

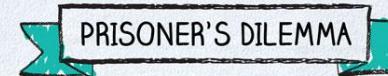
# Game Theory (for Game Designers):

- What is it, and how does it relate to game studies?
- What is the difference between how games are defined across disciplines?
- Can Game Theory be useful in Game Development?

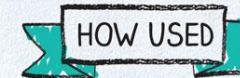
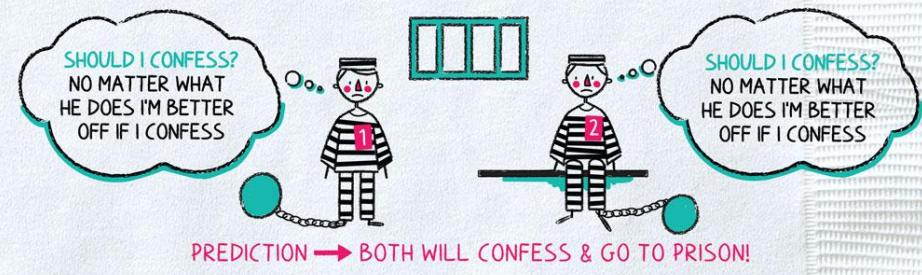
# GAME THEORY



MODEL FOR PREDICTING PEOPLE'S DECISIONS



CLASSIC GAME THEORY EXAMPLE  
SELF-INTEREST VS. BETTER OUTCOME FOR ALL



BUSINESS  
NEGOTIATIONS



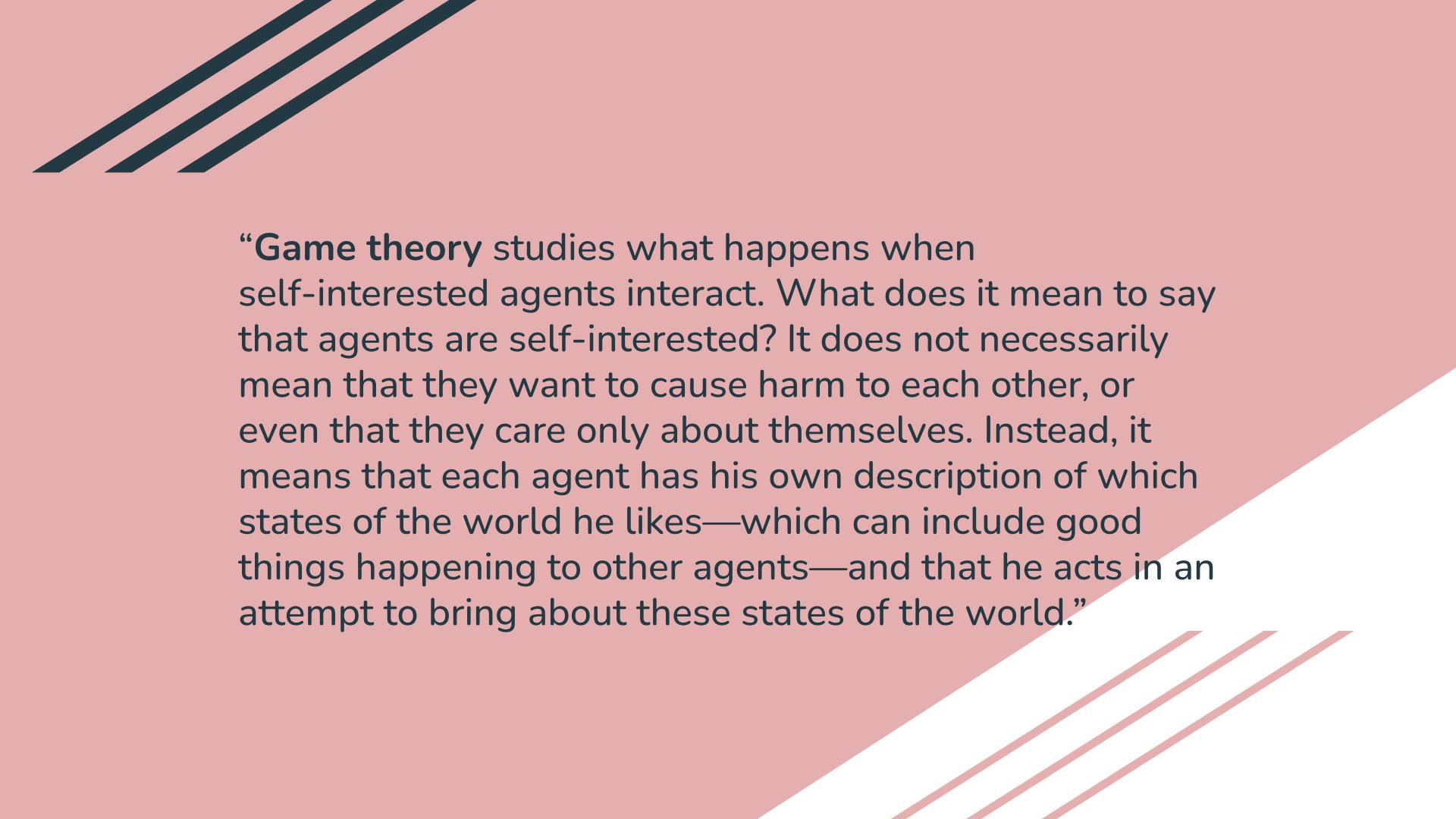
CORPORATE  
STRATEGY



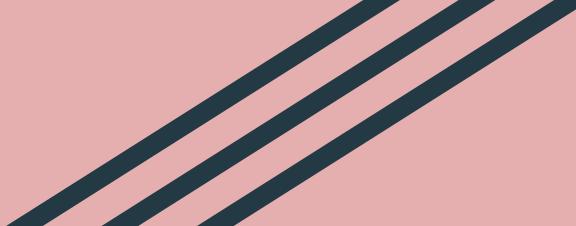
GAMBLING



MILITARY  
TACTICS



**“Game theory** studies what happens when self-interested agents interact. What does it mean to say that agents are self-interested? It does not necessarily mean that they want to cause harm to each other, or even that they care only about themselves. Instead, it means that each agent has his own description of which