

A Rational Information Gathering Account of Infant Exploratory Behavior

Background

Most research on infant cognition uses gaze as the dependent variable. In a classic phenomenological model, Hunter and Ames (1988) suggest that **novelty preference follows a U-shaped dynamics** for a stimulus with exposure: moderately novel stimuli are preferred to more or less familiar ones. On a statistical account, this is puzzling: why should the value of information gathering **not** decline monotonically as a stimulus is sampled?

Proposed model

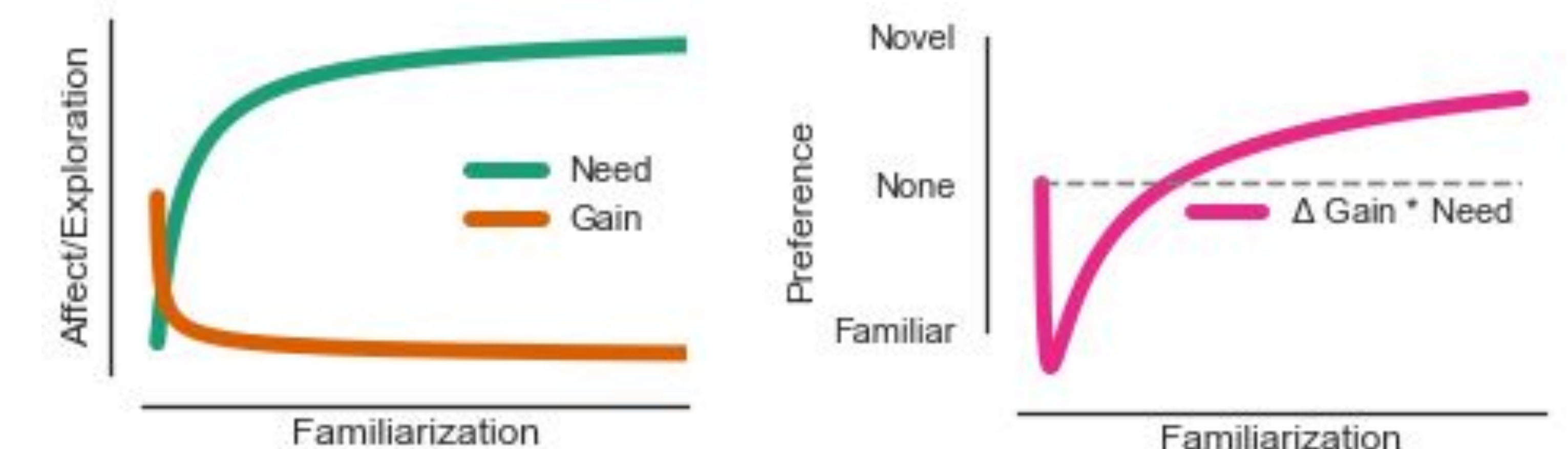
In other settings, Mattar & Daw (2018) and Agrawal et al. (2021) proposed that the expected value of exploration or planning can be decomposed into the product of two terms, which they called **Gain** and **Need**.

- **Gain** reflects the **additional reward** due to exploration producing better decisions at the explored state.
- The value of exploration also depends on **Need**, i.e. expected **future occupancy** of the explored state.
- **Gain** (e.g. UCB margin) decreases with exposures, but **Need** increases, e.g. for IID multinomial encounters

$$Gain_i = \frac{k}{\sqrt{n}}, \quad Need_i = \frac{1}{1+\gamma} \times \frac{N_i}{N_0 + N_i + \alpha}$$

