Visualizing Uncertainty and Alternatives in Event Sequence Predictions

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[1] Adobe

[2] East China Normal University

[3] Tongji University

Predictive Analytics on Event Sequence Data

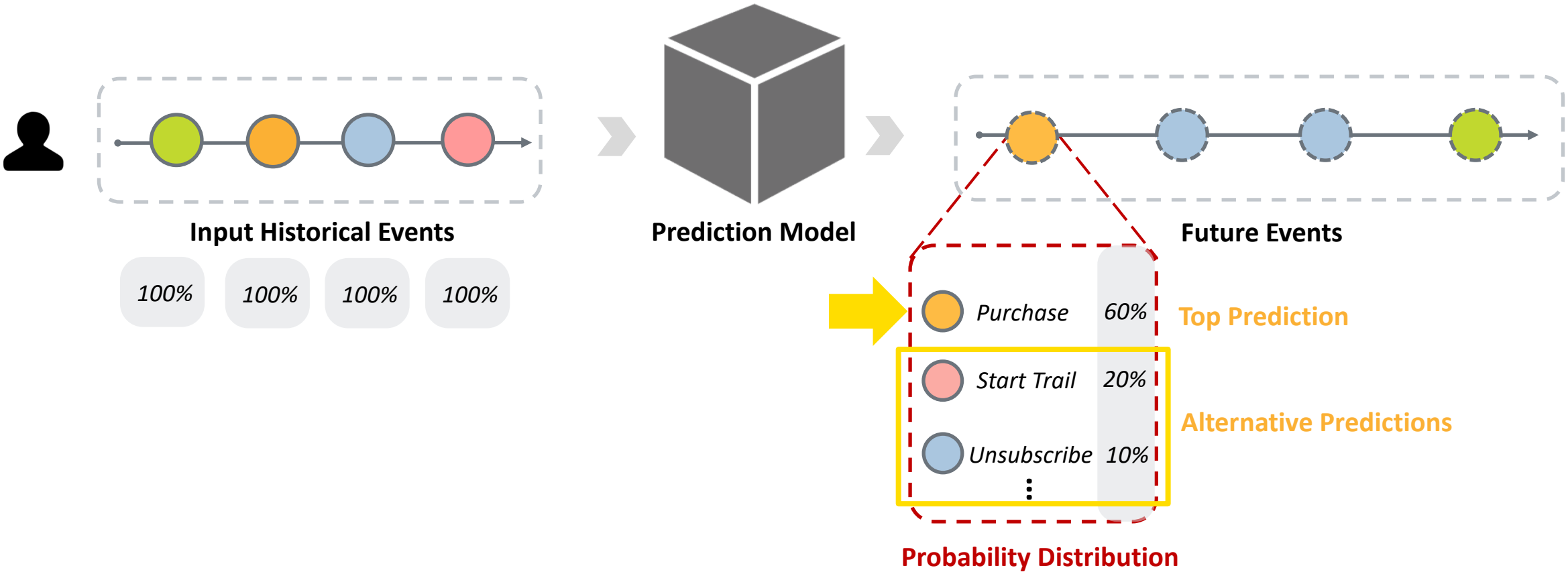
Adobe

Predictive Analytics on Event Sequence Data

Clinical Decision Support

Marketing Strategy Planning

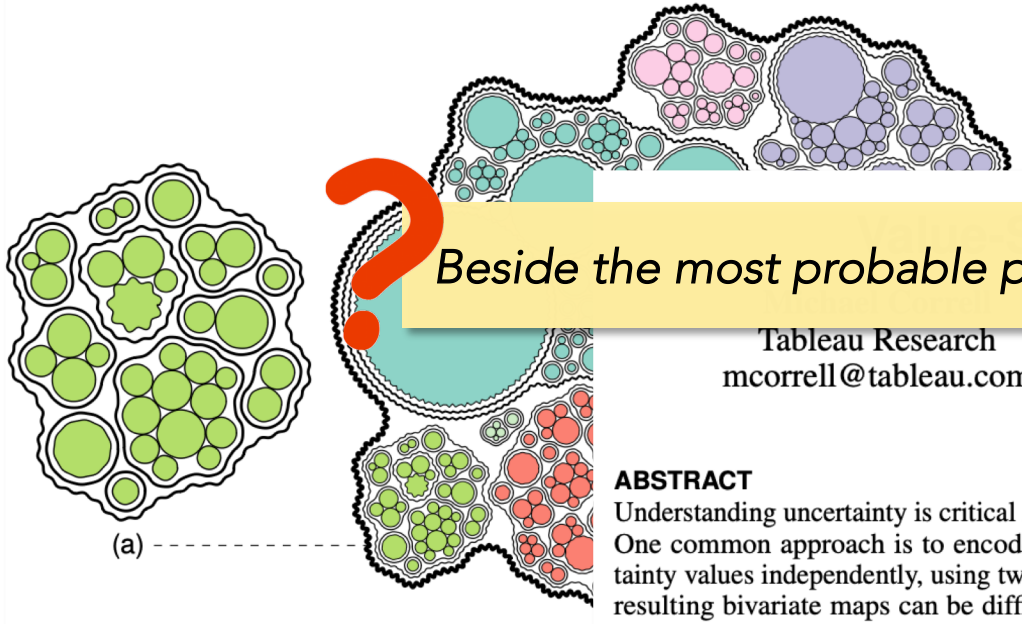
Predictive Analytics on Event Sequence Data

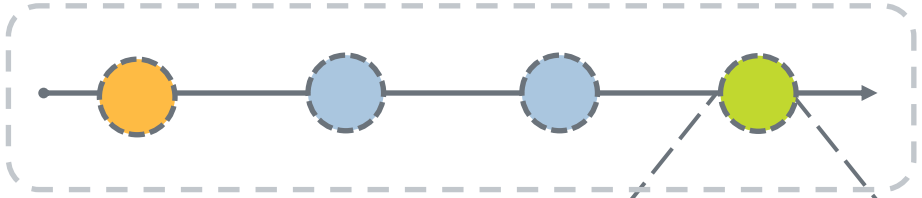


Visualization of Uncertainties

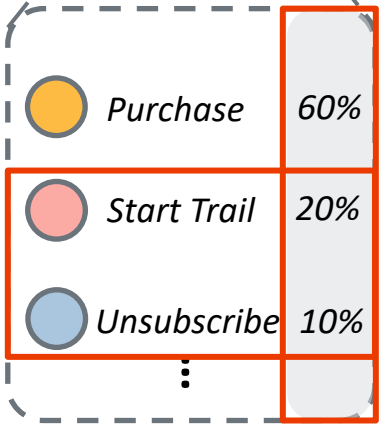
Bubble Treemaps for Uncertainty Visualization

Jochen Görtler, Christoph Schulz, Daniel Weiskopf, *Member, IEEE Computer Society*, and Oliver Deussen





Future Events



Predictions

Beside the most probable prediction, what else may happen and how likely?

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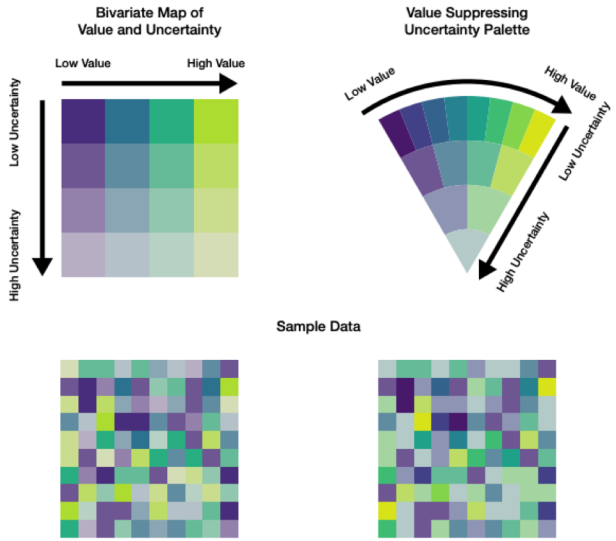
ABSTRACT

Understanding uncertainty is critical for many analytical tasks. One common approach is to encode data values and uncertainty values independently, using two visual variables. These resulting bivariate maps can be difficult to interpret, and interference between visual channels can reduce the discriminability of marks. To address this issue, we contribute Value-Suppressing Uncertainty Palettes (VSUPs). VSUPs allocate larger ranges of a visual channel to data when uncertainty is low, and smaller ranges when uncertainty is high. This non-uniform budgeting of the visual channels makes more economical use of the limited visual encoding space when uncertainty is low, and encourages more cautious decision-making when uncertainty is high. We demonstrate several examples of VSUPs, and present a crowdsourced evaluation showing that, compared to traditional bivariate maps, VSUPs encourage people to more heavily weight uncertainty information in decision-making tasks.



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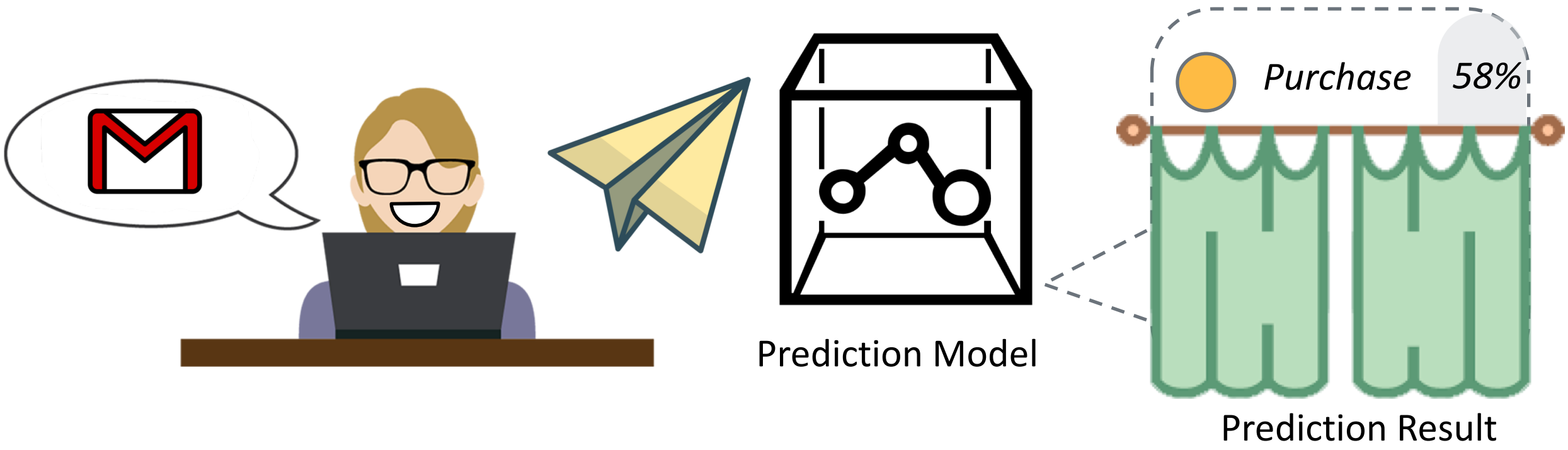
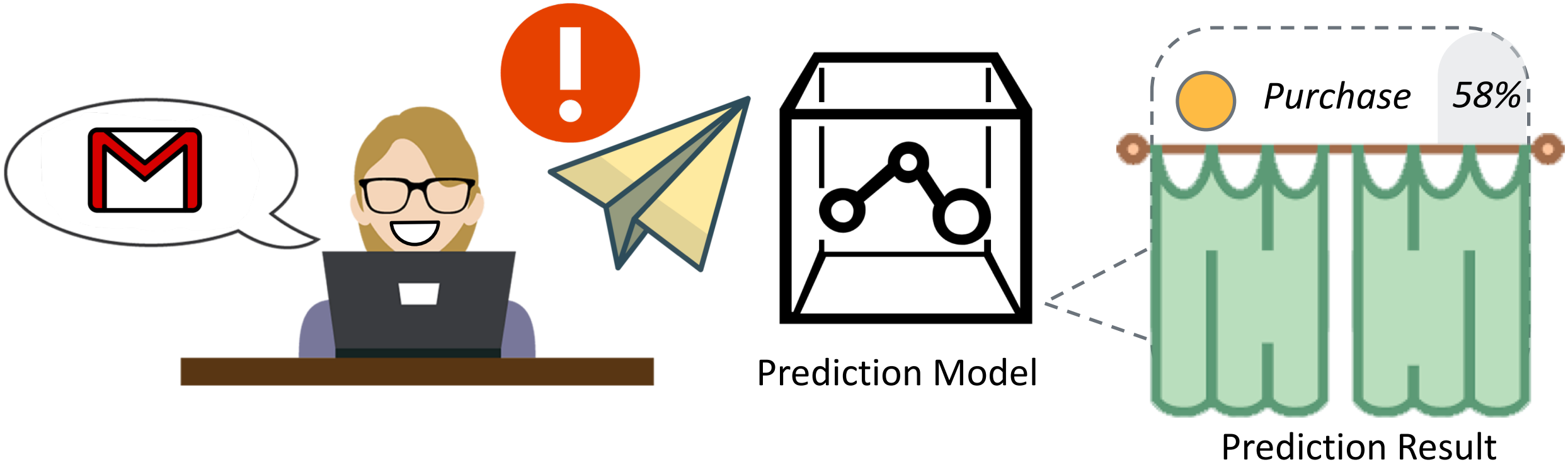
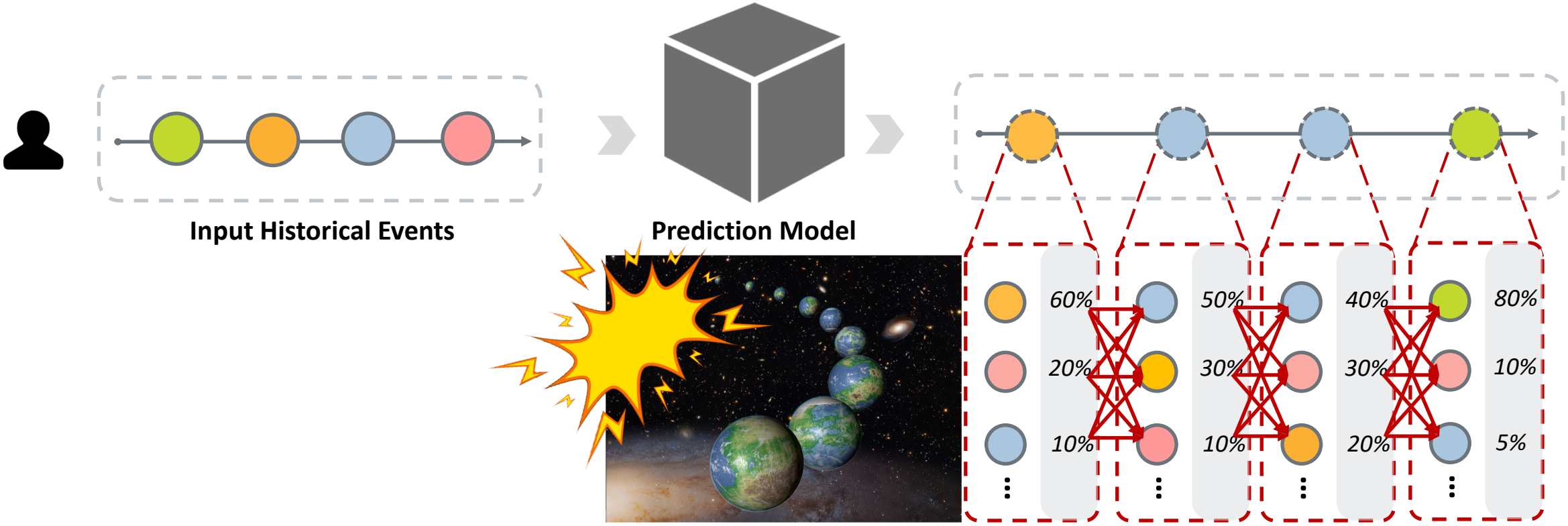
Effect of Alternative Predictions in Decision Making



Effect of Alternative Predictions in Decision Making



Visualizing Event Sequence Predictions is Challenging



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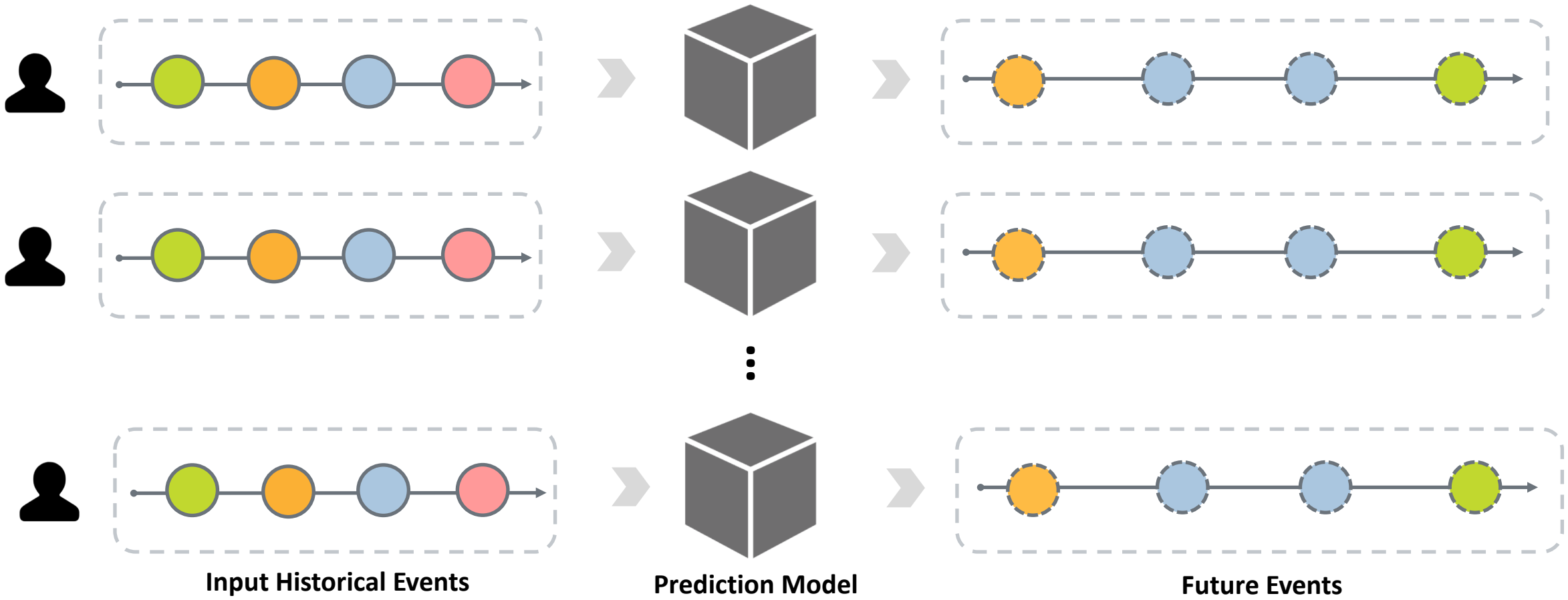

