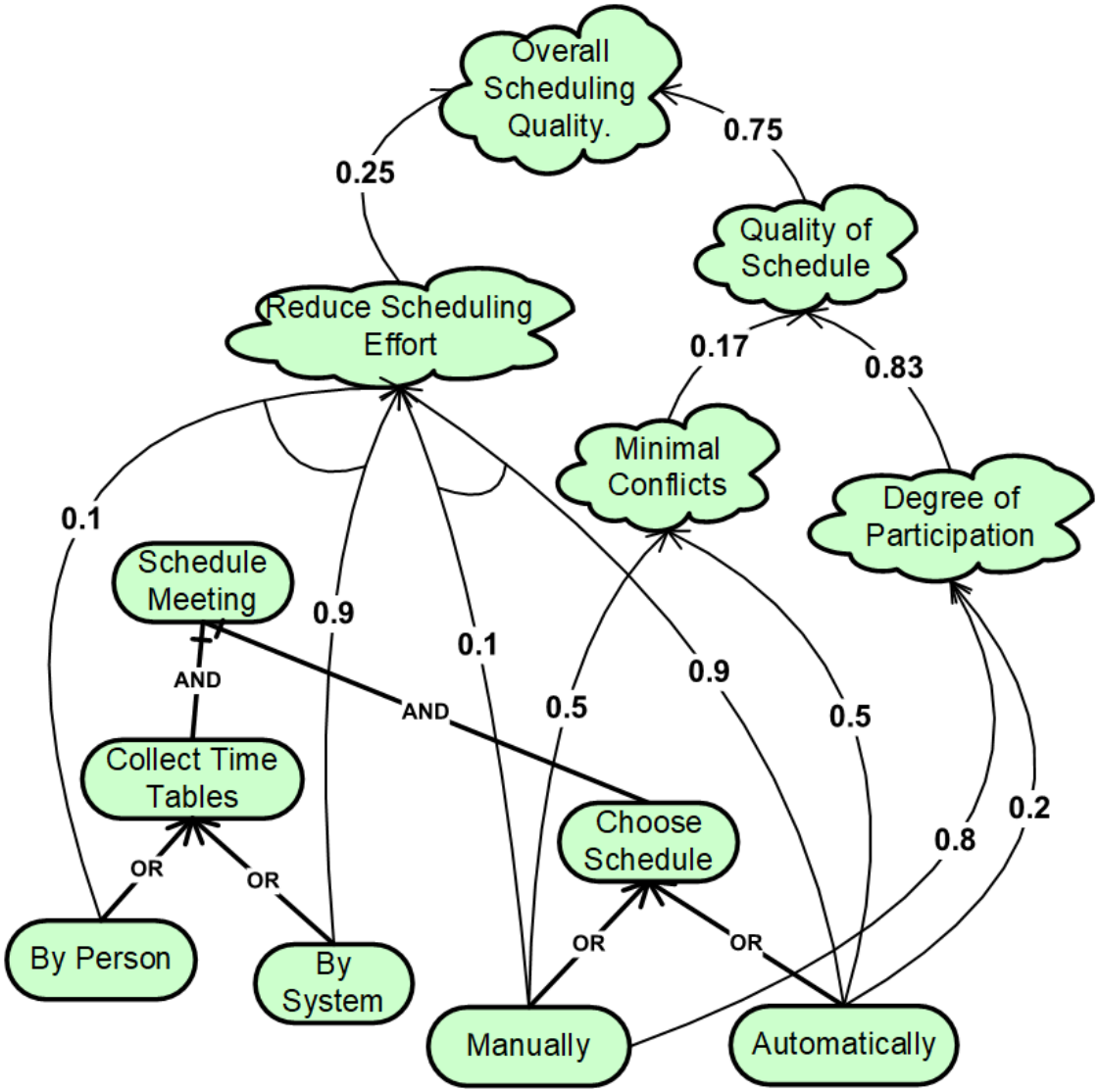
Quantitative Goal Models



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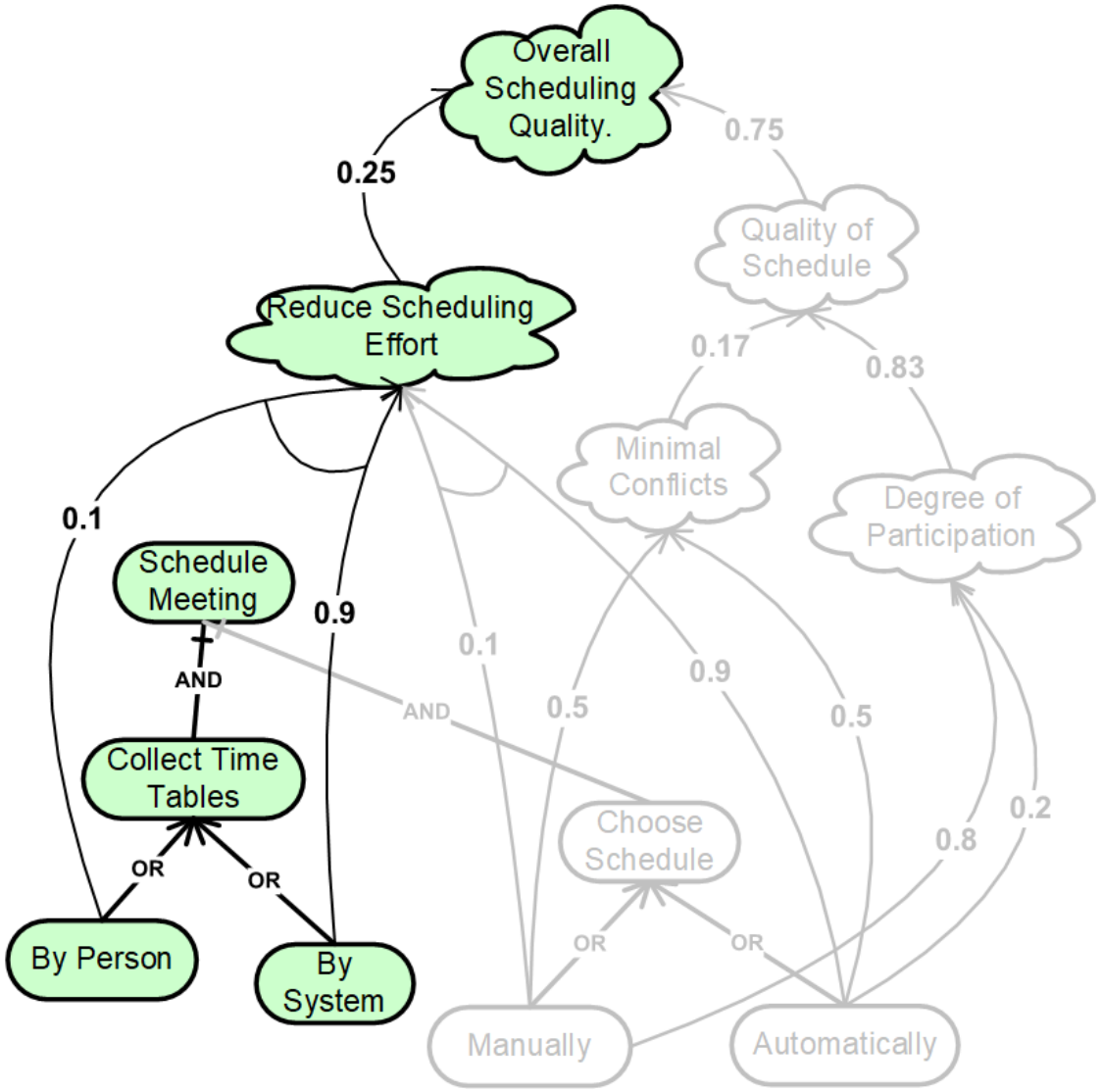

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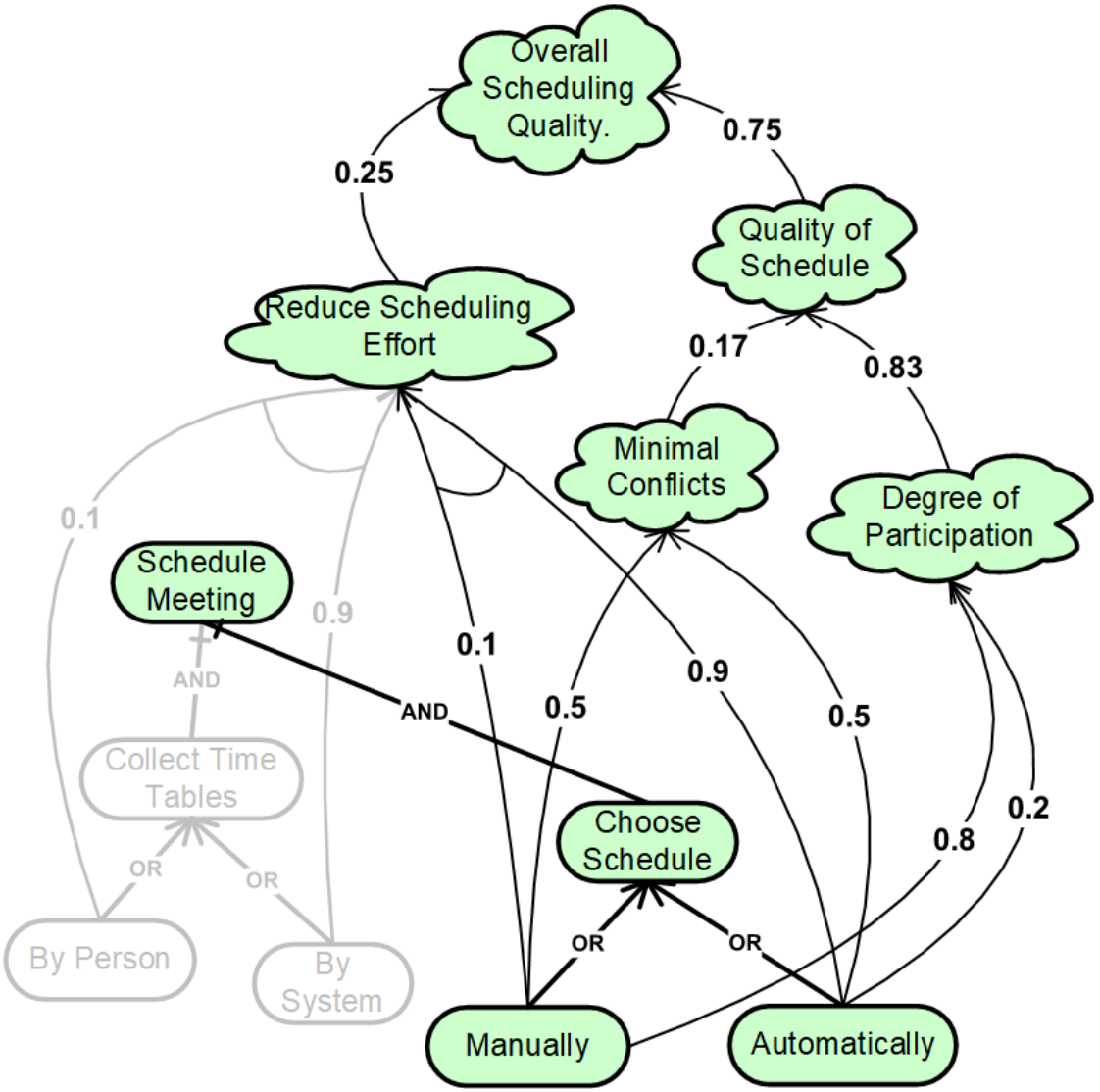
Quantitative Goal Models