states of the world he likes—which can include good things happening to other agents—and that he acts in an attempt to bring about these states of the world.”



The definition of “GAME” in Game Theory vs. Game Studies is:

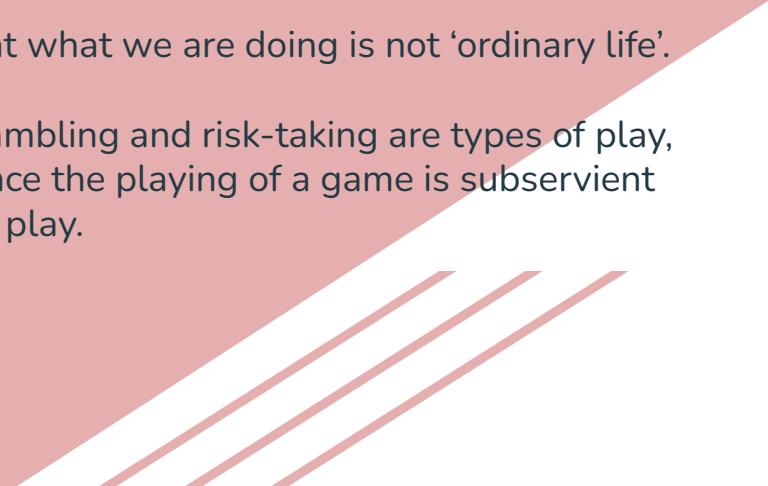
- A. Vastly different.
  - B. Exactly the same.
  - C. It's complicated.
- 

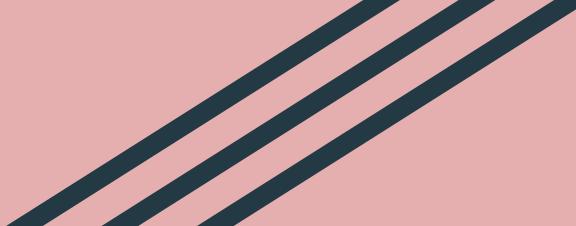
"The name of the game, " in Game Theory: A Very Short Introduction, Ken Binmore, 2007, page 1:

Drivers manoeuvring in heavy traffic are playing a driving game.  
Bargain-hunters bidding on eBay are playing an auctioning game.  
A firm and a union negotiating next year's wage are playing a  
bargaining game. When opposing candidates choose their  
platform in an election, they are playing a political game. The  
owner of a grocery store deciding today's price for corn flakes is  
playing an economic game. In brief, a game is being played  
whenever human beings interact.



