Feedback Promotes Learning and Knowledge of the Distribution of Values Hinders Exploration in an Optimal Stopping Task

Erin H. Bugbee and Cleotilde Gonzalez
{ebugbee, coty}@cmu.edu
Department of Social and Decision Sciences, Carnegie Mellon University

Summary

In many naturalistic situations such as deciding on an apartment to rent or selecting a life partner, people explore options before making a selection. We investigate the following:

- How do **feedback** and **knowledge of the distribution of option values** affect **learning** in sequential search?
- How do people **deviate from optimal** based on these factors, and can this be modeled with a **cognitive model** of decisions from experience?

Introduction

- Previous work indicates that people are suboptimal at stopping exploration and often stop earlier than optimal [1, 5]
- People may learn to stop at the optimal point with experience [3]
- We investigate factors that may influence learning in stopping decisions and extend our previous modeling work [2] to this task

Methods

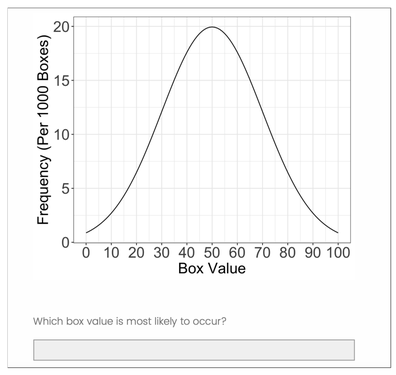
Human Participants

- *Participants*: 2526 from Amazon MTurk
- *Design*: Between-subjects
- *Conditions*: 2 (Knowledge of the Distribution: Known or Unknown) x 3 (Feedback: Outcome, Detailed, or No Feedback)

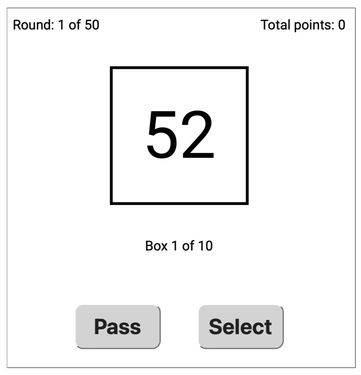
Model Agents

- Simulate 256 IBL model and optimal agents

Optimal Stopping Task



(a) Known Distribution Condition



(b) Choice

Feedback Conditions

- **Outcome Feedback**:
  Your choice was [**Correct**/**Wrong**]. You chose **Box** [**Number**] with a value of [**Value**].
- **Detailed Feedback**:
  Your choice was [**Correct**/**Wrong**]. You chose **Box** [**Number**] with a value of [**Value**]. The maximum value box was **Box** [**Number**] with a value of [**Value**].
- **No Feedback**:
  You chose **Box** [**Number**] with a value of [**Value**].

Cognitive Model: Instance-Based Learning Model

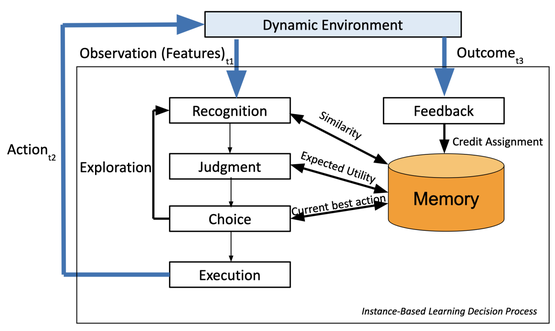


Figure 2: Instance-Based Learning Theory [4]

- Learning occurs through the accumulation of memory units called *instances*
- Past instances are *retrieved* based on *similarity* to the current situation, frequency, and recency
- A *blended value* (BV) is calculated based on the *utility* of retrieved instances
- The agent *chooses* option with the highest BV