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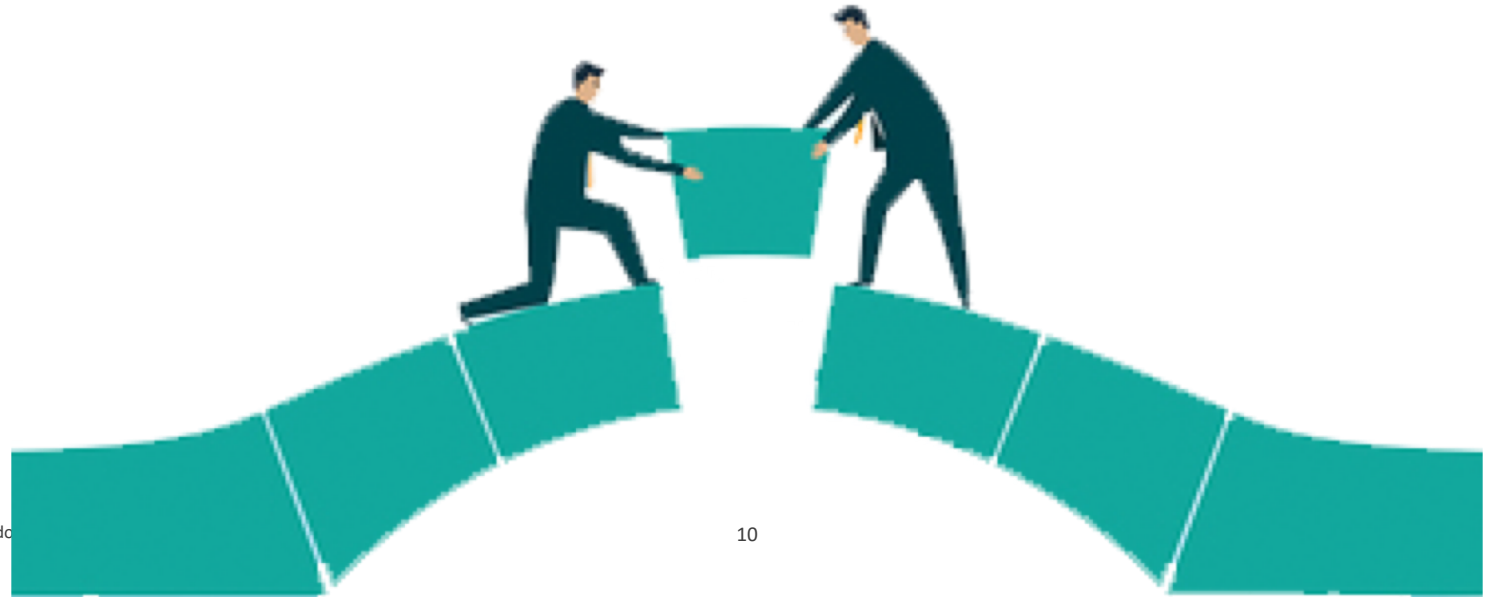
Research Problems

How to effectively visualize event sequence predictions with alternative predictions?

How does showing alternative predictions would affect people's decision making?



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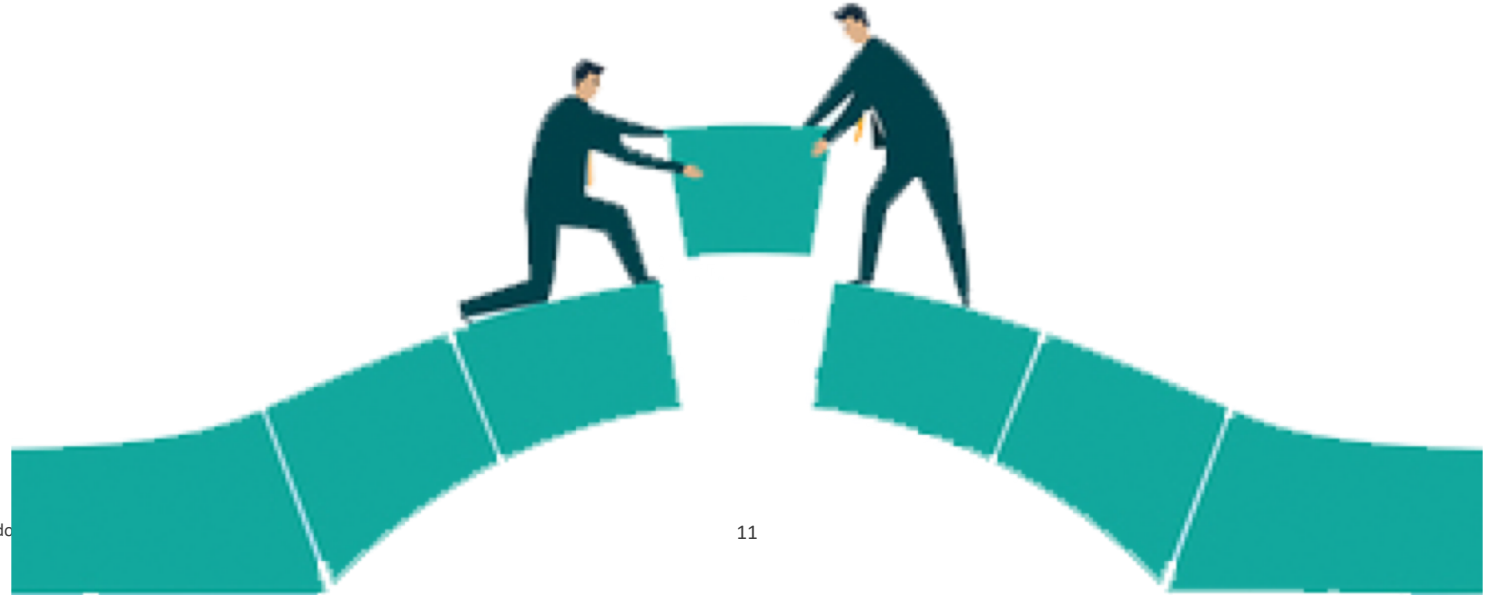

Interview Study

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Design Needs

Predict both outcomes and activities

N1. Predict at the activity level

N2. Combine outcomes and activities

Visually explore event sequences

N3. Explore history and future simultaneously

N4. Show multiple event sequences at a time

N5. Inspect individual records in detail

N6. Reveal the uncertainty and alternatives

Make personalized action plans

N7. Make intervention plans on different audience

N8. Predict the impact of interventions

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Design Needs

Visually explore event sequences

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*”Visually reviewing **what they (customers) have done before** and **what they may do next** can help identify what type of content to send..”*

*“**For early customers**, we often send them awareness emails to introduce our products and **for advanced users**, we send them renewal promotions.”*

Key Designs for Visualizing Future Paths

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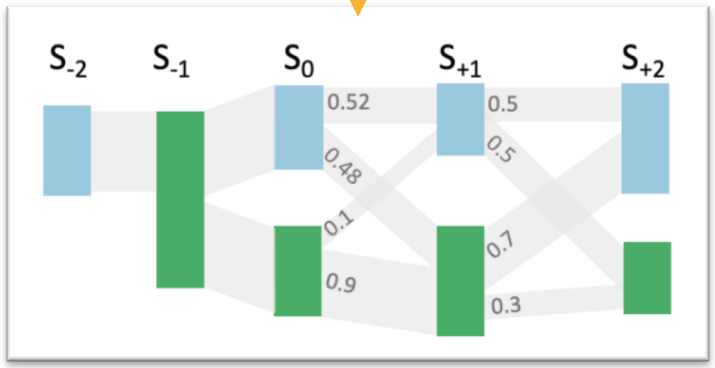
All Possibilities Aggregated

1



2

Top Prediction Preserved

Top + Alternative

3

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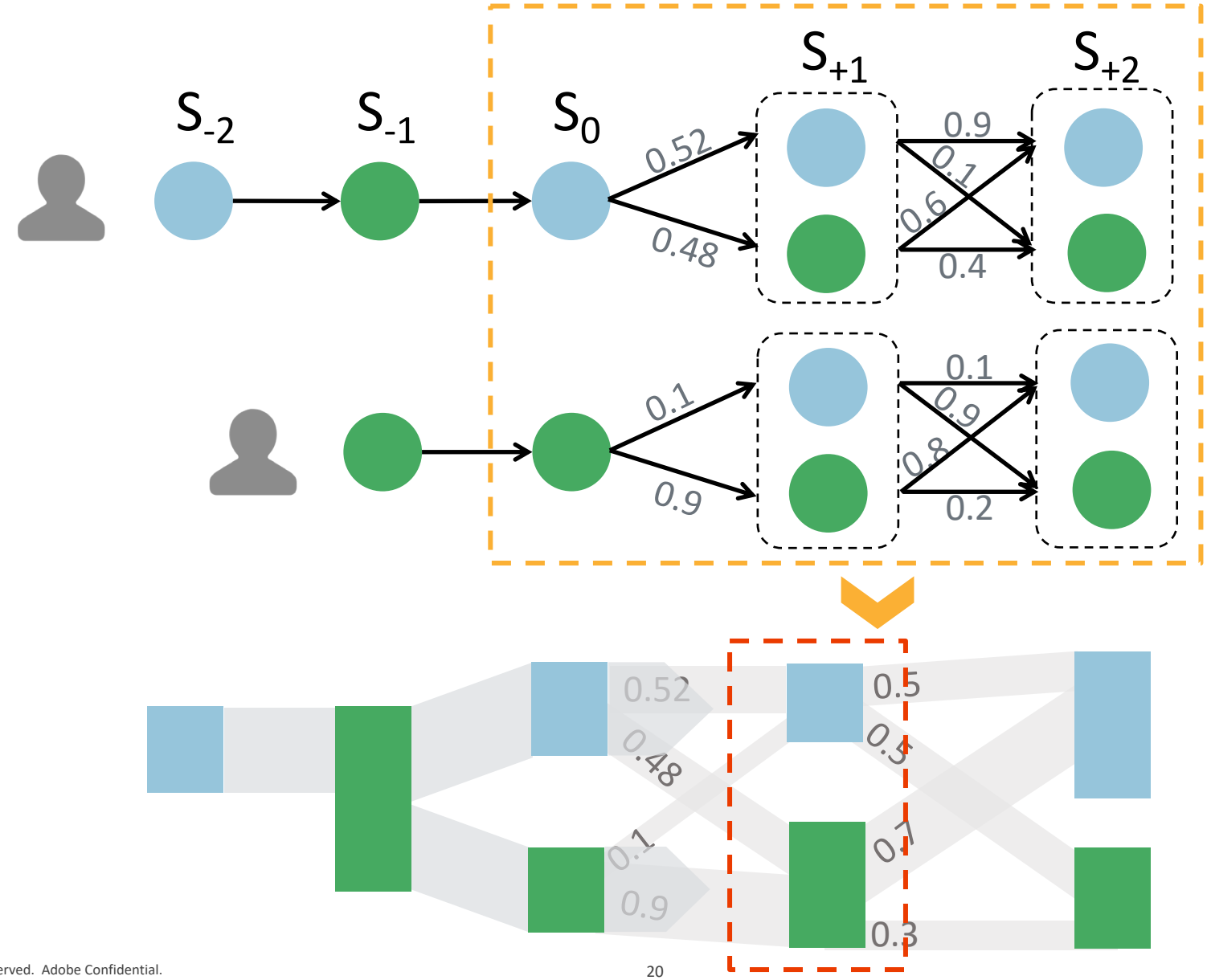
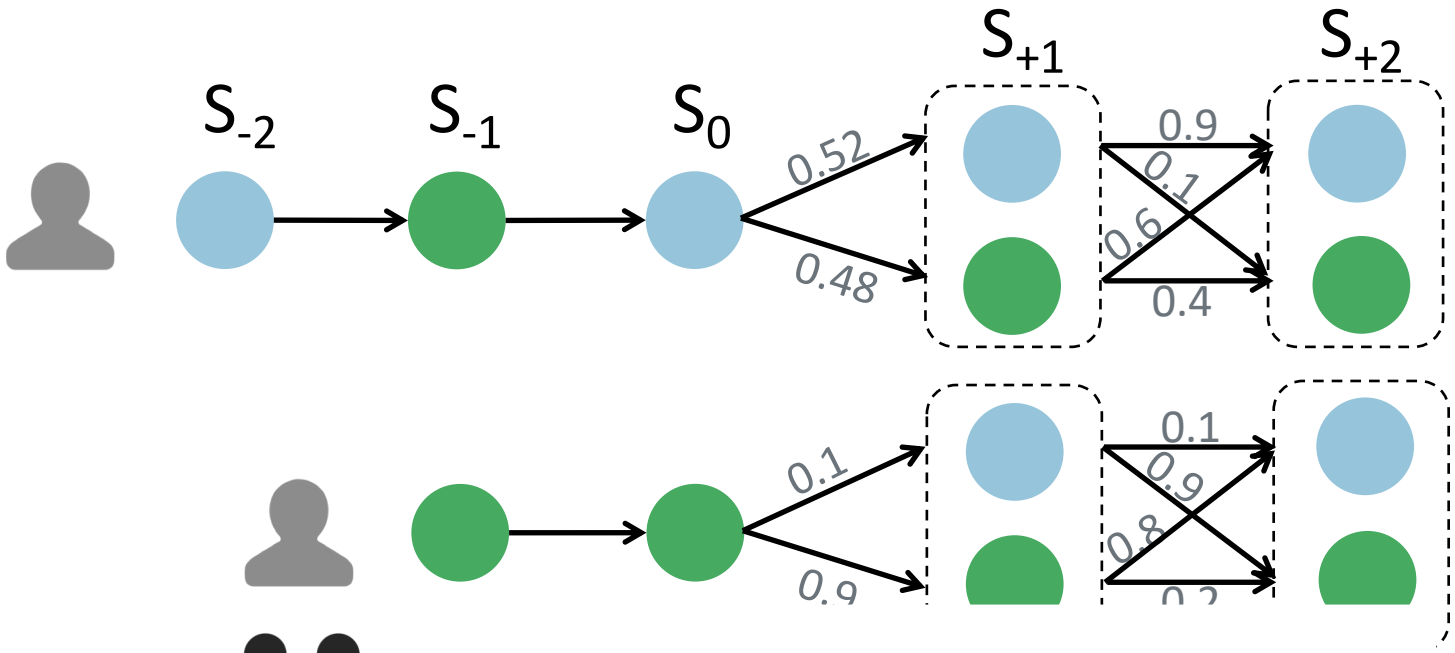
Design I: All Possibilities Aggregated