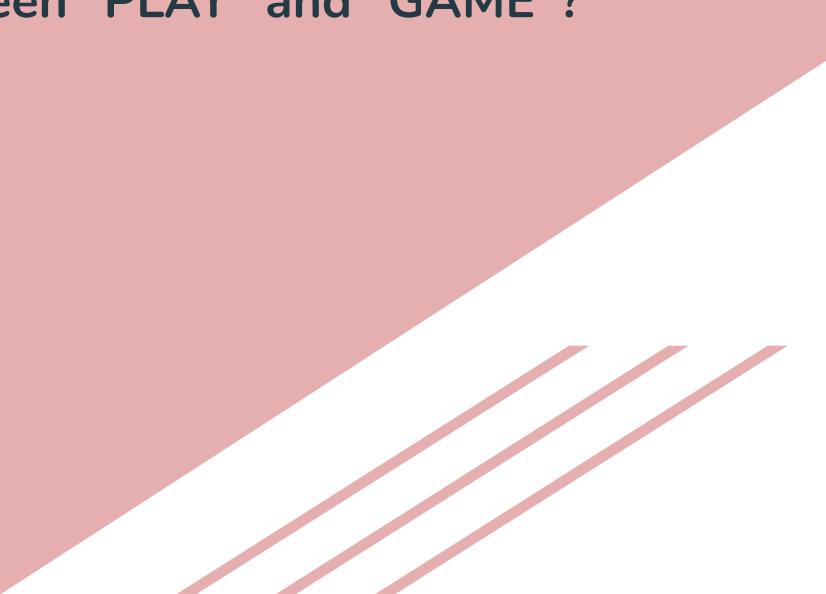
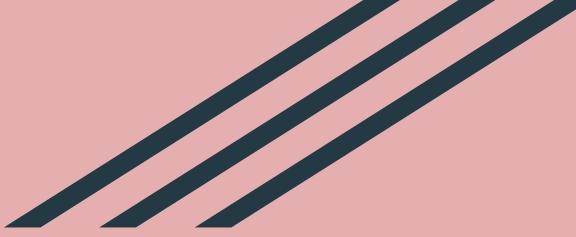
## Huizinga, *Homo Ludens* definition of play:

1. **Play is voluntary.** This contrasts with things we must do for survival.
  2. **Play is Rule Ordered.** When we enter into play, we agree to play by explicit or implied rules.
  3. **Play happens within fixed boundaries: the ‘magic circle.’** When we agree to the restriction of rules, we also agree that these restrictions will only apply for a time and/or place.
  4. **Play is different.** When we play, we are distinctly aware that what we are doing is not ‘ordinary life’.
  5. **Play is not useful or in a material interest.** Even though gambling and risk-taking are types of play, play is nonetheless non-purposeful. Huizinga argues that once the playing of a game is subservient to a material interest it no longer can be understood as pure play.
- 



Miguel Sicart, “Play Is,” in *Play Matters*, 2014

1. Play is contextual. (6)
  2. Play is carnivalesque. (11)
  3. Play is appropriative. (11)
  4. Play is disruptive. (14)
  5. Play is autotelic. (16)
  6. Play is creative. (17)
  7. Play is personal. (17)
- 



**What is the difference between “PLAY” and “GAME”?**

"The name of the game, " in Game Theory: A Very Short Introduction, Ken Binmore, 2007, page 2:

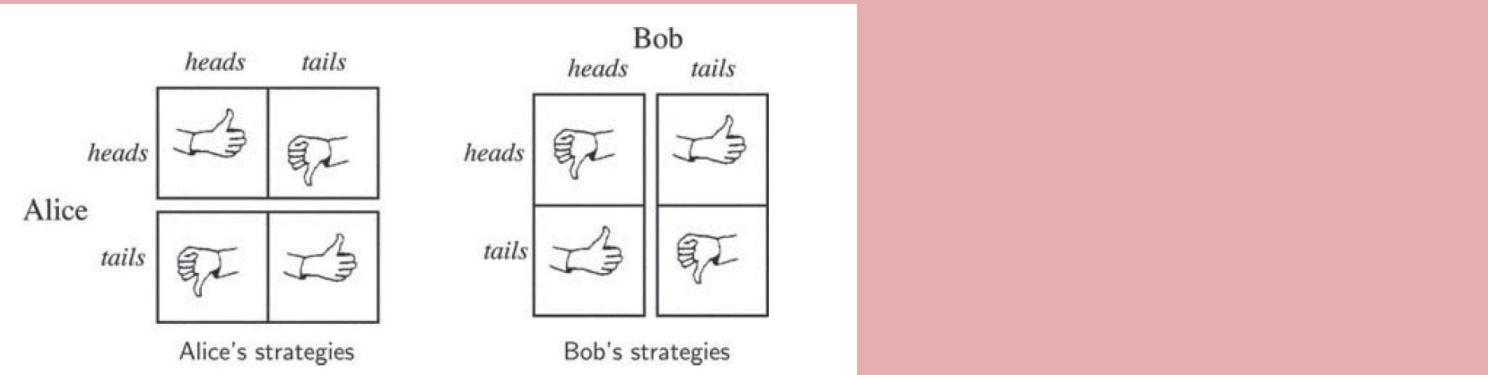
With such a wide field of application, game theory would be a universal panacea if it could always predict how people will play the many games of which social life largely consists. But game theory isn't able to solve all of the world's problems, because it only works when people play games *rationally*. So it can't predict the behaviour of love-sick teenagers like Romeo or Juliet, or madmen like Hitler or Stalin. However, people don't always behave irrationally, and so it isn't a waste of time to study what happens when people put on their thinking caps. Most of us at least try to spend our money sensibly – and we don't do too badly much of the time or economic theory wouldn't work at all.

