

Credit Where It's Due:

Behavioral Patterns & Computational Models of Credit Assignment in Aging

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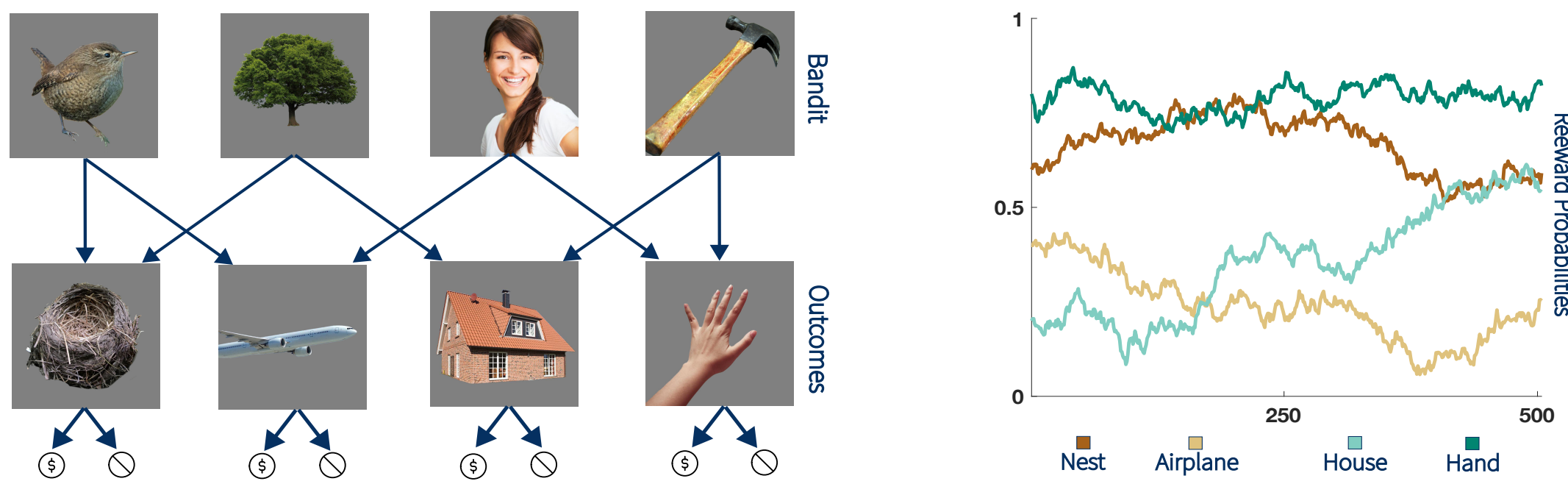


