Loser Takes All – Analyzing POKER Through Simulation

Aaron Foote Advisor: Maryam Gooyabadi Baker '64 Collabria Fellowship in Data Analysis

Introduction

Poker is a *game of skill* [1] such that a dominant stable strategy (e.g. rational play, random play, bluffing) yields the highest wins. In simulating [2] pre-flop *Texas Hold'em* betting between two randomly selected agents from a population with equal number of **rational** and **random** players, **imitation dynamics** lead to rational players taking over. Rationals bet based on the strength of their hand while randoms bet randomly, both select the other strategy when facing a loss. Here, we expand and test **bluffing** using more sophisticated learning dynamics across four different types of agents.

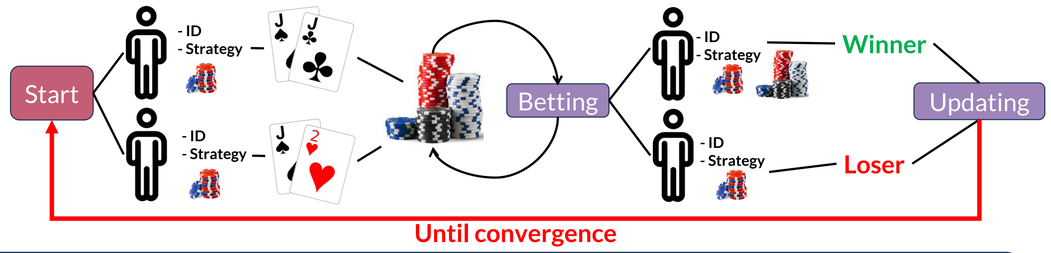
Research Questions

1. Do learning dynamics influence the dominant strategies?
2. Does knowledge (i.e. information) of the other player's strategy influence these strategies?
3. To what extent does the presence of one strategies in the population affect the success of other strategies?

Agents, Dynamics, and Simulations

1. Complete Information Weighted Learning: The losing agent loses confidence in their played strategy proportional to the percent stack lost. The winner strategy's is enforced.

2. Incomplete Information Weighted Learning: The losing agent loses confidence in their played strategy proportional to the percent stack lost. The confidence is distributed uniformly amongst the strategies that the agent did not play.



Strategies

Rational

Plays according to true hand strength

Random

Plays at a random hand strength

AAo Bluffer

Plays as if dealt pocket aces

T8o Bluffer

Plays as if dealt 10 8 off-suit

1. Broad Random: Equity is chosen from 0 to 1
2. Tight Random: Equity is chosen from 0.2923 to 0.8493, the range of possible pre-flop equities

Pairwise Comparison of Strategies

Broad Random Pairwise Strategy Comparison

Strategy	Opponent	Win Rate	Fold Rate	Avg. Winnings per Hand
AAo bluffer	T8o bluffer	0.529	0	5741
AAo bluffer	one choice random	0.741	0	3587
AAo bluffer	rational	0.662	0	-8436
one choice random	AAo bluffer	0.259	0.45	-3587
one choice random	T8o bluffer	0.336	0.322	-4242
one choice random	rational	0.4	0.319	-4772
rational	AAo bluffer	0.338	0.414	8436
rational	T8o bluffer	0.506	0.056	6523
rational	one choice random	0.6	0.166	4772
T8o bluffer	AAo bluffer	0.471	0	-5741
T8o bluffer	one choice random	0.664	0.034	4242
T8o bluffer	rational	0.494	0	-6523

Win Rate: 0.26 0.38 0.5 0.62 0.74

Tight Random Pairwise Strategy Comparison

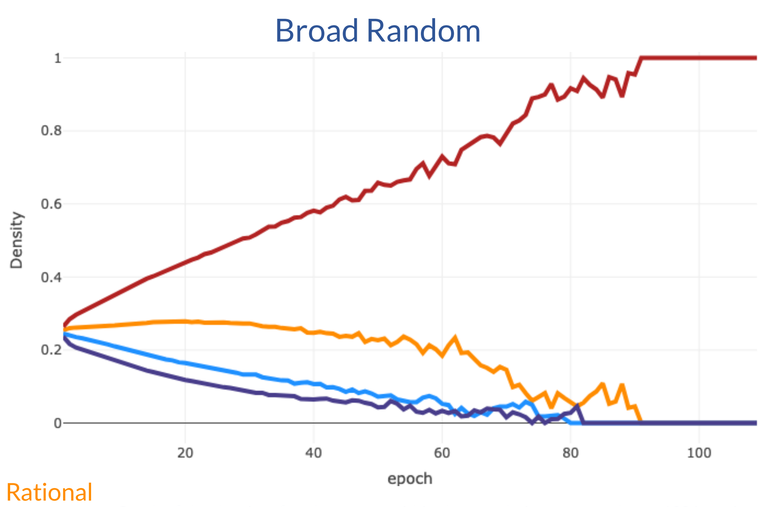
Strategy	Opponent	Win Rate	Fold Rate	Avg. Winnings per Hand
AAo bluffer	T8o bluffer	0.529	0	5720
AAo bluffer	one choice random	0.663	0	4489
AAo bluffer	rational	0.662	0	-8401
one choice random	AAo bluffer	0.337	0.284	-4489
one choice random	T8o bluffer	0.446	0.053	-5712
one choice random	rational	0.519	0.064	-6211
rational	AAo bluffer	0.338	0.414	8401
rational	T8o bluffer	0.506	0.056	6449
rational	one choice random	0.481	0.166	6211
T8o bluffer	AAo bluffer	0.471	0	-5720
T8o bluffer	one choice random	0.554	0	5712
T8o bluffer	rational	0.494	0	-6449