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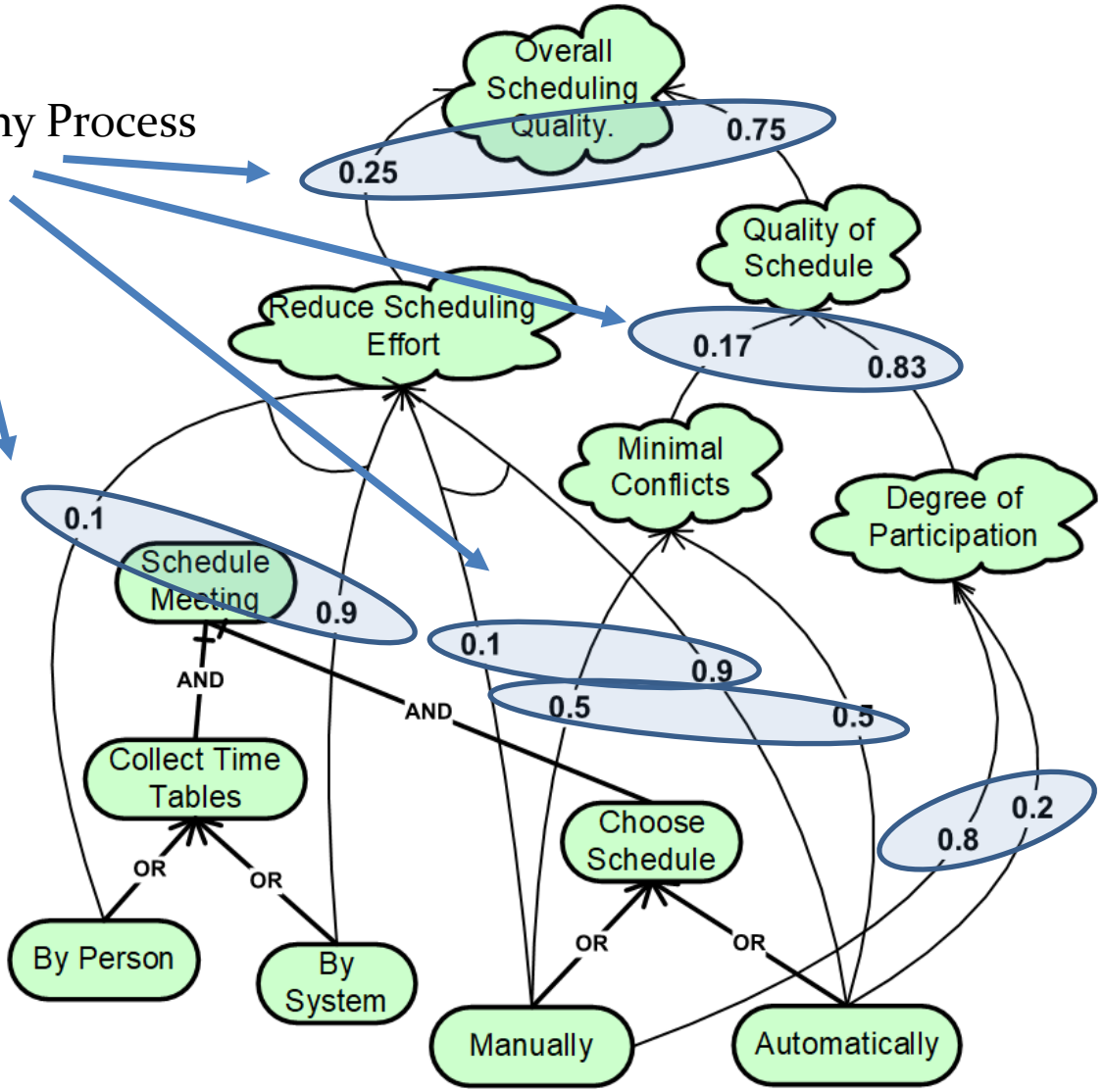
Quantitative Goal Models

Analytic Hierarchy Process
AHP



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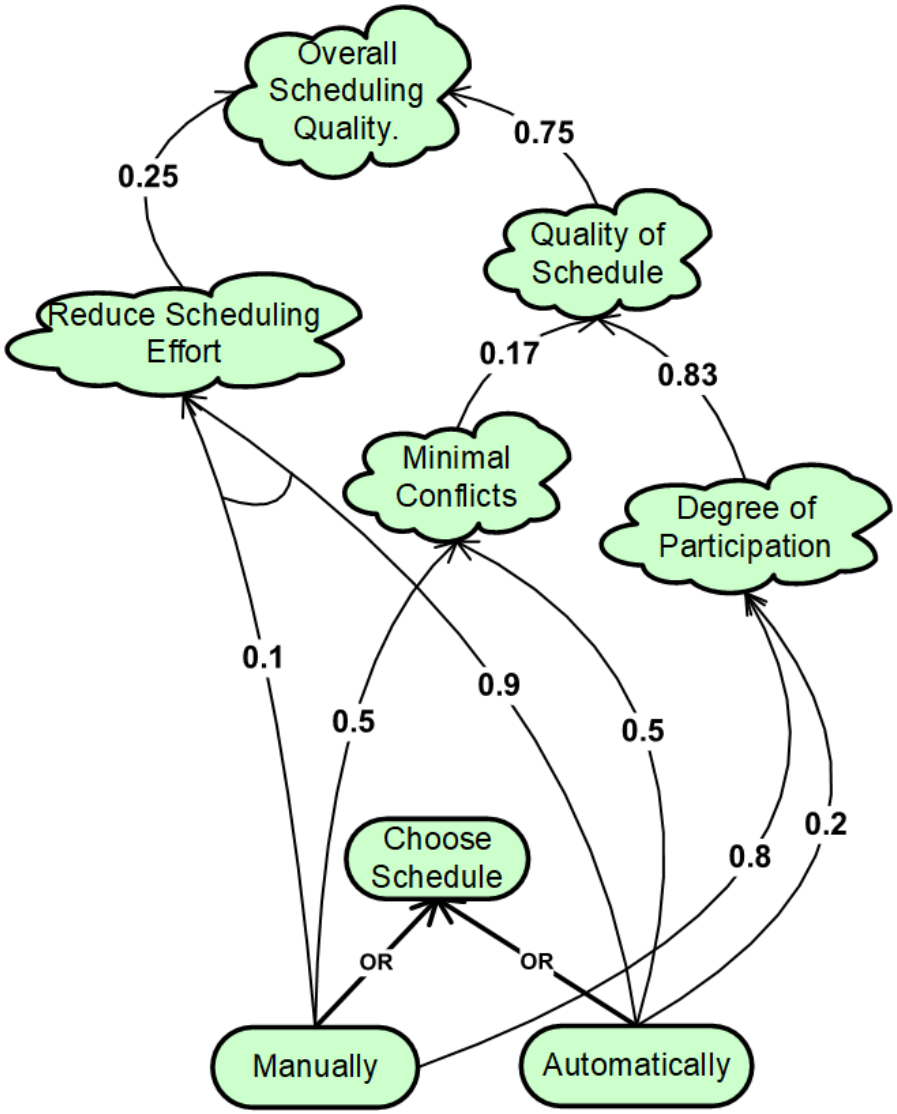

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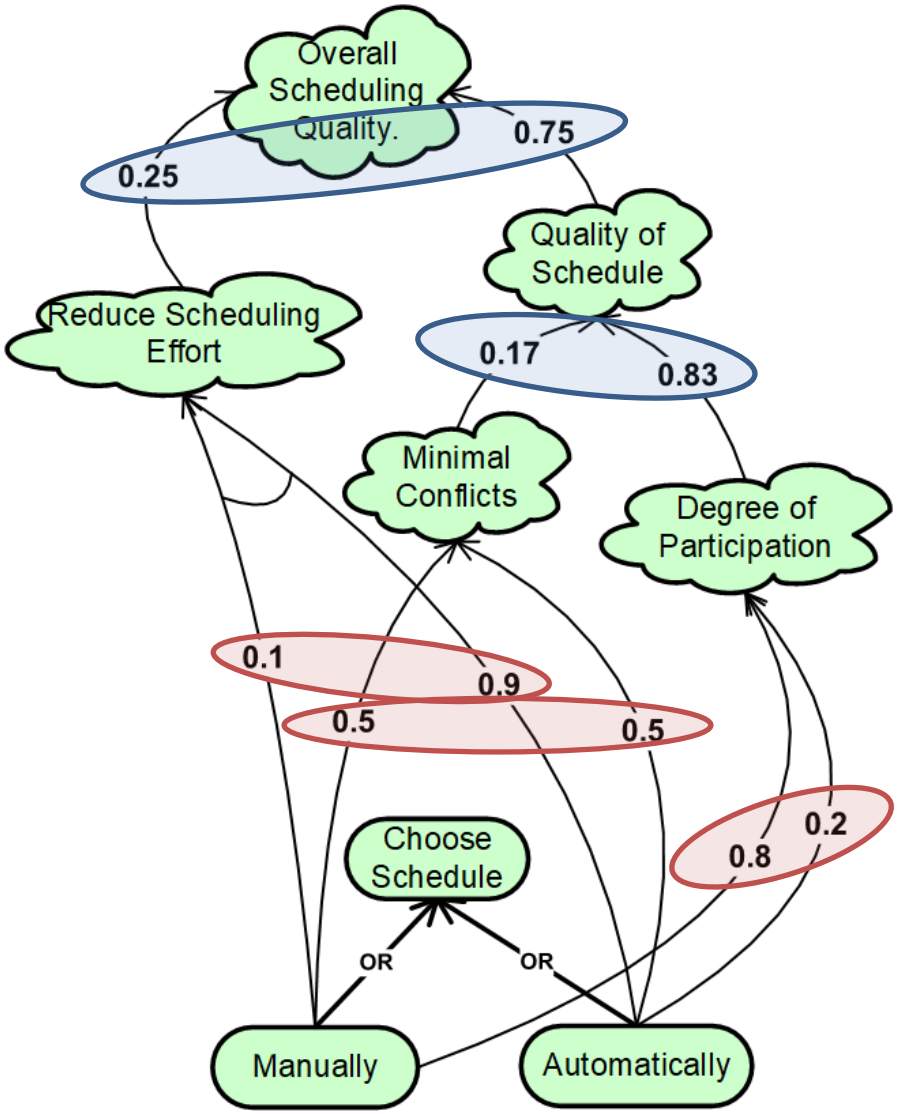

