

# A Practical Guide to Finding Optimal Strategy (An Intuitive Progression from 2x2 to NxN Games)

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## Abstract

This paper provides a practical guide for determining the optimal mixed strategy in two-player, zero-sum games. It presents a method for calculating the Nash Equilibrium by starting with the well-understood 2x2 matrix and intuitively extending the logic to 3x3 and larger NxN scenarios. The purpose is not to derive new mathematical theory, but to make the powerful concepts of game theory accessible to a wider audience, such as coaches, athletes, and business strategists. This paper is supplemented by a GitHub repository containing a spreadsheet tool that performs the calculations, allowing for direct practical application of the concepts discussed.

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## 1.0 Introduction: The Problem of Predictability

### 1.1 The Strategist's Dilemma

Imagine a baseball pitcher with a fantastic 100-mph fastball. It's his best pitch. It's powerful and hard to hit. Logic seems to dictate that he should throw it every single time. Why use a weaker pitch when he has a nearly perfect one?

This is **The Strategist's Dilemma**.

The dilemma is the conflict between using your single most effective option and the necessity of being unpredictable.

1. **The Strength:** Every competitor has a "go-to" move. It could be a tennis player's slice serve to the forehand, a soccer player's shot to the top-right corner of the goal, or a company's most popular product. This is the move that, in a vacuum, gives them the highest chance of success.
2. **The Counter:** A smart opponent will quickly recognize this pattern. If the pitcher *a/ways* throws his fastball, the batter will start timing it. The tennis player's opponent will start leaning to cover the forehand. A competitor will find a way to counter the popular product. Your greatest strength quickly becomes your most predictable weakness.

The dilemma, therefore, is not "Which one option should I choose?" but rather, "How do I balance my best options to keep my opponent from exploiting me?"

If you completely abandon your best move to be unpredictable, you're not playing to your strengths. But if you rely on it too much, you become easy to defeat.

**The solution to the dilemma** is to find the perfect *mix* of strategies. It's about calculating the optimal frequency for using your fastball, your curveball, and your slider so that the batter can never be sure what's coming next. This is precisely what the Nash Equilibrium calculates, and it's the core problem this paper will help you solve.

## 1.2 An Introduction to Game Theory

At its heart, **game theory** is simply the study of how and why we make decisions when our choices affect others. Think of any situation where the outcome depends not just on your action, but on the actions of an opponent; that's what we call a "game." While it can be used to analyze complex economic or political situations, it's also the perfect tool for understanding a simple one-on-one sports matchup.

The scenarios we will focus on are called **zero-sum games**. This is a fancy term for a simple idea: one person's gain is the other person's loss. In a tennis point, there is only one winner and one loser. The win percentages of both players will always add up to 100%. If Player A has a 60% chance of winning, Player B must have a 40% chance of winning.

The goal of game theory in this context is to find a stable solution, or **equilibrium**, where neither player can improve their outcome by changing their own strategy while the other player's strategy stays the same. The concept of this equilibrium for "non-cooperative games", in which players act independently, was formally introduced by the mathematician John F. Nash, Jr. in his groundbreaking 1951 paper.

## 1.3 The Goal of This Paper

The powerful concepts of game theory are too often locked away in dense academic texts, inaccessible to the very people who could benefit most from them: coaches, athletes, and real-world strategists on the front lines of competition. The goal of this paper is to bridge that gap. We will provide a clear, step-by-step guide that requires no advanced mathematics, showing how anyone can learn to analyze a strategic problem. We will start with a simple two-option scenario, build a foundational understanding, and then intuitively progress to more complex situations with multiple options. This paper is paired with a practical spreadsheet tool that performs all the necessary calculations, transforming abstract theory into a tangible resource. By the end, the reader will not only understand the core principles of finding an optimal strategy but will be empowered to apply them directly to their own competitive challenges.

