Adaptive Enemy Behavior through Reinforcement Learning

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Introduction

- Rule-based and hardcoded patterns can lead to a decrease in engagement.
- Reinforcement Learning opens the gate for interesting strategies and combat encounters.
- Evaluation of player experience, combat behavior and fairness between Reinforcement Learning and Behavior Trees.

Figure 1: In-game combat showcase of the enemy in Shattered Bonds

Methods

- Experimental Design: Developed two variants (RL vs. BT) of a new enemy sharing an identical, diverse skill set.
- RL Architecture: Proximal Policy Optimization (PPO) implemented via the UE5 Learning Agents Plugin
- Manager: Coordinates the core training pipeline
- Interactor: Processes environmental observations and executes actions.
- Environment: Computes the reward function and manages episode resets.
- Gameplay Ability System: Used for creating combat abilities and buffs

Results & Discussion

- A blinded crossover study was conducted with 44 participants.
- Player Engagement: Overwhelming preference for the RL agent, p-value of 0.0001.
- The perceived unpredictability of the RL agent was higher compared to the Behavior Tree with a p-value of 0.0056, while both maintained a very similar fairness rating with a p-value of 0.93

The results indicate a positive direction towards using a Reinforcement Learning enemy to create unpredictable yet fair encounters that hold more engagement.

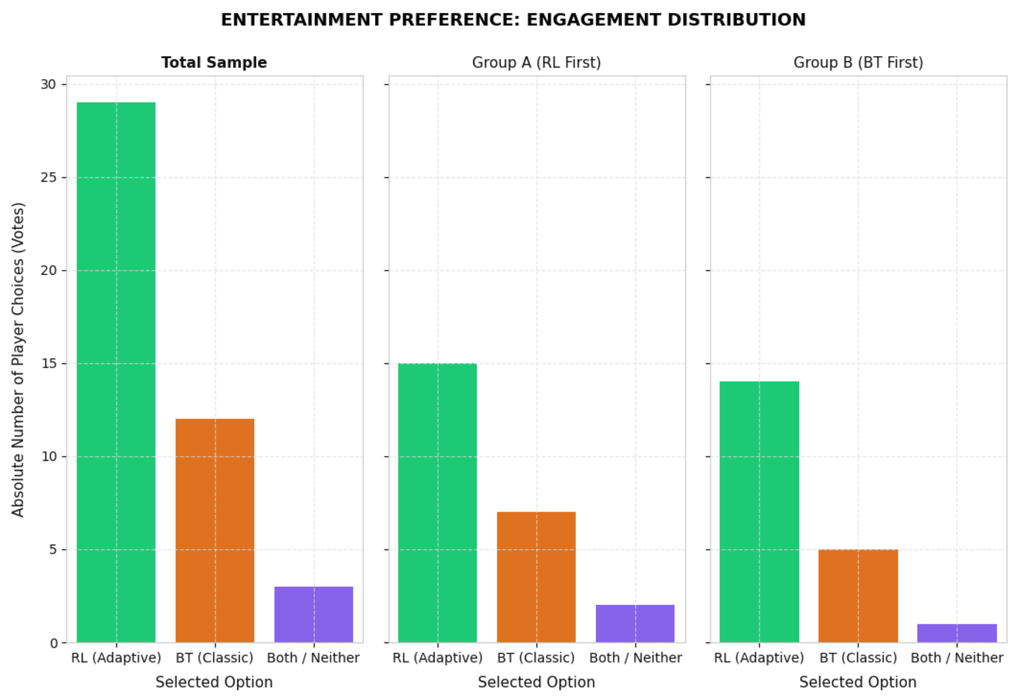

Figure 2: Participant preference regarding combat engagement and entertainment between AI configurations