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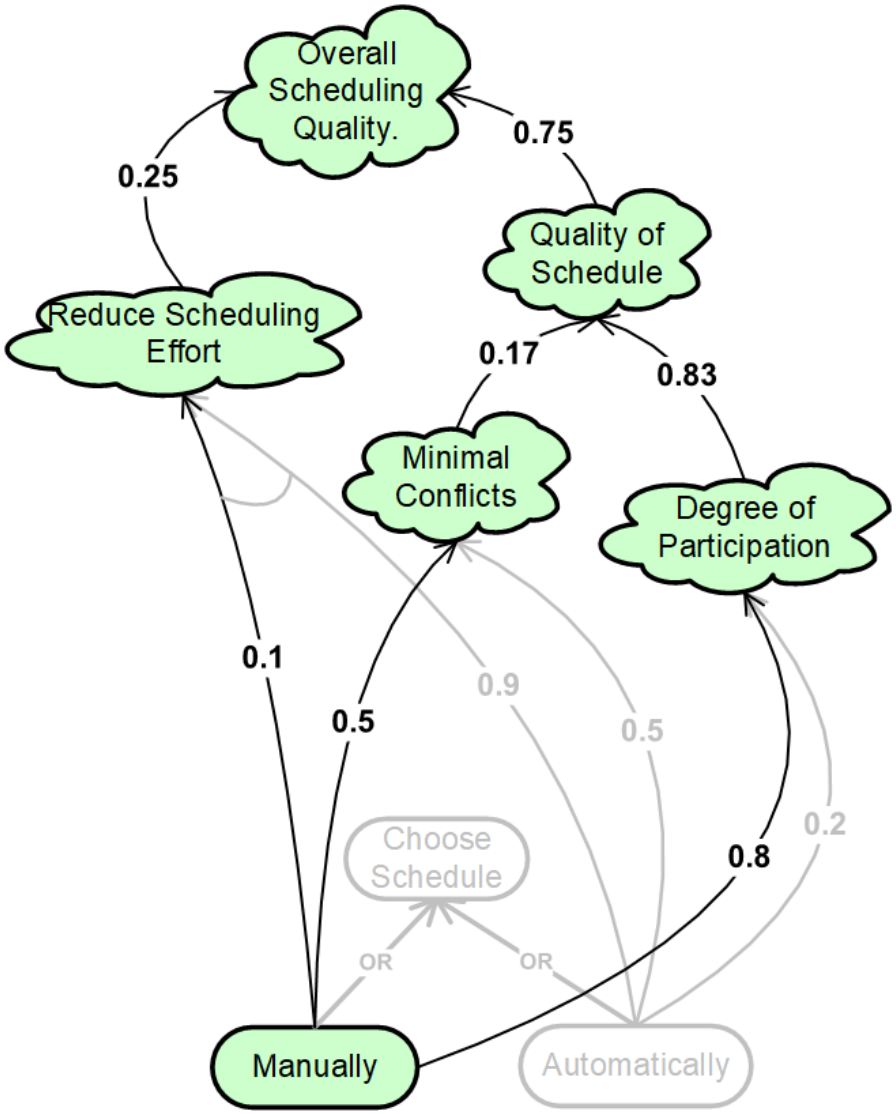
Satisfaction Calculation



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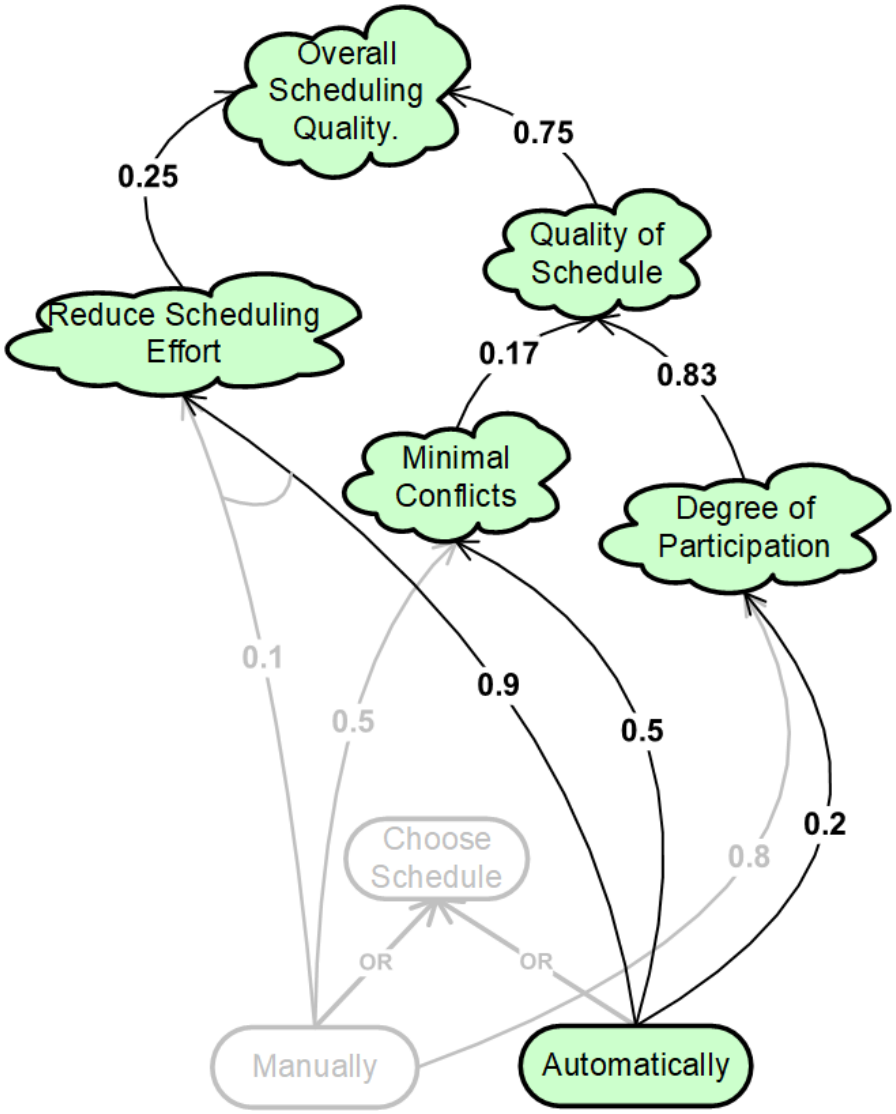

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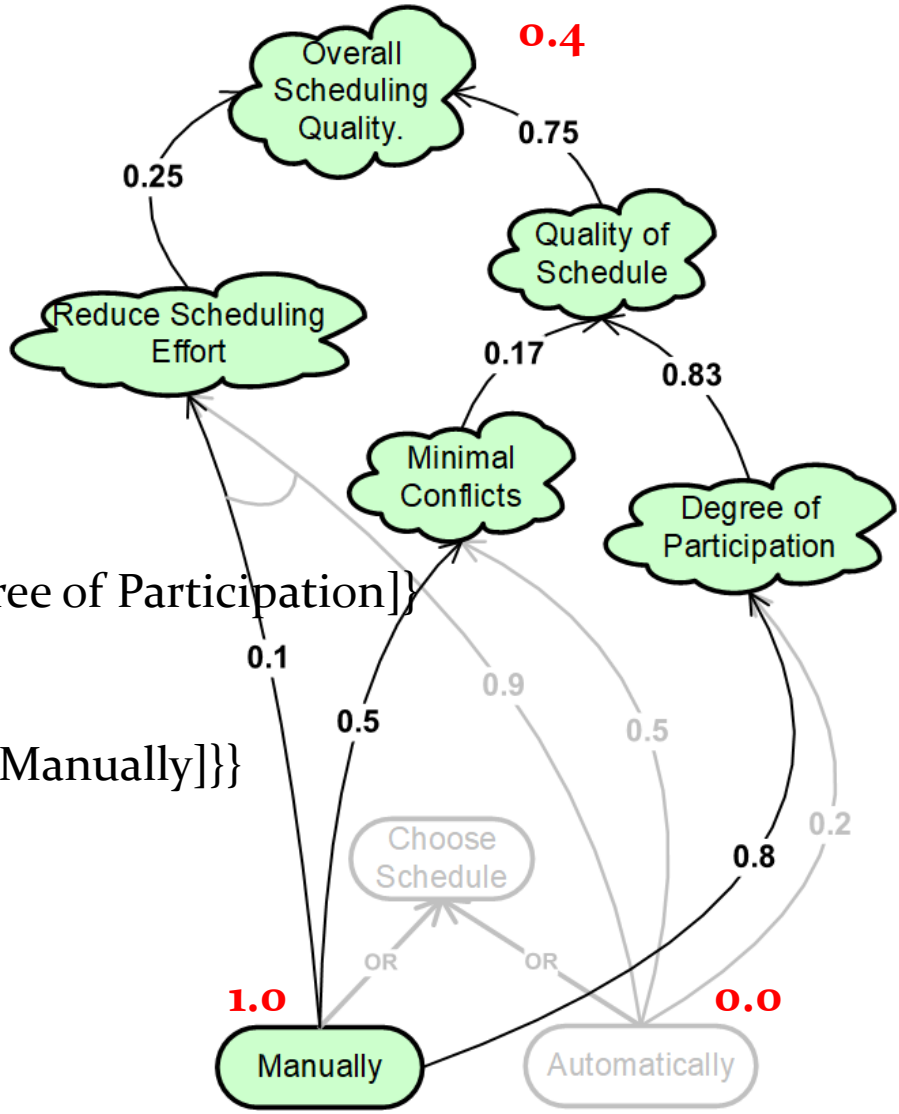
Satisfaction Calculation

[Overall Scheduling Quality]
=
0.25 × [Reduce Scheduling Effort] +
0.75 × [Quality of Schedule]
=
0.25 × {0.1 × [Manually]} +
0.75 × {0.17 × [Minimal Conflicts] + 0.83 x [Degree of Participation]}
=
0.25 × {0.1 × [Manually]} +
0.75 × {0.17 × {0.5 × [Manually]} + 0.83 x {0.8 × [Manually]}}
=
0.25 × {0.1 × 1.0} +
0.75 × {0.17 × {0.5 × 1.0} + 0.83 x {0.8 × 1.0}}
=
0.3995



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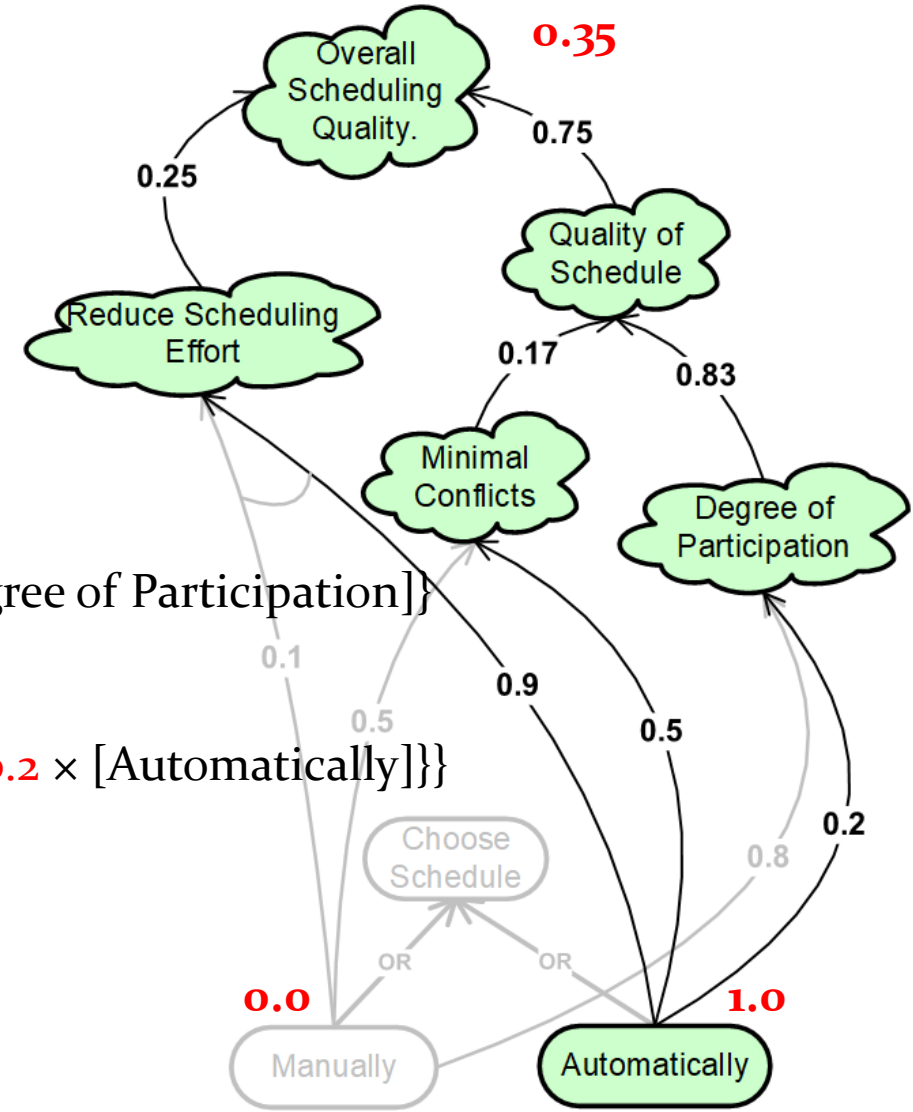
Satisfaction Calculation

