Heuristic Models Outperform Traditional Discounting Utility Models Across Multiple Discounting and Reward Domains

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Background

Heuristic models outperform traditional utility discounting models for intertemporal choice tasks[1]. The Intertemporal Choice Heuristics Model (ITCH) model, for example, relies on four psychological principles instead of making assumptions about the existence of a discount function.

1) Options are compared to reference points (Kahneman & Tversky 1979)
2) Comparisons are performed by relative (division) and absolute (subtraction) terms (Thurstone 1927)
3) Comparisons are independent for monetary and time dimensions (Lichtenstein & Slovic 1927)
4) Comparison results are aggregated linearly using a set of decision weights (Busemeyer & Townsend 1993)

To evaluate domain generality, we examined how well the ITCH model predicted choice behavior on temporal, probability, and physical effort discounting tasks for social, health, and monetary rewards.

[1] Marzilli Ericson, K. M., White, J. M., Laibson, D., & Cohen, J. D. (2015). Money earlier or later? Simple heuristics explain intertemporal choices better than delay discounting does. *Psychological science*, *26*(6), 826-833.

Methods

98 healthy participants, ages 22-83 (mean 50, SD=18, 59.1% F) completed nine runs of hypothetical discounting tasks. We conducted an out-of-sample, cross-validation comparison of the ITCH model and three standard utility discounting models (exponential, hyperbolic, and quasi-hyperbolic) for each task.

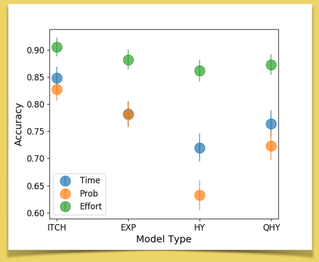
The choice between smaller sooner rewards (x1, t1) and larger later rewards (x2, t2) was formalized as:

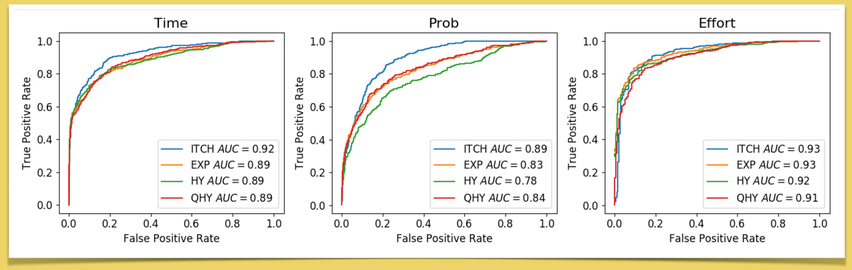
$$P(LL) = L(\beta_I + \beta_{xA}(x_2 - x_1) + \beta_{xR}\frac{x_2 - x_1}{x^*} + \beta_{tA}(t_2 - t_1) + \beta_{tR}\frac{t_2 - t_1}{t^*})$$

where, β_I is the intercept, β_{xA} is the weighting of the reward absolute heuristic, β_{xR} is the weighting of the reward relative heuristic, β_{tA} is the weighting of the time absolute heuristic, and β_{tR} is the weighting of the time relative heuristic.

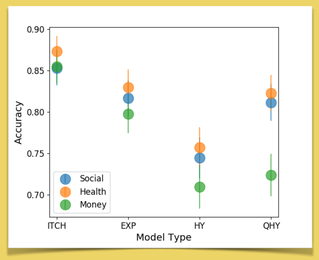
Results

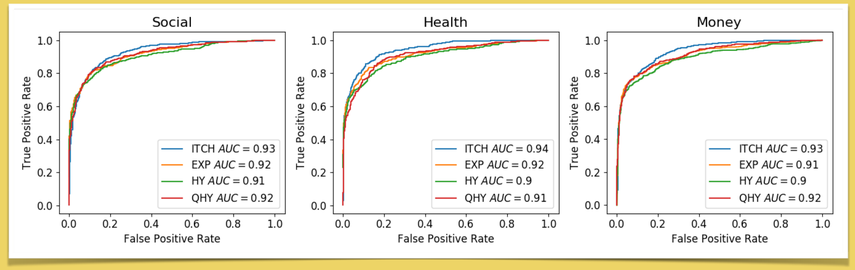
Discount Type





Reward Type





The ITCH model had higher predictive accuracy and the highest AUC across all discount and reward types.

Conclusions

The ITCH model out-performed standard utility discounting models across all task conditions suggesting that **heuristics may better account for human choice behavior across a wide variety of decision tasks and reward domains.** Ongoing analyses are examining age and other individual difference effects.

GitHub Repository

This work introduces a framework for easily creating Bayesian discounting and utility models, which can be fit using a variety of GPU accelerated gradient and non-gradient optimization methods from PyMC3.

https://github.com/mhamilton723/bayesian-psych

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