

Prisoner's Dilemma: An Experiment

Ankur A. Kulkarni*

1 Introduction

On December 3, 2010, I introduced game theory to a class of third year undergraduates in OR by playing a game in class. I posed the question of the *Prisoner's dilemma*, in which the students were to play the role of a prisoner. This also served as an experiment to study the responses of real players when posed with situations of strategic decision making.

The class was divided into three groups.

1. Two girls who are good friends were told that they were to think of themselves as the two prisoners. They were not allowed to talk to each other and were seated so that they could not make eye contact or could see each other's answers. (Group C)
2. Two students, a girl and a boy were put together as a group and were asked to think of themselves as the two prisoners. But they were allowed to discuss and make their decision together. (Group B)
3. All others were asked to imagine the other suspect. (Group A)

Purpose: The purpose of the experiment was to assess for myself, how students (or people in general) reason through a game theoretic situation and assess first-hand the "real-world" applicability of game theoretic concepts. For the class, this playing this game would serve to teach or demonstrate to them three concepts. (a) The concept of a game and coupled decision-making, (b) the distinction between cooperative and noncooperative games and (c) the concept of a Nash equilibrium.

There were a total of 24 students. Group A consisted of 20 while B and C had 2 each. Of the 20 in Group A, 4 claim to have heard of the Prisoner's dilemma or a similar question. The question I posed could be summarized as follows.

	The other suspect remains silent	The other suspect testifies against you
You remain silent	1 year for you, 1 year for him	You get 10 years, he goes free
You testify against the other suspect	You go free, 10 years for him	6 years for you, 6 years for him

Based on this, they were asked to answer the following questions.

1. What is your decision? Tick only one:
 - a. Remain silent
 - b. Tell on the other suspect
2. What do you think is the other suspect's decision? Tick only one:
 - a. Remain silent
 - b. Tell on you.
3. **Only for group A:** Were you assuming that the other suspect is a friend or someone you know?
 - a. Yes
 - b. No

If yes, suppose you did not make that assumption and the suspect was a stranger to you, would your decision change? Yes / No
4. **Only for group B:** Was your group unanimous in your decision? If no, explain the situation in your group.
5. Explain your reasoning. If you have heard of this or a similar question before, mention that in your explanation.

*Department of Industrial and Enterprise Systems Engineering, UIUC

2 Results

The Appendix has the full question and the details of every student’s response. The results may be summarized as follows.

- 12 out of 24 chose to “Tell” and thought the other suspect would also choose “Tell”.
- An additional 4-5 chose “Silent” and thought the other suspect would also choose “Silent”. But they were assuming the other suspect to be a friend and said that if the other suspect was a stranger, they would alter their decision and choose “Tell”.
- The friends in Group C chose “Silent” for themselves and their friend. One of them said that she would change her decision to “Tell” if the suspect was a stranger.
- Unsurprisingly, in Group B the students chose “Silent”. They said they were unanimous in their choice.
- Most students suggested that the primary choice they had to make was whether they “trusted” the other suspect. This was important, since communication was forbidden.
- 2 students said they chose “Silent” for themselves and “Silent” for the other based on the reasoning that the other suspect would also think it is the “smarter” choice, although they were not assuming a trust between them and the suspect.

Q 1 (your choice)	Q 2 (other suspect’s choice)	Q 3 (assume the suspect to be a friend)	Number (out of 24)
Tell	Tell	No	11
Tell	Tell	Yes, No	1
Silent	Silent	Yes, Yes	4-5 (one response was Yes, May be)
Silent	Silent	No	2
Silent	Tell	No	1
Silent	Silent	Yes, No	0-1 (one response was Yes, May be)
Tell	Tell	N/A	1
Silent	Silent	N/A	1

2.1 Student reasoning

All students reasoned in the following way:

1. They attempted to guess what the action of the other suspect, based on their trust in the other suspect.
2. Based on this guess they guessed the motivations behind that action, i.e. whether the other suspect wishes to cooperate or not.
3. Based on this, they fixed their decision.

It appears therefore that there is a choice of *Cooperate v/s Not Cooperate* being made before students choose their actions and a clear decision cannot be arrived at until this is fixed. This speaks to Nash’s clarification of games as being of two kinds – cooperative and noncooperative – and the distinction between their solution concepts.

No student sought to check the *stability of his/her initial guess* about the other suspect’s action given his/her own choice. When I asked the class “If you assume the other suspect stays silent and then decide to stay silent yourself, did you consider if he will really remain silent if you are staying silent?”, they were taken aback and admitted to have not thought about this.