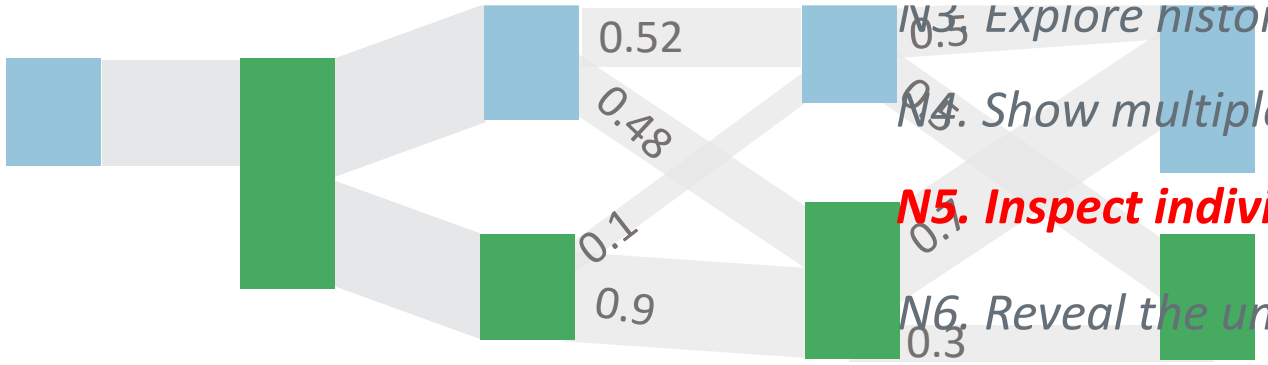
open email

purchase

Design I: All Possibilities Aggregated



Focus on high probabilities



open email

purchase

N3. Explore history and future simultaneously

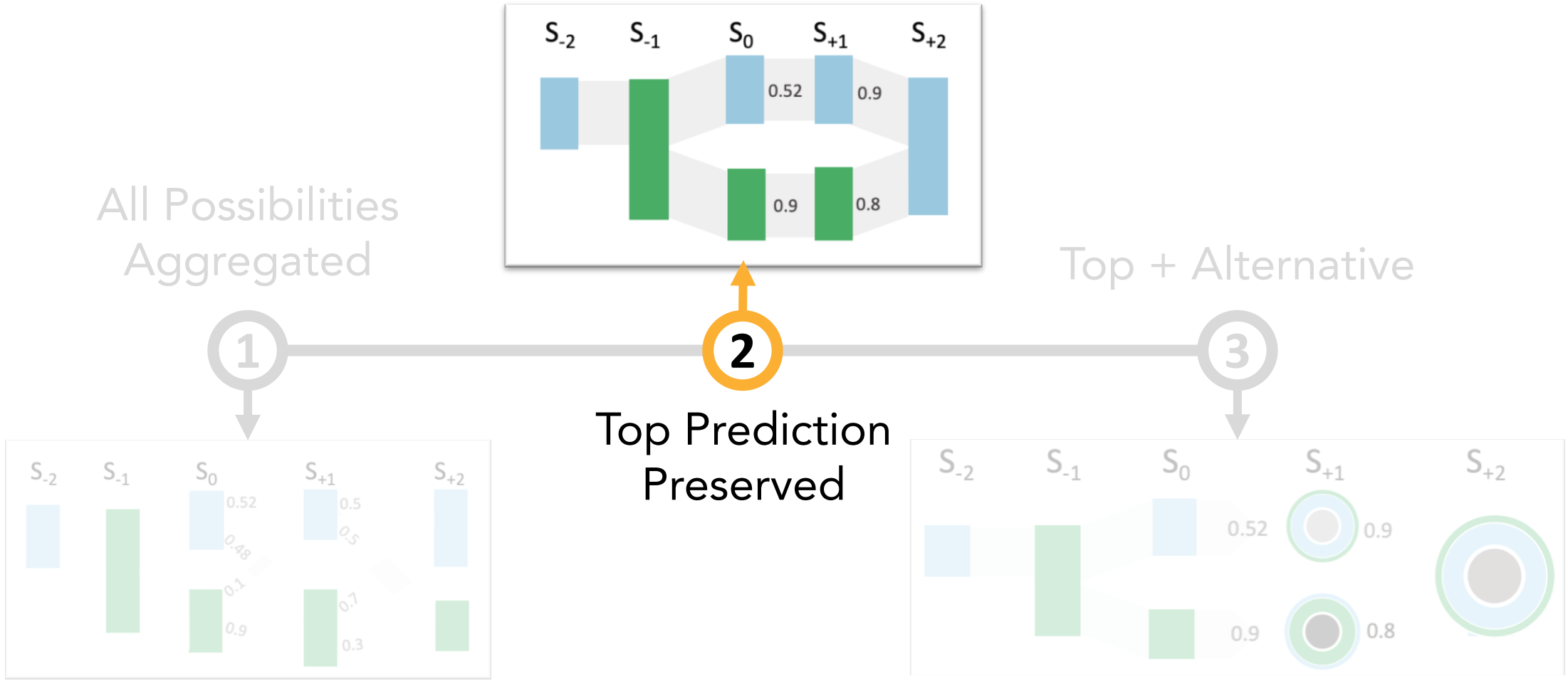
N4. Show multiple event sequences at a time

N5. Inspect individual records in detail ✗

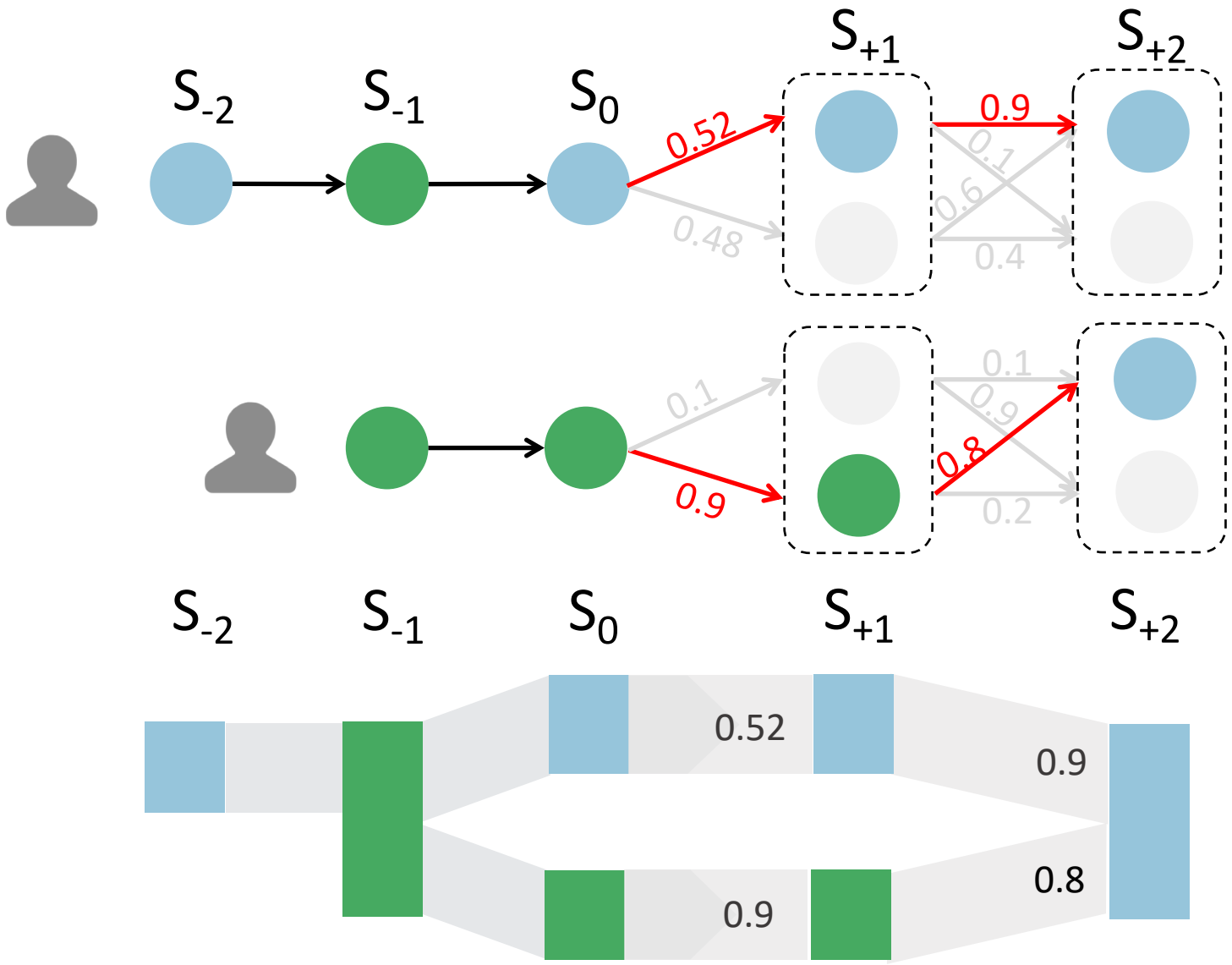
N6. Reveal the uncertainty and alternatives

Adobe

Key Designs for Visualizing Future Paths



Design II: Top Prediction Preserved



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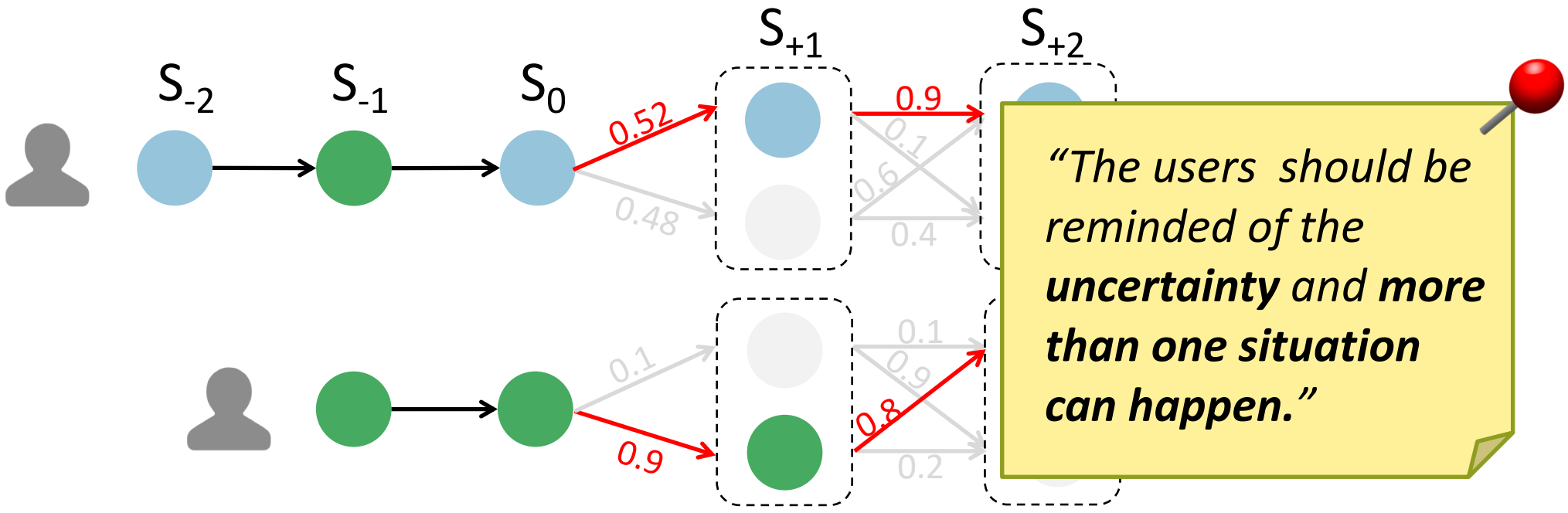

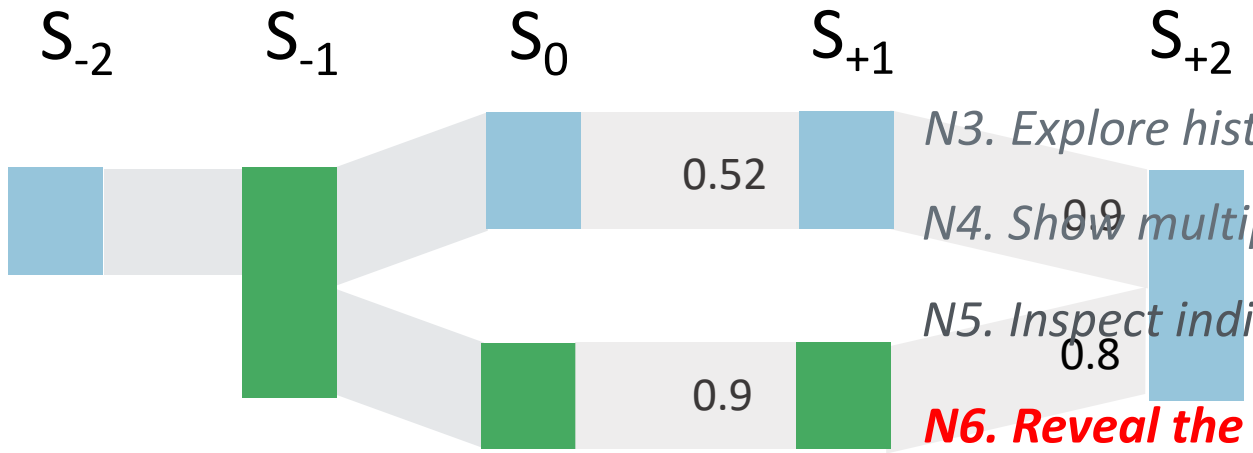

open email

purchase

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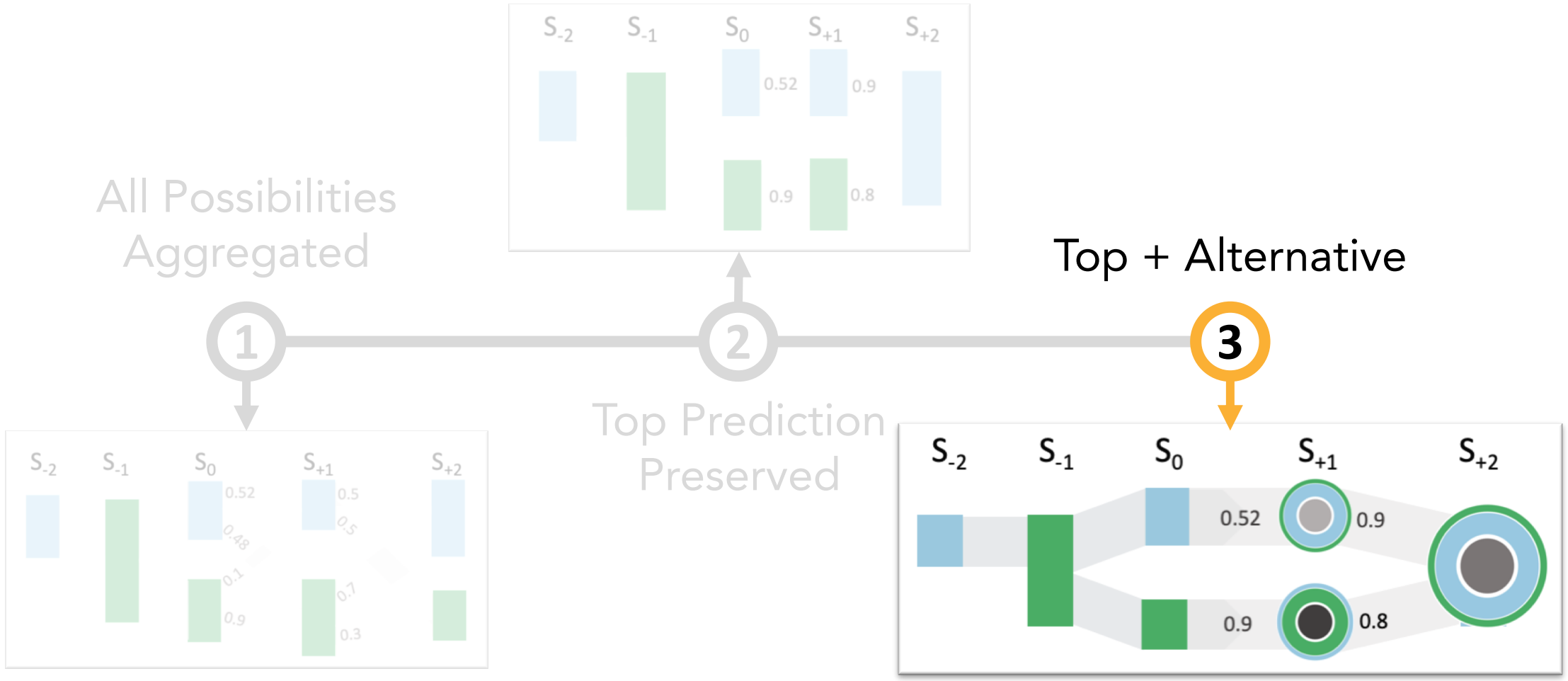
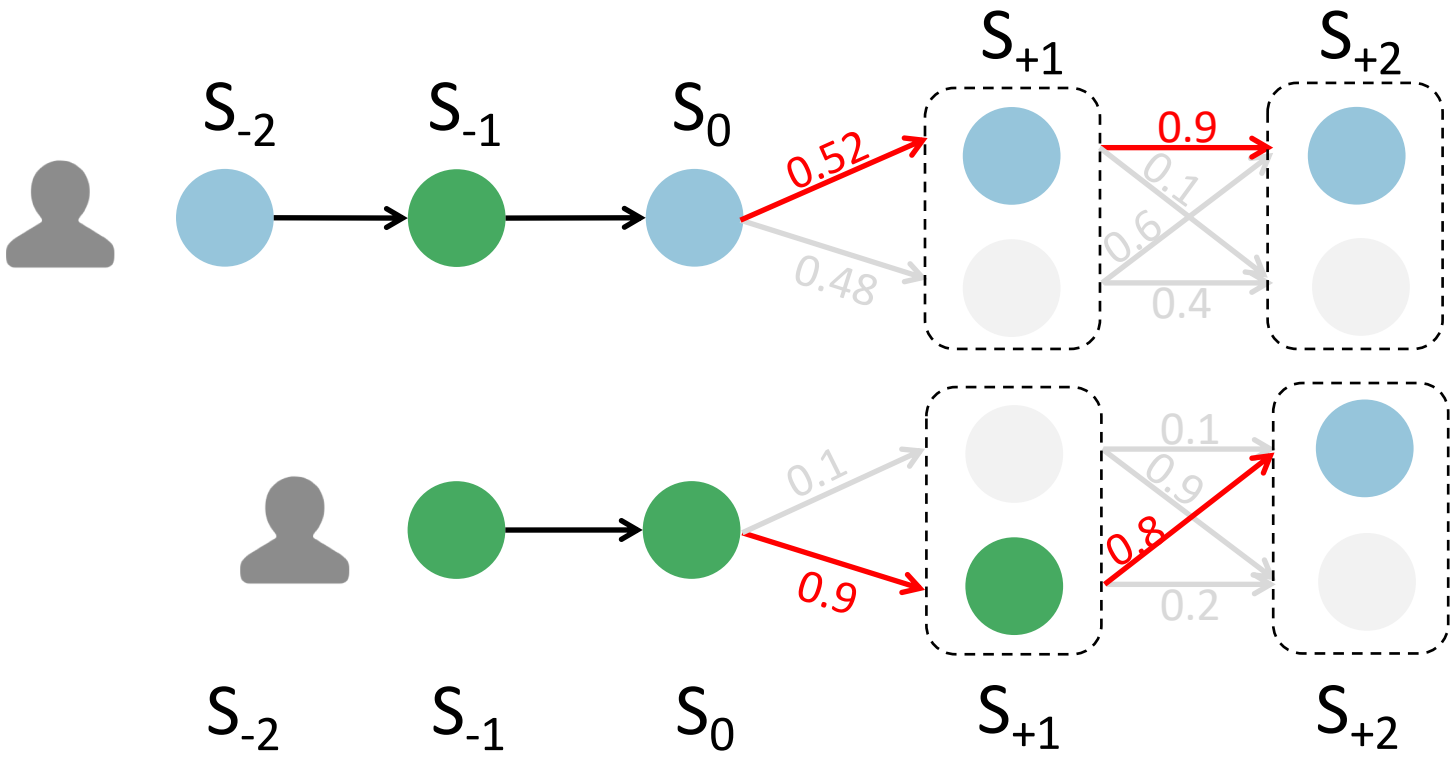
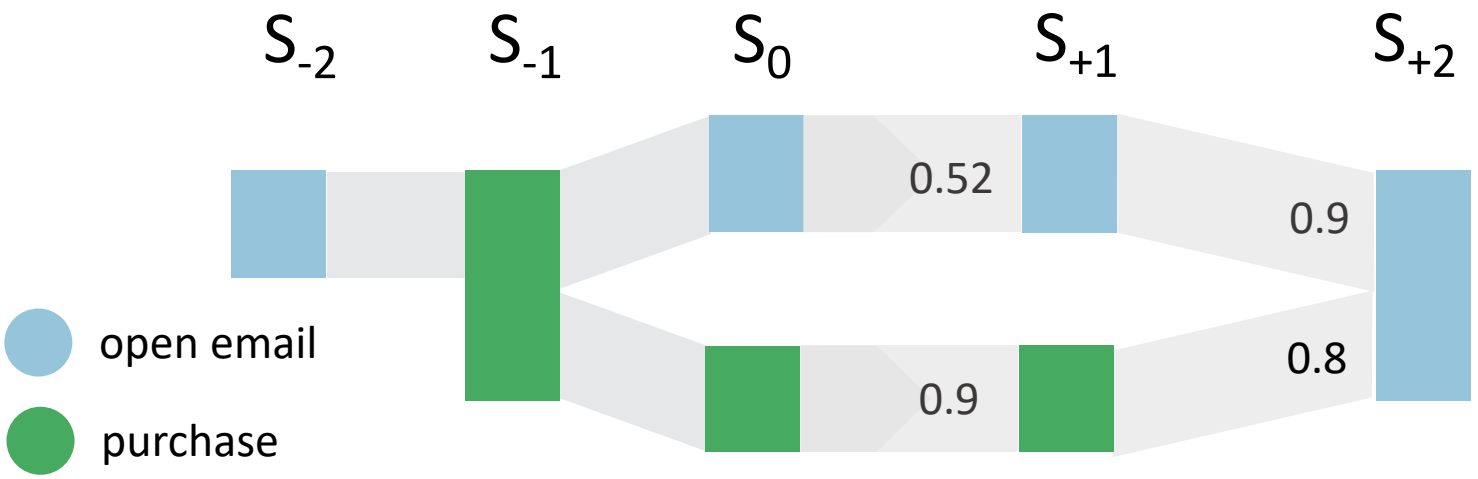
Key Designs for Visualizing Future Paths



