



# Intransitivity in Intertemporal and Risky Choice

Villalobos, E & Bouzas, A.  
Universidad Nacional Autónoma de México

distribuciones  
juegos  
riesgo  
contingencias  
coordinación  
preferencias  
información  
modelos  
tiempo  
swap  
reforzamiento  
evolución  
aprendizaje  
incentivos  
elección  
restricciones  
a justas  
dinámicas  
incertidumbre  
interacción  
Lab25  
comportamiento  
adaptable

## Background

Transitivity refers to choosing A over B, B over C, and A over C. In Intertemporal choice, there is evidence against transitivity, known as *interval effects* (superadditivity and subadditivity) (Scholten et al., 2014). In Risky choice, transitivity is also violated (Tversky, 1969). However, if choice variability and individual differences are considered, people show transitive preferences in both kinds of choices (Regenwetter et al., 2011; Dai, 2016; Cavagnaro & Davis-Stober, 2014).

The existence of transitivity within subjects has not been studied. Therefore, the **purpose** of the present work was to examine whether people show transitive/intransitive patterns in intertemporal and risky choices, considering choice variability and individual differences.

Two models were evaluated: one from the alternative-based choice family (Hyperboloid model) and the other from the attribute-based choice family (Trade-off model). The latter model can account for intransitive patterns, which the alternative-based models cannot accommodate. The models' comparison was done with Bayesian Modeling in order to infer individual parameters.

## Method

### Participants

- 25 participants from the School of Psychology, UNAM.

### Procedure

- Two experimental sessions, one for the time task, and another for the probability task.

*Which alternative do you prefer?*

(TIME)

- 5450 pesos in 3 weeks or 6050 pesos in 7 weeks

(PROBABILITY)

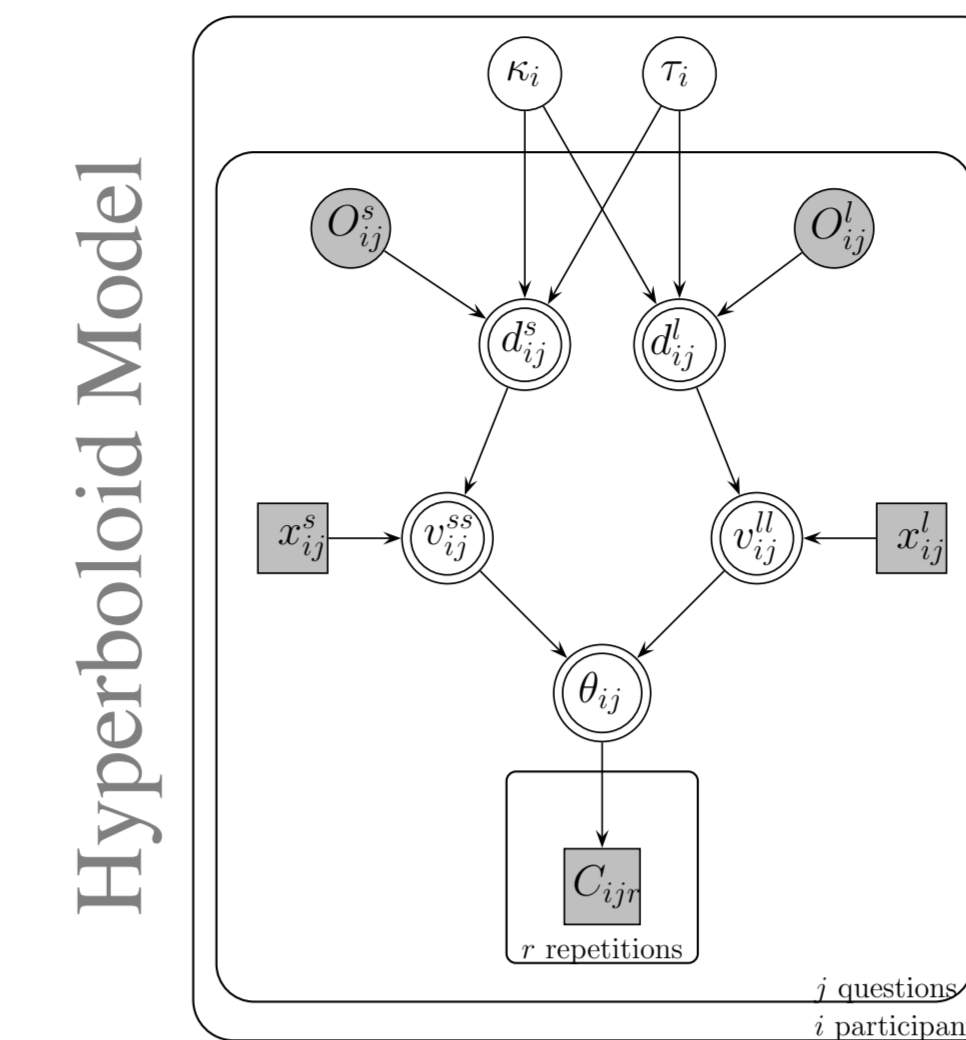
- 5450 pesos with 80% of probability or 6050 pesos with 40% of probability