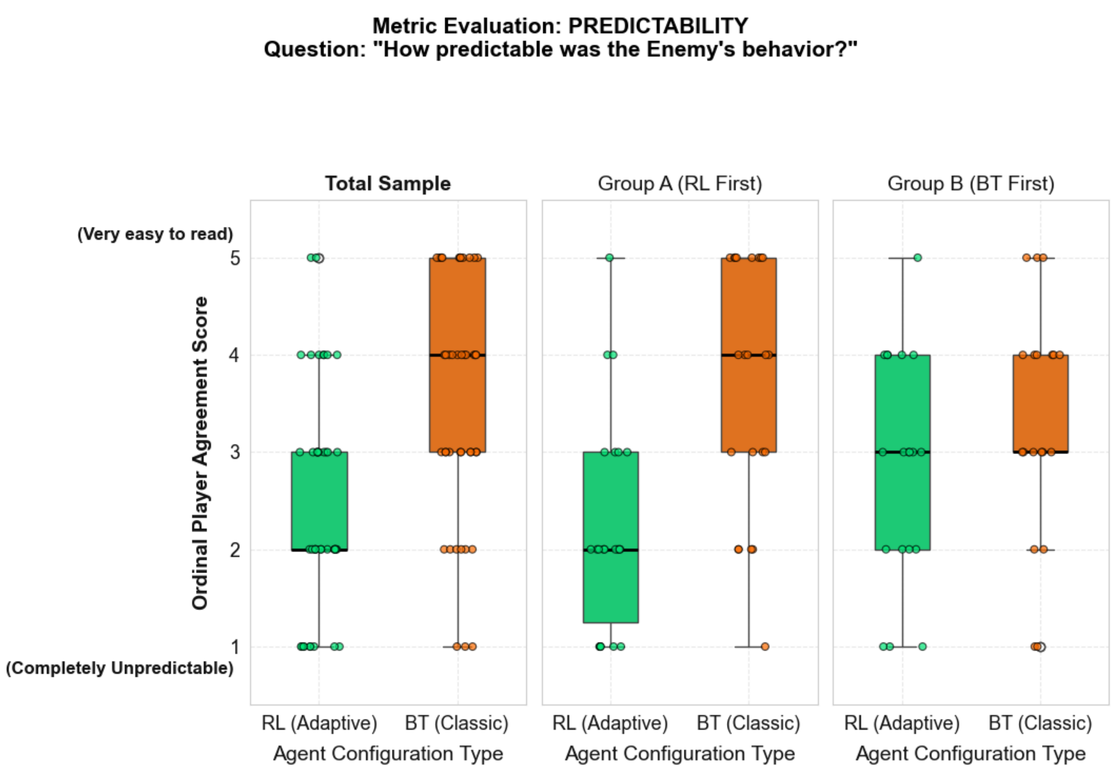

Figure 3: Player-rated predictability across AI architectures for the total sample and experimental groups

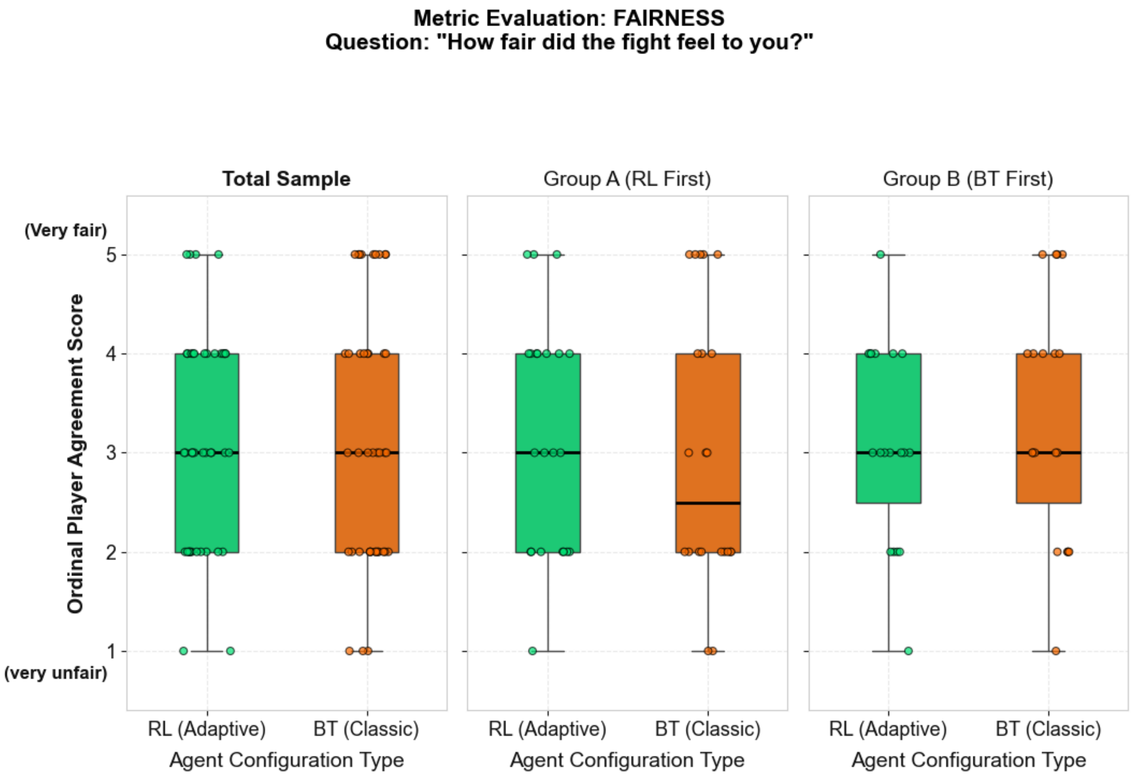

Figure 4: Player-rated fairness across AI architectures for the total sample and experimental groups

References

[1] Spronck, P., Ponsen, M., Sprinkhuizen-Kuyper, I., & Postma, E. (2006). Adaptive game AI with dynamic scripting. *Machine Learning*, *63*(3), 217–248. https://doi.org/10.1007/s10994-006-6205-6