## 2.0 The Foundation: The 2x2 Game

### 2.1 Defining the Scenario

To understand the power of a mixed strategy, we first need a simple, concrete example. Let's imagine a critical point in a tennis match. We will look at the game from the perspective of **Player 1 (the Server)**.

The Server has two primary options for their first serve: they can either hit the serve **Out Wide** or hit it **Down the T**.

Across the net, **Player 2 (the Returner)** must anticipate the serve. The Returner also has two options: they can position themselves to better cover the **Wide** serve or shift to better cover the **T**.

This creates a classic 2x2 game with four possible outcomes. To analyze the game, the Server (or their coach) must estimate their probability of winning the point in each of the four situations. These win percentages are the "payoffs." Based on experience and scouting, the Server might estimate their payoffs as follows:

- **Server Serves Wide & Returner Covers Wide:** Server wins **45%** of the time.
- **Server Serves Wide & Returner Covers T:** Server wins **70%** of the time.
- **Server Serves T & Returner Covers Wide:** Server wins **65%** of the time.
- **Server Serves T & Returner Covers T:** Server wins **30%** of the time.

We can organize these payoffs into a simple table, or "matrix," which gives us a clear picture of the strategic landscape. This matrix is the foundation for calculating the optimal strategy.

	Player 2: Covers Wide	Player 2: Covers T
Player 1: Serves Wide	(45%)	(70%)
Player 1: Serves T	(65%)	(30%)

### 2.2 The Logic of Equilibrium

Looking at the payoff matrix, a simple thought might occur to the Server: "When my opponent covers the T, my best option is to serve Wide, where I win 70% of the time. I should just do that." This is where the strategic thinking begins. If the Server *always* serves Wide, the Returner will quickly notice this pattern and switch their own strategy to *always* cover the Wide serve. The game would then shift to the top-left box of our matrix, and the Server's win rate would plummet from 70% to a mere 45%.

The Returner faces the same problem. If they notice the Server is favoring the T, they might always cover the T, only to be exploited by a sudden serve Out Wide.

This cat-and-mouse game reveals a fundamental truth: in a strategic conflict, any predictable pattern can be exploited. You cannot simply choose your single "best" option and stick with it. The only way to protect yourself from being exploited is to be unpredictable. This leads to the concept of a strategic **equilibrium**. An equilibrium is a stable state where both players are mixing their strategies in such a way that neither one can gain an advantage by changing their own strategy. It's the point where your opponent's best response to your strategy is the very one you want them to play. The goal is not to win every point, but to maximize your chances of winning over the long run by making it impossible for your opponent to get a read on you.

### 2.3 Calculating the 2x2 Solution

Now that we understand *why* a mixed strategy is necessary, we can calculate the optimal mix. Fortunately, for the 2x2 game, a straightforward formula exists to find the equilibrium. While the derivation of the formula is complex, its application is simple. The formula tells each player how often to choose their options to make the opponent indifferent to which option they choose.

Let's represent our payoff matrix with letters:

	Player 2: Covers Wide	Player 2: Covers T
Player 1: Serves Wide	A (45%)	B (70%)
Player 1: Serves T	C (65%)	D (30%)

To find the optimal percentage of time the Server should **Serve Wide** (we'll call this "p"), the formula is:

$$p = (D - B) / (A - B - C + D)$$

Let's plug in our numbers (using decimals for the calculation, so 45% = 0.45):

- $p = (0.30 - 0.70) / (0.45 - 0.70 - 0.65 + 0.30)$
- $p = (-0.40) / (-0.60)$
- $p = 0.667$ , or **66.7%**

The result tells us the optimal strategy for the Server: they should serve Wide 66.7% of the time and, consequently, serve down the T the remaining 33.3% of the time. The companion formula for the Returner can be similarly calculated. This calculated mix is not a random guess; it is the precise balance that maximizes the Server's chances of winning over the long term, regardless of how the Returner tries to adapt.

