Mathematics: Game Theory

■ CONTENT VOCABULARY

Look at the picture and read the caption. What is meant by a "hypothetical problem"? Do you know any other games that involve hypothetical problems?

The Prisoner's Dilemma is a **hypothetical** problem about two people that are arrested and detained as suspects in a crime. It is based on the **mathematical calculations** of two mathematicians from the Rand Corporation who were studying game **theory** in 1950. Although the problem is more than 50 years old, the **implications** of The Prisoner's Dilemma are still discussed today.

Look up any words in the caption you don't know. Write each word, its definition, and a sentence that illustrates its use in your vocabulary journal.

■ THINK ABOUT IT

Sometimes we are faced with a dilemma that has several possible solutions. There are pros and cons to each side, and the "right" choice is not obvious. Write for five minutes about a difficult choice you have had to make.

■ GRAMMAR IN CONTENT

CD1, TR25

A **Read and listen to the following article.**

The Prisoner's Dilemma

In this game, you and a partner imagine that you have committed a serious crime and the police have arrested you. The police **didn't** find **any** evidence to convict you of the crime, but they found **some** evidence of a lesser crime. The police **haven't** interrogated **either** one of you yet, but they are planning to do so soon. You and your partner will have **no** opportunity to speak to each other before the interrogation. After the interrogation is over, you will **not** be able to change your statement. There will be **no** chance of making or withdrawing a confession.

You are faced with a problem that requires a rational solution. You **can't** let your emotions tell you what to do. Should you confess or should you remain silent? There is **no** right answer, and the problem **isn't** easy to solve because there are several possible courses of action.

Possibility 1: When you are interrogated, you **don't** confess to the crime and your partner **doesn't either.** In this case there **won't** be **any** evidence to convict you or your partner of the serious crime, so you will both go to prison for six months for the lesser crime.

Possibility 2: You confess to the serious crime, but your partner **doesn't.** In this case, you **won't** have to spend any time in prison because you will have helped the police. Your partner, however, will be sentenced to three years because of your evidence.

Possibility 3: You **don't** confess, but your partner does. You will be sentenced to three years because of your partner's evidence, and your partner will spend **no** time in prison.

Possibility 4: You both confess. A judge can convict you and sentence you both to three years in prison on the basis of your confession. But in exchange for your cooperation, the judge will be lenient. He **won't** sentence you to prison for the full term. Instead, you'll both be sentenced to two years.

to confess: to admit something, especially guilt for doing something bad

to convict: to find someone guilty of a crime in a court of law

evidence: words or objects that support the truth of something

to interrogate: to ask questions, often in a strong or aggressive way; questioning by the police

to sentence: to give a punishment, usually prison time

B Reread the passage. Look at the negative constructions and study the chart below.

Negative Statements with *Not*	Notes
I**'m not** guilty.	The negative *not* comes after the verb *to be* or the first auxiliary verb.
The judge **did not give** the defendants the maximum sentence. They **might not have been given** such a lenient sentence if they hadn't had such a good attorney.	*Not* comes between an **auxiliary verb** and a **main verb.** It comes after the first auxiliary verb if there are two or more auxiliaries.
The prisoner claims he **hasn't** committed a crime. He insists he **isn't** guilty.	*Not* can contract with the auxiliary verb or the verb *to be.*
He **doesn't** have **any** good excuses for his behavior.	If there is no auxiliary verb or the verb *to be,* add the correct form of *do.* (Use the same tense, person, and number as the main verb, and change the main verb to the base form.) *Any* is used to make negative statements with **count** and **noncount nouns.**
We **don't** have **much time** to make up our minds.	*Much* is used only with **noncount nouns.**
The prisoner **won't ever** be released from prison.	Use *ever* in questions and negative statements. You can use *never* in negative statements too, but only with verbs in the affirmative. **Correct:** *You'll never know the answer.* **Correct:** *You won't ever know the answer.* **Incorrect:** *You won't never know the answer.*

Negative Statements with *No*	Notes
The judge gave **no reason** for his decision.	*No* can be used to modify the **object** of a verb.
There is **no logical argument** in favor of a confession.	*No* can also be used to modify the subject of a sentence. The **main verb** must be in the affirmative.
No judge would agree to that.	*No* can be used to modify a **noun phrase.**

C Fill in the blanks, using the negative form of the verbs in parentheses.