### Experimental Design

Each task:

- Had 22 questions, repeated 10 times, and presented randomly.
- 4 Sets (6 questions each) (Scholten et al., 2014, 2<sup>nd</sup> Study)
  - Large Outcomes
    1. Short delays / Large probabilities
    2. Long delays / Small probabilities
    3. Long Intervals / Long Intervals
  - Small Outcomes
    4. Long Intervals / Long Intervals

## Models



$$\tau_i, \kappa_i \sim \text{Lognorm}(0, 1)$$

$$d_{ij}^t \leftarrow \frac{1}{(1 + \kappa_i + O_{ij}^t)^{\tau_i}}$$

$$v_{ij}^t \leftarrow d_{ij}^t * x_{ij}^t$$

$$v_{ij}^p \leftarrow d_{ij}^p * x_{ij}^p$$

$$\theta_{ijh} \leftarrow \frac{d_{ij}^h}{v_{ij}^h + v_{ij}^p}$$

$$C_{ijr} \sim \text{Bernoulli}(\theta_{ij})$$

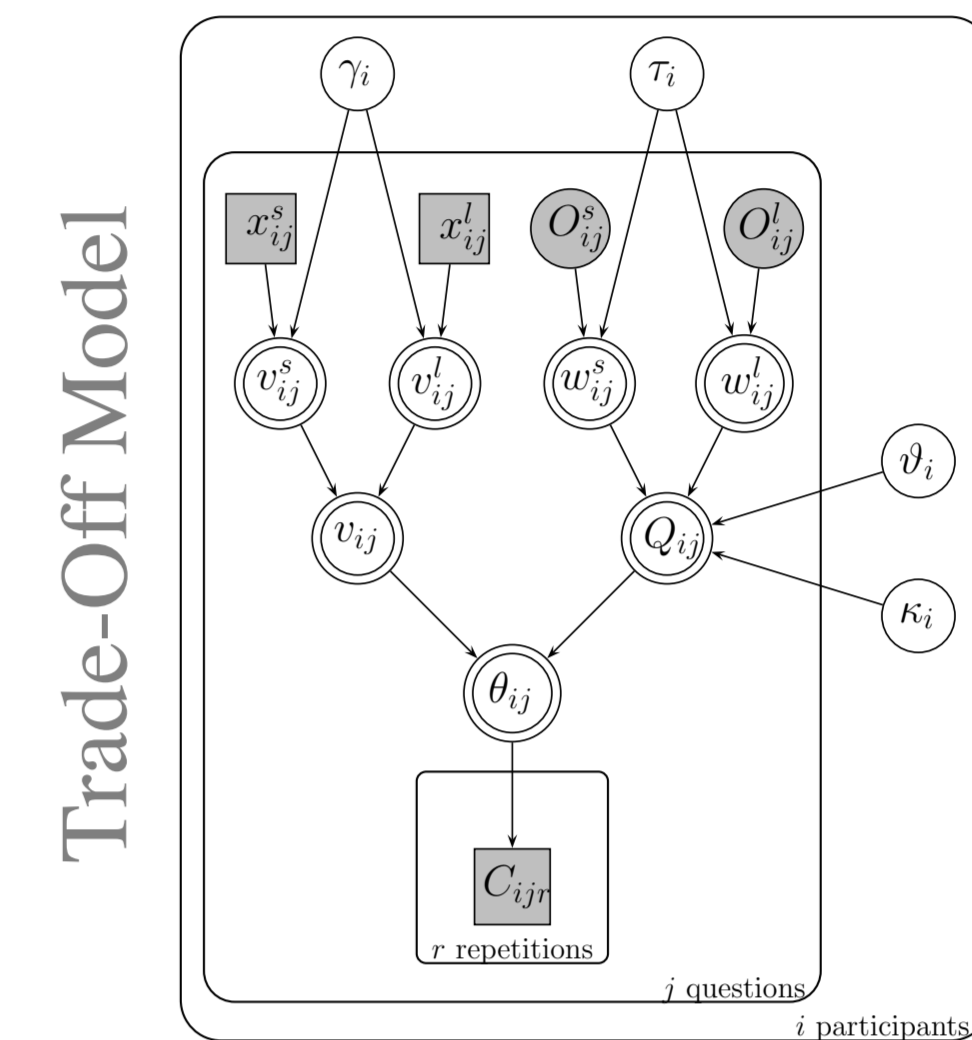
In both models:

TIME

$$O_{ij}^t \leftarrow t_{ij}^t$$

PROBABILITY

$$O_{ij}^p \leftarrow \Omega_{ij}^p \leftarrow \frac{1 - \frac{r_{ij}^p}{P_{ij}}}{P_{ij}}$$



$$\theta_i \sim \text{Lognorm}(1, 1)$$

$$\tau_i, \gamma_i, \kappa_i \sim \text{Lognorm}(0, 1)$$

$$v_{ij}^t \leftarrow \frac{1}{\theta_i} \log(1 + \gamma_i * x_{ij}^t)$$

$$u_{ij}^p \leftarrow \frac{1}{\theta_i} \log(1 + \tau_i * O_{ij}^p)$$

$$Q_{ij} \leftarrow \kappa_i \log \left( 1 + \left( \frac{v_{ij}^t - u_{ij}^p}{u_{ij}^p} \right)^{\theta_i} \right)$$

$$v_{ij} \leftarrow v_{ij}^t - v_{ij}^p$$

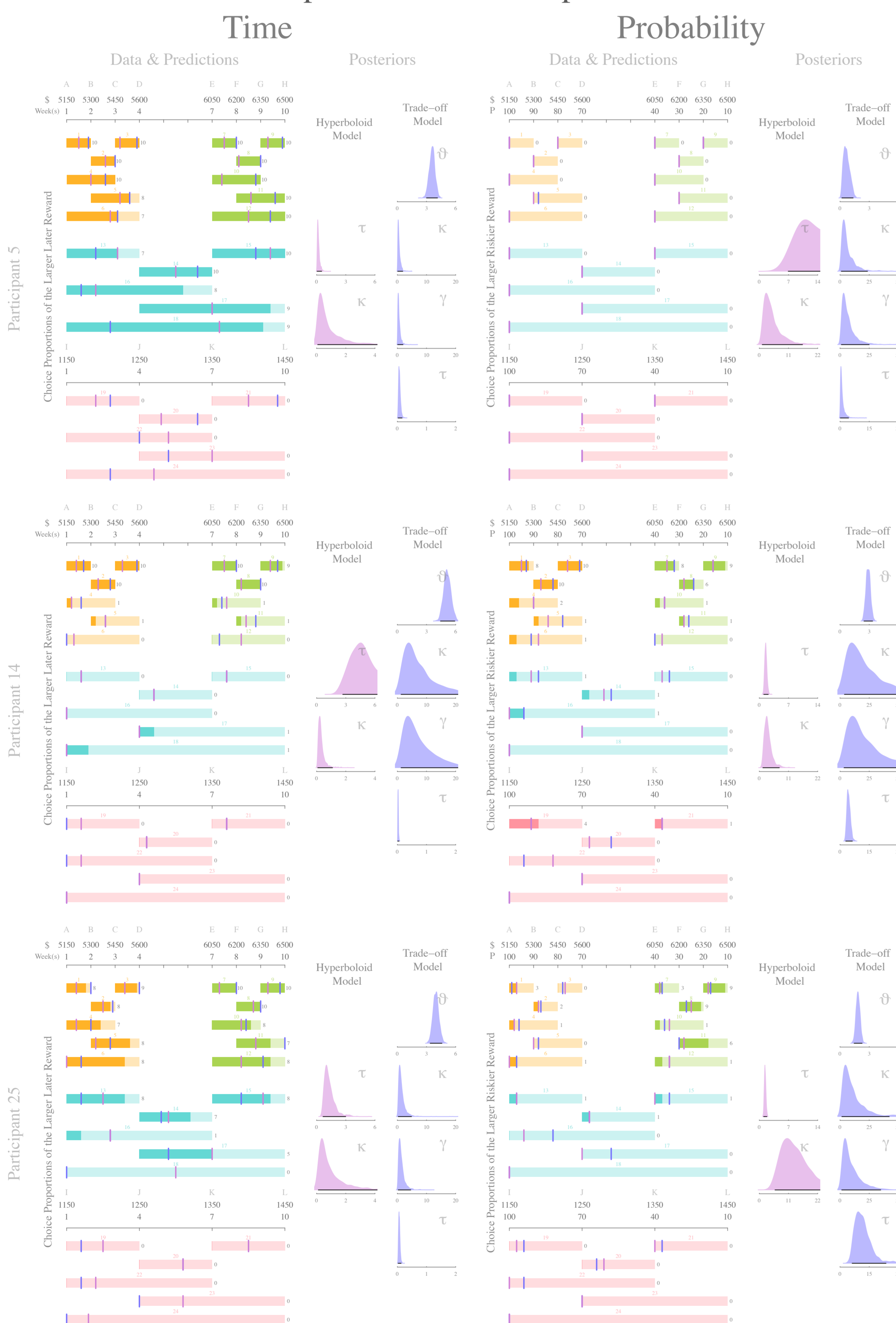
$$\theta_{ijh} \leftarrow \frac{v_{ij}^t}{v_{ij}^t + v_{ij}^p}$$