"The name of the game, " in Game Theory: A Very Short Introduction, Ken Binmore, 2007, page 2:

Even when people haven't thought everything out in advance, it doesn't follow that they are necessarily behaving irrationally.

Game theory has had some notable successes in explaining the behaviour of spiders and fish, neither of which can be said to think at all. Such mindless animals end up behaving as though they were rational, because rivals whose genes programmed them to behave irrationally are now extinct. Similarly, companies aren't always run by great intellects, but the market is often just as ruthless as Nature in eliminating the unfit from the scene.

"The name of the game," in Game Theory: A Very Short Introduction, Ken Binmore, 2007, page 4:



In our toy version, Alice and Bob each show a coin. Alice wins if both coins show the same face. Bob wins if they show different faces. Alice and Bob therefore each have two strategies, *heads* and *tails*. Figure 1 shows who wins and loses for all possible strategy combinations. These outcomes are the players' *payoffs* in the game. The thumbs-up and thumbs-down icons have been used to emphasize that payoffs needn't be measured in money.

"The name of the game," in Game Theory: A Very Short Introduction, Ken Binmore, 2007, page 5:

		heads	tails
heads			
tails			

Matching Pennies

		left	right
left			
right			

Driving Game

2. Payoff tables. Alice chooses a row and Bob chooses a column

Figure 2 shows how all the information in Figure 1 can be assembled into a payoff table, with Alice's payoff in the southwest corner of each cell, and Bob's in the northeast corner. It also shows a two-player version of the very different Driving Game that we play every morning when we get into our cars to drive to work. Alice and Bob again have two pure strategies, *left* and *right*, but now the players' payoffs are totally aligned instead of being diametrically opposed. When journalists talk about a win-win situation, they have something like the Driving Game in mind.

"The name of the game, " in Game Theory: A Very Short Introduction, Ken Binmore, 2007, page 10:

	<i>heads</i>	<i>tails</i>
<i>heads</i>	-1	+1
<i>tails</i>	+1	-1

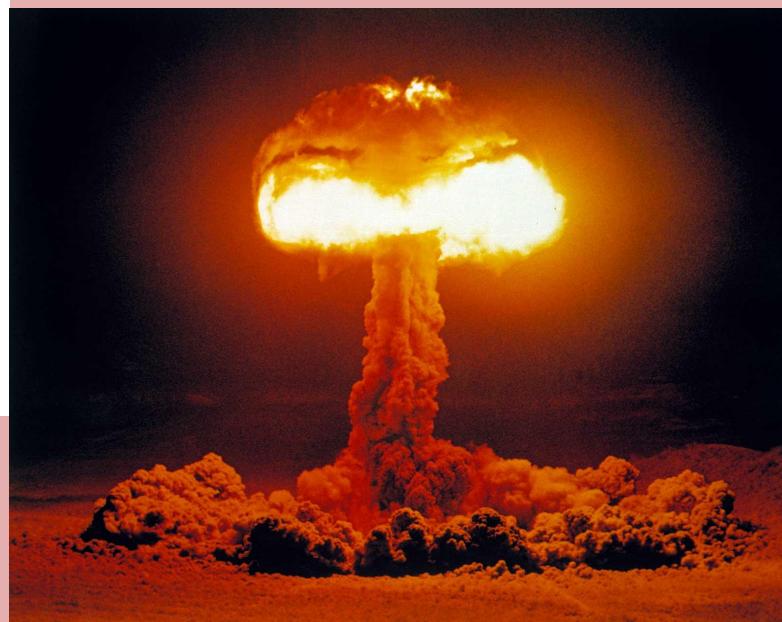
Matching Pennies

### 3. Numerical payoffs

	<i>left</i>	<i>right</i>
<i>left</i>	+1	-1
<i>right</i>	+1	-1

Driving Game

A "zero sum" game: all the numerical payoff digits end in 0. There are only WIN and LOSE conditions.