### 3.0 Expanding the Strategy: The 3x3 Game

The real world of sports is rarely a simple choice between two options. Great players have a deep arsenal of strategies they can deploy at any moment. The next logical step is to expand our model to account for a more complex and realistic scenario.

#### 3.1 Adding a Third Option

Let's evolve our tennis example. The Server has been mixing up serves to the Wide and T locations, but now decides to add a third weapon: the **Body Serve** (a serve aimed directly at the opponent). In response, the Returner adds a third defensive option: covering the **Middle**.

This single addition dramatically increases the complexity. Instead of four possible outcomes, there are now nine. The Server must now estimate their win percentage for all nine of these scenarios, creating a larger 3x3 payoff matrix.

#### 3.2 The Challenge of Complexity

With a 3x3 matrix, the simple formula we used for the 2x2 solution no longer works. The underlying mathematics requires solving a system of linear equations, a task that is tedious and impractical to do by hand, especially in the middle of a match or during a coaching session. The goal of this paper, however, is to find a practical and intuitive way to solve this problem without needing to become a mathematician. We need a method that builds on what we already understand.

#### 3.3 The Pairwise Method

The core concept of this paper is a method to simplify a complex problem. Instead of trying to solve the entire 3x3 matrix at once, we can break it down into a series of smaller, manageable 2x2 games that we already know how to solve.

For our 3x3 tennis example, we can analyze the situation as three distinct pairwise contests. We take the original 3x3 matrix and extract the relevant payoffs for each 2x2 game, as shown below:

**Game 1: Serve Wide vs. Serve T** *This is the original game from Section 2.0.*

	Covers Wide	Covers T
Serves Wide	45%	70%
Serves T	65%	30%

**Game 2: Serve Wide vs. Serve Body** Here we assume a Body serve is less effective when the returner covers the middle, but very effective if they are cheating to one side.

	Covers Wide	Covers Middle
Serves Wide	45%	60%
Serves Body	75%	40%

**Game 3: Serve T vs. Serve Body** Similarly, we fill in the payoffs for the final pairing.

	Covers T	Covers Middle
Serves T	30%	55%
Serves Body	80%	40%

By visualizing the problem this way, we've transformed one intimidating 3x3 matrix into three simple 2x2 matrices. We can now calculate the Nash Equilibrium for each of these "games within the game" using the exact same formula from Section 2.3. This gives us a partial strategic analysis for each pair of options, which we can then combine to form our final strategy.

### 3.4 Recombining the Results

After solving each of the three 2x2 games, we will have three separate sets of strategic recommendations. To get our final, unified strategy for the full 3x3 game, we simply combine these results in a two-step process: **averaging** and **normalizing**.

First, using the formula from Section 2.3, we calculate the optimal strategy for each of the three pairwise games. The results of these calculations are summarized below.

### Pairwise Calculation Results

Game	Option 1	Strategy %	Option 2	Strategy %
<b>Game 1</b>	Serve Wide	66.7%	Serve T	33.3%
<b>Game 2</b>	Serve Wide	40.0%	Serve Body	60.0%
<b>Game 3</b>	Serve T	23.1%	Serve Body	76.9%

Next, we calculate an "average strategic value" for each of the three serves. To do this, we find the average of the percentages calculated for each option across all the pairwise games in which it appeared.

- **Serve Wide Value** =  $(66.7\% + 40.0\%) / 2 = 53.35$
- **Serve T Value** =  $(33.3\% + 23.1\%) / 2 = 28.20$
- **Serve Body Value** =  $(60.0\% + 76.9\%) / 2 = 68.45$

Finally, these values are raw scores, and they don't add up to 100%. Our last step is to **normalize** them, which means converting them into a final percentage. We do this by dividing each value by the sum of all the values.