$$C_{ijr} \sim \text{Bernoulli}(\theta_{ij})$$

Figure 1. The four evaluated models. The Hyperboloid Model for time and probability. The Trade-off Model for time and probability. Notation was adopted from Lee & Wagenmakers (2013).

## Results

### Representative Participants



### Pooled data

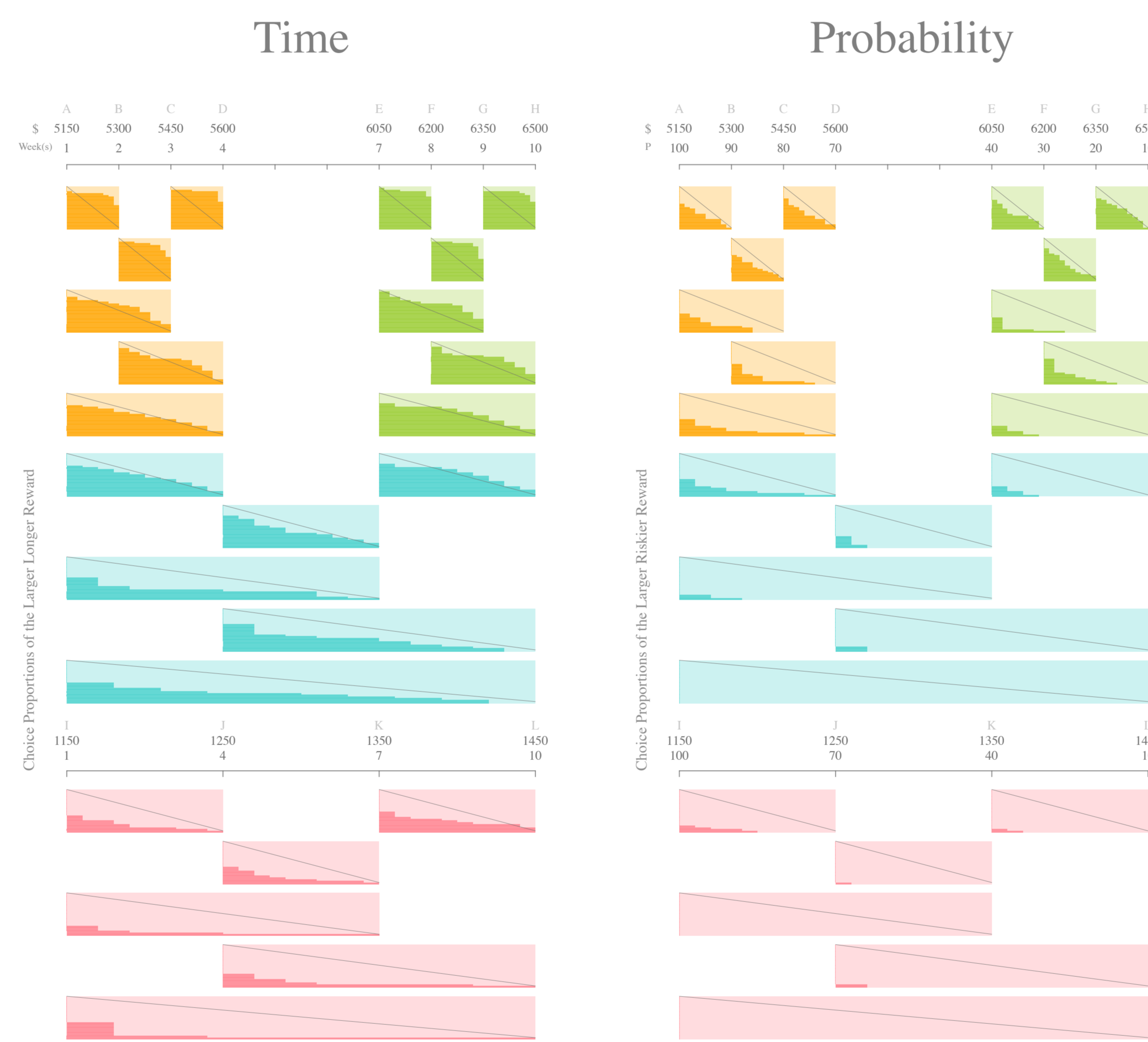


Figure 3. Choice proportions from pooled data, following the structure of Figure 2. Each rectangle has 25 lines, representing the choice proportions for the larger reward (darker color) from all participants. The lines are organized from lowest to highest choice proportion. The left side of the graphic shows the choice proportions for the time task, while the right side shows the choice proportions for the probability task.

## Discussion

The main finding was that most of the sample chose the larger reward in the shortest intervals, and the smaller reward in the longest interval (superadditivity); there was more variability in medium-size intervals. These patterns were found mostly in the time task.

Results were better accounted for by the Trade-off (attribute-based) model than by the Hyperboloid (alternative-based) model. However, the Trade-off Model overpredicted interval effects for Small Outcomes.

Furthermore, participants did not show the same intransitive pattern across both tasks.