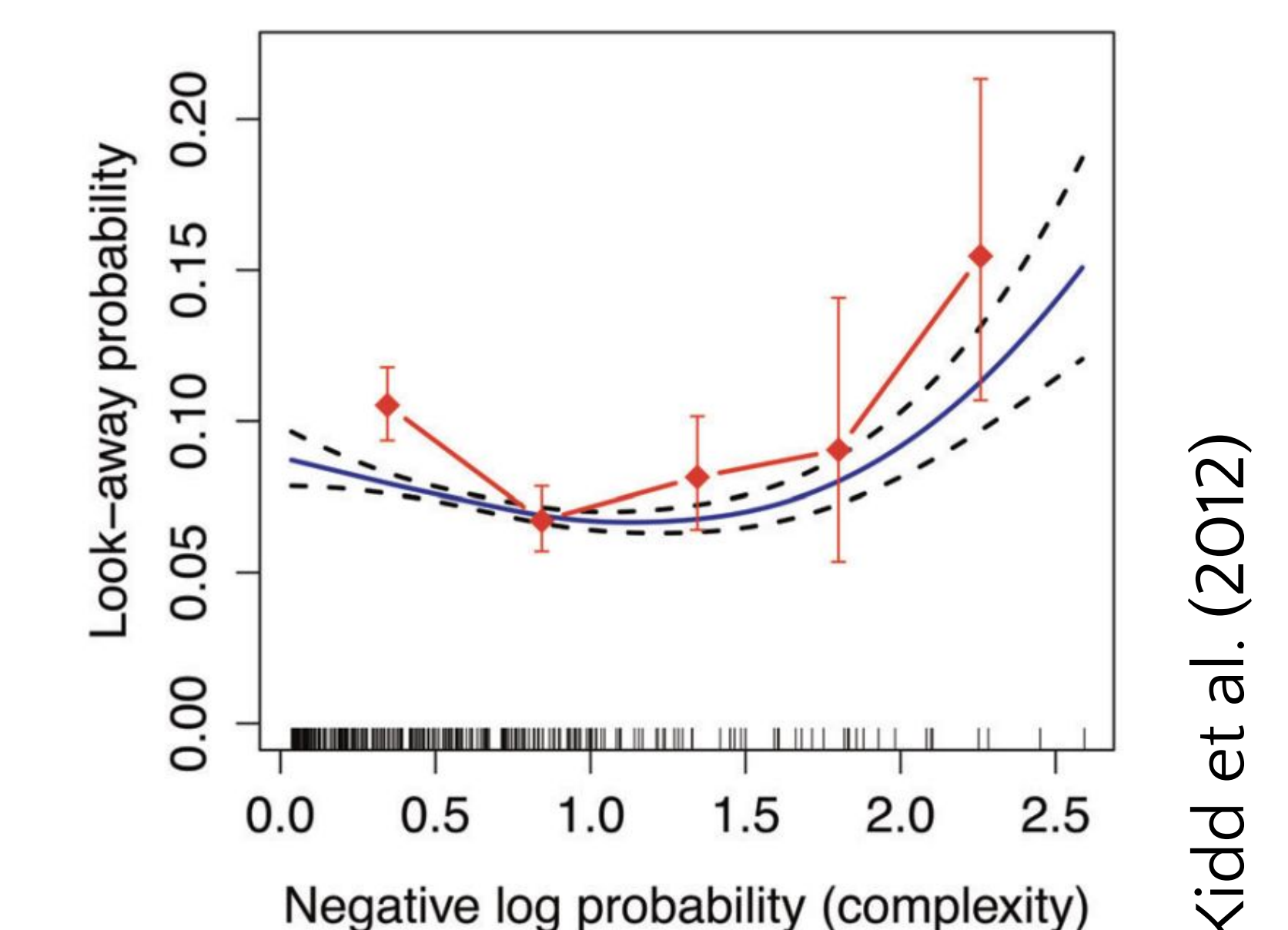
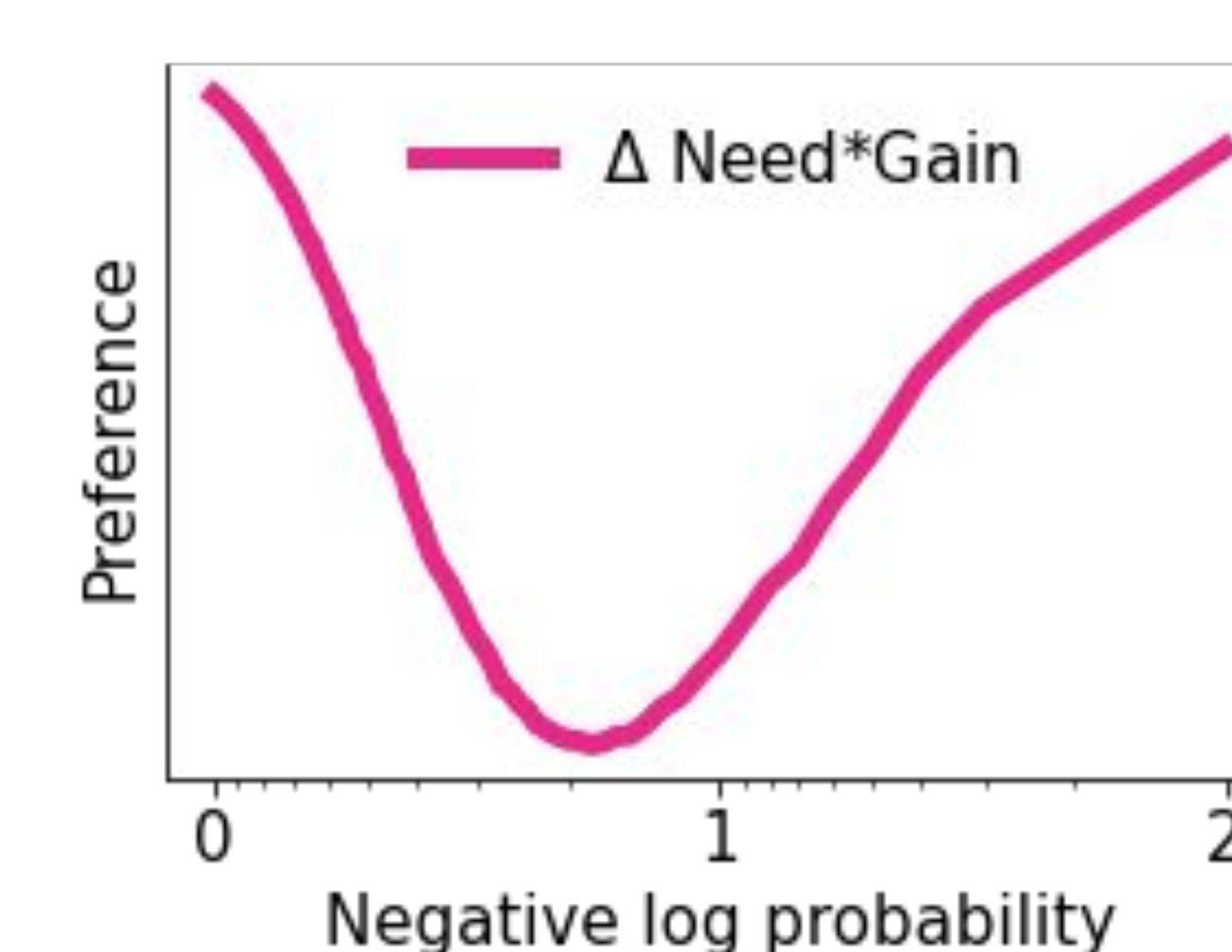
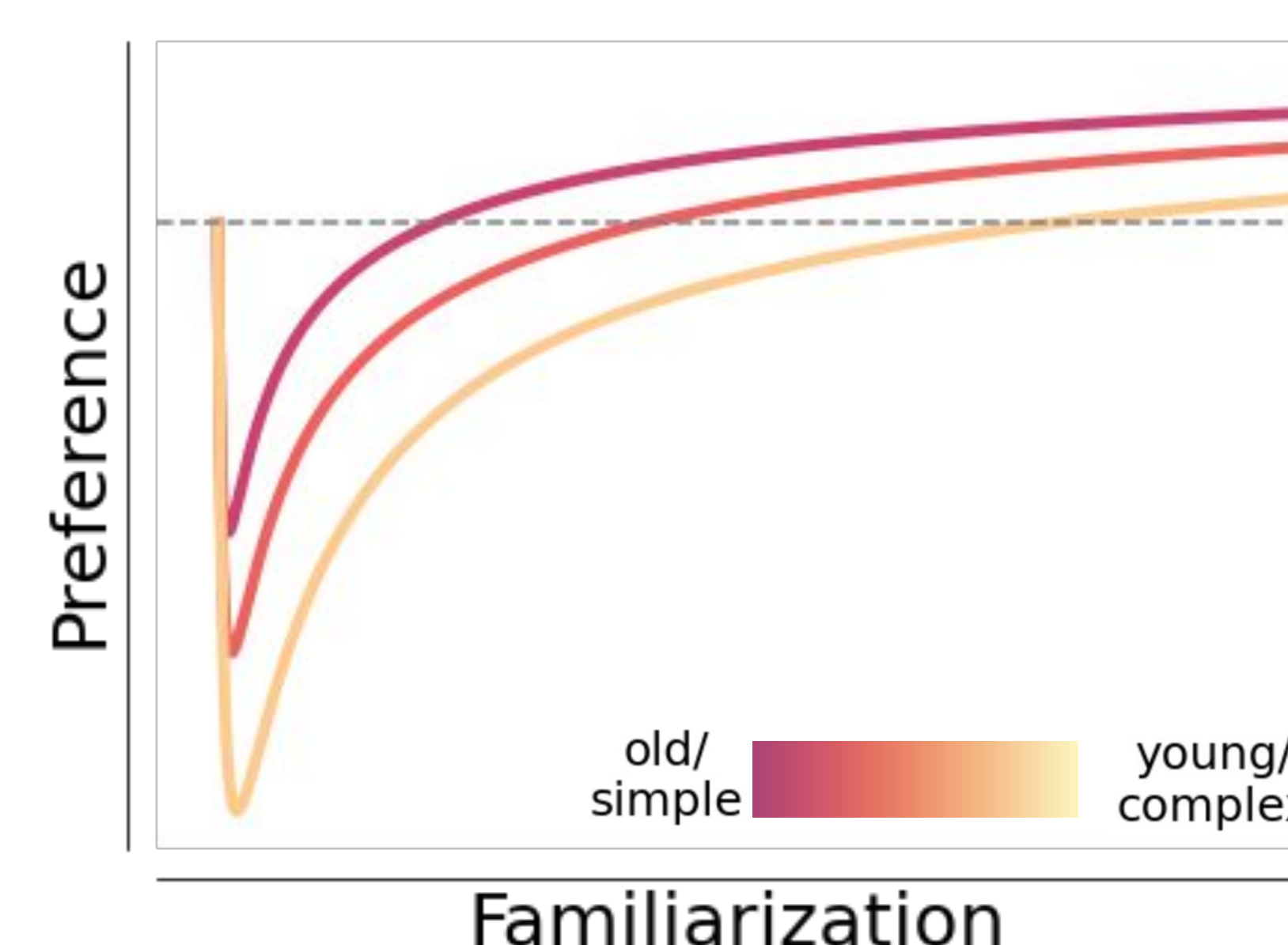
Here, their product, relative to a standard, rationalizes a nonmonotonic **Novelty Preference**:

$$V_0 - Gain \times Need$$



Results

- (1) The proposed decomposition grounds gaze in concrete, manipulable parameters whose variation may also underlie how preference dynamics change (per Hunter & Ames) with factors like age and stimulus complexity
- (2) The model replicates Kidd et al. (2012) data demonstrating nonmonotonic gaze with stimulus encounter rate



Kidd et al. (2012)

Conclusion

This work offers a new formal connection between infant gaze and other cases of exploration, and new interpretations and testable predictions about the factors that impact infants' exploratory attention.