About 50% more of the students admitted to base their reasoning on a kind of *probabilistic assessment* of the other suspect’s actions. They did not however consider it as a tool towards giving them or the other suspect a strategic advantage. In other words, they were not thinking in terms of *mixed strategies*. And about 20% seemed to base their choice on “*regret minimization*”.

Other interesting findings: One of the friends in Group C showed signs of nervousness while deciding her choice. That both she and her friend coincided in their decisions to stay “Silent” brought relief to her, as if it were reaffirming their friendship. One student said that regardless of whether the other suspect is a friend or not, he cannot trust him and therefore chose “Tell”. One student took inspiration from a Batman movie to explain her choice. One student said she would remain silent because she had not committed the crime and she cited a curious rule¹ to conclude that the other suspect would “Tell”.

3 Conclusion

- To cooperate or not seems to be the first decision that all students try to make. Trust plays a dominant role in making this decision.
- Once it is clear to them that they are playing a noncooperative game, at least 66% chose to “Tell” on the other suspect, whereby the Nash equilibrium is the outcome.
- Students tried at most one iteration of “best-response dynamics” in their reasoning for their own action and no such iteration for the other suspect’s action. This speaks to *bounded computation* as a serious concern.
- Although probabilistic assessments came naturally to students, a deliberate strategic randomization, namely the use of a mixed strategy, did not occur to any students.

¹See response 13 in Appendix B.

A The question

Imagine that you and another suspect have been arrested for a crime and are being held in as prisoners in **two separate cells** in a jail. The police have **insufficient evidence** to convict either of you. Tomorrow you will be presented before the judge where the judge will ask you about the **other suspect**. You have two choices.

1. To testify that the other suspect committed the crime.
2. To remain silent.

The other suspect has **also been given the same choices**: to testify against you or to remain silent. The police come to your cell and offer this deal:

1. If you remain silent, and the other suspect also remains silent, the judge will give **each of you 1 year in jail**.
2. If you testify against the other suspect, but the other suspect chooses to remain silent, **you get to go free and the other suspect gets 10 years in jail**.
3. Similarly if you choose to remain silent and the other suspect testifies against you, **the other suspect goes free and you get 10 years in jail**.
4. If you testify against the other suspect and the other suspect also testifies against you, **each of you get 6 years in jail**.

The exact same deal is offered to the other suspect. In short we can summarize this situation as follows.

	The other suspect remains silent	The other suspect testifies against you
You remain silent	1 year for you, 1 year for him	You get 10 years, he goes free
You testify against the other suspect	You go free, 10 years for him	6 years for you, 6 years for him

Take your time and think through the situation. Your punishment depends not only on what you choose to do but also on what the other suspect chooses. **You don't have an opportunity to meet, see, talk or discuss anything with the other suspect. You don't have a chance to know what the other suspect chooses when you are making your decision.**

Now answer the following questions:

1. What is your decision? Tick only one:
 - a. Remain silent
 - b. Tell on the other suspect
2. What do you think is the other suspect's decision? Tick only one:
 - a. Remain silent
 - b. Tell on you.
3. **Only for group A:** Were you assuming that the other suspect is a friend or someone you know?
 - a. Yes
 - b. No

If yes, suppose you did not make that assumption and the suspect was a stranger to you, would your decision change? Yes / No
4. **Only for group B:** Was your group unanimous in your decision? If no, explain the situation in your group.
5. Explain your reasoning. If you have heard of this or a similar question before, mention that in your explanation. You can use the reverse side for q. 4 and 5.