Background

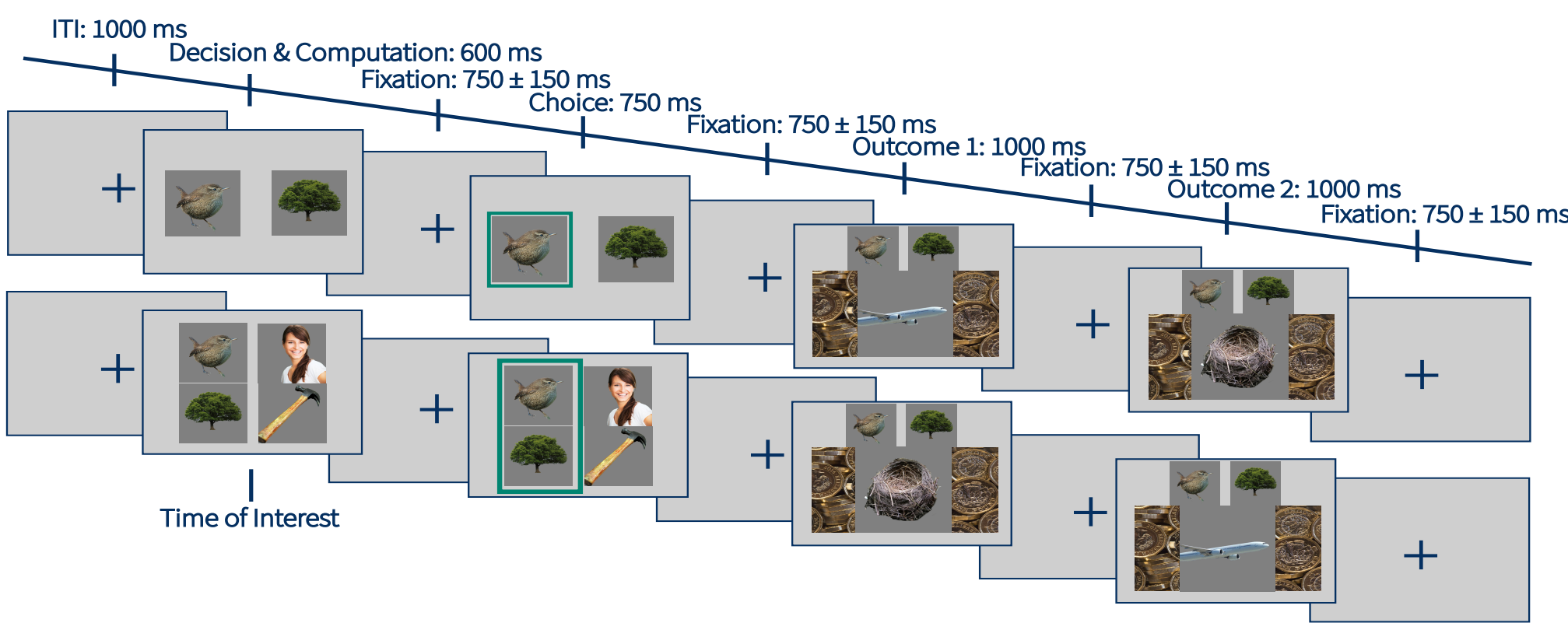
- Younger adults flexibly integrate model-free (MF) and model-based (MB) strategies to assign credit and guide decisions – even in situations with uncertainty (Moran et al., 2019).
- Older adults tend to rely more heavily on model-free learning (Ruel et al., 2023). However, it remains unclear whether and how they engage MF, MB, or intermediate strategies when faced with uncertainty.
- This study investigated how the use and interaction of these learning strategies shift with aging.

Experimental Design

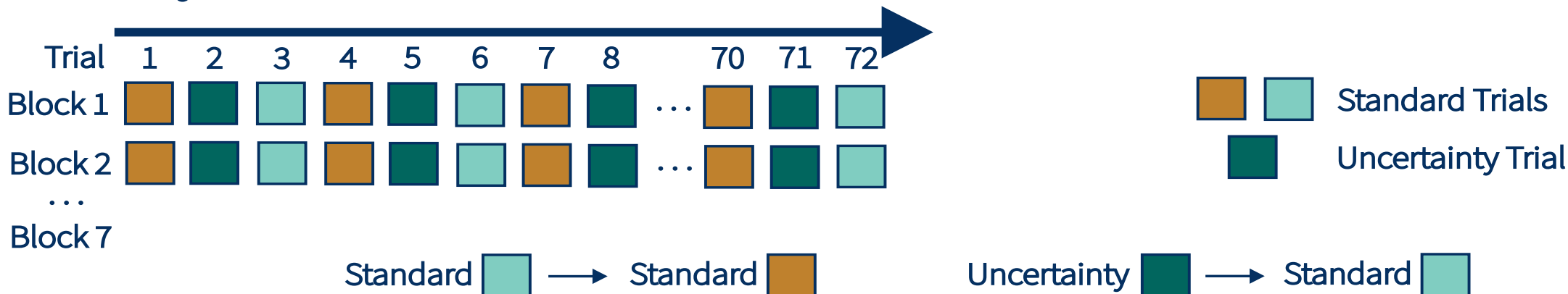
- **Transition Structure:** One bandit leads to two fixed outcomes
- **Reward Probabilities:** Drifted as independent Gaussian random walks



- **Dual-Bandit Task:** Two trial types interleaved
 - **Standard trials:** Choose between two individual bandits
 - **Uncertainty trials:** Choose between two pairs of bandits - one from the selected pair is chosen randomly by a "glitch"