The Prisoner's Dilemma was worked out by two Rand Corporation scientists in 1950. At first ____*it was not*____ (1) (was) a dilemma story. It was a mathematical problem. Later, another scientist articulated the problem in terms of a dilemma, or story, so that it _____ (2) (would be) so difficult to explain to people who _____ (3) (were) mathematicians. The story _____ (4) (is) about law and legal processes. It proposes a situation in which there _____ (5) (is going to be) an easy or obvious choice.

It _____ (does say) what to do or what
(6)

_____ (to do), but it nevertheless presents a challenge to basic
(7)

game theory. One of the fundamental questions in game theory is whether there is always

a rational move to make in any given game. Game theory assumes that the participants

_____ (are) irrational and that there is always a rational move to
(8)

make if the opponents' interests are in opposition.

D **Complete the dialog, using the correct word in parentheses. Discuss your choices.**

Lin: Have you _____ (ever/not ever) heard of game theory?
(1)

Charles: No. Why?

Lin: I'm taking some math classes this quarter, and one of them is game theory.

_____ (It's not/It's no) as easy as you might think.
(2)

Charles: That sounds interesting. I'm not taking _____ (some/any)
(3)

classes now, because I'm taking the semester off. Who do you have for game

theory?

Lin: His name is Jones. Have you _____ (ever/not ever) had him?
(4)

Charles: I've _____ (never/not ever) heard of him. Is he a good
(5)

instructor?

Lin: Yes, I really like how he teaches. He never gives us _____
(6)

(any/no) boring assignments. This week, for example, he asked us to design

our own game.

■ **COMMUNICATE**

E **GROUP WORK** **Create a chart summarizing all of the possibilities in The Prisoner's
Dilemma. (Reread the passage on page 82 if necessary.) Draw your group's chart on the
board. Explain it to the class.**

	Prisoner B Stays Silent	Prisoner B Confesses
Prisoner A Stays Silent	Each prisoner serves six months.	
Prisoner A Confesses		

■ **G R A M M A R I N C O N T E N T**

A   Reread the passage on page 82. <u>Underline</u> a combined negative sentence. If you need help, use the chart below.

Negative Statements with *Either*	Negative Statements with *Neither*
The prisoner said, "I don't want to be released from prison, but I don't want to be executed, either."	The prisoner wanted **neither** freedom nor death.
The prisoner won't confess. His partner won't confess **either.**	The prisoner won't confess and **neither** will his partner.
A police officer cannot judge a suspect. He can't convict a suspect **either.**	A police officer can **neither** judge **nor** convict a suspect.
Erin doesn't think the suspect is guilty. Zora doesn't think he's guilty **either.**	**Erin:** I don't believe the suspect is guilty. **Zora: Neither** do I.

Notes:
- *Either* can be used to show a choice between two possibilities (*There are two pieces left. You can have either one.*)
- *Either* is used with *or* to state two possibilities or choices (*We can either stay or go.*)
- *Either* shows similarity or agreement between two negative statements. The verbs in both sentences are in the negative. *Either* comes at the end of the second sentence (*I'm not convinced and the jury isn't either.*)
- Like *either,* the negative *neither* also shows similarity or agreement between two negative statements. The verb in the first sentence is in the negative; the verb in the second sentence is in the simple (affirmative) form, with *neither* coming first, followed by the verb and then the subject (*I'm not convinced and neither is the jury.*)
- If two verbs in the same sentence are in the simple (affirmative) form, use *neither* before the first verb and *nor* before the second verb. *Neither* and *nor* can also be used with other parts of speech (*The answer is neither right nor wrong.*)
- *Neither* is combined with an **auxiliary** to show agreement with a previous statement (*Teri doesn't understand chess. Neither does Samuel.*)
- *Neither* can be used to refer back to two previously mentioned nouns (*Both players did their best, but neither scored a point.*) Here, *neither* refers to "both players."

B   Fill in each blank with *either, neither,* or *nor,* as appropriate.

The game of chess is <u> *neither* </u> easy <u> *nor* </u> simple. The pieces are divided
(1)   (2)

into two matching sets. The players can use _____ color. A player can _____
(3)   (4)

move to an empty space or capture an opponent's piece. A pawn can move _____
(5)

backwards _____ sideways. After their first move, pawns cannot move more than
(6)

one square at a time. _____ can the king. When the king can _____ advance
(7)   (8)

_____ retreat, he is in checkmate and the game is over.
(9)

C **PAIR WORK** Play The Prisoner's Dilemma with a partner. Each person writes down his or her choice in secret. Both players then reveal their written answers to each other at the same time. Play 10 times. Keep track of how much time each person has to spend in prison. Report the results of your game to the class.