Final Design: Top + Alternative



① Preserve the most probable future path



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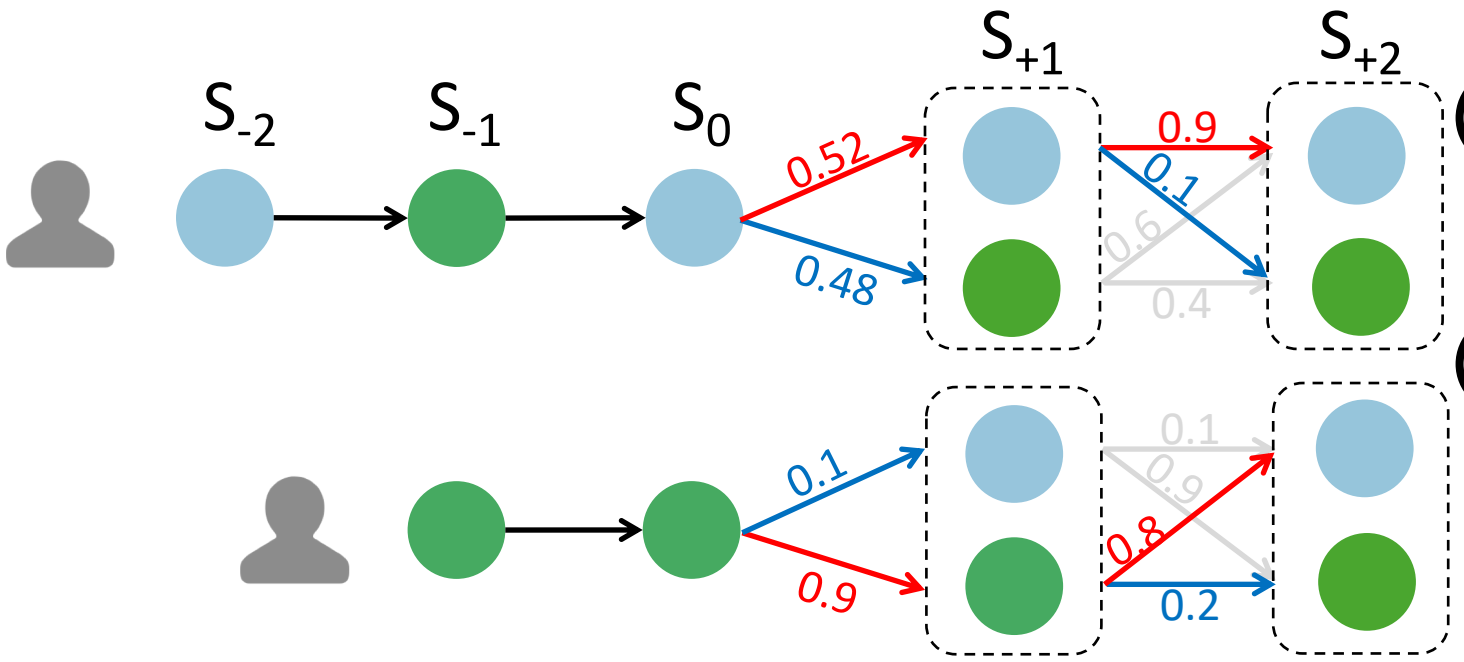
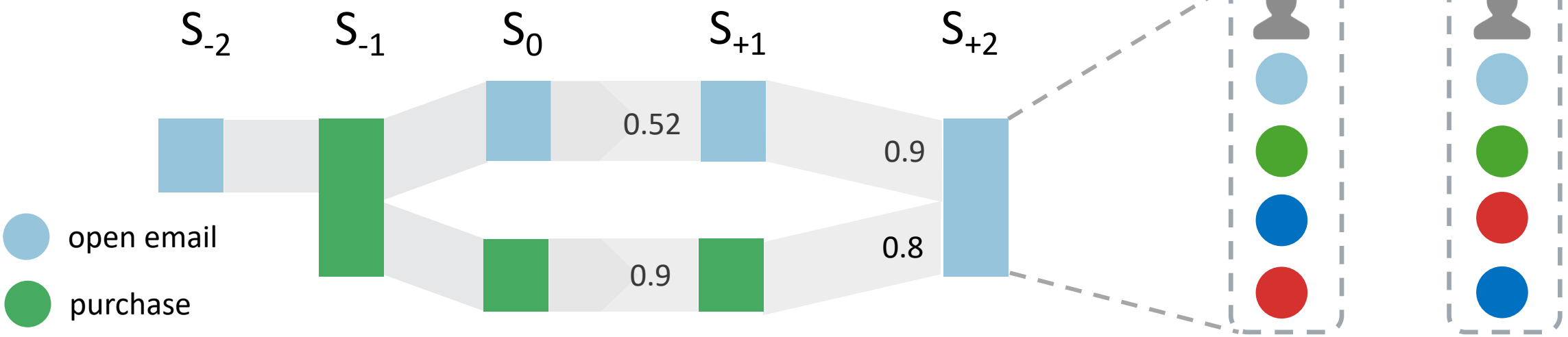


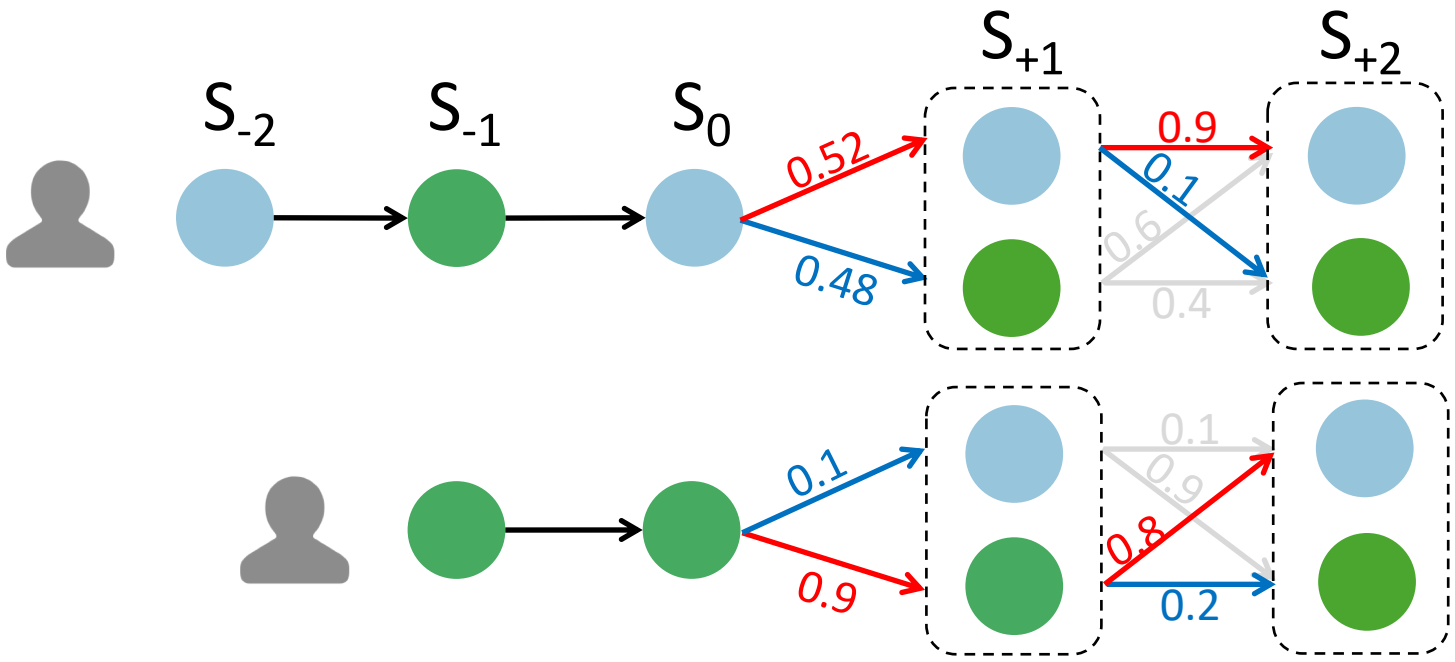
1. Preserve the most probable future path

2. Highlight alternative predictions

Top Predictions → Alternative Predictions →



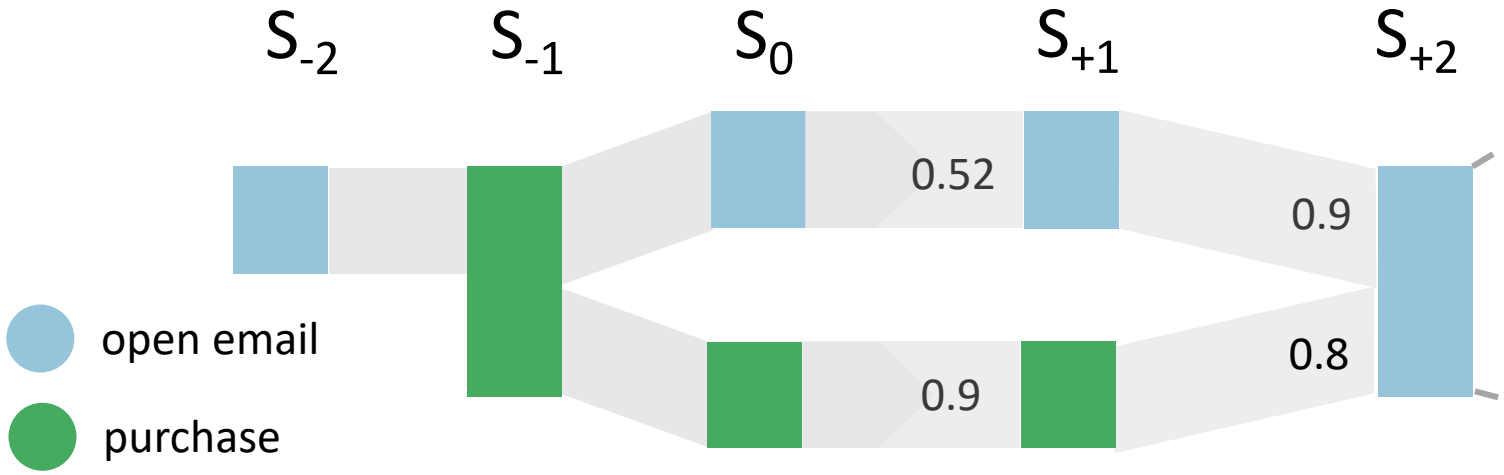
Design Question: Visualizing Alternative Predictions

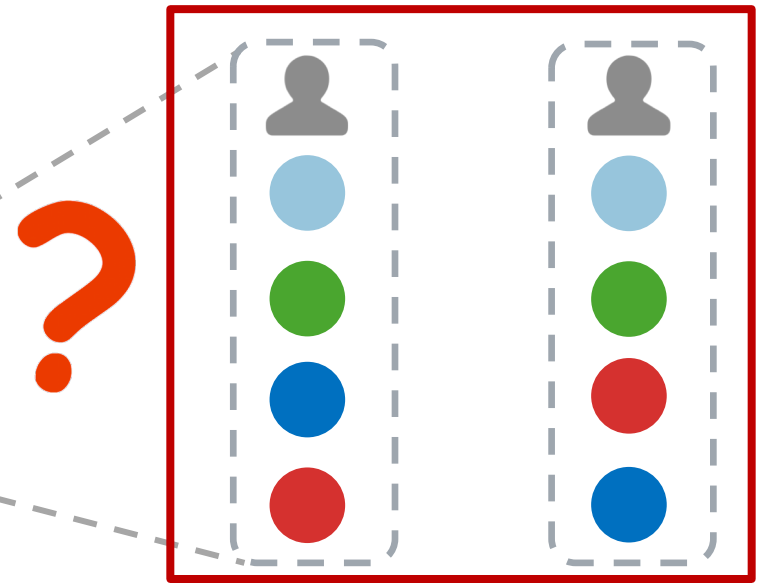


① Preserve the most probable future path

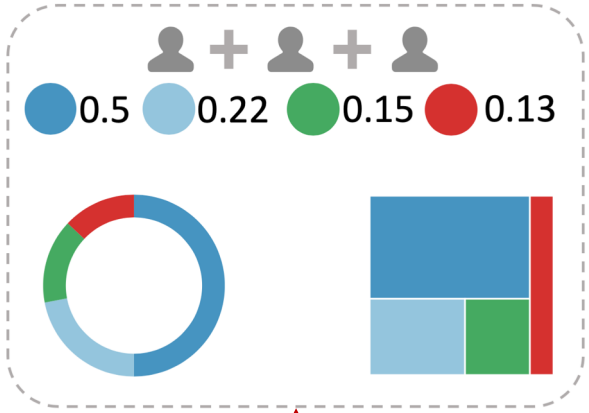
② Highlight alternative predictions

Top Predictions → Alternative Predictions →





Key Designs for Visualizing Alternative Predictions

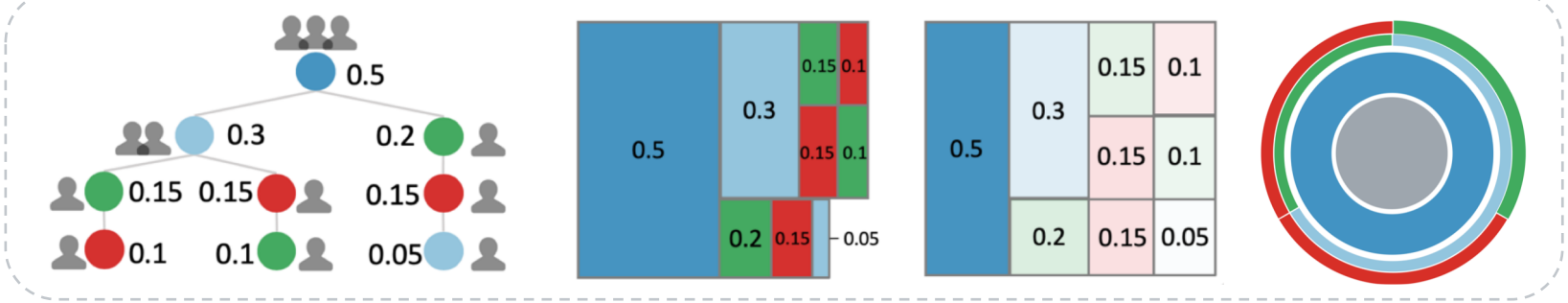


Hierarchical-Oriented

1

2

Composition-Oriented



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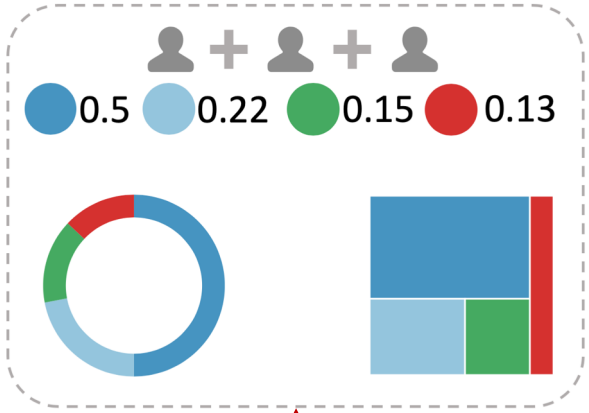
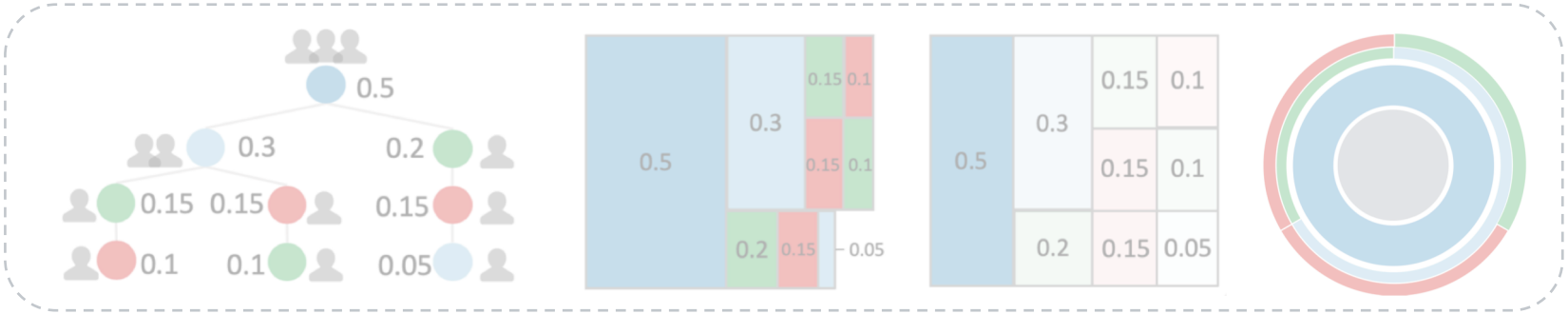