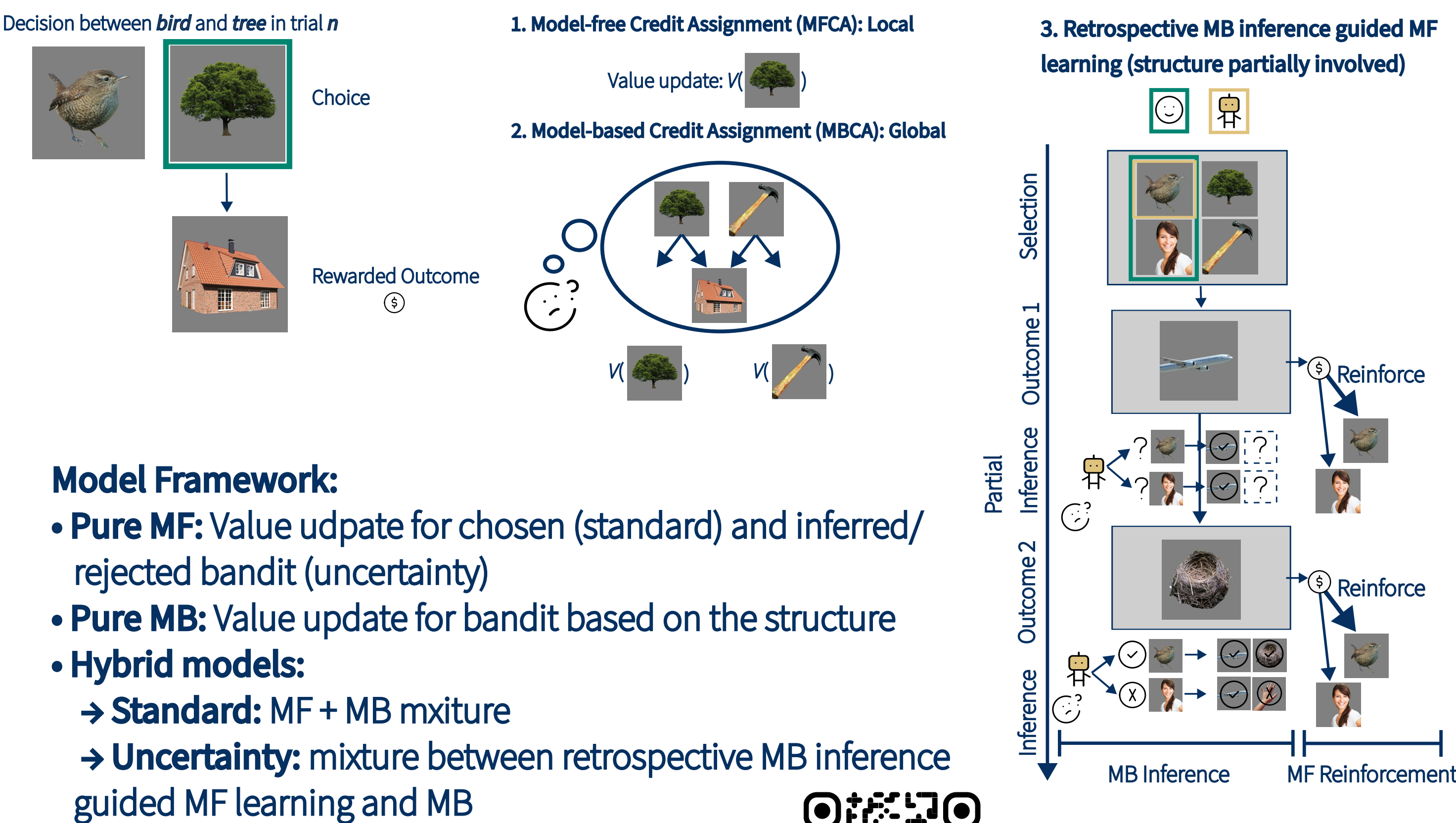


- **Trial Structure:**
 - **Standard → Standard:** Dissociation between MF and MB learning (control)
 - **Uncertainty → Standard:** Interplay between different strategies when uncertainty involved