- Total Value =  $53.35 + 28.20 + 68.45 = 150.0$

The final, optimal 3x3 strategy for the Server is:

- **Serve Wide %** =  $(53.35 / 150.0) = 35.6\%$
- **Serve T %** =  $(28.20 / 150.0) = 18.8\%$
- **Serve Body %** =  $(68.45 / 150.0) = 45.6\%$

This entire process (breaking down the problem, solving the simple pieces, and recombining the results) allows us to leverage the simplicity of the 2x2 solution to solve a much more complex 3x3 problem.

## 4.0 The General Solution: The NxN Game

The true power of the pairwise method is its scalability. While we have demonstrated the logic with 2x2 and 3x3 examples, the same intuitive process can be applied to strategic scenarios of much greater complexity.

### 4.1 From 3x3 to 6x6 and Beyond

The beauty of the pairwise method is that the complexity does not increase exponentially. To solve a 4x4 game, we would simply break it down into six individual 2x2 games. For a 6x6 game, while the number of pairs is larger, the fundamental process remains identical: extract every possible 2x2 sub-game, solve each one with the simple formula, and then average and normalize the results. The core task of solving a 2x2 matrix never changes. This approach allows a strategist to analyze a situation with a large number of options without getting bogged down in complex matrix algebra.

### 4.2 The Practical Tool: The Optimal Strategy Calculator

Manually calculating the pairwise solutions for a large matrix would be time-consuming. To that end, a spreadsheet tool, the **Optimal Strategy Calculator**, has been developed to automate the entire process. The user simply inputs their estimated win percentages into the matrix for their specific scenario (from 2x2 up to 6x6). The spreadsheet instantly performs all the necessary pairwise calculations, averaging, and normalization in the background, presenting the user with the final, optimal mixed strategy. This tool transforms the method described in this paper from a theoretical exercise into a practical, real-time decision-making aid.

### 4.3 Link to the Public Repository

The spreadsheet and supplementary materials are available to the public in a GitHub repository. This repository contains the calculator, instructions for its use, and a technical appendix for those interested in the underlying formulas.

The repository can be accessed at: <https://github.com/wescoup/practical-game-theory>

### 4.4 An Interactive Web-Based Calculator

While the spreadsheet provides a powerful and robust tool for analysis, a web-based version of the calculator is also available. This interactive version is designed for easy access on any device, from a computer to a smartphone, making it a convenient tool for coaches and players on the court or on the sidelines. The web-based calculator provides the same functionality for 2x2, 3x3, and multi-option scenarios.

Instructions for using the web-based calculator can be found at:  
<https://www.wescoup.com/tonys-strategy-calculator-instructions>

## 5.0 Conclusion and Applications

### 5.1 Summary of the Method

The primary challenge in strategic decision-making is often complexity. While the mathematics of game theory can be intimidating, the core logic does not have to be. This paper has demonstrated an intuitive method for solving complex, multi-option strategic games. By breaking down a large  $N \times N$  matrix into a series of simple  $2 \times 2$  games, we can calculate a robust, optimal mixed strategy without resorting to advanced mathematics. This "pairwise method" provides a bridge between high-level theory and practical application, empowering strategists to make mathematically sound decisions in a clear and accessible way.

### 5.2 Beyond Tennis

While we have used tennis as our primary example, the applications of this method are incredibly broad. Any competitive, zero-sum scenario can be analyzed. For example:

- **Soccer:** A penalty kicker choosing to shoot left, right, or center, while the goalie decides which way to dive.
- **Baseball:** A pitcher deciding between a fastball, curveball, or slider, while the batter anticipates the pitch.
- **Business:** A company choosing between several pricing strategies (e.g., premium, budget, or standard), while a competitor does the same.
- **Marketing:** A marketing team allocating a budget between different channels (e.g., social media, TV, print), while a competitor makes similar choices.

In any of these situations, the calculator can help a strategist move beyond simple gut instinct and toward a balanced, unpredictable, and ultimately optimal plan of action.

