



Experience-weighted Attraction Learning

Source: Camerer, C. and Teck-Hua Ho, „Experience-weighted Attraction Learning in normal form games“, in *Econometrica*, Vol. 67, No. 4, 1999



Outline

- Motivation
- Belief-based and reinforcement learning
- EWA
 - Core Model Parameters
 - The EWA Model
 - Parameter interpretation
- Conclusion



Motivation

- How can the patterns of convergence towards an equilibrium in games be explained?
- Psychologically it makes sense that people adopt and evolve towards an equilibrium
- EWA was designed to describe this process

Belief-based and reinforcement learning



- Belief-based models:
 - History of the game is used to form beliefs
 - Players chose the best-response given these beliefs
- Reinforcement models
 - Strategies are reinforced by their previous payoffs
 - Players do not generally have beliefs about what others will do



Core Model Parameters

- 1) δ : reinforcement parameter of unchosen strategies
 - Unchosen strategies are reinforced according to their possible payoffs
- 2) ϕ decay rate for past attractions
 ρ decay rate for experience
 - These two features control the growth rate of attractions



Core Model Parameters

- 3) $N(0)$ the initial experience weight
 $A_i^j(0)$ the initial attraction of strategy j
- These three core parts together constitute the basis of how EWA tries to mix appropriate elements of both models



The EWA-Model

■ Notation

- s_i Strategy of player i
- $s_i(t)$ Strategy played by player i in period t
- s_{-i} Strategy combination without i 's strategy
- $s_{-i}(t)$ Strategies played by the other players in period t

- $\pi_i(s_i, s_{-i})$ Payoff function of player i
- $\pi_i(s_i(t), s_{-i}(t))$ Player i 's payoff in period t



The EWA-Model

- The updating rules

- 1) The experience measure

$$N(t) = \rho \cdot N(t - 1) + 1, \quad t \geq 1.$$

The previous experience is weighted by the decay rate of experience



The EWA-Model

- 2) the level of attractions

$$A_i^j(t) = \frac{\phi \cdot N(t-1) \cdot A_i^j(t-1) + [\delta + (1-\delta) \cdot I(s_i^j, s_i(t))] \cdot \pi_i(s_i^j, s_{-i}(t))}{N(t)}.$$

This updating rule now incorporates all elements of the EWA-Model we have encountered so far



The EWA-Model

- The updating rule of the reinforcement model

$$R_i^j(t) = \phi \cdot R_i^j(t-1) + I(s_i^j, s_i(t)) \cdot \pi_i(s_i^j, s_{-i}(t)).$$

- The EWA updating rule

$$A_i^j(t) = \frac{\phi \cdot N(t-1) \cdot A_i^j(t-1) + [\delta + (1-\delta) \cdot I(s_i^j, s_i(t))] \cdot \pi_i(s_i^j, s_{-i}(t))}{N(t)}.$$

- Setting $\delta = 0$, $N(0) = 1$, and $\rho = 0$ gets us back to the reinforcement model



The EWA-Model

- The updating rule of a belief-based model

$$E_i^j(t) = \frac{\rho \cdot N(t-1) \cdot E_i^j(t-1) + \pi(s_i^j, s_{-i}(t))}{\rho \cdot N(t-1) + 1}.$$

- The EWA updating rule

$$A_i^j(t) = \frac{\phi \cdot N(t-1) \cdot A_i^j(t-1) + [\delta + (1-\delta) \cdot I(s_i^j, s_i(t))] \cdot \pi_i(s_i^j, s_{-i}(t))}{N(t)}.$$

- Setting $\delta = 1$, and $\rho = \phi$, the EWA-updating rule breaks down to the belief-based model's



The EWA-Model

- What can we actually do with this model?
 - Explain how players learn by estimating the core parameters of the model
 - The resulting estimates give us an impression of how players learn in different situations encountered in different games.
 - That means the model explains how much players take previous game history into account, how fast their experience decays, and how they value payoffs, actual as well as forgone
- Can we really do that?
 - Depends on the „quality“ of the parameters



Parameter interpretation

- 1) the reinforcement parameter δ

This measures the impact of forgone payoffs on the attraction of a strategy

Reinforcement model: $\delta = 0$, so that only realised payoffs matter

Belief-based model: $\delta = 1$, so that realised and unrealised payoffs matter equally

EWA: size is not fixed, could depend on for example the size and sign of forgone payoffs or the loss-sensitivity of players



Parameter interpretation

- 2) The decay rates ρ and ϕ
 ϕ depreciates past attractions
 ρ depreciates the experience measure

Thus, if a player follows the reinforcement strategy, the depreciation of the experience measure will equal zero.

On the other hand, if a player keeps track of attractions as well as of experience, both decay rates will matter

Together these two parameters capture the rate of learning in a sense



Parameter interpretation

- 3) initial attraction $A_i^j(0)$

Belief-based models derive initial attraction from prior beliefs

EWA leaves $A_i^j(0)$ unrestricted so that it can be filled with a theory of first-period play



Parameter interpretation

- 4) the initial experience weight $N(0)$

This captures the influence of pregame experience on initial attractions

If $N(0)$ is small, the impact of initial attractions fades away fast

If it is large, experience will only slowly replace initial attractions



Conclusion

- The EWA-model shows that reinforcement and belief-based models have one common source
- EWA fits the data better than reinforcement models in all tested games, and most of the time better than belief-based models
- The EWA-model is more flexible than the other two models
- But:
 - Slight identification problem
 - Many parameters to estimate