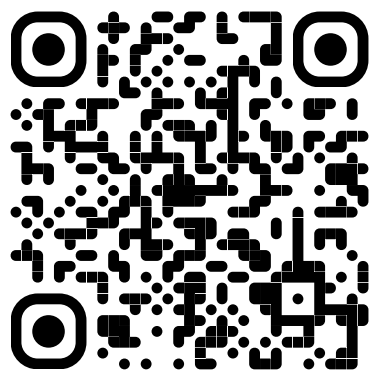


Model Specification

- **Three Strategies for Credit Assignment:**
 1. **MF credit assignment (MFCA):** assign reward to chosen bandit only
 2. **MBCA:** full task structure is used to generalize reward to related bandits (chosen and unchosen)
 3. **Retrospective MB inference MF learning:** resolve uncertainty using partial task structure and update bandit value in a MF way



- **Model Framework:**
 - **Pure MF:** Value update for chosen (standard) and inferred/rejected bandit (uncertainty)
 - **Pure MB:** Value update for bandit based on the structure
 - **Hybrid models:**
 - **Standard:** MF + MB mixture
 - **Uncertainty:** mixture between retrospective MB inference guided MF learning and MB



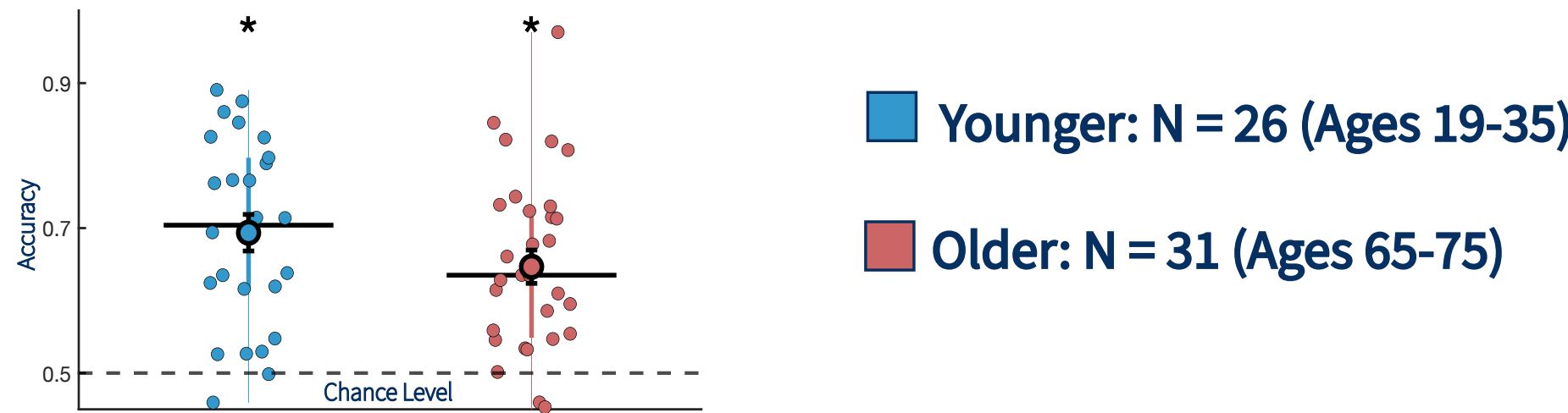
References: Moran, R., Keramati, M., Dayan, P., & Dolan, R. J. (2019). Retrospective model-based inference guides model-free credit assignment. *Nature Communications*, 10(1), 750. <https://doi.org/10.1038/s41467-019-08662-8>
Ruel, A., Bolenz, F., Li, S.-C., Fischer, A., & Eppinger, B. (2023). Neural evidence for age-related deficits in the representation of state spaces. *Cerebral Cortex*, 33(5), 1768–1781. <https://doi.org/10.1093/cercor/bhac171>