[Overall Scheduling Quality]
=
0.25 × [Reduce Scheduling Effort] +
0.75 × [Quality of Schedule]
=
0.25 × {0.9 × [Automatically]} +
0.75 × {0.17 × [Minimal Conflicts] + 0.83 x [Degree of Participation]}
=
0.25 × {0.9 × [Automatically]} +
0.75 × {0.17 × {0.5 × [Automatically]} + 0.83 x {0.2 × [Automatically]}}
=
0.25 × {0.9 × 1.0} +
0.75 × {0.17 × {0.5 × 1.0} + 0.83 x {0.2 × 1.0}}
=
0.3505



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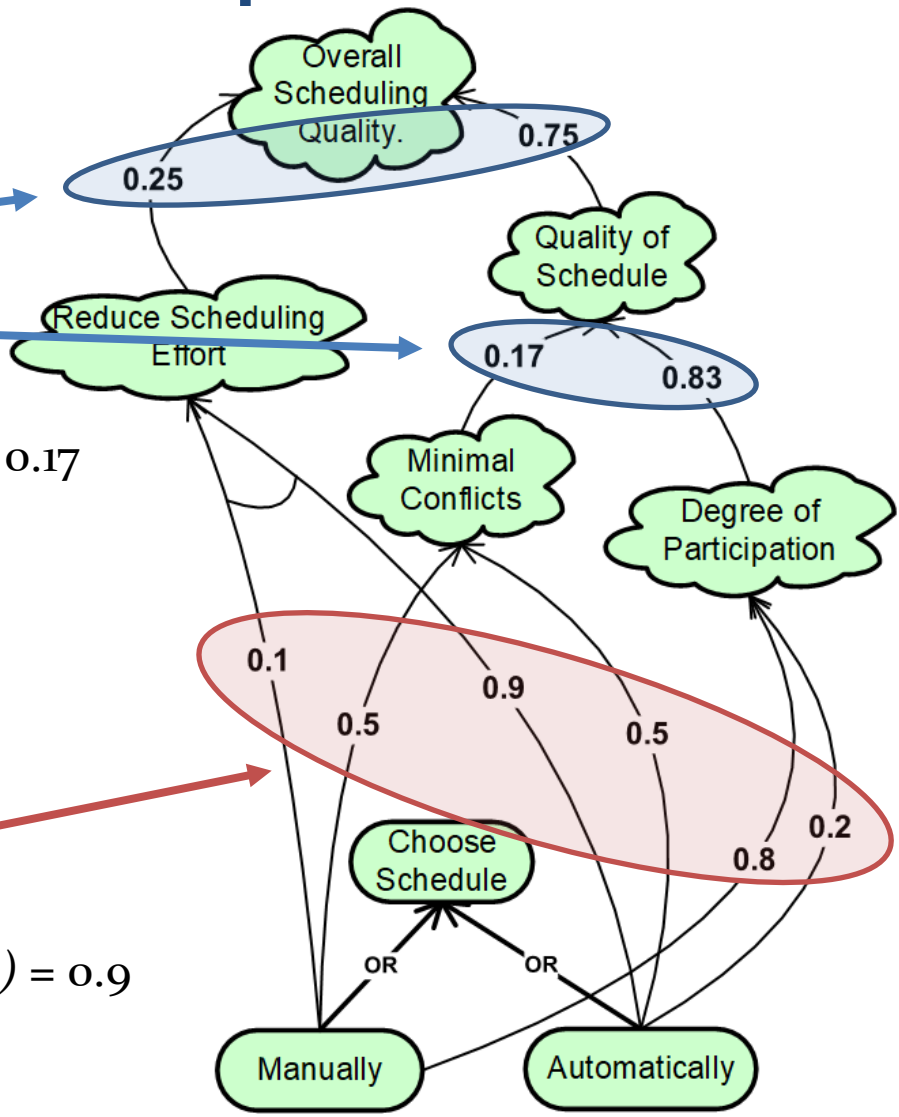
Performance and Importance

Importance

Relative Importance:
ir([Minimal Conflict], [Quality of Schedule]) = 0.17
(Absolute) Importance:
ir([Minimal Conflict]) = 0.17 × 0.75 = 0.1275

Performance:
pr([Manually], [Minimal Conflicts]) = 0.5
pr([Automatically], [Reduce Scheduling Effort]) = 0.9



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Cognitive Fit Theory

- Not all visualizations are suitable for all tasks.
- Symbolic Tasks:
  - Handle (find, extract etc.) individual data values.
- Spatial Tasks:
  - Identify relationships, make associations and interpolate values.
- Cognitive Fit Theory
  - Symbolic tasks → symbolic representations.
  - Spatial tasks → spatial representations.

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Visualizing Decision Problems within Goal Models

- A spatial task:
  - Performances and Importances need to be combined.
  - Despite being a diagrams, goal diagrams are symbolic representations **wrt. weights.**
- Solution:
  - Turn numbers into visual variables.
- Two options
  - Charts: a combination of bar-charts and pie-charts.
  - Treemaps.

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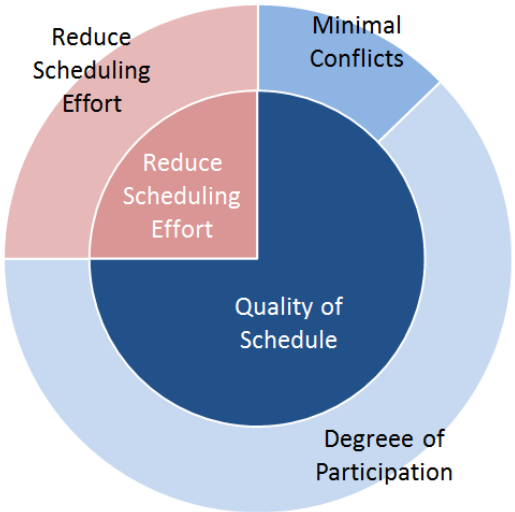
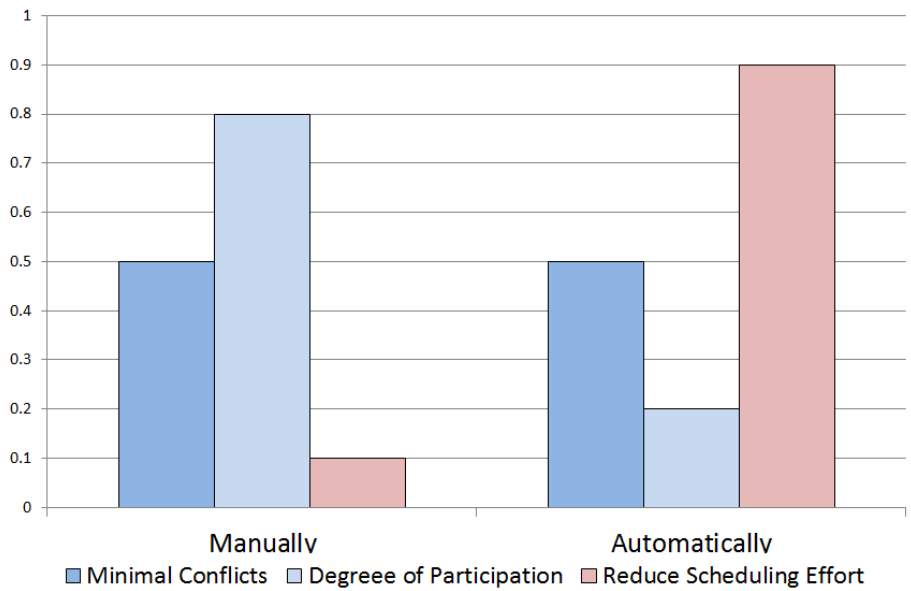
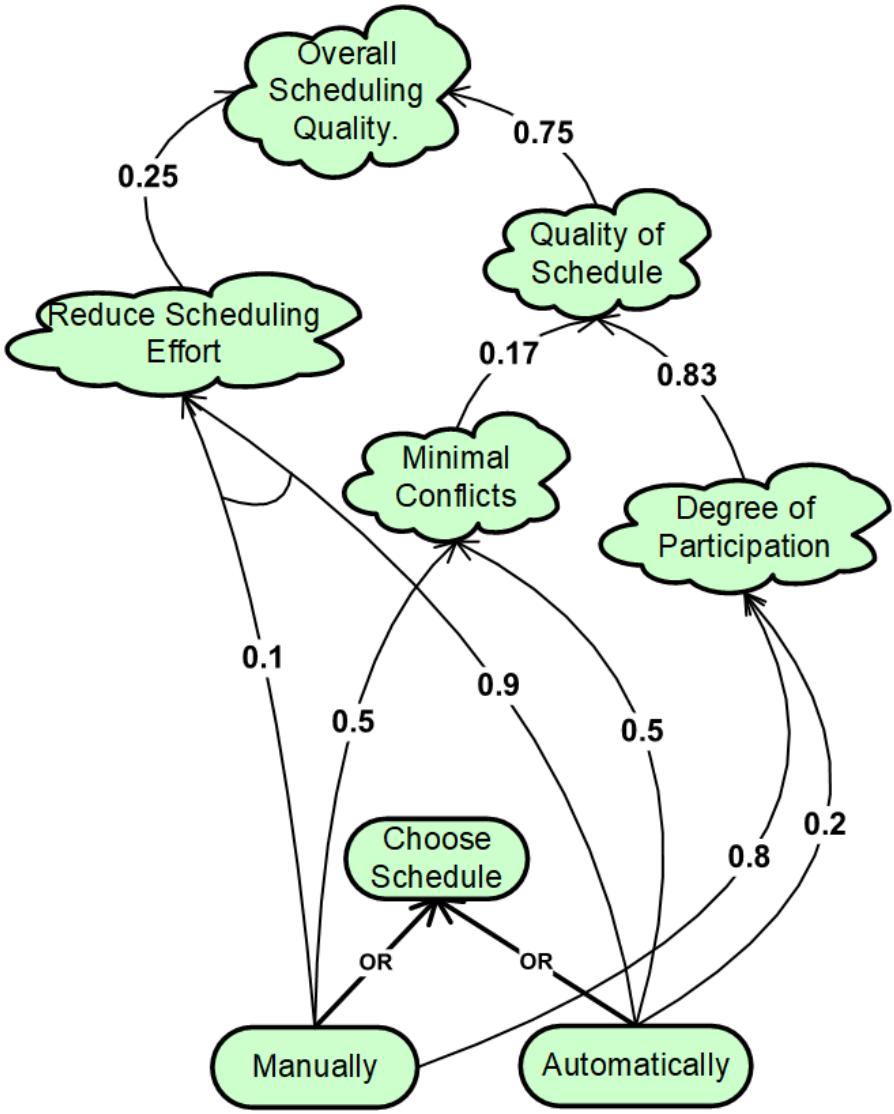
Charts