Boom.

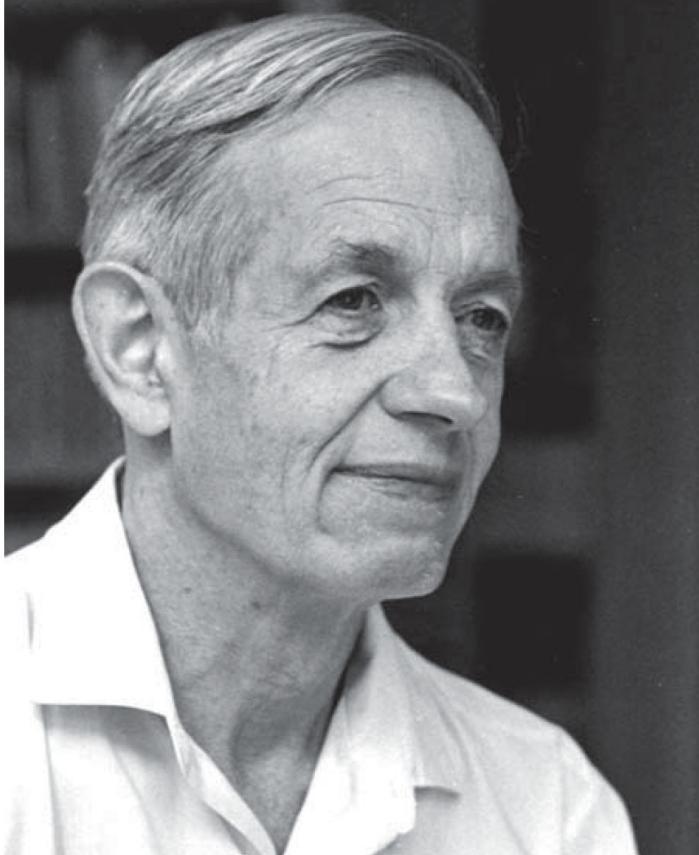
## Game Theory Criticism:

- This also covers the idea of “utility,” which early economists used to which allows each player to assign a numerical value to each possible outcome of a game. There is no compromise or emotion linked to these theories; this is pure gain and pure profit calculation, with no nuance for how we understand games as they are actually played.
- Game Theory covers “rational agents,” but we do not argue how some choices are MORE rational than others. We consider the matrices of possibilities and how they play out. Numbers can be associated with the degree of risk an agent has in making certain decisions.
- While this might sound like ways to theorize different gambling systems, what this doesn't take into account is non-rational or particularly motivated agents—gambling addicts, magical thinking and superstitions, or self-selection (not everyone gambles).

"The name of the game, " in Game Theory: A Very Short Introduction, Ken Binmore, 2007, page 7:

We don't try to explain *why* Alice or Bob behave as they do. Instead of an explanatory theory, we have to be content with a descriptive theory, which can do no more than say that Alice or Bob will be acting inconsistently if they did such-and-such in the past, but now plan to do so-and-so in the future. In game theory, the object is to observe the decisions that Alice and Bob make (or would make) when they aren't interacting with each other or anyone else, and to deduce how they will behave when interacting in a game.

"The name of the game," in Game Theory: A Very Short Introduction, Ken Binmore, 2007, page 2:



	<i>slow</i>	<i>speed</i>
<i>slow</i>	3 3	0 0
<i>speed</i>	0 4	-1 -1

Chicken

#### 4. Games with mixed motivations

A Nash equilibrium is just a pair of strategies whose use results in a cell in which *both* payoffs are circled. More generally, a Nash equilibrium occurs when all the players are simultaneously making a best reply to the strategy choices of the others.