1

Composition-Oriented

Hierarchical-Oriented

2



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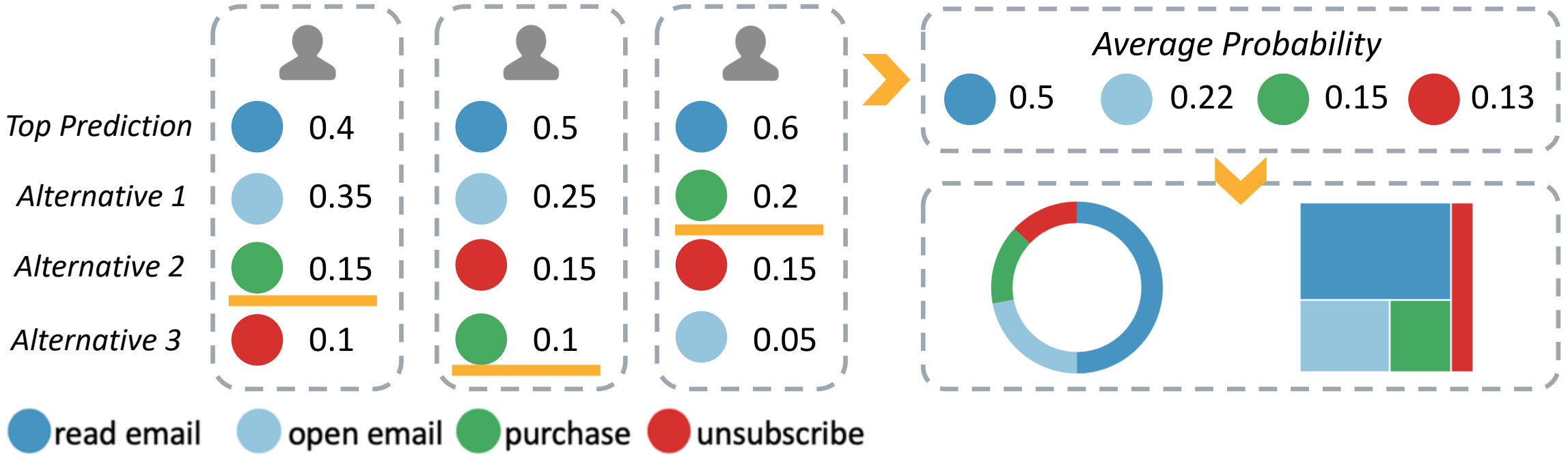
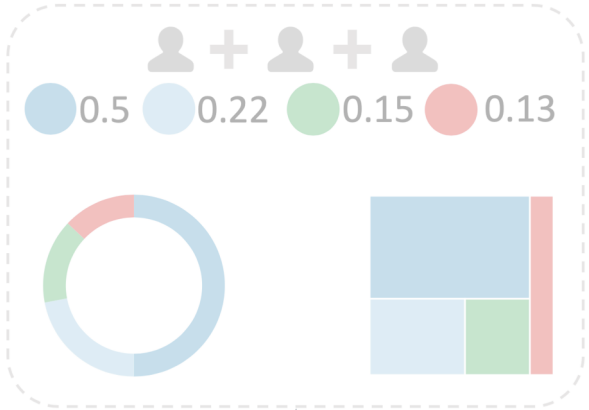
Design I: Composition-Oriented Designs



- Distract users from reviewing top predictions
- Averaging probabilities of alternative predictions at different levels lead to biases

Key Designs for Visualizing Alternative Predictions

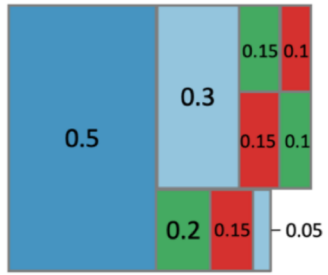


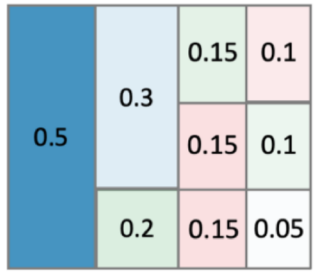
1

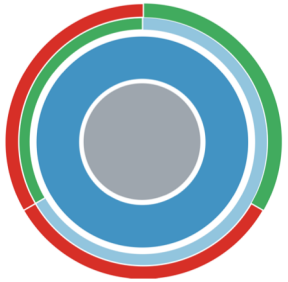
Composition-Oriented

Hierarchical-Oriented

2







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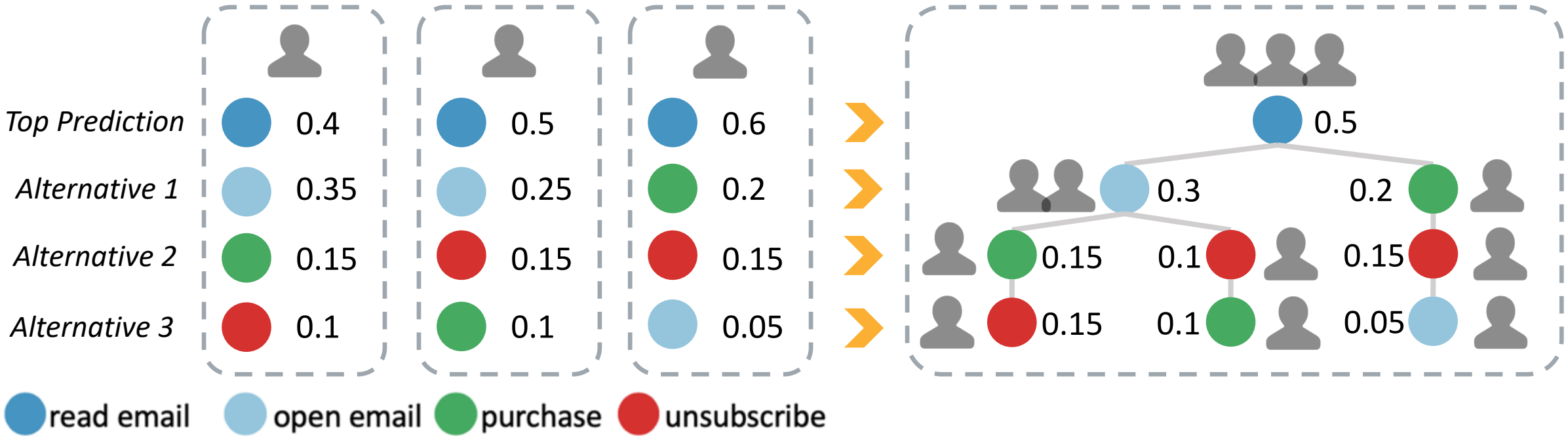
Design II: Hierarchical-Oriented Designs



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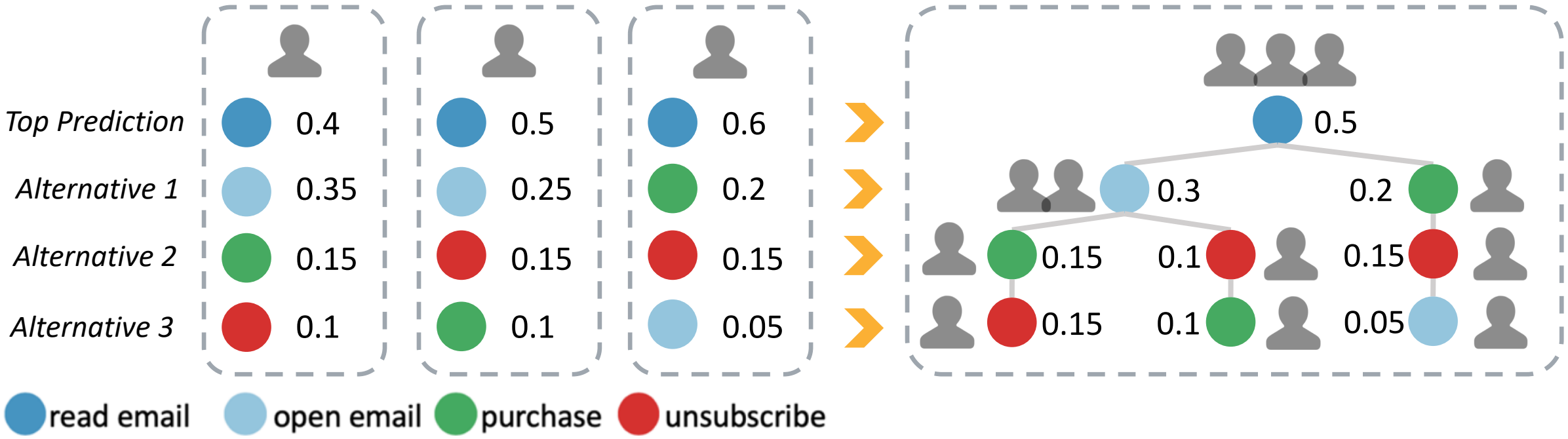

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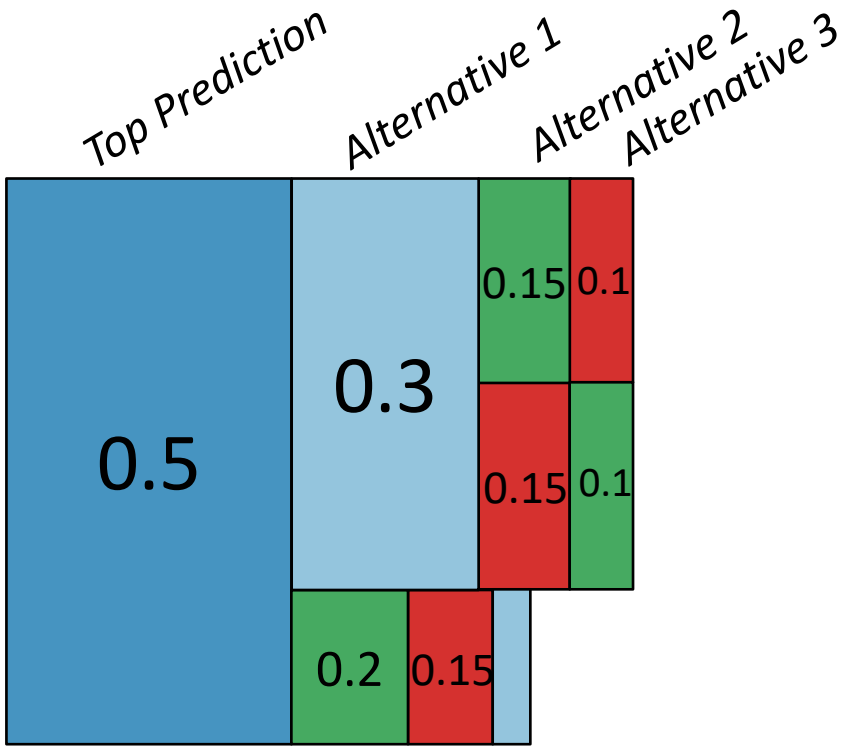
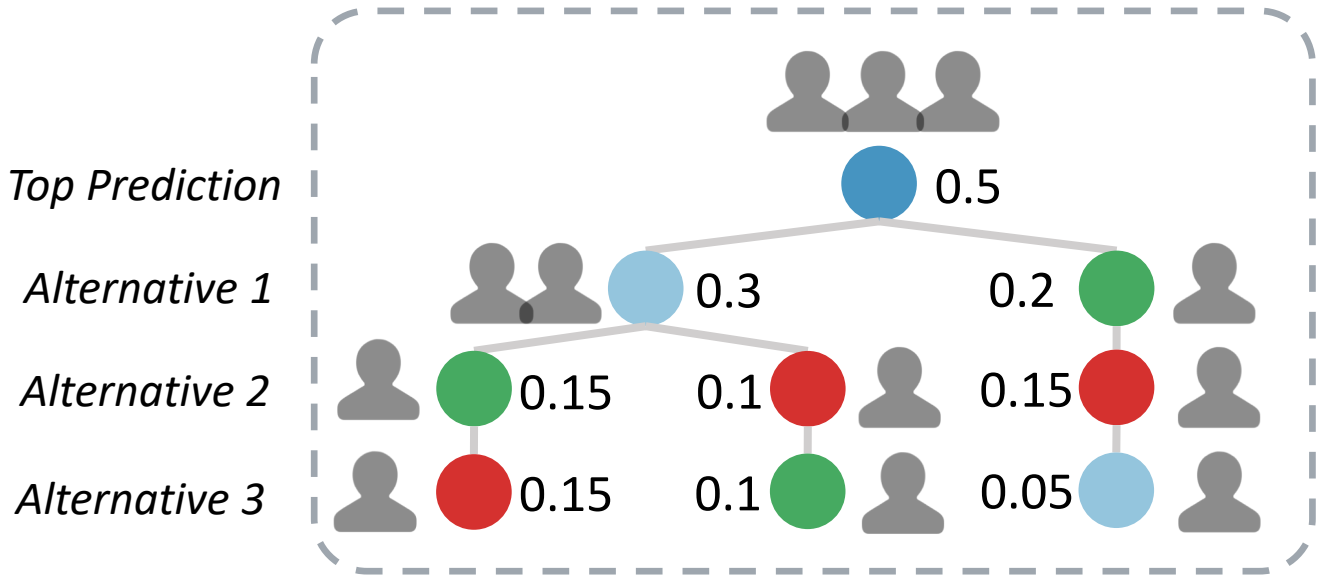
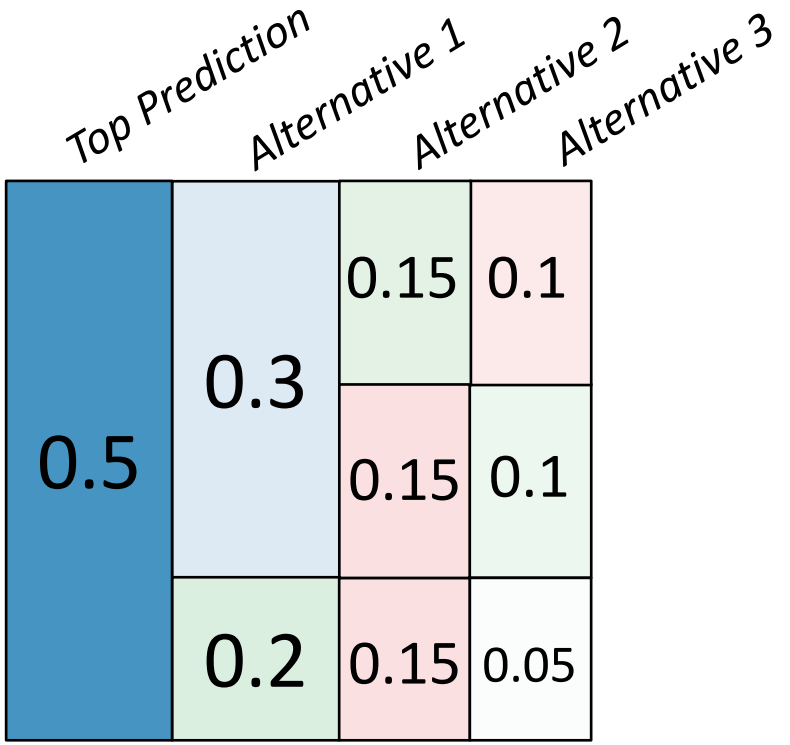