B Samples

B.1 Hypothetical suspect

	Q 1	Q 2	Q 3	Explanation
1.	Tell	Tell	No	Everyone hopes to go free. Silent: Choose either 1 year or 10 years → 4.5 years average. Tell: Choose either free or 6 years → 3 years average.
2.	Silent	Silent	N/A	Remaining silent is the best choice to get least years in jail
3.	Tell	Tell	N/A	Because you get less time
4.	Tell	Tell	No	Whether the other guy stays silent or testifies against me, the outcome is better for me when I testify against him. If he is silent, I'll be free instead of spending 1 year and if he testifies against me, I only get 6 years instead of 10. I also assume we will testify against me as well.
5. *	Tell	Tell	No	Yes, either go free or 6 years is better than 1 year or 10 years. (I've heard of a this same question however)
6.	Tell	Tell	No	I don't want to let the other person screw me over
7.	Silent	Silent	No	I know I did not do it and so I am confused as to whether this implies automatically that the other suspect did it. So, I will remain Silent and not make anything up. Insufficient evidence means perhaps neither of us committed the crime. Unless I knew 100% that the other person did it, I would remain silent.
8.	Tell	Tell	No	I wouldn't trust someone that I don't know who is suspected of committing a crime. I would assume that they would throw me under the bus. The mean of jail time this way is 3 years instead of 5.5 years.
9. *	Silent	Silent	Yes, Yes	I studied about the Prisoner's dilemma in psychology. I would stay silent and hopefully other suspect will as well because that option has the lowest expected value of punishment.
10. *	Tell	Tell	No	I don't want to go to jail at all, or at least have that chance. (Also I have heard/done stuff with this before: assume other people go for most attractive thing for themselves) Go free best, at worst 6 years - 3 average, other 6 best 10 worst.
11.	Tell	Tell	No	If the suspect is a complete stranger I would expect them to testify against me. I look at it as getting off free and minimizing the sentence to 6 years. I feel like remaining silent is too big of a gamble.
12. *	Tell	Tell	Yes, No	I read this problem about 8 years ago and do not remember the optimal answer. However, I would tell on the other because then I would have 0 or 6 years in prison. If I'm silent, I get 1 or 10 years in prison. The other person ultimately wants 0 years I think they will tell on me. I can't risk getting 10 years so I need minimize that possibility.
13.	Silent	Tell	No	I would choose to remain silent unless I know the other one did it. In that case I would tell on the other suspect. I would probably also tell on the other suspect if I had committed the crime. By the @\$\$hole rule, I assume that the other person tells on me, but I don't care to be the @\$\$hole in case he didn't. I don't think I could live with the consequences of that decision.

* indicates student has heard of Prisoner's dilemma or something similar.

	Q 1	Q 2	Q 3	Explanation
14.	Silent	Silent	Yes, May be	I'd choose to remain silent just because if neither of us did commit the crime, we would be happy to get 1 years in jail. However if we see then the odds are against us in 2 out of 4 situations. In one they tip in our favour and in remaining silent, they go equal both ways. Thus I'd choose remaining silent over telling on the other suspect. Also, yes I did assume that the other suspect is a known person since both of us have been arrested.
15.	Silent	Silent	No	How I see the problem is that there is a 50% chance that the other suspects stays silent or testifies against me. If the other suspect is smart enough we should realize that if both suspects talk we can get 6 years but being silent gives us only 1 year.
16.	Tell	Tell	No	I chose to testify because regardless of what they do I come out with the best result. I don't have enough trust they wouldn't testify against me. However if my accomplice was a close friend I trusted I would remain silent trusting that they would and serve 1 years rather have the guilt of giving them 10 years when they trusted me.
17.	Tell	Tell	No	N/A
18.	Tell	Tell	No	The expected value is lower. If you don't choose telling then you are open to getting beat by the choice that the other prisoner would probably make.
19.	Tell	Tell	No	I want the smallest punishment possible and cannot trust the other person would not talk. If it was a very close friend I would say nothing trusting they would do the same. My risk lowest if I talk.
20.	Silent	Silent	Yes, Yes	If I assume the other suspect to be my friend then I <u>trust</u> him to be silent. So this way we both end up in jail for 1 year. But if the other suspect is a stranger, I would definitely testify against him since this would completely neglect my chances of going to jail for 10 years. I could also go free. It would be like a coin toss between going free and 6 years of jail. I would prefer this coin flip than between 1 year of jail and 10 years of jail.

B.2 Friend as the other suspect: noncooperative

	Q 1	Q 2	Q 3	Explanation
21.	Silent	Silent	Yes, Yes	By me testifying, my options become go free (if the other suspect doesn't) or 6 years (if the other suspect does). By remaining silent I either have 1 year or 10 years. I would guess that the other suspect would assume that I am deciding the same as them and would prefer 1 year to 6 years. There is a similar scene in Batman with the prisoner and the citizens on the boat deciding if they will blow each other up. They both decide not to blow up the other boat even though they are threatened to.
22.	Silent	Silent	Yes, Yes	I know ##### and I think that the chance of her remaining silent are high so that we both serve one year. If I didn't know the person I might testify against them because the chance of them testifying against me are probably higher. I think most of the people in this class choose to testify against. So using them as the other suspect I would testify against them.

B.3 Friend as the other suspect: cooperative

	Q 1	Q 2	Q 3	Q 4	Explanation
23.	Silent	Silent	N/A	Yes	Both remain silent, best for us.
24.	Silent	Silent	N/A	Yes	I would never tell on #####!