## KEY TAKEAWAYS

- The Nash equilibrium is a decision-making theorem within game theory that states a player can achieve the desired outcome by not deviating from their initial strategy.
- In the Nash equilibrium, each player's strategy is optimal when considering the decisions of other players. Every player wins because everyone gets the outcome that they desire.
- The prisoner's dilemma is a common game theory example and one that adequately showcases the effect of the Nash equilibrium.
- The Nash equilibrium is often discussed in conjunction with dominant strategy, which states that the chosen strategy of an actor will lead to better results out of all the possible strategies that can be used, regardless of the strategy that the opponent uses.
- The Nash equilibrium does not always mean that the most optimal strategy is chosen.<sup>[1]</sup>

# Example of Nash Equilibrium

Imagine a game between Tom and Sam. In this simple game, both players can choose strategy A, to receive \$1, or strategy B, to lose \$1. Logically, both players choose strategy A and receive a payoff of \$1.

If you revealed Sam's strategy to Tom and vice versa, you see that no player deviates from the original choice. Knowing the other player's move means little and doesn't change either player's behavior. Outcome A represents a Nash equilibrium.

TOM

	A	B
A	1,1	1,-1
B	-1,1	0,0

## Prisoner's Dilemma

The [prisoner's dilemma](#) is a common situation [analyzed in game theory](#) that can employ the Nash equilibrium. In this game, two criminals are arrested and each is held in solitary confinement with no means of communicating with the other. The prosecutors do not have the evidence to convict the pair, so they offer each prisoner the opportunity to either betray the other by testifying that the other committed the crime or cooperate by remaining silent.

If both prisoners betray each other, each serves five years in prison. If A betrays B but B remains silent, prisoner A is set free and prisoner B serves 10 years in prison, or vice versa. If each remains silent, then each serves just one year in prison.

In this example, the Nash equilibrium is for both players to betray each other. Even though mutual cooperation leads to a better outcome if one prisoner chooses mutual cooperation and the other does not, one prisoner's outcome is worse.

## Prisoners' dilemma

Case A		Case B		Case C	
Prisoner 1 Remain Silent	Prisoner 2 Betrayal	Prisoner 1 Remain Silent	Prisoner 2 Remain Silent	Prisoner 1 Betrayal	Prisoner 2 Betrayal
					
20 years	Released	1 year	1 year	5 years	5 years

## Nash Equilibrium:

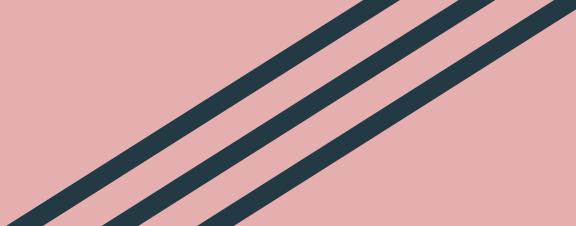
Both players defect (or rat each other out) even if the outcome is worse all around. This remains the same even when one knows of the others' strategy.

## What are the limitations of Nash equilibrium?

The primary limitation of Nash equilibrium is that it requires an individual to know their opponent's strategy. A Nash equilibrium can only occur if a player chooses to remain with their current strategy if they know their opponent's strategy.

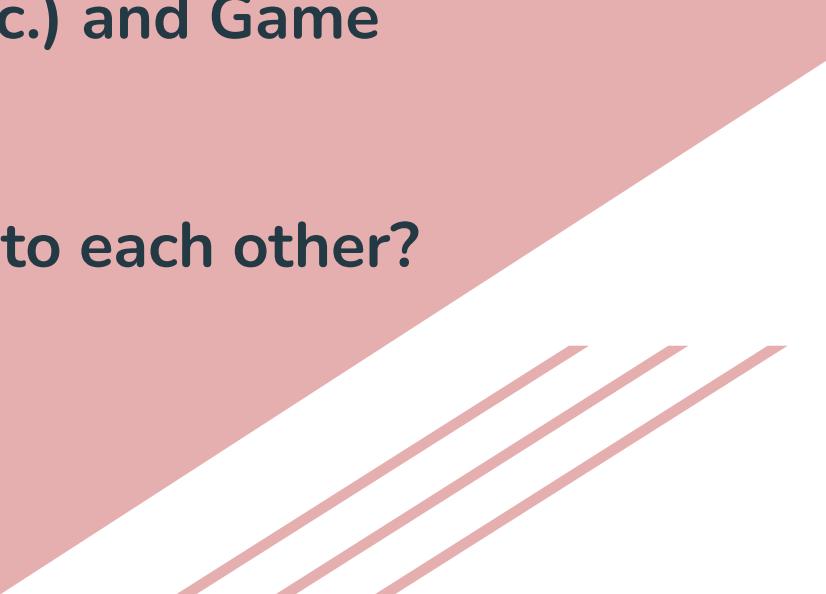
In most cases, such as in war—whether that be a military war or a bidding war—an individual rarely knows the opponent's strategy or what they want the outcome to be. Unlike dominant strategy, the Nash equilibrium doesn't always lead to the most optimal outcome. It just means that an individual chooses the best strategy based on the information they have.