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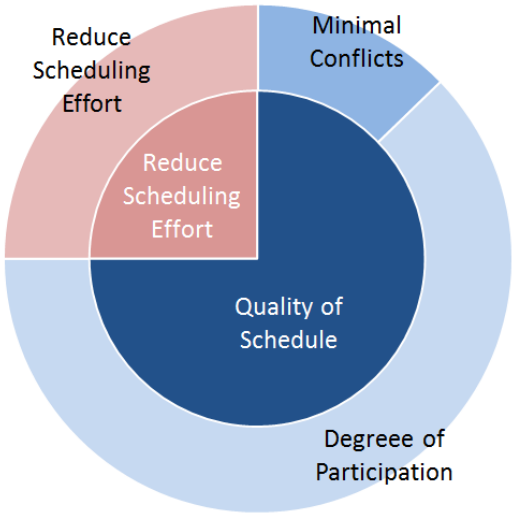
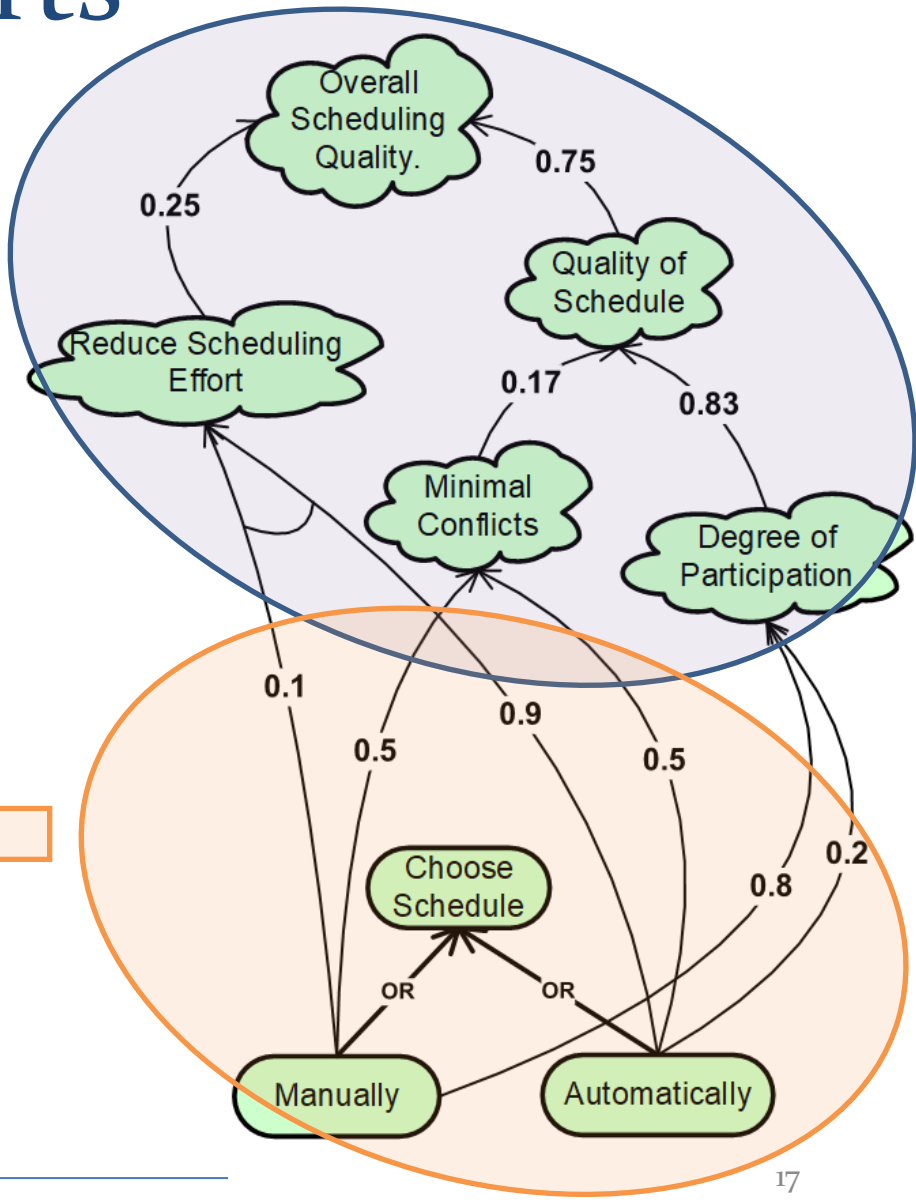
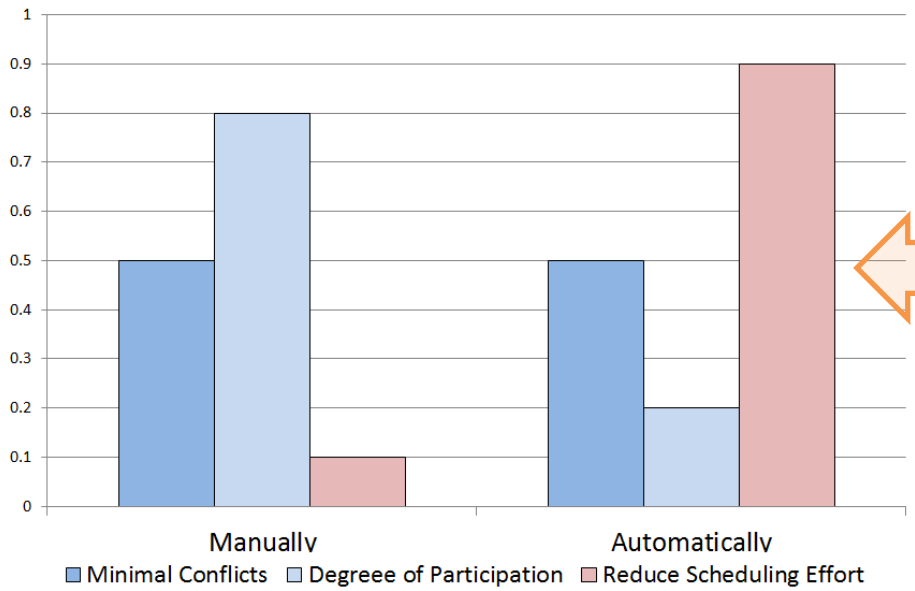
Charts







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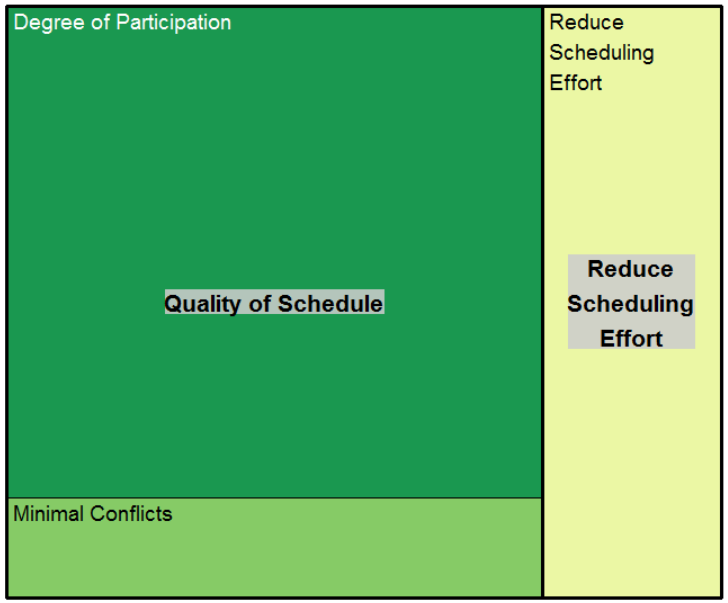
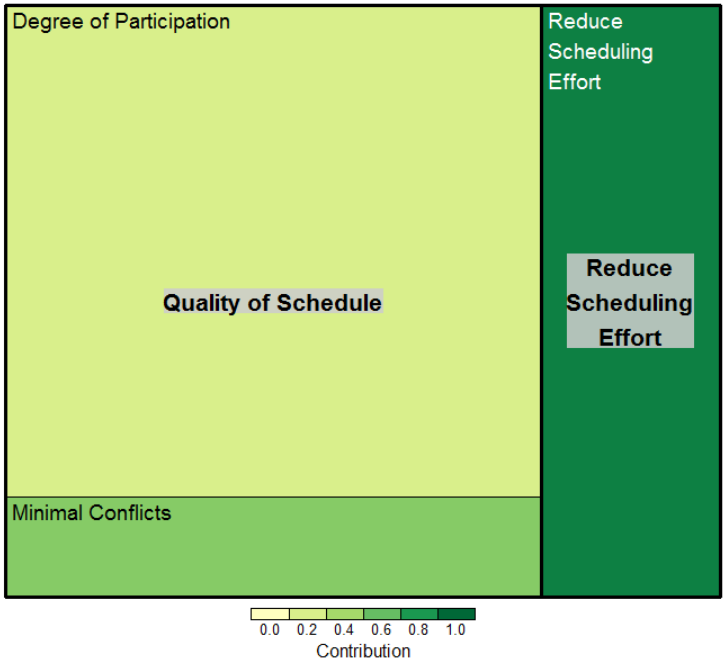
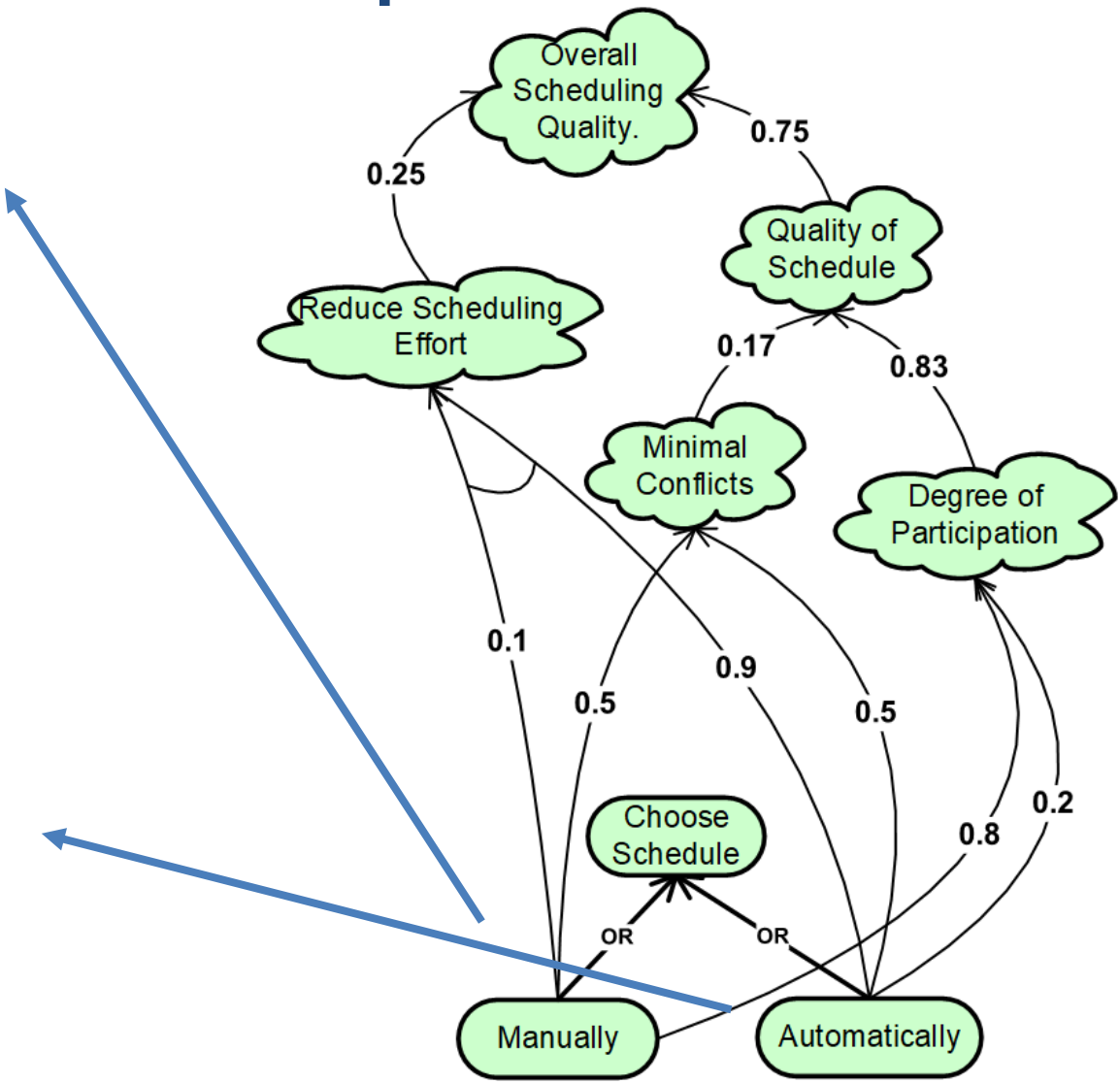
Treemaps