Win Rate: 0.34 0.46 0.5 0.54 0.66

Complete Information Weighted Learning

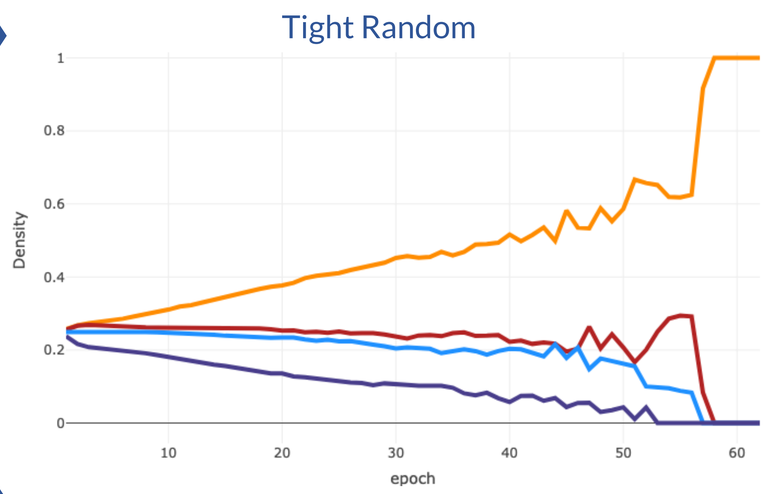
Strategy Density Under Complete Information Weighted Learning

Broad Random



Graph of the density of each strategy within the population, averaged over 100 iterations.

Tight Random

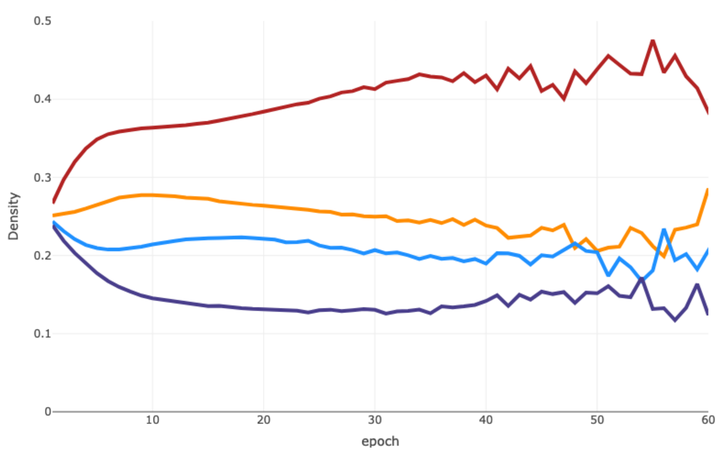


Graph of the density of each strategy within the population, averaged over 100 iterations.

Incomplete Information Weighted Learning

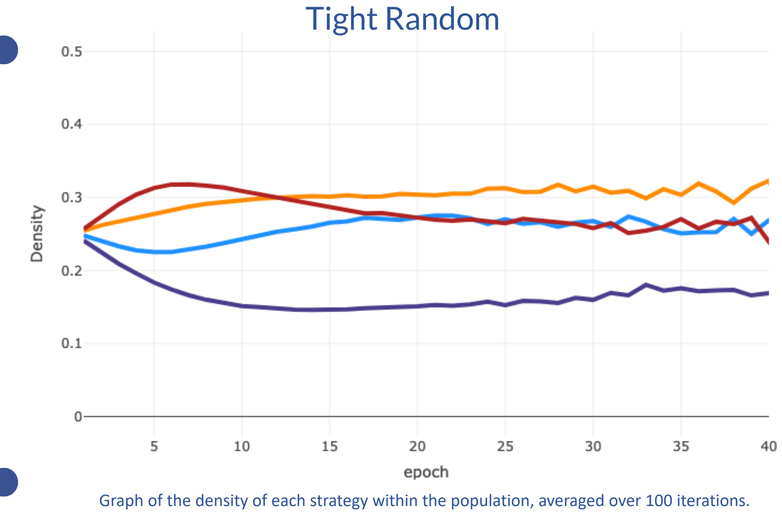
Strategy Density Under Incomplete Information Weighted Learning

Broad Random



Graph of the density of each strategy within the population, averaged over 100 iterations.

Tight Random



Graph of the density of each strategy within the population, averaged over 100 iterations.

Death Dynamic

Death Dynamic Win Rates

Strategy	Tight Random Win Rate	Broad Random Win Rate
AAo Bluffer	0.154	0.132
One Choice Random	0.21	0.184
Rational	0.44	0.492
T8o Bluffer	0.196	0.192

The win rate is the proportion of the 500 simulations ran for which the last agent standing used that strategy.

Discussion

Pairwise play shows winning hands is not the cause of winning money, rather one must play to the strength of their hand! Under a death dynamic, the ability of a rational agent to maximize the value of their hands allows them to dominate.

With broad random, random agents learn at a lower rate by folding much more than any other strategy. Once an agent experiences a bad beat and becomes random, they don't change back. The revision to equity sampling fixes this. Incomplete information greatly slows the learning process, preventing complete convergence.

Reference:
[1]: M.A. Javarone, Poker as a skill game: rational versus irrational behaviors, J. Stat. Mech. 2015 (2015) P03018.
[2]:Javarone MA. Modeling Poker Challenges by Evolutionary Game Theory. *Games*. 2016; 7(4):39.https://doi.org/10.3390/g7040039

Funding for this research was generously provided by the Baker '64 Collabria Fellowship in Data Analysis through the QAC