Furthermore, in multiple games played with the same opponents, the Nash equilibrium does not take into consideration past behavior, which often predicts future behavior.



What are the fundamental  
differences between Game Studies  
(Huizinga, Sicart, etc.) and Game  
Theory (Nash)?

How do they relate to each other?





Balance in D&D is difficult to achieve, but it's a great way to learn how the game works! [Credit: WotC](#).

# BALANCE DATASLATE

AUTUMN 2023

However you choose to play Warhammer 40,000, the recommendations in this document are designed to create the most balanced and enjoyable experience for all players, taking into consideration the latest data and feedback from a wide variety of sources. They will be applied in full at all official Games Workshop matched play and Crusade events, and reviewed periodically. Where existing passages of rules text are presented, new or revised sections are marked in red.

## CORE RULES

### Devastating Wounds

**28** Delete the example from this ability, and change the text to:

### DEVASTATING WOUNDS

Some weapons can inflict strikes of such power that they make a mockery of armor.

### STRATEGAMS THAT CAN BE USED MORE THAN ONCE PER PHASE TURN

Rules that allow you to use a Strategam even if another unit has been targeted by that Strategam this phase or turn, but that do not specify the name of the Strategam, can only be used to use Battle Tactic Strategams.

■ Saving throws cannot be made against Critical Wounds scored by this weapon [including invulnerable saving throws].

### Strategams

**41** Add the following:

**MODIFY A STRATEGAM'S CP COST**  
Rules that modify the CP cost of a Strategam when you target a particular unit can only do so for a Strategam that targets multiple units if every unit you target has the same ability to modify the CP of that Strategam.

Rules that modify the CP cost of a Strategam but that do not specify the name of the Strategam can only be used to affect the CP cost of Battle Tactic Strategams. This does not apply to the Air Caste Colossus, Striding Colossus or Towering Wrath Construct abilities.

**Example 1:** A Captain's Rites of Battle ability enables that model to be targeted by a Strategam for OCP. This ability does not specifically name a Strategam, and so it can only be used to use a Battle Tactic Strategam for OCP. Asmussen's Tactical Acumen ability, however, enables you to target this model's unit with the Fire Overwatch Strategam for OCP. As the name of the Strategam is specified, that ability can be used even though Fire Overwatch is a Strategic Play Strategam.

**Example 2:** A Calidius Assassin's Reign of Confusion ability, when used, increases the cost of one of your opponent's Strategams by 1 CP. This ability does not specifically name a Strategam, and so it can only be used to increase the CP cost of a Battle Tactic Strategam.

### STRATEGAMS THAT CAN BE USED ONLY ONCE PER PHASE TURN

Rules that allow you to use a Strategam even if another unit has been targeted by that Strategam this phase or turn, but that do not specify the name of the Strategam, can only be used to use Battle Tactic Strategams.

■ Saving throws cannot be made against Critical Wounds scored by this weapon [including invulnerable saving throws].

### FIRE OVERWATCH

**CORE – STRATEGIC PLAY STRATEGAM**

A half of wildfire can drive back advancing foes.

**WHEN:** Your opponent's Movement or Charge phase, just after an enemy unit is set up or when an enemy unit starts or ends a Normal, Advance, or Retreat charge move.

**TARGET:** One enemy unit in your army that is within 24" of your enemy unit that would be eligible to shoot if it were your Shooting phase.

**EFFECT:** If that enemy unit is visible to your unit, your unit can shoot that enemy unit as if it were your Shooting phase.

**RESTRICTIONS:** You cannot target a TITANIC unit with this Strategam. Until the end of the phase, each time a model in your unit makes a ranged attack, an unmodified Hit roll of 6 is required to score a hit. The downside of the attacking weapon's Ballistic Skill or any modifiers. You can only use this Strategam once per turn.

Rules that modify the CP cost of a Strategam but that do not specify the name of the Strategam can only be used to affect the CP cost of Battle Tactic Strategams. This does not apply to the Air Caste Colossus, Striding Colossus or Towering Wrath Construct abilities.