Manually



Automatically





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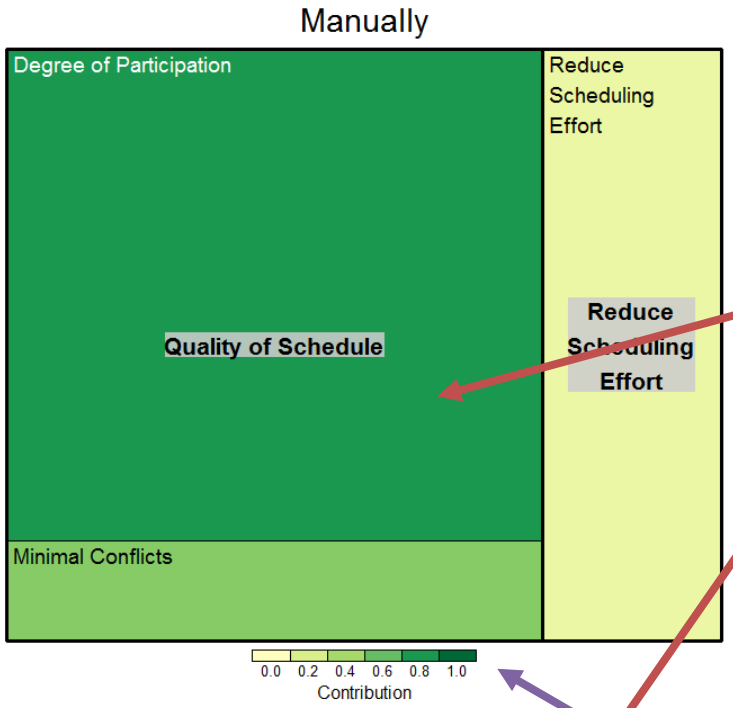
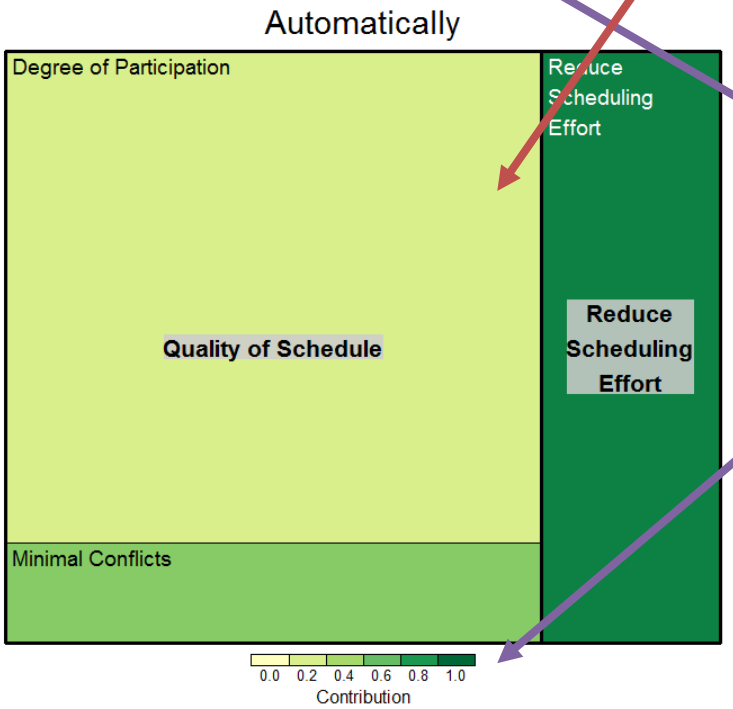
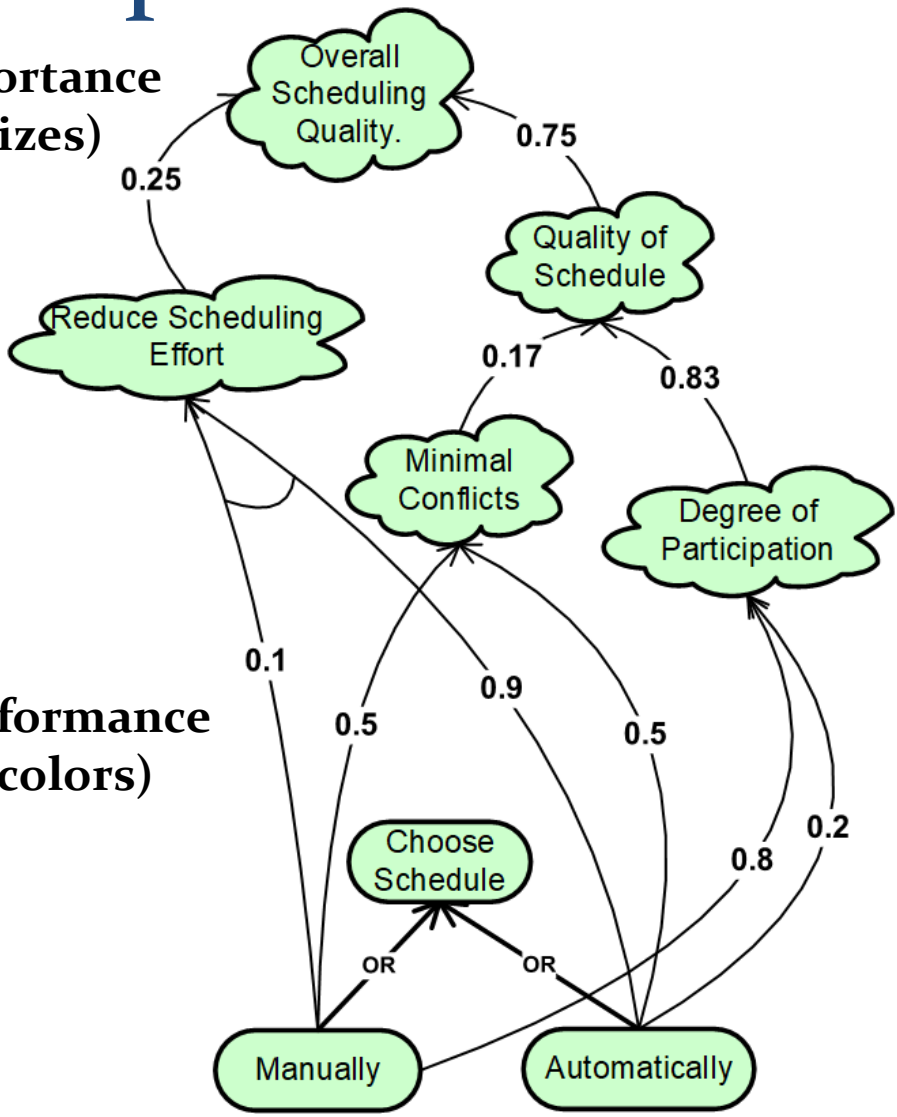
Treemaps





Importance (sizes)

Performance (colors)



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Experiment - Goals

- Goals:
  - Accuracy
    - Do participants find the optimal alternative?
  - Efficiency
    - Do participants find the alternative *quickly*?
  - Confidence
    - Do participants declare confident of their decision?

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Experiment - Design

- Constructed 3 × 3 × 3 = 27 separate models
  - Of 3 different sizes (simple, medium, complex)…
    - … each from 3 different domains (apartment, course, transportation choices)
      - … each with 3 different number sets.
        - » Number sets are randomly sampled from consistent AHP inputs.
        - » There is a globally optimal alternative
        - » max 0.1 (small, medium) or 0.2 (large) distance between first and second alternative.
- Visualized the models in three ways
  - Diagrams, Charts and Treemaps

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Experiment - Design

- Factors:
  - Between Subjects: Visualization Choice (Diagram vs. Chart vs. Treemaps)
  - Within Subjects: Model Size (Simple vs. Medium vs. Complex)
- Measures:
  - Total Correct Answers (Accuracy)
  - Response Time (Efficiency)
  - Response Confidence Self-Report (Confidence)
- Instrument
  - Show the models and:
    - Ask ranking of alternatives / from best to worse.
    - Measure response time.
    - Ask confidence to response.

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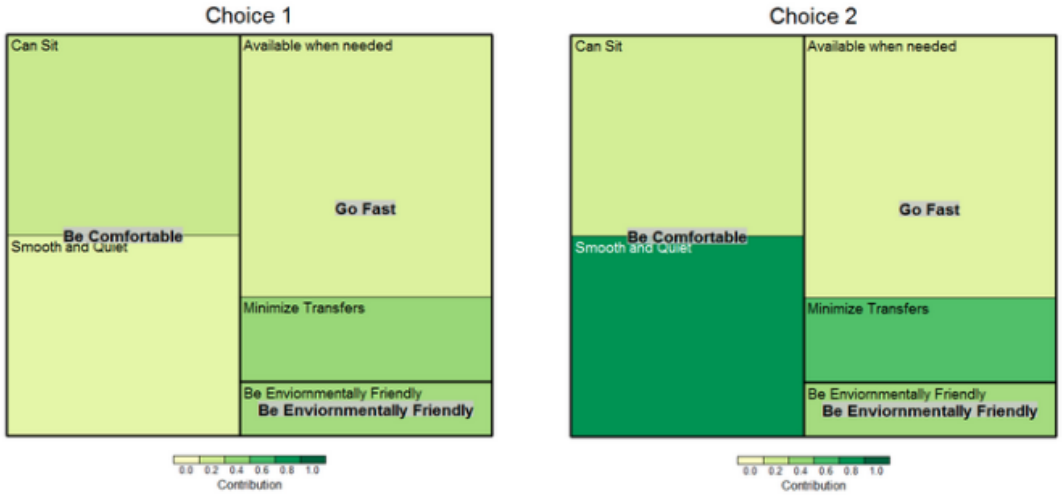
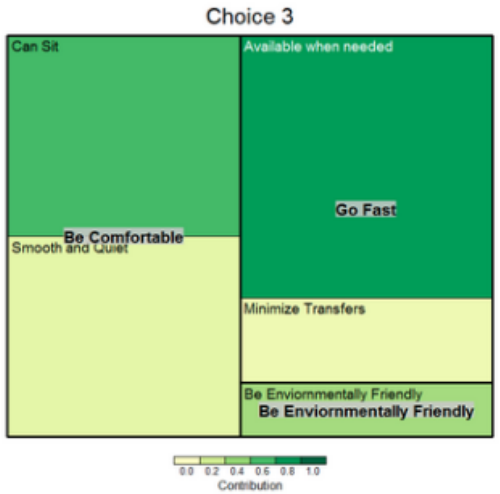




49. According to the above visualization, rank the choices or transportation means from the most optimal to the least optimal? *

Drag items from the left-hand list into the right-hand list to order them.