Highlights

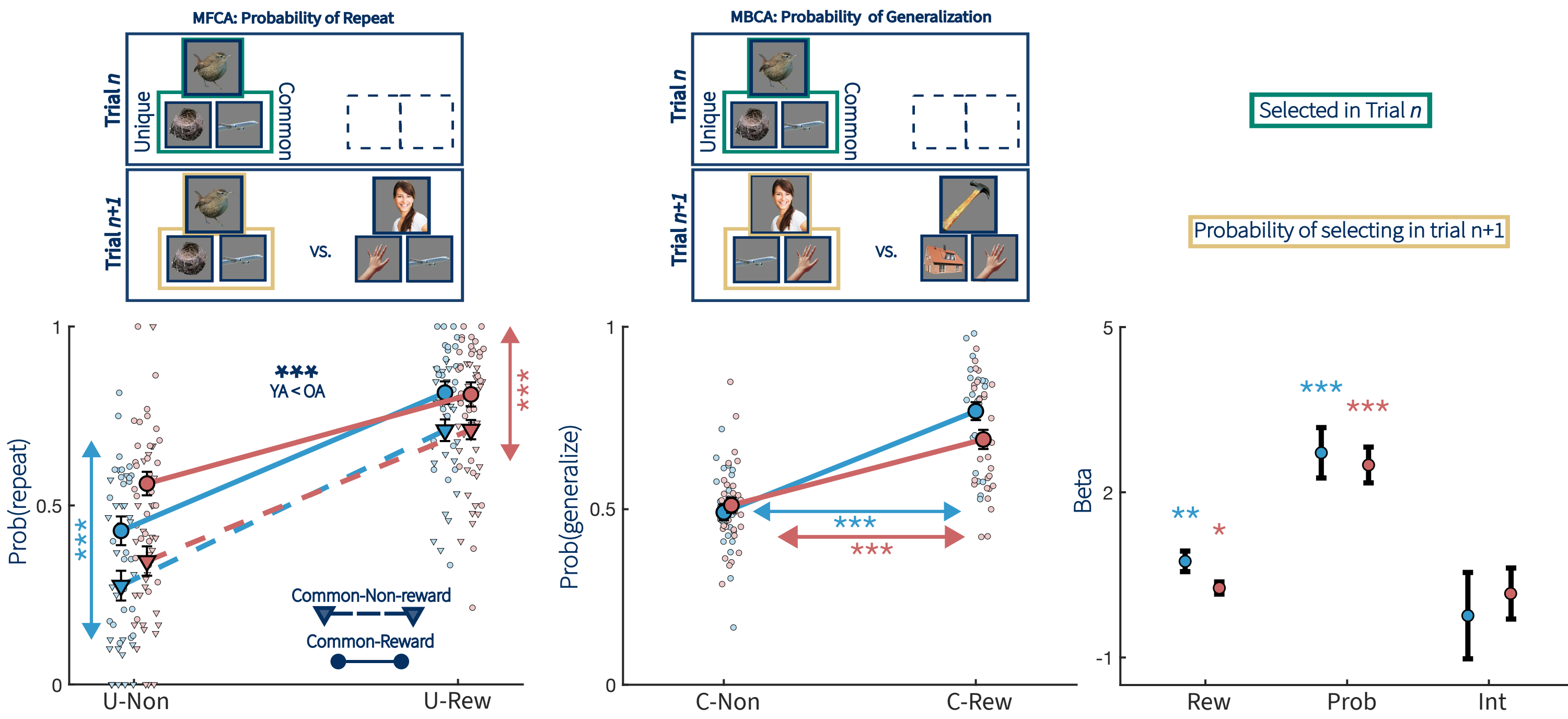
- Older and younger adults achieved comparable accuracy in the dual-bandit task by relying on a similar mixture of learning strategies, which can be behaviorally dissociated.
- Both age groups showed similar model-based (MB) learning rates.
- Older adults were able to engage in retrospective model-based inference-guided model-free learning under uncertainty, but with a reduced learning rate compared to younger adults.