### Predictions for pooled data

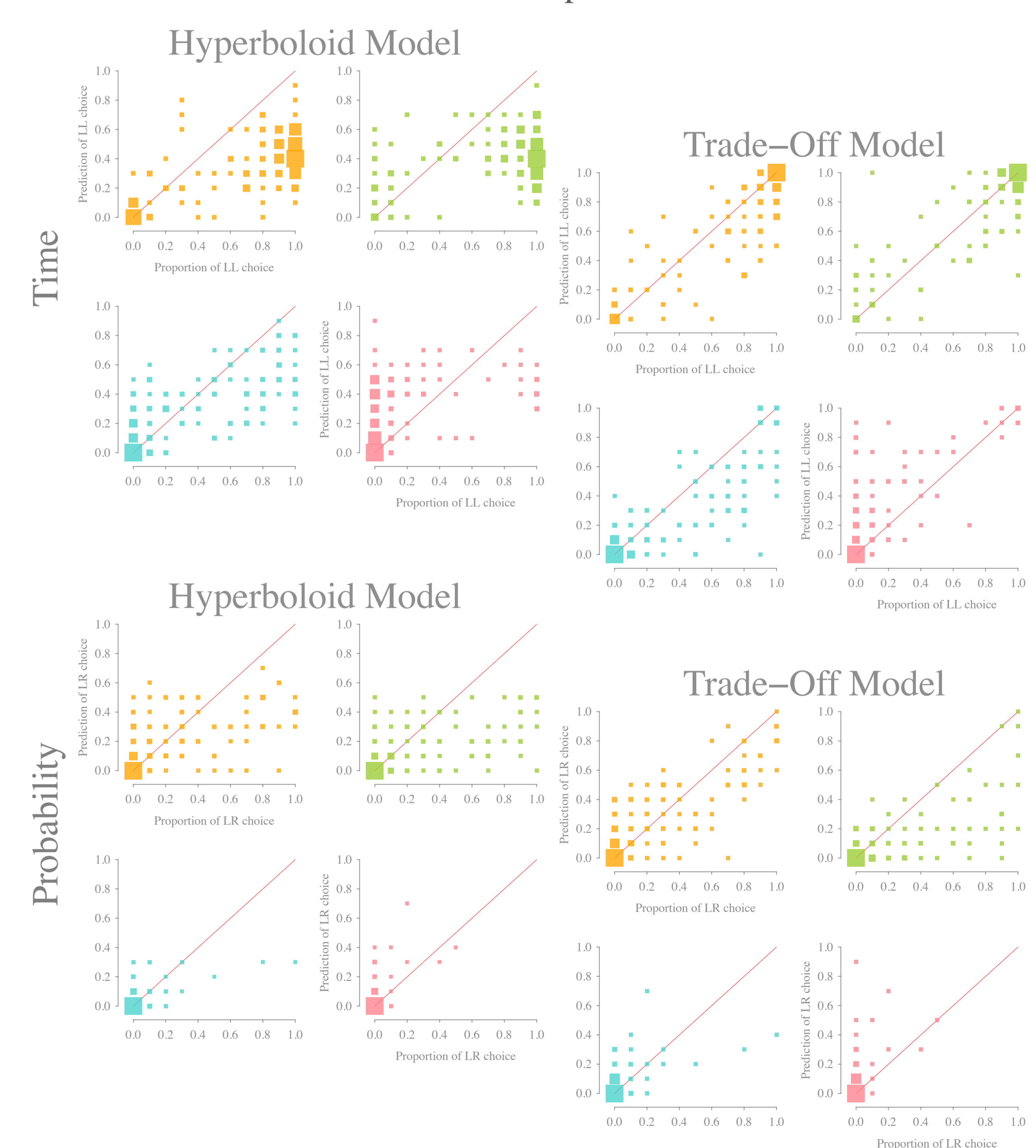


Figure 4. Predictions of choice proportions for all participants for each model, ordered by sets/colors. The X-axis shows the choice proportions of the larger reward, while the Y-axis presents the prediction of choice proportions from each model. The squares show the number of choice proportions and predictions.

## Contact information and acknowledgements

Elena Villalobos: [villalobos14@gmail.com](mailto:villalobos14@gmail.com)  
<https://sites.google.com/site/adaptabilidad25/>  
Supported by PAPIIT IN307214 and PAPIIME PE310016



## References

- Cavagnaro, D. R & Davis-Stober, P. C. (2014). Transitive in Our Preferences, But Transitive in Different ways: An Analysis of Choice Variability. *Decision*, 1(2), 102-122.
- Dai, J. (2016). Are Intertemporal Preferences Transitive? A Bayesian Analysis of Repeated Individual Intertemporal Choices. *Decision*, 1, 1-4.
- Lee, M.D. & Wagenmakers, E.J. (2013). *Bayesian Cognitive Modeling: A Practical Course*. United Kingdom: Cambridge University Press.
- Regenwetter, M., Jason, D & Davis-Stober, C. P. (2011). Transitivity of Preferences. *Psychological Review*, 188(1), 42-56.
- Scholten, M., Read, D & Sanborn, A. (2014) Weighing Outcomes by Time or Against Time? Evaluation Rules in Intertemporal Choice. *Cognitive Science*, 38(3), 399-438.
- Tversky, A. (1969). Intransitivity of Preferences. *Psychological Review*, 76, 31-48.

Figure 2. For each participant (one per row) there are two graphics, time and probability. In each graphic, there are 24 bars (6 by set/color). Each bar represents a question, the leftmost end indicates the smaller reward, and the rightmost end the larger reward; alternatives are indicated in the superior axis. The darkness of the bar represents the participant's choice proportion of the larger reward. For example, if the participant opted for the larger reward 8 times, the proportion of the bar is darker 8/10. Furthermore, in each bar there are two vertical lines, the pink one represents the prediction from the Hyperboloid model while the purple one represents the prediction from the Trade-off model. The right panel shows the posterior densities from each model.