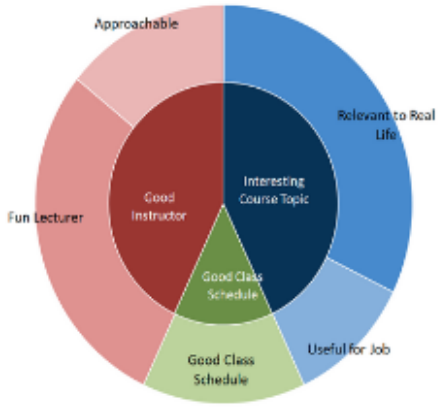
Choice 1
Choice 2
Choice 3

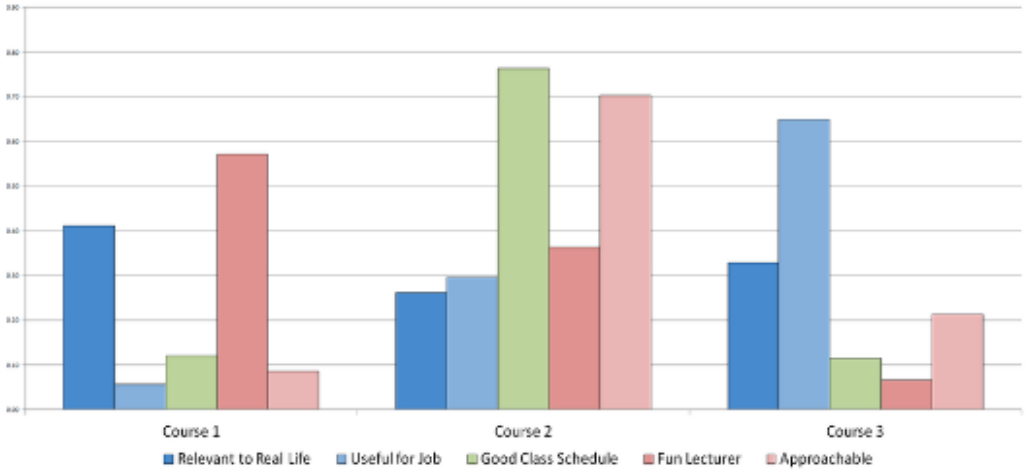
50. How confident are you of your answer above? *

Very Confident	Confident	Unconfident	Very Unconfident
○	○	○	○

Back Next

3%





43. According to the above visualization, rank the course choices from the most optimal to the least optimal? *

Drag items from the left-hand list into the right-hand list to order them.

Course 1
Course 2
Course 3

44. How confident are you of your answer above? *

Very Confident	Confident	Unconfident	Very Unconfident
○	○	○	○

Back Next

3%

Experiment - Design

- Participants:
  - 116 Students (80 males, 36 females, 21-29 year's old) attending an HCI class.
- Approach:
  - Mixed-factorial ANOVA
  - F, Kruskal-Wallis, Welch's W
  - Simple effects for interactions.

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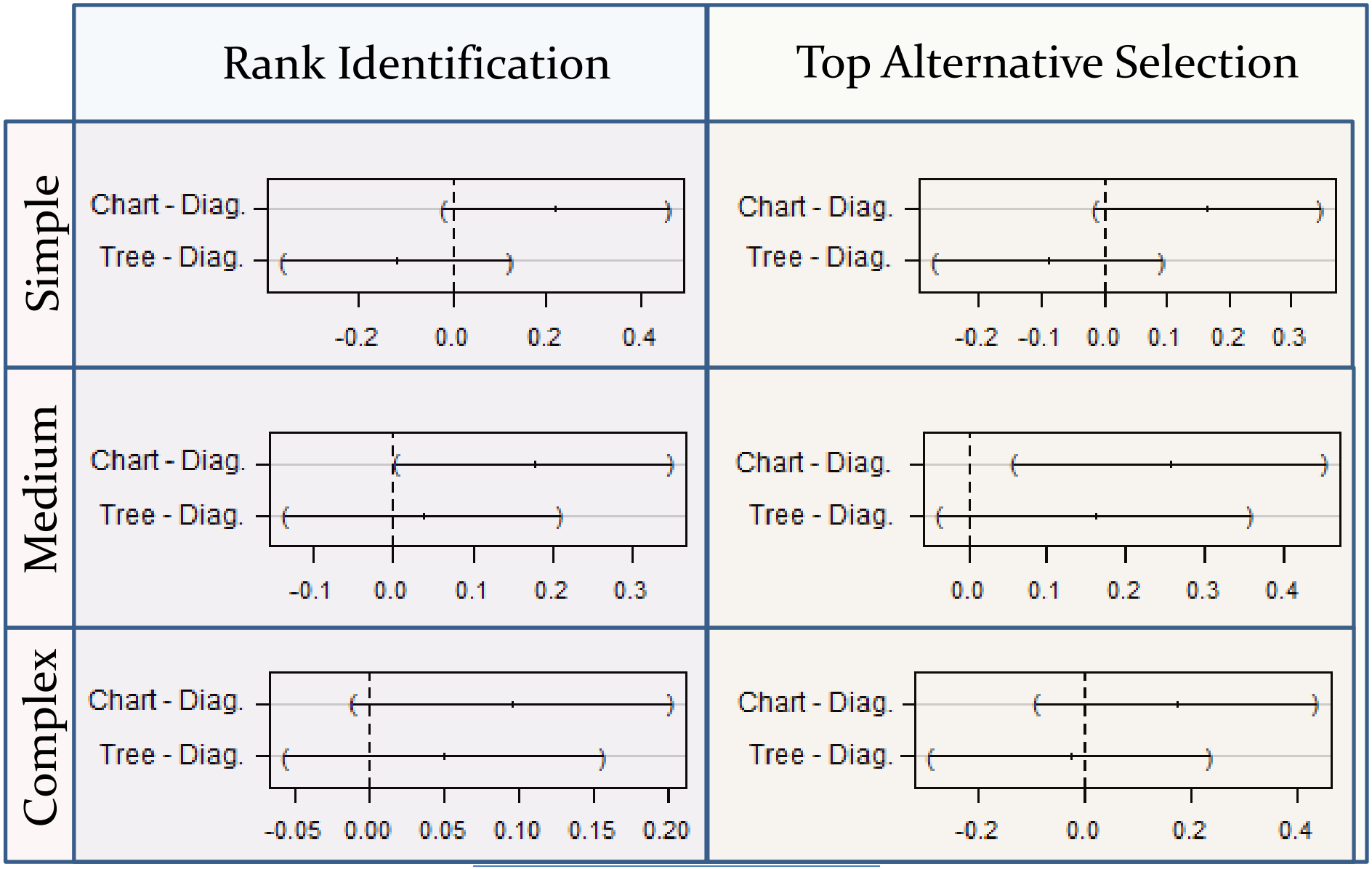
Results - Accuracy



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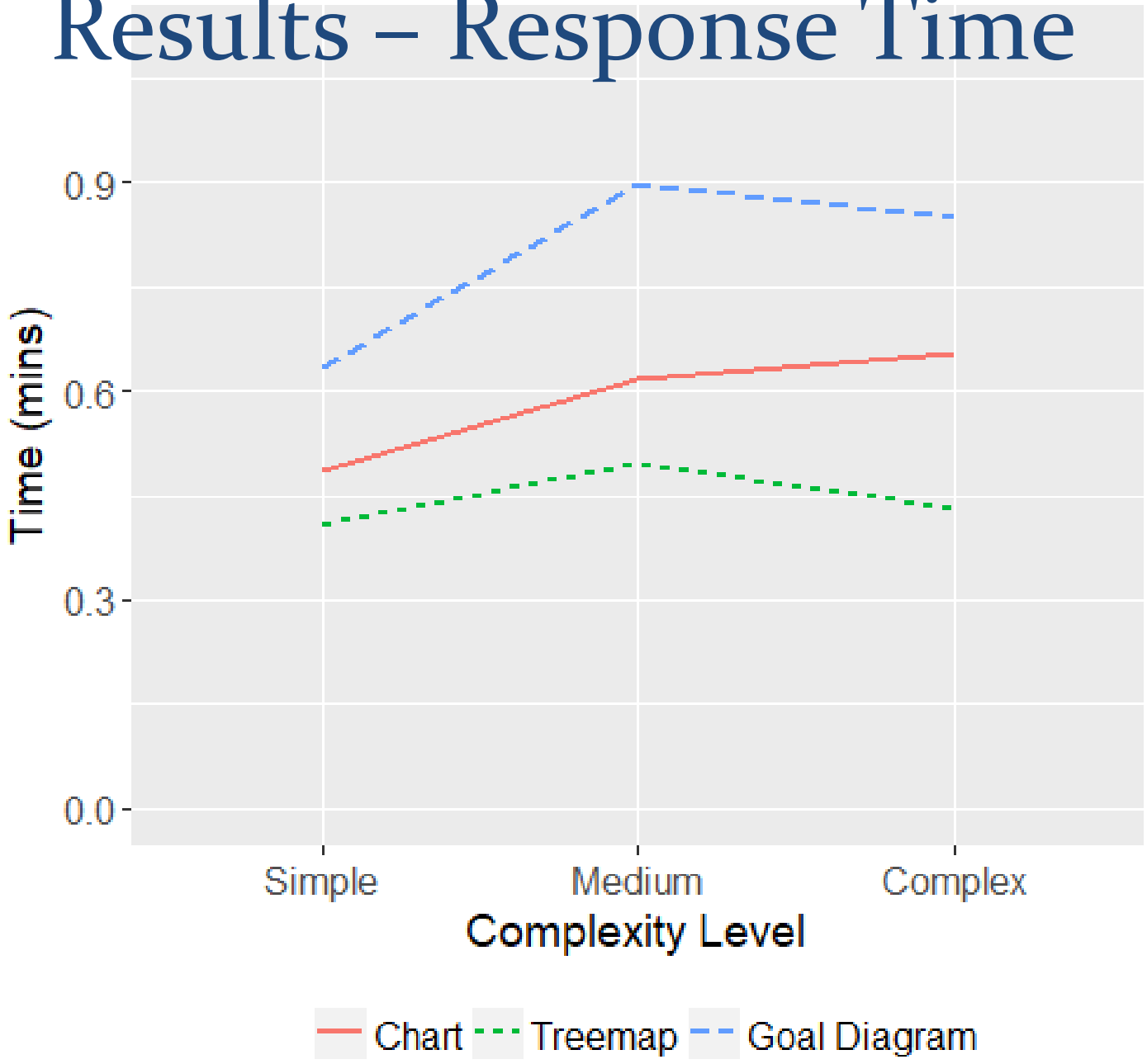
Results – Response Time