Behavioral Results

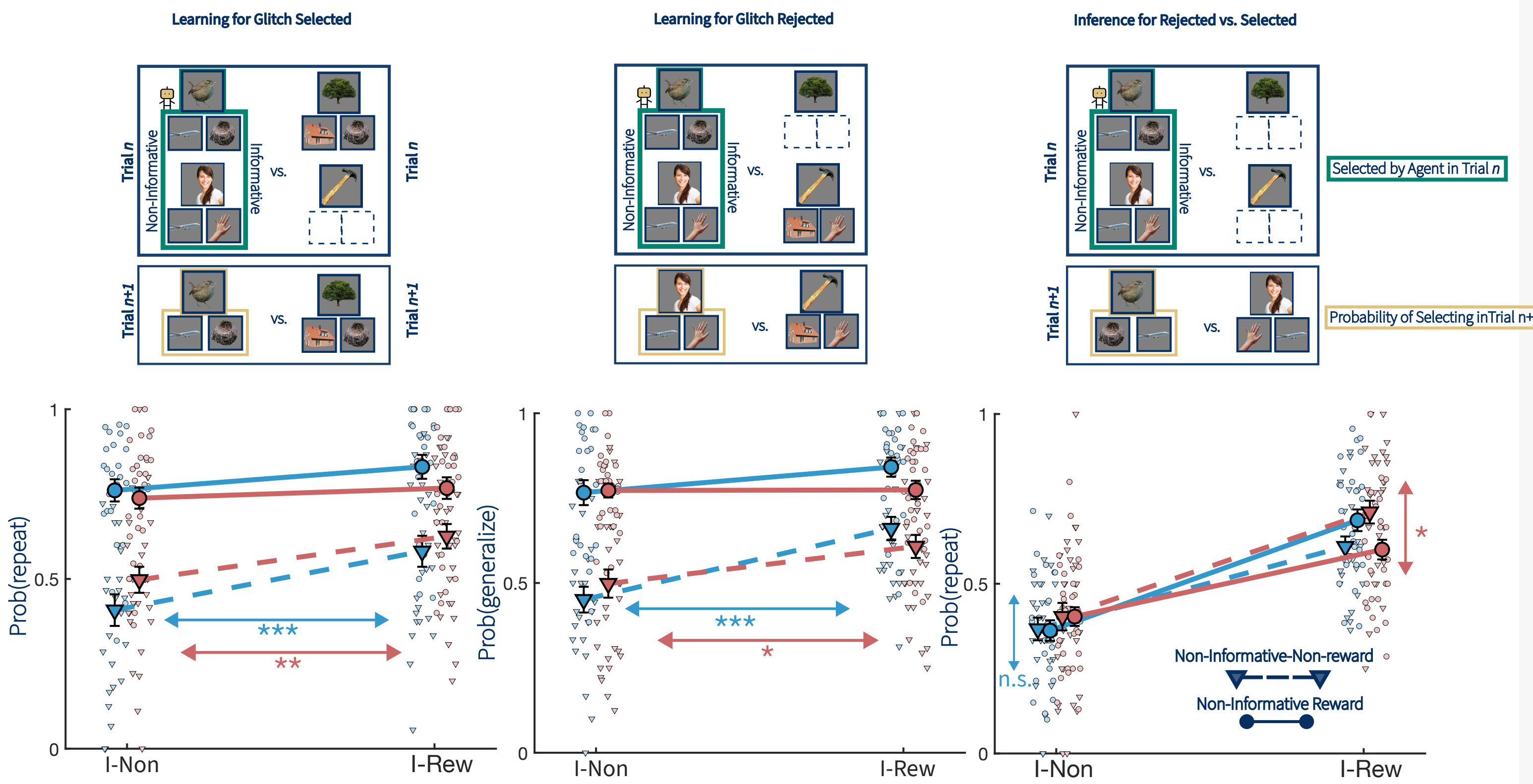
- **Task Feasibility:** Participants performed well above chance.



- In Standard → Standard trial sequences (□→□), both groups engage in model-free (MFCA), and model-based credit assignment (MBCA). However, younger adults rely less on MFCA and more on MBCA compared to older adults.



- In Uncertainty → Standard trial sequences (■→□), both age groups engage in retrospective MB inference guided MF learning and MB learning. Older adults exhibit a weaker lose-stay pattern toward the inferred bandit.



Model Comparison & Prediction

- Hybrid models best captured participants' behavior in both age groups. Older adults exhibited a reduced learning rate when they engaged in retrospective MB inference-guided MF learning. In contrast, their MB learning rate didn't differ significantly from that of younger adults.