Partitions at the same level may fail to align with each other

Design II: Hierarchical-Oriented Designs

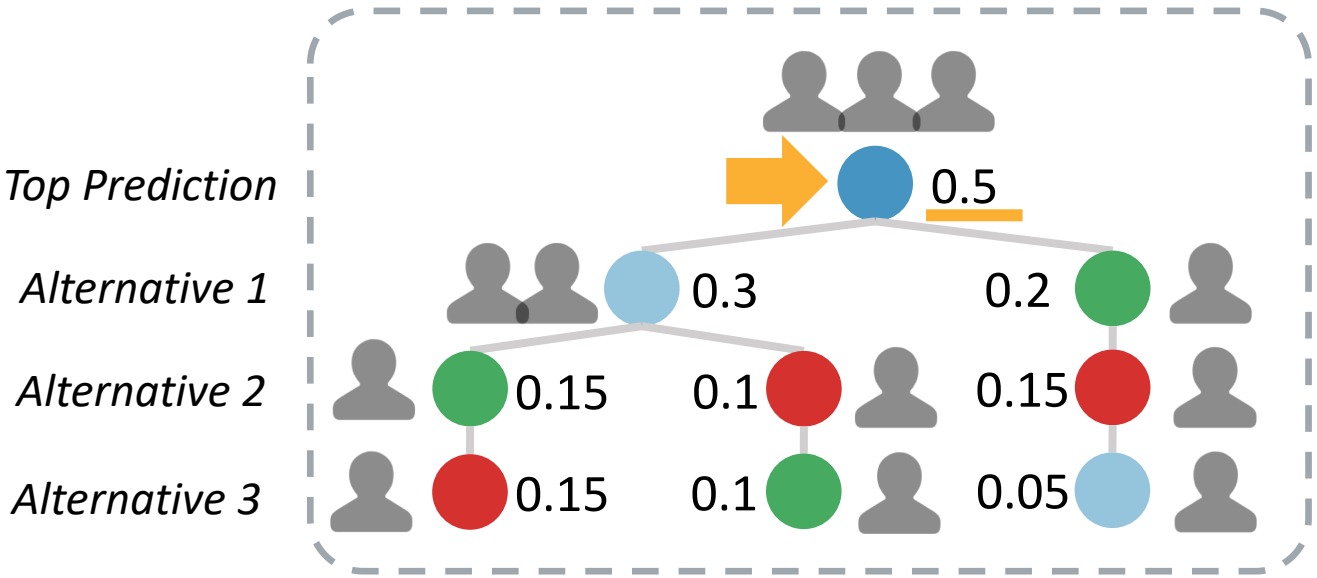


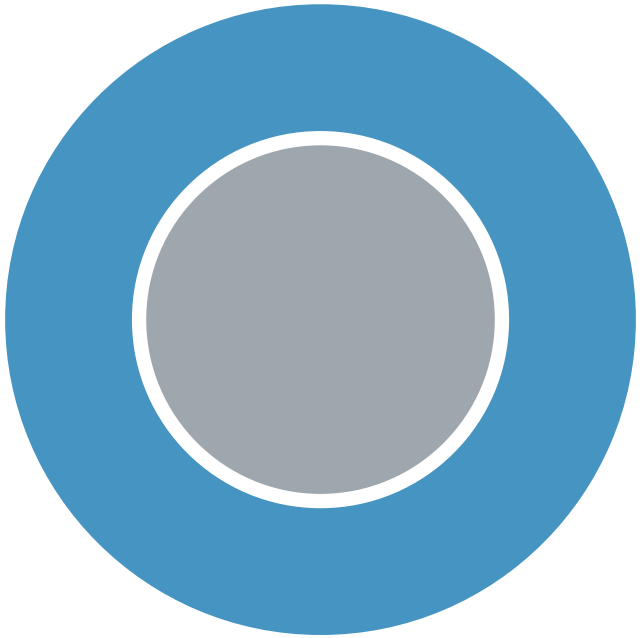


Colors are confusing

Fail to intuitively imply the order of the levels

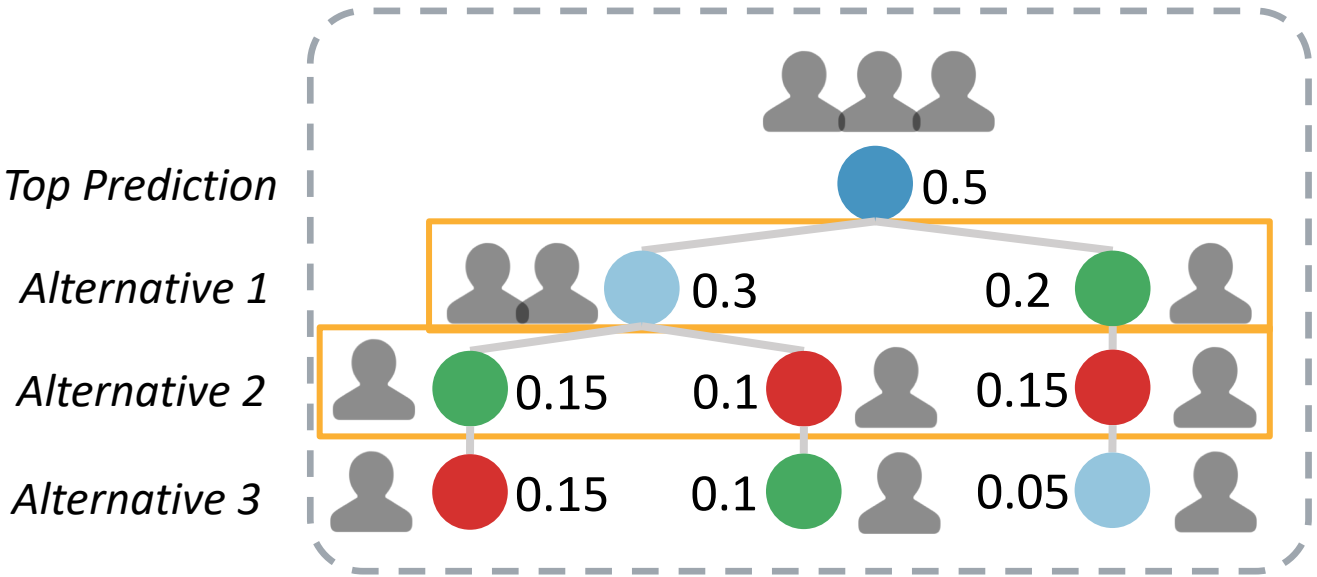
Final Design: Hierarchical-Oriented Circular Glyph

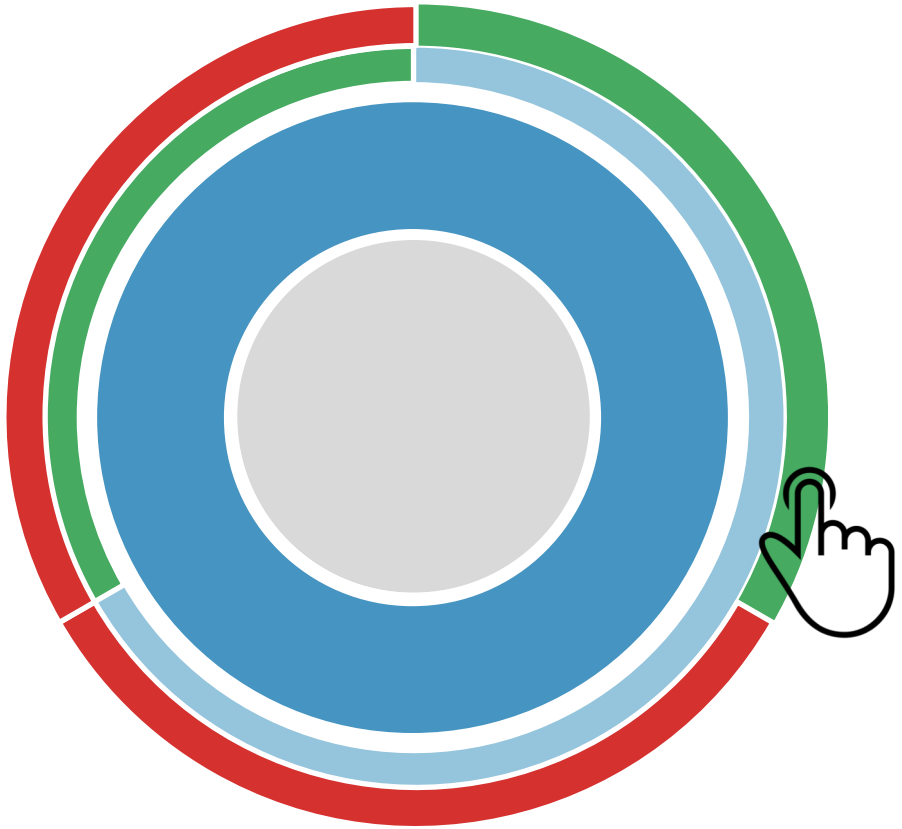




Probability: *Low* *High*

Final Design: Hierarchical-Oriented Circular Glyph

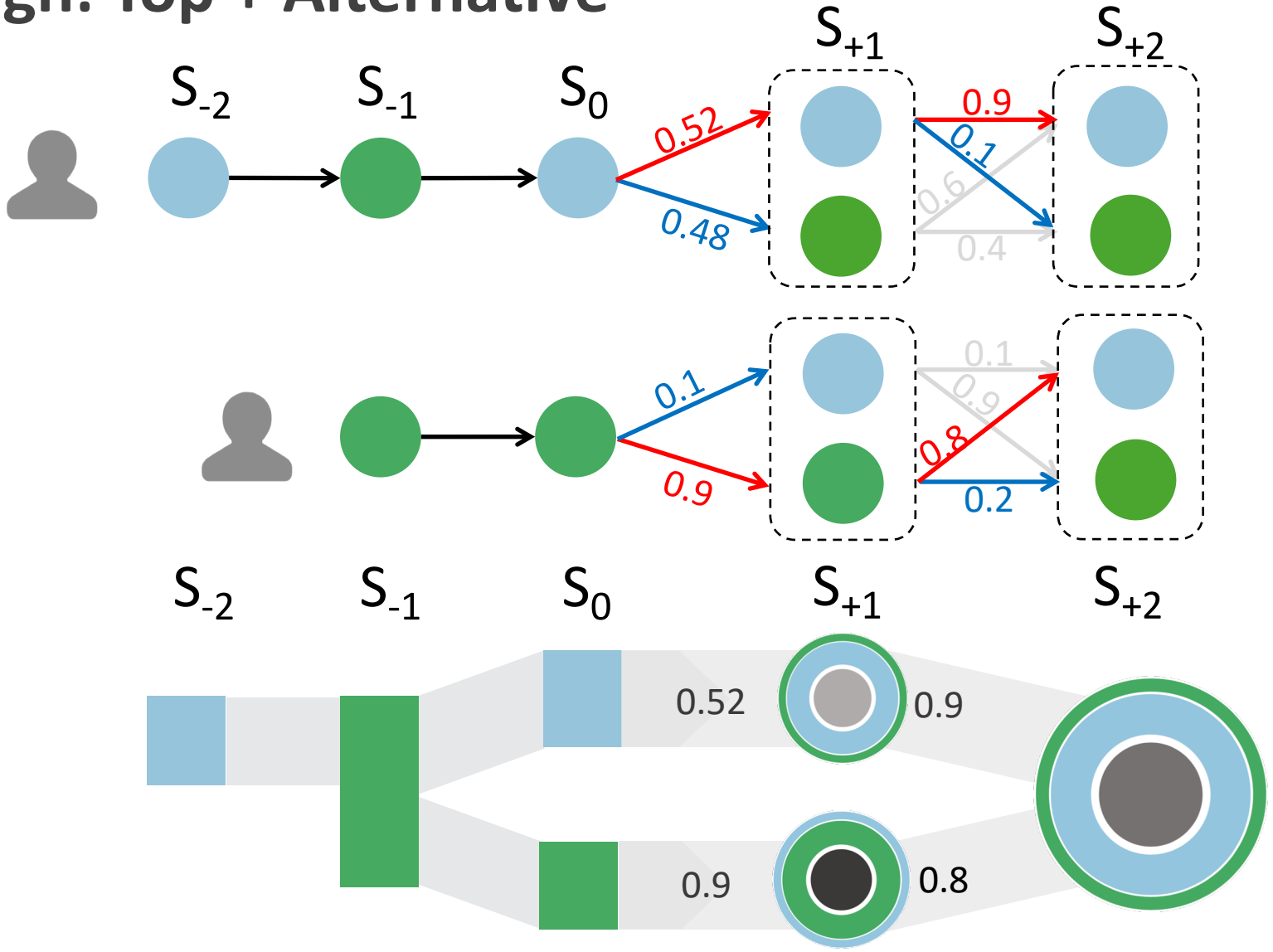




Probability: *Low* *High*

Population: *0%* *100%*

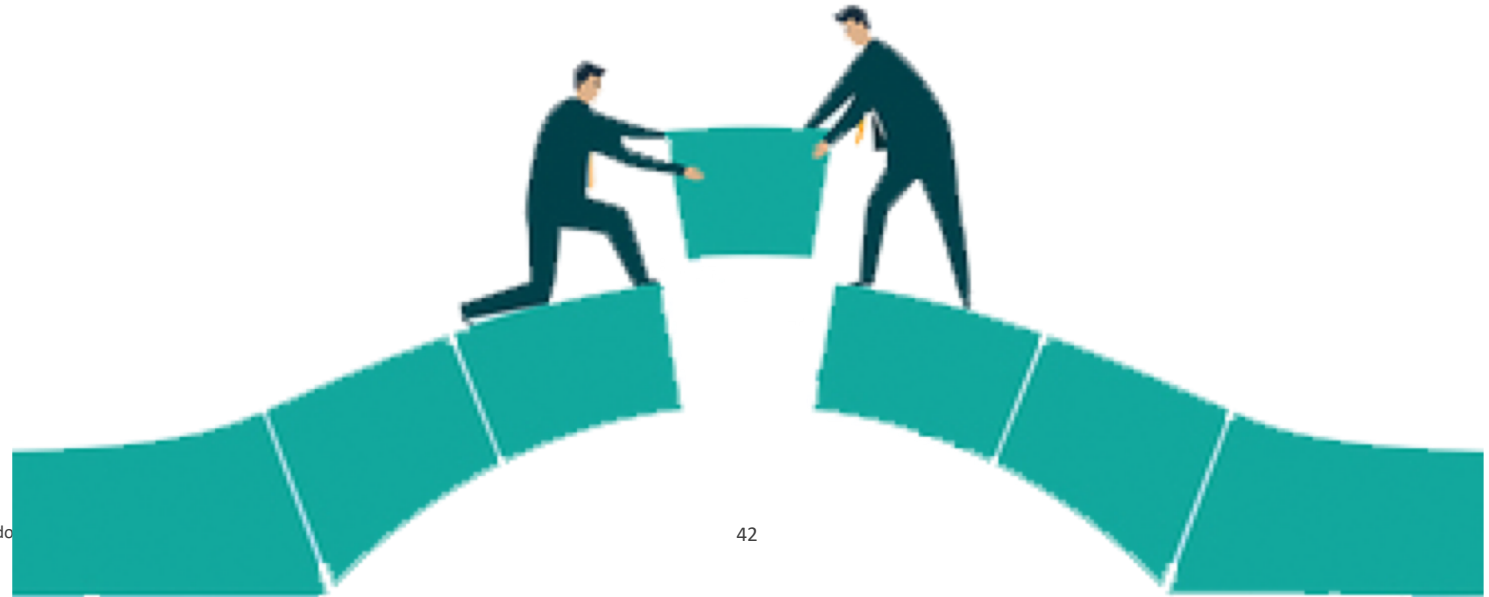
Final Design: Top + Alternative



Research Problems

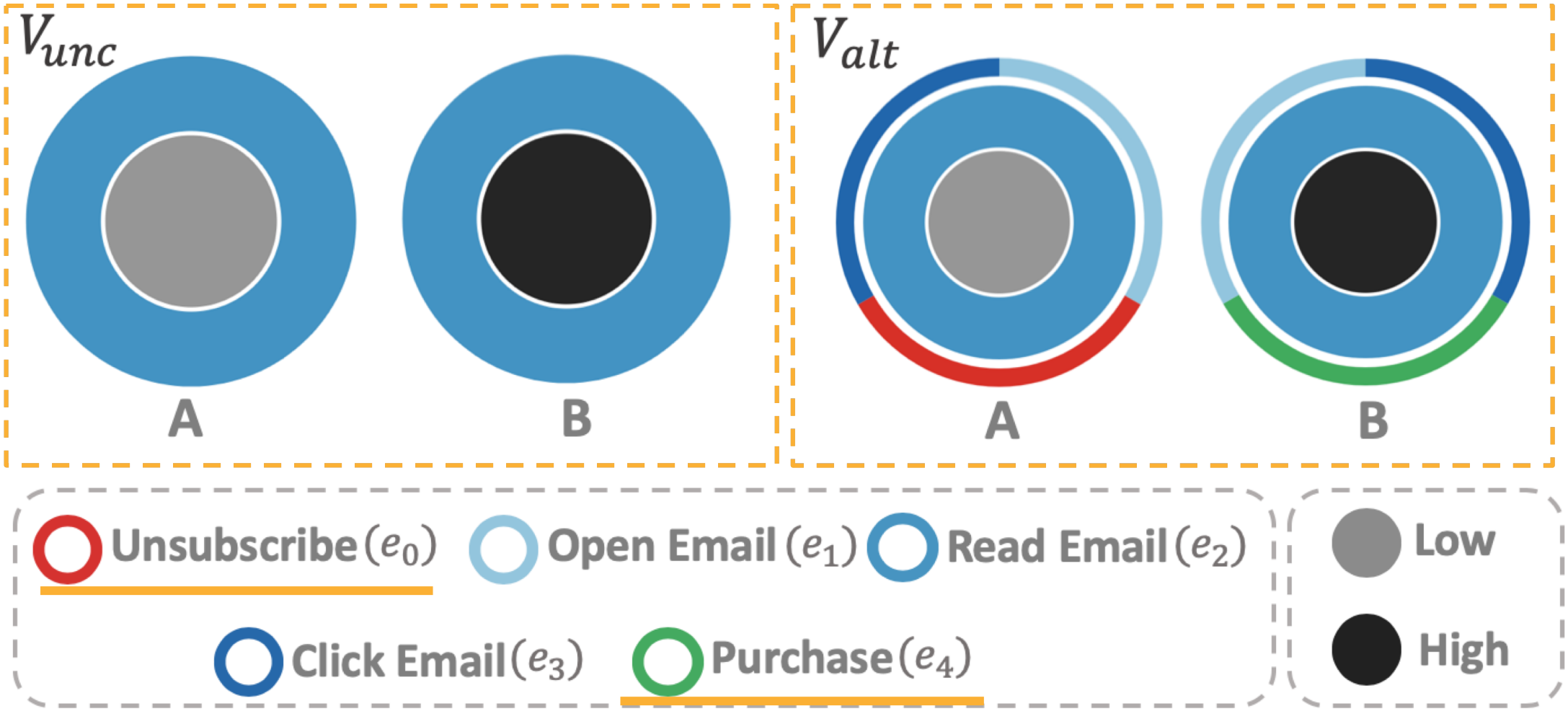
How to effectively visualize event sequence predictions with alternative predictions?

