# **Games Meet Evolution: Strategic Behavior**

*CSCI 165 Project*

*Levi sumbela, Surya Gona, Wyatt Miller* *April 23, 2025*

## **The Idea**

Ever think about why some strategies survive while others fail? Or why certain behaviors are adopted by an entire population? I've spent the last few months studying this fascinating world where game theory meets evolution, and I can't wait to share what I've found..

In this study, I explored four classic games most people know in some form. Rock-Paper-Scissors, Chicken, Battle of the Sexes, and Stag Hunt . These simple games actually show patterns in how we coordinate, compete, and make decisions under uncertainty.

My work builds on Paul Straub's 1995 research that showed something counterintuitive, that people choose safer, less rewarding strategies over riskier ones with bigger reward.

**The Science**

Instead of assuming everyone makes perfect decisions, which we know isn't true, evolutionary game theory looks at how strategies naturally spread when winning players are imitated or have more "offspring" who use their approach.

Two big ideas guided my paper:

**Nash equilibrium**: A sweet spot where nobody benefits by changing their strategy alone. It's like when everyone settles into habits that work well enough given what others are doing.

**Replicator dynamics**: The mathematical way to track how strategies grow or shrink in a population over time. This would be similar to natural selection for strategies rather than species.

## **My Approach**

I created virtual worlds with 100 digital players, had them compete against each other repeatedly, and watched how their strategy choices evolved over generations. The most successful strategies would spread, while unsuccessful ones would disappear. with a small chance of random exploration to keep things interesting.

Each game needed its own special setup:

* For Rock-Paper-Scissors, I used the classic even scoring system we all know
* In Chicken, I played with different values for victory (V) versus the cost of a crash (C)
* For Battle of the Sexes, I gave players different preferences but the desire to coordinate
* With Stag Hunt, I set up one strategy (hunting stag together) as higher-reward but riskier

I then tracked these virtual populations across 200+ generations to see what patterns emerged.

## **What I Found**

### **Rock-Paper-Scissors: The Eternal Dance**

This game showed something beautiful. A perfect, never-ending cycle. My virtual players would swing from mostly Rock, to mostly Paper, to mostly Scissors, and back again in an eternal dance. The population never settled down to equal thirds as theory might predict, but instead kept cycling with each strategy having its moment in the sun before being overthrown.

Think of it like fashion trends that cycle through society, no single style ever wins permanently.

### **Chicken: Finding the Balance**

Remember the game where two drivers speed toward each other, and whoever swerves first loses face but whoever crashes loses everything? In my simulation, players found a natural balance point with about 40% "Swervers" and 60% "Straight" drivers.

This mix created a fascinating self-regulating system: if too many players got bold and drove straight, crashes increased, making swerving suddenly more attractive. It's like how aggressive driving might spread until accidents make everyone cautious again, creating natural cycles of boldness and caution.

### **Battle of the Sexes: First Mover Advantage**

This coordination game (where a couple wants to be together but has different preferences) showed something dramatic: small initial advantages snowball quickly. Starting with just slightly more "Football fans" than "Opera lovers," the population rapidly became almost entirely football-oriented within 20 generations.

This helps explain why social conventions and cultural practices can become so dominant - once a practice gains even a slight edge, it can quickly become "just how things are done" in a community.

### **Stag Hunt: The Tipping Point**

This game about risky cooperation revealed the most fascinating pattern of all - a tipping point that determines everything. When I started with 50% of players hunting stag (the risky but rewarding strategy), almost everyone ended up as stag hunters. But additional tests showed that dropping below a critical threshold of about 43% stag hunters would send the whole population toward the safer, less rewarding "hunt hare" strategy instead.

This perfectly mirrors Straub's insight about risk dominance - when cooperation seems uncertain, people often choose safety over potential rewards. Think about new technologies or social movements - they need to reach a critical mass of early adopters before they can spread widely!

## **The Study**

Looking across all four games reveals fascinating patterns in how strategies evolve:

1. **Stability vs. Change**: While Rock-Paper-Scissors kept cycling forever, the other games eventually settled down - either completely (Battle of Sexes, Stag Hunt) or to a mixed but stable state (Chicken).
2. **Balancing Risk and Reward**: Both Chicken and Stag Hunt show how groups naturally balance potential gains against potential losses, but in different ways - one through mixed strategies, the other through winner-takes-all dominance.
3. **Small Beginnings, Big Endings**: small differences in starting conditions completely determined the final outcomes in coordination games - a powerful reminder of how small initial advantages can shape entire cultural landscapes.
4. **How Groups "Choose"**: These simulations help explain how societies naturally select between multiple possible equilibria - through natural feedback loops rather than conscious collective decisions.

## **Why This Matters**

These findings go way beyond abstract game theory. They help explain real-world phenomena like:

* Why certain technologies dominate markets despite not being technically superior (think VHS vs. Betamax)
* How social norms establish themselves and persist
* Why organizations sometimes fail to coordinate on obviously better solutions
* How risk aversion shapes collective behavior across domains

Understanding these dynamics could help design better policies, organizational structures, and intervention strategies when we need to shift established patterns.

## **Presenting This Work**

Explaining this research to a general audience was challenging! The mathematical models are complex, but I found that visualizations of the shifting strategy landscapes helped make the concepts click. If I could do it again, I'd spend more time on relatable real-world examples for each game pattern.

The most effective part of my presentation was showing the side-by-side comparison of how each game evolved differently - seeing those distinct patterns emerge made the abstract theory suddenly concrete and meaningful.

## **References**

Straub, P. G. (1995). Risk Dominance and Coordination Failures in Static Games. The Quarterly Review of Economics and Finance, 35(4), 339-363.

Livnat, A. & Papadimitriou, C. (2016). Sex as an Algorithm: The Theory of Evolution Under the Lens of Computation. Communications of the ACM, 59(11): 84–93.

Sandholm, W. H. (2010). Population Games and Evolutionary Dynamics. MIT Press.

Nowak, M. A. (2006). Evolutionary Dynamics: Exploring the Equations of Life. Harvard University Press.