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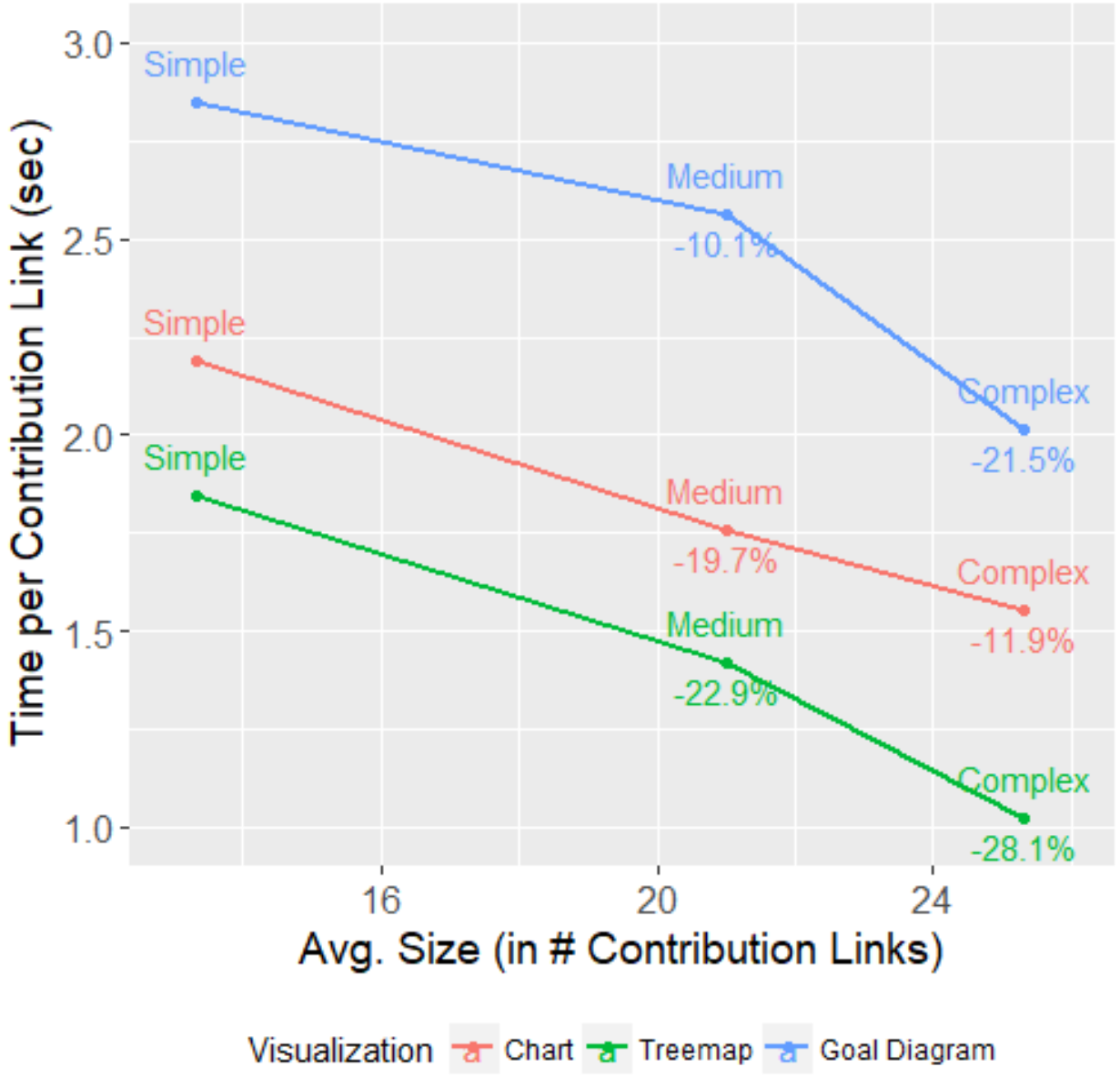
Results – Response Time



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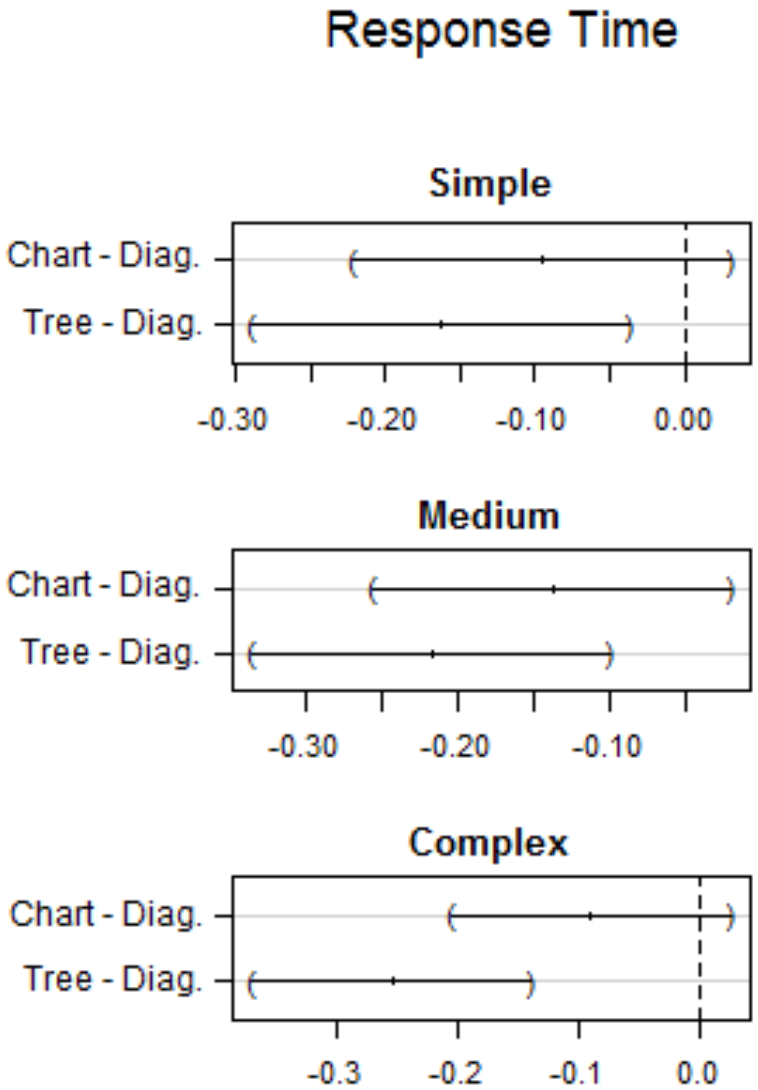
Results – Response Time



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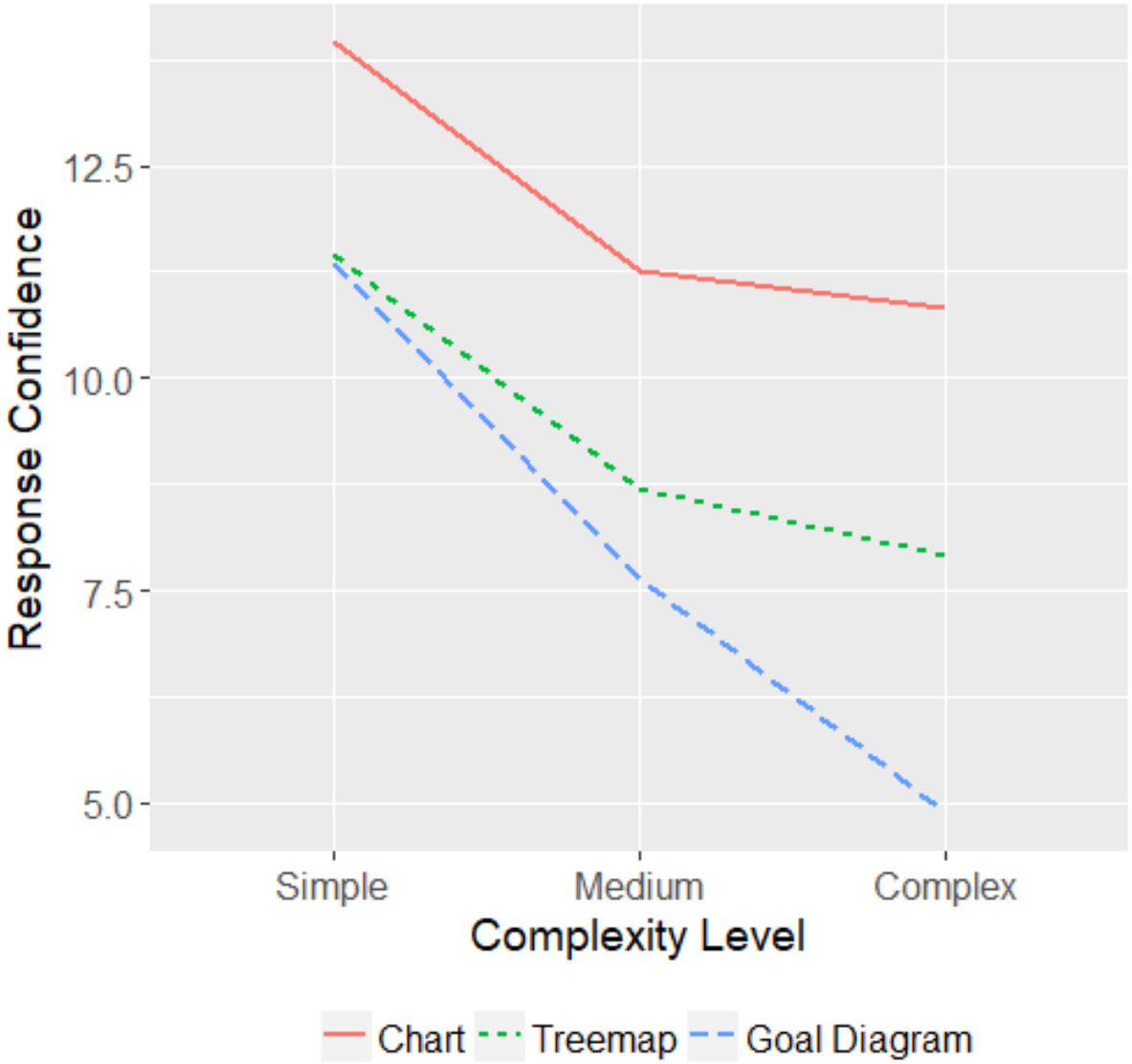
Results - Confidence



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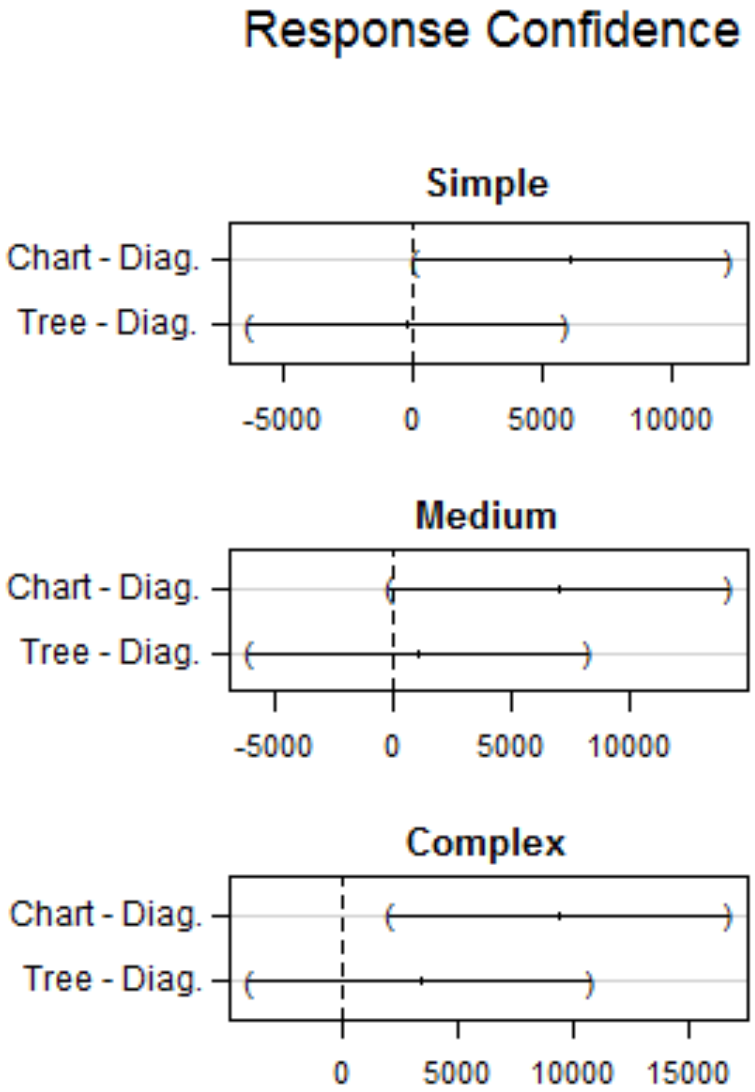
Results – Confidence



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Experiment Overall

- Nowhere are diagrams really better
- Charts lead to significantly more accurate response.
  - And are faster than diagrams.
- Treemaps are fast but not necessarily more accurate.
- Participants less confident with diagrams.

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Validity Threats

- Statistical Conclusion
  - Normality / Heteroskedacity
- Internal/Construct
  - Training Videos
  - Measures
- External
  - Subjects
  - Models

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Summary

- Conceptual Model ≠Visualization
- Visualization needs to fit the task at hand.
- Replacing numbers with visual variables:
  - Increases accuracy
  - Is faster
  - Allows model users to be more confident.

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Thank you!

(questions?)

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