How does showing alternative predictions would affect people's decision making?

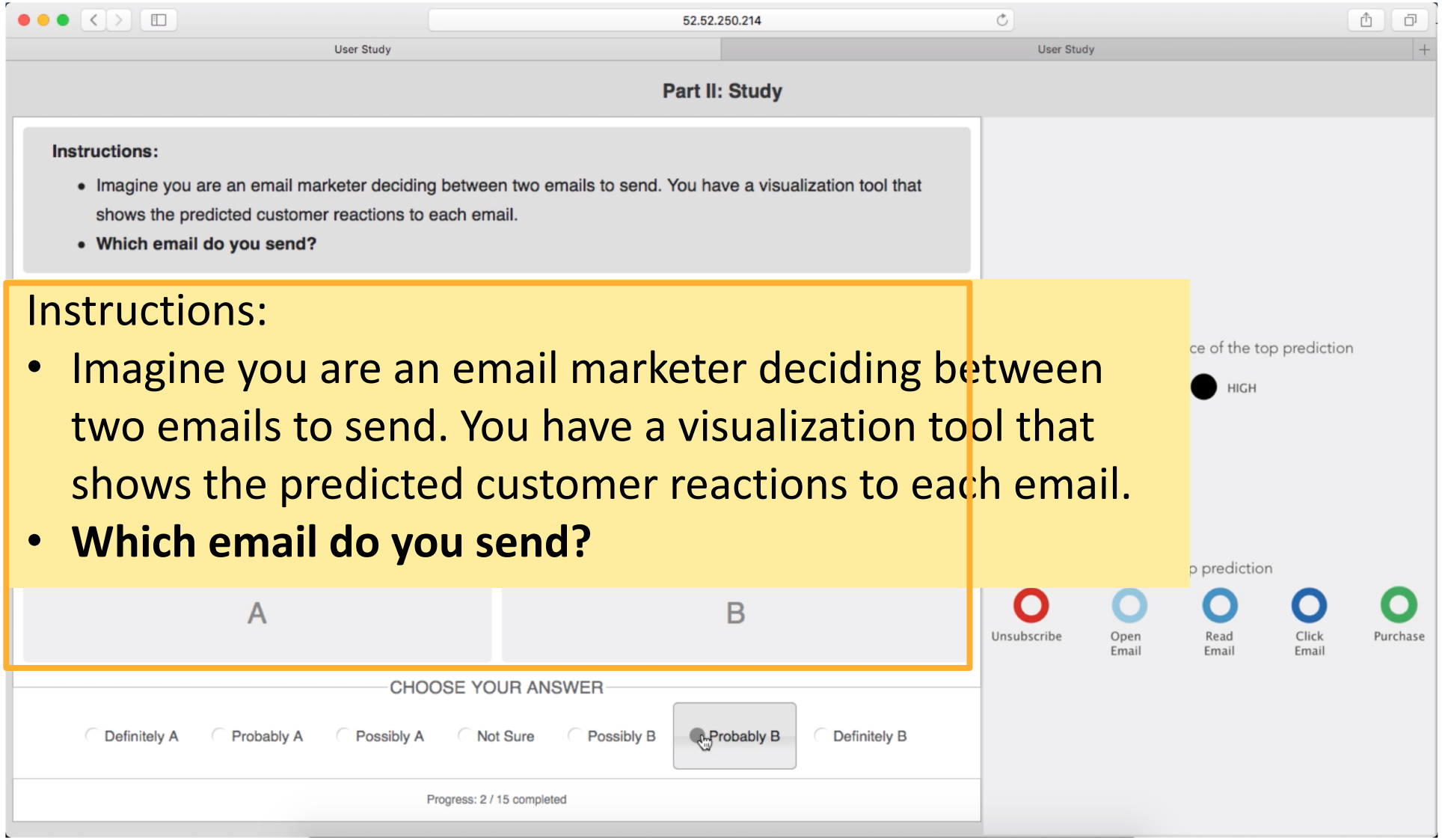


User Study

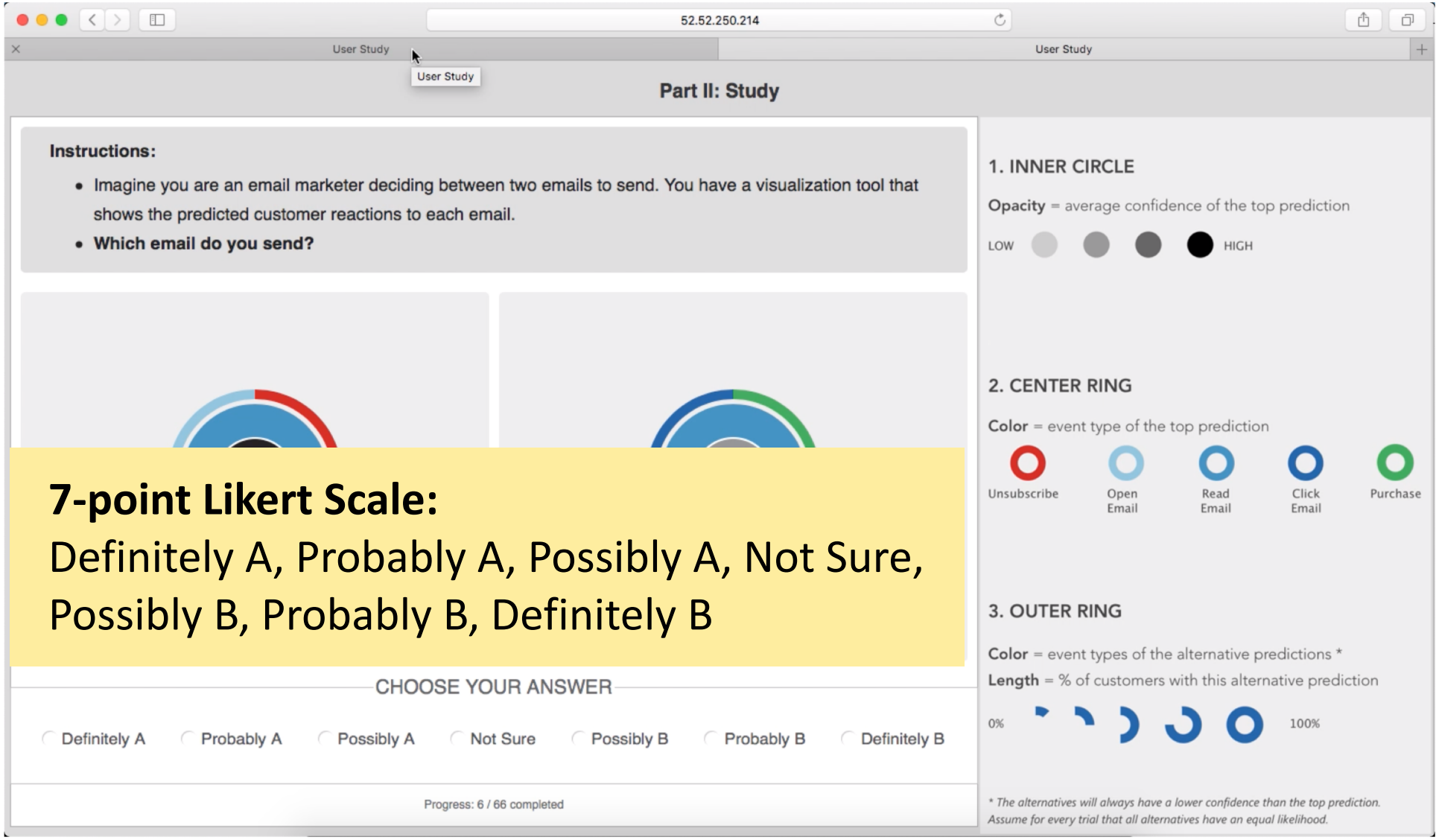
Making decisions with different predictive information



User Study



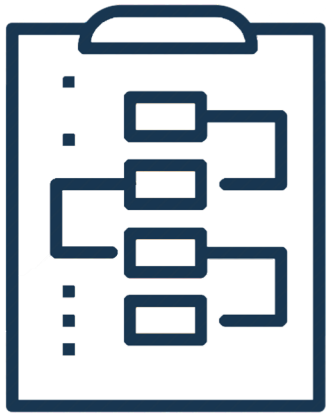
User Study



7-point Likert Scale:
Definitely A, Probably A, Possibly A, Not Sure, Possibly B, Probably B, Definitely B

User Study

18 Participants (10 males and 8 females, aged 20–30)



Procedures *(~45min per participant)*

Introduce basis of event sequence prediction (Introduction)

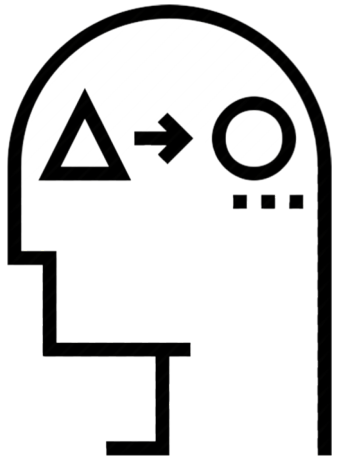
Training tasks, study tasks (per session, counterbalanced)

Questionnaire, feedback and suggestions (after finishing all study tasks)

Study Results

Level of Confidence

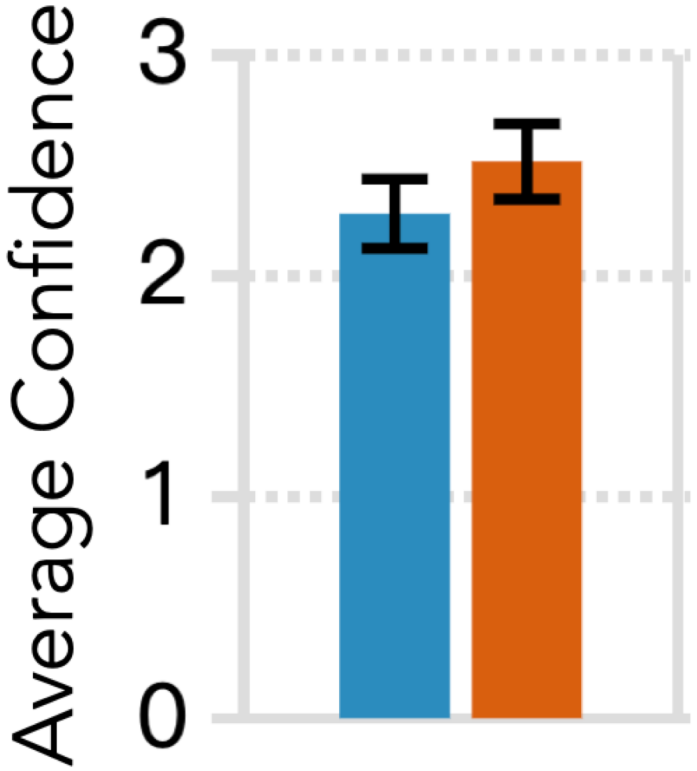
*Inferred from users' choices in 7-point likert scale: Definitely(**3**), Probably(**2**), Possibly(**1**), Not Sure(**0**)*



Change of Decision

Identical top predictions and prediction probability, user choose differently

Level of Confidence



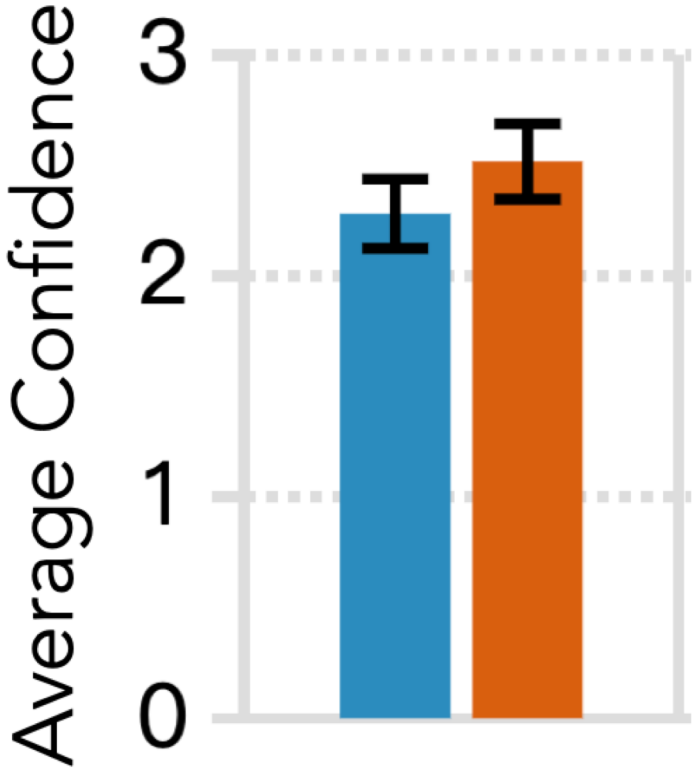
Top Prediction Only *(M = 2.30, SD = 0.78)*

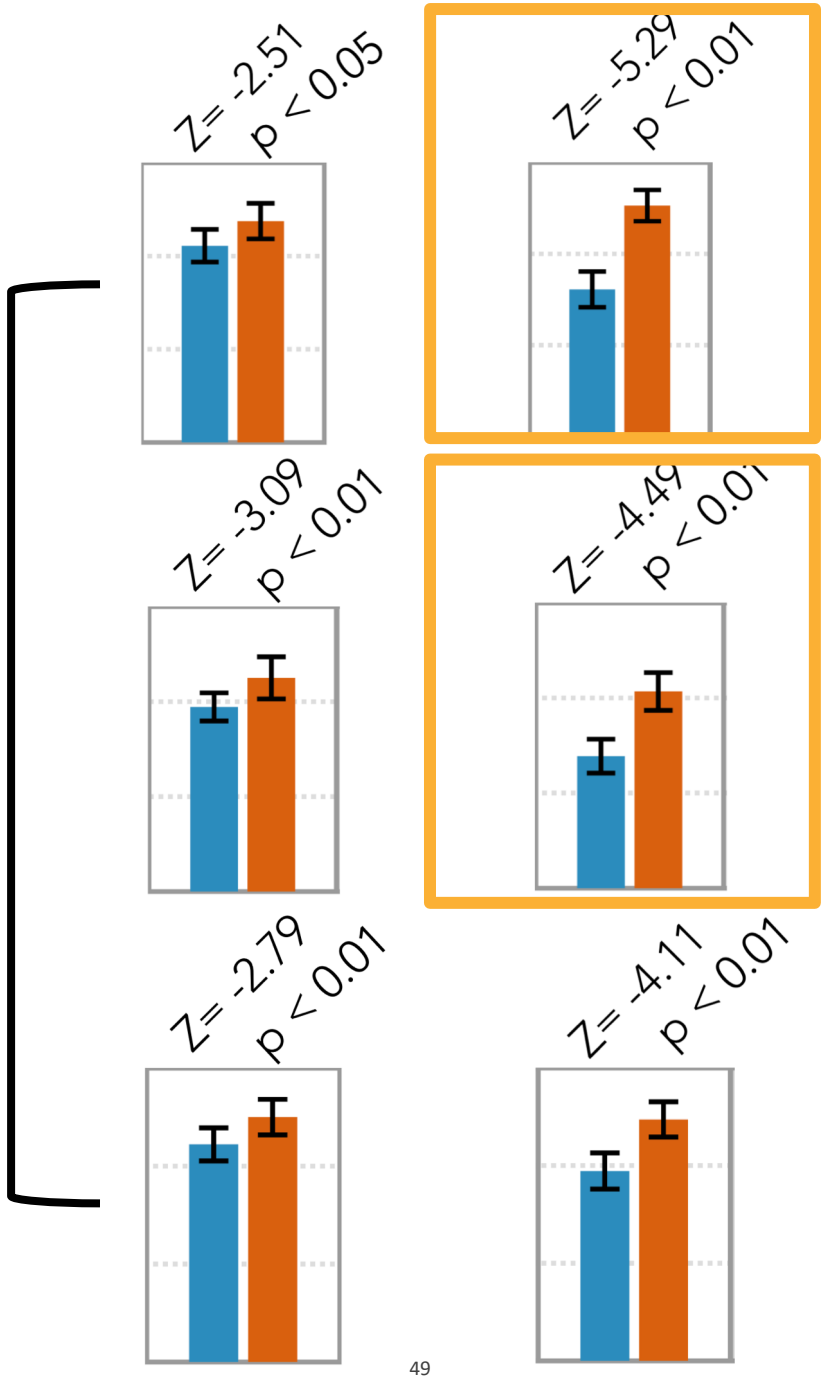
Top + Alternative *(M = 2.56, SD = 0.72)*

Users are generally more confident in making decisions when provided with alternative predictions