Connection | Putting It Together

GRAMMAR AND VOCABULARY Do you have a favorite game of chance or skill? Write the rules and directions for the game, using as many negative constructions as you can. Give any necessary background information, and then write a detailed set of instructions for playing the game. Share your work with classmates in a small group.

The Game of Mahjong

The game of Mahjong originated in China thousands of years ago, but these days it isn't just played in China. People around the world are crazy about it.

To play this fascinating game, you need a Mahjong board and tiles. The first player turns up two tiles. If the tiles match, the player keeps the tiles and takes another turn. If the tiles don't match, the player doesn't get to keep the tiles.

Play continues in this way until the players have matched all the tiles. The game stops if neither player can match any more tiles. The player with the most tiles is the winner.

So you see, you don't need to travel to China to play Mahjong. You don't even need to have a partner, nor do you really need a board. You can simply play by yourself on your home computer, if you have the right software.

INTERNET Search an online encyclopedia for the subject "game theory." You can learn the basic theories that game designers use when creating games. Consulting these guidelines will help you in doing the project.

PROJECT In a group, design your own game. Decide on the following elements: What is the goal of the game? What are the rules? How does a player win, or how does the game end? Present your idea to the class, and play one or two rounds of the game with other groups.

A **Complete the following dialog with the correct form/tense of the verb in parentheses, or choose from the words or phrases in parentheses.**

Rachel: I _____ (cough) continuously for a couple
(1)

of weeks now. I _____ (not sleep), and I
(2)

_____ (not go) to work since Monday.
(3)

Nurse: For how long exactly _____ (have) you _____
(4)   (5)

(have) this cough?

Rachel: It _____ (begin) a few weeks ago at work. By
(6)

tomorrow evening _____ (cough) nonstop for
(7)

exactly three weeks. I _____ (not ever, have) a
(8)

cough like this before. My throat _____ (be) dry and
(9)

my ribs _____ (hurt) for the last few days.
(10)

Nurse: _____ (do) you _____ (have) any other
(11)   (12)

symptoms before the cough _____ (start)?
(13)

Rachel: Well, I _____ (not feel) very well for a couple of
(14)

days before the cough _____ (begin).
(15)

Nurse: _____ (do) you _____ (have) a fever during
(16)   (17)

the last three weeks?

Rachel: I _____ (not think) so.
(18)

Nurse: It could be an allergy. _____ (have) you
(19)

_____ (be) around any new or different plants
(20)

during the last few weeks?

Rachel: Now that you mention it, I _____
(21)

(receive) some beautiful flowers from a friend the day before I

_____ (start) coughing. That might be the cause.
(22)

B Select the modal or phrasal modal from the words in parentheses.

Louis: I went to the library to print out my paper, but it's closed.

Marv: It _____ (can't/isn't going to) be closed. Today's a
(1)
Thursday, and the library stays open until 10:00 on Thursdays.

Louis: Well, it is. They _____ (may/are going to) be having
(2)
a problem with power. I noticed that there were no lights on.

Marv: Or they _____ (might/should) have closed because of
(3)
a fire drill. It _____ (should/can) be open now.
(4)

Louis: Well, it isn't. So what _____ (should/would) I do?
(5)

Marv: Dr. Black _____ (is going to/might) accept the paper
(6)
late if you e-mail her and let her know what's happening.

C Fill in each blank with the correct negative form of the verbs *be, do, could,* or *have.* Use contractions whenever possible.

Mehmet: When I tried to register for the History of English class, there

_____ any room left, so I _____ get in.
(1)   (2)

Arturo: I _____ either. My problem was that I _____
(3)   (4)
remember to register in time.

Mehmet: Yeah, I _____ either. And I _____
(5)   (6)
been able to register in three other classes I need to graduate. There

_____ an advisor in the English Department who could help
(7)
me. I _____ want to put off graduation, but I may have to.
(8)

LEARNER LOG Check (✔) *Yes* or *I Need More Practice.*

Lesson	I Can Use . . .	Yes	I Need More Practice
6	Present and Present Perfect, Past and Past Perfect, Future and Future Perfect		
7	Tense Sequencing in Discourse, Simple Present as Background Information		
8	Present Perfect Progressive, Past Perfect Progressive, Future Perfect Progressive		
9	Common Modal Verbs, Negation of Modals		
10	Negative Statements, Negative Statements with *Either* and *Neither*		