**Example 1:** A Captain's Rites of Battle ability enables that model to be targeted by a Strategam for OCP. This ability does not specifically name a Strategam, and so it can only be used to use a Battle Tactic Strategam for OCP. Asmussen's Tactical Acumen ability, however, enables you to target this model's unit with the Fire Overwatch Strategam for OCP. As the name of the Strategam is specified, that ability can be used even though Fire Overwatch is a Strategic Play Strategam.

**42** **Insane Bravery Strategam**  
Change to:

**41CP**

## FACTION RULES

### ADEPTUS CUSTODES

**Unwavering Sentinels Strategam, Type**  
Change to 'Epic Deed Strategam'.

### Custodian Guard Datasheet, Unit Composition

Change bullet point to:  
• 4-5 Custodian Guards

### Custodian Wardens Datasheet, Unit Composition

Change bullet point to:  
• 4-5 Custodian Wardens

### Vertus Praetors Datasheet, Unit Composition

Change bullet point to:  
• 2-3 Vertus Praetors

### ADEPTUS MECHANICUS

#### Skitarii Rangers Datasheet

Change this unit's Save characteristic to 4+ and its invulnerable save to 5+.

#### Skitarii Vanguard Datasheet

Change this unit's Save characteristic to 4+ and its invulnerable save to 5+.

### AELDARI

#### Pantasma Strategam, Target Section

Change to:  
**TARGET:** One AELDARI INFANTRY unit from your army.

### AGENTS OF THE IMPERIUM

#### Exaction Squad Datasheet

Unit Composition – change bullet points to:

- 1 Pector Exactor
- 3 Exaction Vigilants
- 0-1 Cyber-mastiff

#### Geargar Options – change the first bullet point to:

- Up to 2 Exaction Vigilants can have their Arbitrarius combat shotguns replaced with one of the following [duplicates are not allowed]:

## GENESTEALER CULTS

### Cult Ambush Arm Rule

Change the first paragraph to:  
If your Army Faction is GENESTEALER CULTS, each time a unit with this ability is destroyed, roll one D6, adding 1 to the result if it is a BATTLELINE unit, and adding 1 to the result if it is the first or second battle round. On a 5+, add a new unit to your army identical to your destroyed unit, in Cult Ambush, at its Starting Strength and with all of its wounds remaining, and you can place one Cult Ambush marker anywhere on the battlefield that is more than 9" horizontally away from all enemy units [if this is not possible, no marker is placed].

### Atalan Jackals Datasheet, Outrider Gangs Ability

Change to:

Each time you use the Cult Ambush ability to set this unit back up on the battlefield, in addition to the normal rules, all its models must be set up wholly within 9" of a battlefield edge and at least one of its models must be touching one of your Cult Ambush markers [that marker is then removed from the battlefield]. If this cannot be done, this unit cannot be set back up.

### GREY KNIGHTS

**Haloed in Sulfure Strategam, Type**  
Change to 'Strategic Play Strategam'.

### IMPERIAL KNIGHTS

#### Bondsman Abilities

Change to:

Combat stress models have a Bondsman ability, tagged with the word 'Bondsman'. In your Command phase, one or more models from your army with a Bondsman ability can use that ability. For each one that does, select one friendly ARMIGER model within 12" of that model [you cannot select an ARMIGER model that is already being affected by a Bondsman ability]. Until the start of your next Command phase, the ARMIGER model you selected is affected by that Bondsman ability.

### Thunderstomp Strategam, Type

Change to 'Epic Deed Strategam'.

### Trophy Claim Strategam, CP Cost

Change to '2CP'.

### Valiant Last Stand Strategam, CP Cost

Change to '2CP'.

## LEAGUES OF VOTANN

### Ruthless Efficiency Detachment Rule

Change first two paragraphs to:  
At the start of the battle, select a number of units from your opponent's army depending on the battle size, as shown below:

- Incursion: 2 units
- Strike Force: 4 units
- Onslaught: 6 units

Each of those units start the battle with 2 Judgement tokens [see Eye of the Ancestors].

If, at the start of any of your Command phases, any of those units have been destroyed, you gain a number of CP depending on how early in the battle you destroyed it, as shown below [you can only gain CP in this way once per battle, and CP gained in this way are an exemption to the Core Rules that limit the maximum number of CP you can gain per battle round 1]:

### SPACE MARINES

#### Desolation Squad, Unit Composition

Change bullet points to:  
• 1 Desolation Sergeant  
• 4 Desolation Marines