Adobe

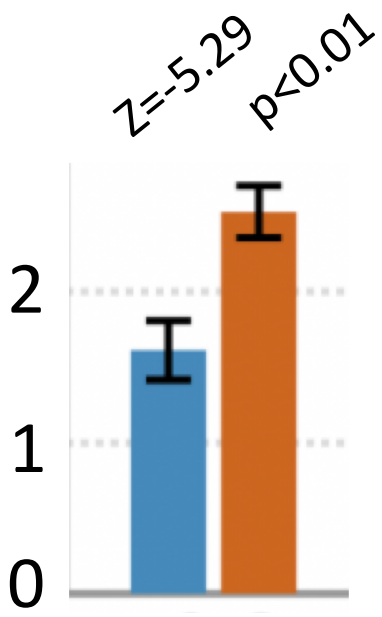
Level of Confidence

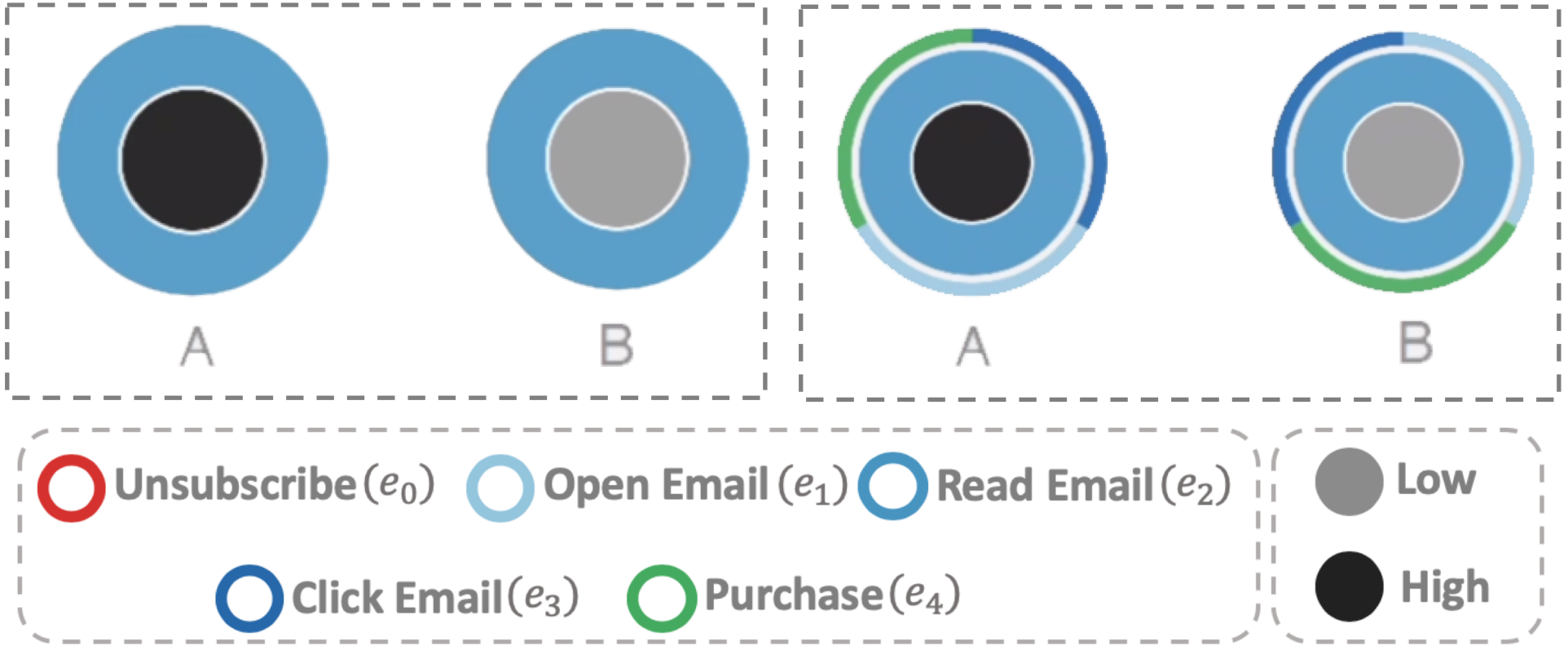




Significant Difference found in **similar top predictions**

Level of Confidence





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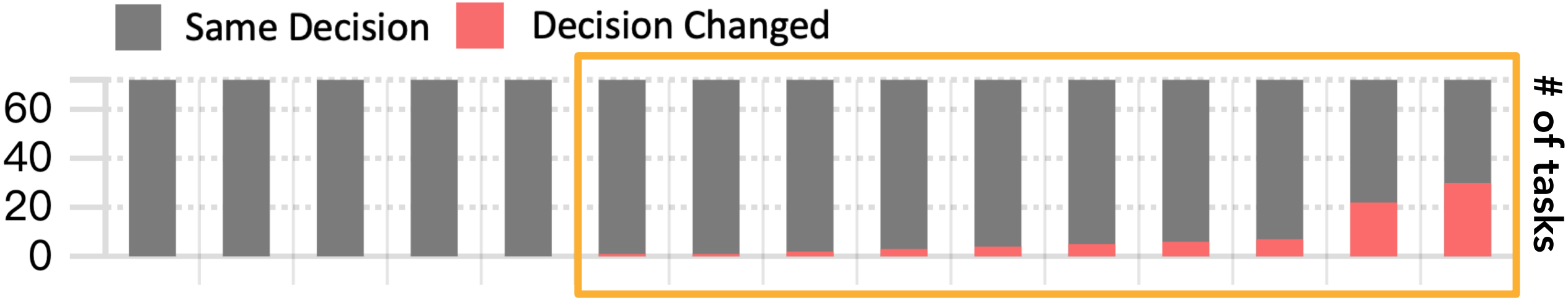
Level of Confidence

Showing alternative predictions has a greater impact on users' confidence when deciding between two options with similar top predictions

Change of Decision

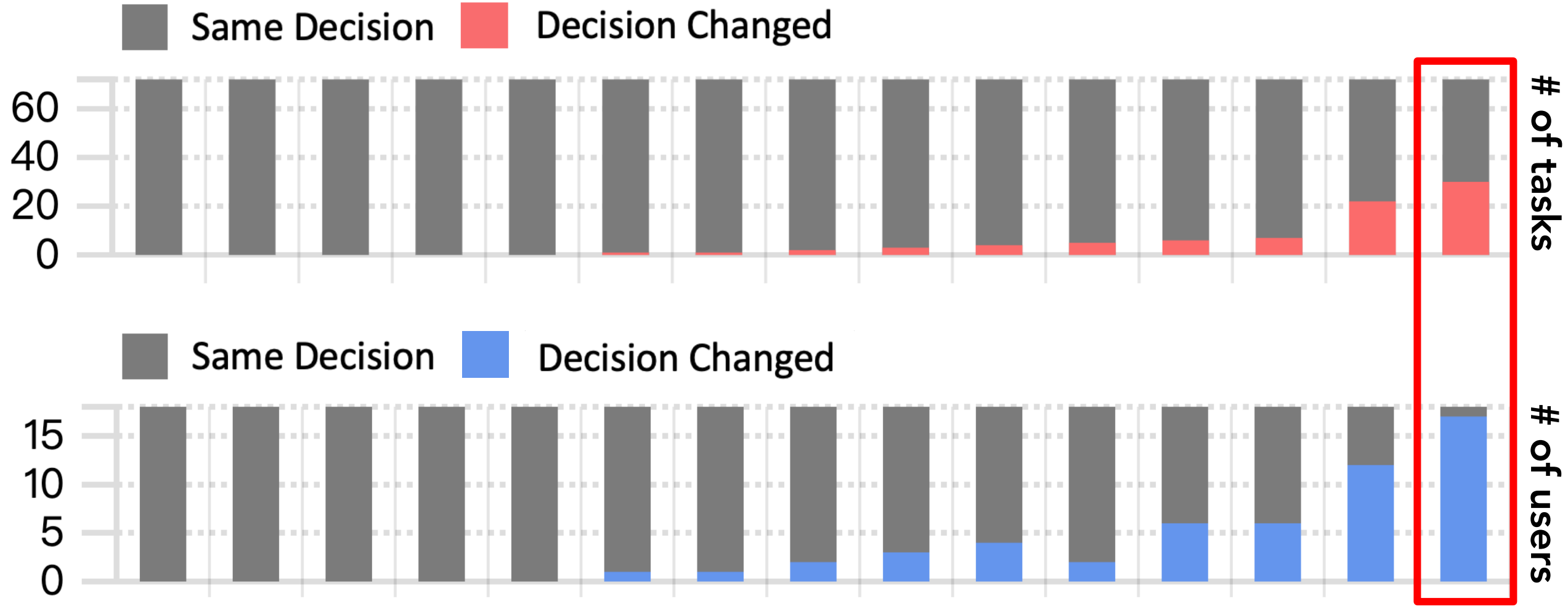


Similar top predictions, opposite alternative predictions: Purchase vs. Unsubscribe

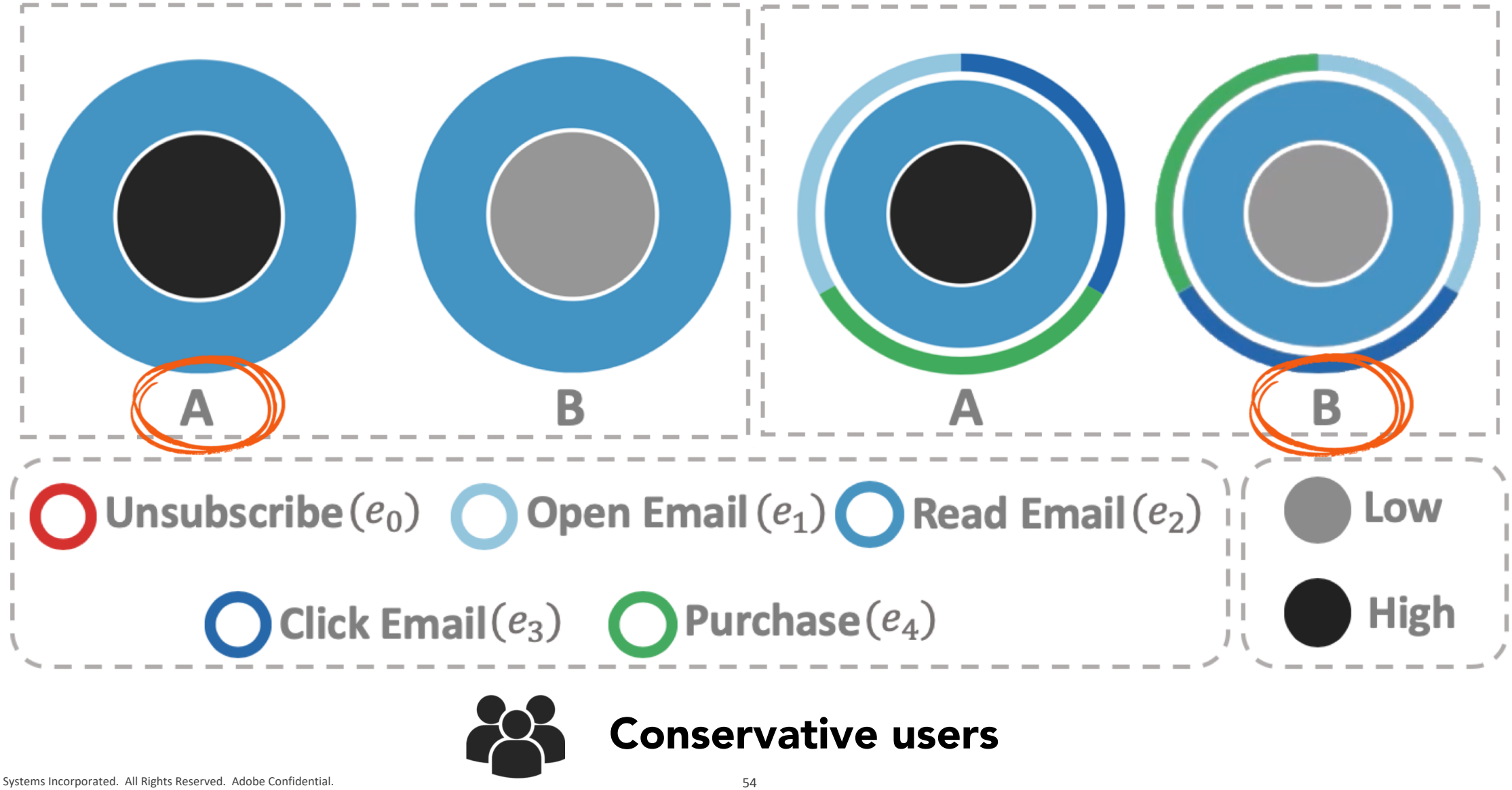
Users' decision may change
when the alternatives contain risk or value.

Adobe

Change of Decision

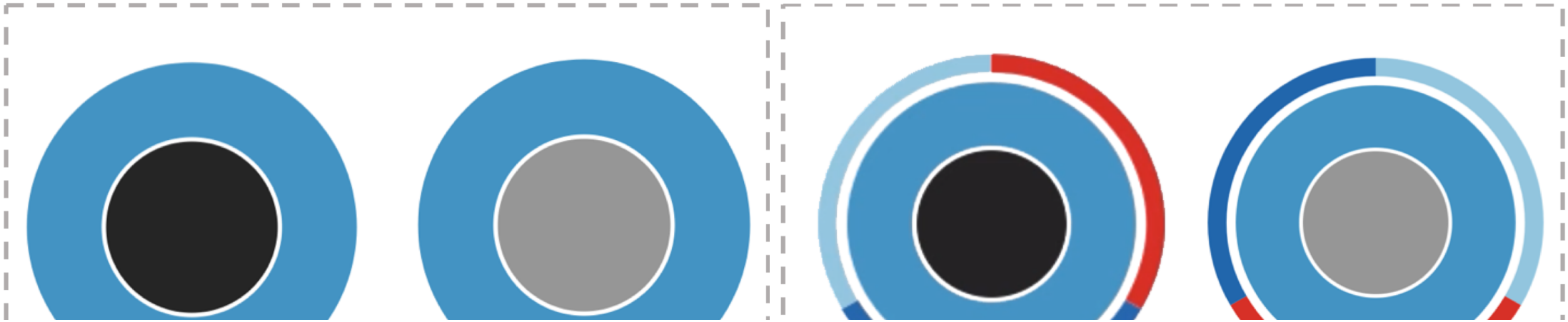


Change of Decision



Conservative users

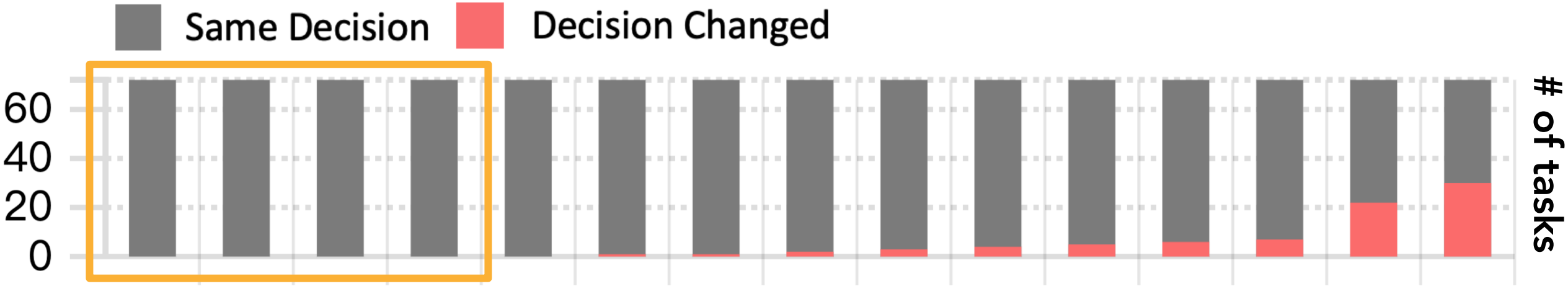
Change of Decision



Alternative predictions may determine the nature of top predictions

Risk-takers

Change of Decision



Extremely different top predictions: Purchase vs. Unsubscribe

Users' decisions are hardly changed
when top predictions were extremely different

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Qualitative Feedback

Usefulness

"Do you think seeing alternative predictions is useful? Why?"

Risk Control:

"When the top prediction is good but has a low certainty, then I will consider alternative predictions to make sure that, ***in the worst case the top prediction does not come out, the result is still tolerable****."*

Utility

"Rank the importance of
1.Top prediction
2.Top prediction probability
3.Alternative predictions"

13 our of 18 ranked: 1>2>3

Risk-takers: 1=3>2

"I would take any risk for purchase because it is the ultimate goal in marketing.

Ease of Understanding

"How easy was the visualization to understand?"

1=very difficult, 7=very easy
(M = 6.17, SD = 0.62)

"The design is well aligned with people's cognition. The top prediction shown in the middle indicates a highest priority. The surrounding alternatives represent additional information."

Adobe

Summary

We proposed

An alternative-aware uncertainty visualization for exploring event sequence predictions.

We found

People are more confident in making decisions when alternative predictions are displayed.

They consider the alternatives more when deciding between two options with similar top predictions.

Future Directions

Generalized design requirements in other domains

Generalized design guidelines after formally compare other uncertainty encodings

Thank you!

Visualizing Uncertainty and Alternatives in Event Sequence Predictions

Shunan Guo[2], *Fan Du*[1], *Sana Malik*[1], *Eunyee Koh*[1], *Sungchul Kim*[1], *Zhicheng Liu*[1], *Donghyun Kim*[1], *Hongyuan Zha*[2], *and Nan Cao*[3]

[1] Adobe

[2] East China Normal University

[3] Tongji University

Key Take-aways

We proposed

An alternative-aware uncertainty visualization for exploring event sequence predictions.

We found

People are more confident in making decisions when alternative predictions are displayed.

They consider the alternatives more when deciding between two options with similar top predictions.

Future Directions

Long-term case study with domain experts

Generalized design guidelines after formally compare other uncertainty encodings