State		Action	Utility
Value	Boxes Remaining	{Select, Pass}	{0, 1}

Table 1: Instance Structure

Results

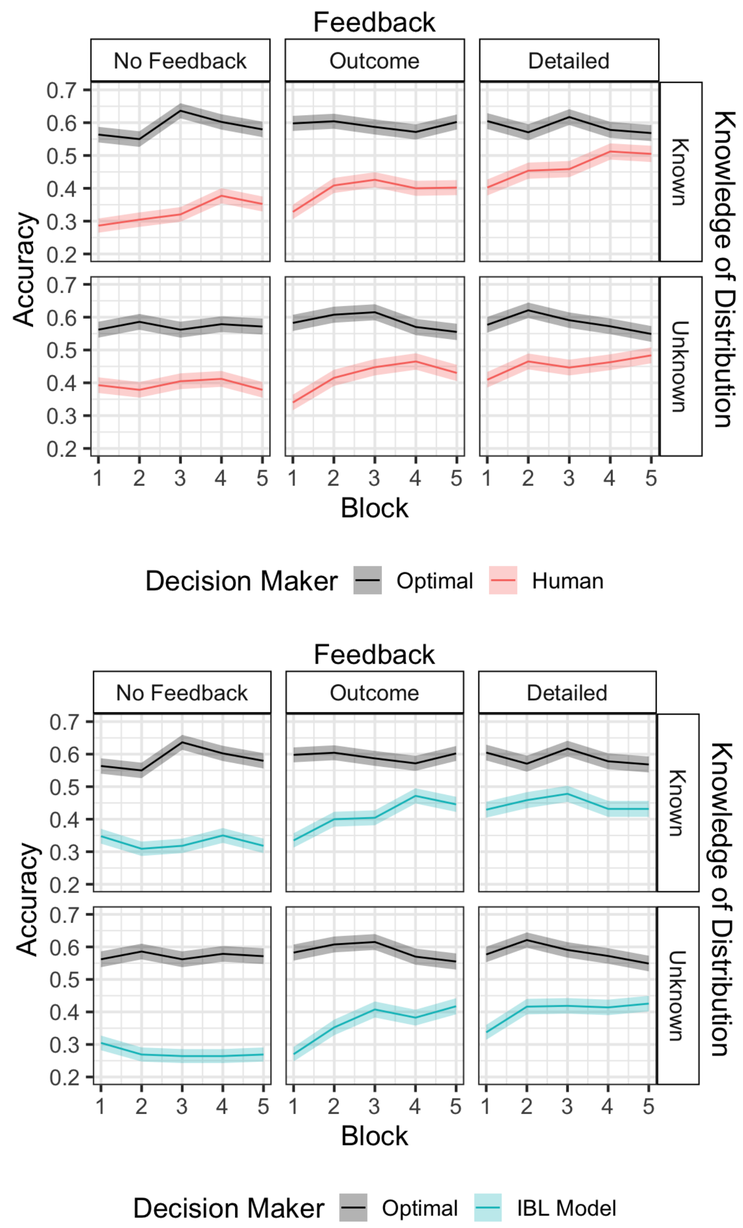


Figure 3: Accuracy for Human Participants (top, red), IBL Agents (bottom, blue), and Optimal Agents (both, black) over Blocks of 10 Problems

Conclusion

Key Findings:

- **Feedback Promotes Learning**: Participants in the feedback conditions stopped closer to the optimal position and earned greater rewards.
- **Knowledge of Distribution Hinders Exploration**: Participants with distribution knowledge were less exploratory and stopped earlier than those without this knowledge.
- **Model Predictive Accuracy**: The IBL model accurately predicted human stopping behavior across conditions.

Future Work:

- Investigate additional factors (variability of sequence length, crowd decisions)

Future Work: Investigate additional factors (variability of sequence length, crowd decisions)

References

[1] Christiane Baumann, Henrik Singmann, Samuel J. Gershman, and Bettina von Helversen. A linear threshold model for optimal stopping behavior. *Proceedings of the National Academy of Sciences*, 117(23):12750–12755, June 2020.

[2] Erin H. Bugbee and Cleotilde Gonzalez. Deciding When to Stop: Cognitive Models of Sequential Decisions in Optimal Stopping Tasks. 2022. Publisher: Carnegie Mellon University. Under review.

[3] Daniel G. Goldstein, R. Preston McAfee, Siddharth Suri, and James R. Wright. Learning When to Stop Searching. *Management Science*, 66(3):1375–1394, March 2020.

[4] Cleotilde Gonzalez, Javier F. Lerch, and Christian Lebiere. Instance-based learning in dynamic decision making. *Cognitive Science*, 27, 2003.

[5] Maime Guan, Ryan Stokes, Joachim Vandekerckhove, and Michael D. Lee. A cognitive modeling analysis of risk in sequential choice tasks. *Judgment and Decision Making*, 15(5):823–850, September 2020.

Additional Information

- **Lab Website:** cmu.edu/ddmlab
- **Personal Website:** erinbugbee.com
- **For Materials, Paper, Poster:** Scan QR code