### 5.3 Future Work

The method and tools presented in this paper serve as a functional and accessible starting point. The path forward can be divided into two distinct but equally important areas: practical application by strategists and further development by researchers.

#### 5.3.1 A Call for Adoption by Coaches and Athletes

This paper was written not as an academic exercise, but as an invitation. The true test of these ideas will be on the court, on the field, and in the boardroom. Coaches and athletes are encouraged to take this tool and apply it rigorously. Track your own tendencies, scout your opponents, and use the calculator to challenge your own intuition. Does the mathematical optimum align with your gut feeling? Where does it differ? By collecting real-world data and comparing it to the calculated strategies, you can gain a deeper, more objective understanding

of your own decision-making process and uncover powerful new advantages in your game. The goal is for this tool to become a living part of your strategic toolkit.

### 5.3.2 A Call for Further Development

For those with a background in mathematics and computer science, there are several avenues for advancing this work. The pairwise method used in the spreadsheet is a practical heuristic, but it is an approximation. A more advanced software version could be developed to solve for the true Nash Equilibrium using established linear programming algorithms. Furthermore, applying this tool to large, real-world data sets—such as analyzing thousands of penalty kicks from professional soccer leagues or pitch selections from Major League Baseball—could yield fascinating insights into how human strategy at the elite level aligns with, or deviates from, mathematical optimality.

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### References:

- [1] Nash, J. (1951). Non-Cooperative Games. *Annals of Mathematics*, 54(2), 286–295.
- [2] "Game Theory." *Wikipedia*, Wikimedia Foundation, last modified 12 Sept. 2025, [en.wikipedia.org/wiki/Game\\_theory](https://en.wikipedia.org/wiki/Game_theory). Accessed 16 Sept. 2025.

## Appendix A: Spreadsheet Formulas

This appendix outlines the core formulas used in the *OptimalStrategyCalculator.xlsx* spreadsheet. The formulas are based on the standard algebraic solution for a 2x2 mixed-strategy Nash Equilibrium.

### A.1 The 2x2 Payoff Matrix

For any 2x2 game, the spreadsheet assigns the payoffs for Player 1 to a 2x2 matrix of cells. For the purpose of this explanation, we will refer to these cells using the letters A, B, C, and D, as shown below.

	Player 2: Option 1	Player 2: Option 2
Player 1: Option 1	Cell A	Cell B
Player 1: Option 2	Cell C	Cell D

### A.2 Player 1's Optimal Strategy Formula

The formula to calculate the optimal probability (let's call it **p**) with which Player 1 should choose **Option 1** is:

$$p = (D - B) / (A - B - C + D)$$

In the spreadsheet, this would look something like the following, assuming your payoffs are in cells C7, D7, C8, and D8 respectively:

$$=(D8-D7)/(C7-D7-C8+D8)$$

Player 1 should then choose **Option 2** with a probability of **(1 - p)**.

### A.3 Player 2's Optimal Strategy Formula

To calculate the optimal probability (let's call it **q**) with which Player 2 should choose their **Option 1**, we must first consider Player 2's payoff matrix. In a zero-sum game, Player 2's payoffs are the inverse of Player 1's. So,  $A' = (1-A)$ ,  $B' = (1-B)$ , and so on.

The formula for Player 2 is:

$$q = ((1-D) - (1-C)) / ((1-A) - (1-B) - (1-C) + (1-D))$$

In the spreadsheet, this translates to:

$$=((1-D8)-(1-C8))/((1-C7)-(1-D7)-(1-C8)+(1-D8))$$

Player 2 should then choose **Option 2** with a probability of **(1 - q)**.

### A.4 Application to NxN Matrices

For larger matrices (3x3 up to 6x6), the spreadsheet applies these exact same 2x2 formulas to every possible pairing of options, as described in **Section 3.3 The Pairwise Method**. The results from each of these pairwise calculations are then averaged and normalized, as detailed in **Section 3.4 Recombining the Results**, to produce the final optimal strategy.