Ultimatum Game

**Overview**: It has long been known that low serotonin levels are associated with groups of people prone to impulsiveness and problems with emotional control. Neuroscientists use a version of the Ultimatum Game as a method of testing the connection between impulse control and serotonin levels.

The Ultimatum Game is a game in which two people interact to decide how to divide a sum of money. The first person proposes how to divide the sum between the two people and the second person can either accept or reject the proposal. If the second person rejects, neither receives anything. If the second person accepts, the money is split according to the proposal.The game is only played once so that reciprocation is not an issue.

**Materials:**

* An individually wrapped kind of candy that you know your students will like (e.g. Hershey’s kisses, Rolos, Starbursts, bite sized candy bars) for ⅓ of the class.
* Responders from another class-try to keep variables to a minimum, so choose students from the same age level. Enough so each group has 3 total responders for the activity. Ex: if you have 8 groups in your class, you will need 24 responders.
* Copies of the survey for EACH responder (see below)
* Copies of the scoring rubric for Group C to use as quantitative analysis, 3 per group (see below)

**Procedure:**

* Divide students into groups of 3: 1 person (Group A) will time how long it takes for the responder to accept or reject the proposal; another person (Group B-the proposer) will describe the choice and then document whether the responder accepts or rejects the proposal, and the third person (Group C) will make and record observations of the responders facial expressions, body language, mood etc using scoring rubric (below). It might be helpful to video the person as they make the decision with a cell phone or an IPad to review.
* Give students a few minutes to create a data table in their science notebooks for the observations/measurements they are responsible for documenting.
  + Group A: Proposal type and time to decide
  + Group B: Proposal type and accept/reject
  + Group C: Proposal type and qualitative analysis of body language
* Describe to your students the rules of the ultimatum game. As scientists they should not comment or react during the experiment.
* The proposer (Group B) invites the first responder to sit across from them.
  + On the table, put a pile of 20 candies in full view of the responder. Tell the responder “There are 20 pieces of candy here that can be divided between us. I propose that we divide this candy 50/50.”
  + Divide the pile in half to show the split.
  + Continue by saying “You can accept this proposal or reject it. If you reject, we both get nothing. Do you accept or reject the offer?”
  + At this time, Group A will begin timing how long it takes the responder to make a decision and the observers in Group C start recording body language, facial expressions etc. A cell phone, iPad or other recording device might be helpful.
  + When the responder makes a decision, that decision is documented by group B (accept or reject) and timing is stopped and recorded by Group A.
* Now give the responder the short survey to be completed in the hallway.
* For the next set of responders, repeat the procedure but change the percentages to 60/40 (the responder gets the smaller amount). Then repeat with different responders setting the percentages at 70/30 (the responder gets the smaller amount).

Repeat the procedure until all groups see 3 different responders: 50/50, 60/40, 70/30.

**Analyzing the Data:**

Have each group A, B, and C average their results and input their data into class data table, which will be displayed in the front of the classroom.

**Class discussion**

Have each group develop a claim that can be made from their data and share with the whole class.

Questions to be discussed:

* What correlations between the 3 sets of data can you see?
* Why do you think the responders answered the way they did?
* What factors might be influencing their decision to accept or reject the proposal?
* How do you think scientists study decision making by individuals?
* What kinds of scientists study decision making?

**Read and Share**

Pair up your students and have each one read an article from below and explain to their partner. Then work together to answer the questions below.

Deal or No Deal (see below)

The Chemistry of Choice: How serotonin affects decision-making (see below)

**Questions:**

1. What is serotonin?

2. How do neurologists use the Ultimatum game to study the effects of serotonin on decision

making?

3. How does lowering serotonin levels affect decision making?

4. Does our experimental evidence support your claim? Explain.

5. What societal issues could benefit from this type of research?

**Extension Possibilities:**

To extend the investigation, students could come up with a new experiment that tests different variables within the confines of the Ultimatum Game, for example, male vs. female response times, testing responses of different age groups, time of day, etc. (Don’t forget to adjust your Responder Survey accordingly).

Require students to present experimental design and results.

Show the this interview with Dr. Churchland and Dr. Crockett.

<http://thesciencenetwork.org/programs/the-science-studio/patricia-smith-churchland-and-molly-crockett>

***Document Overview:***

This lesson plan provides an investigation that correlates to the Medicine/Genetics strand content that will be presented at the Nobel Conference. Further, it can be used as an activity/investigation in the areas of Bioethics, Neurobiology, or Anatomy and Physiology.

***Minnesota State Academic Science Standards:***

9.1.1.1.2. Understand that scientists conduct investigations for a variety of reasons, including: to discover new aspects of the natural world, to explain observed phenomena, to test the conclusions of prior investigations, or to test the predictions of current theories.

9.1.1.1.4. Explain how societal and scientific ethics impact research practices.

9.1.1.2.1. Formulate a testable hypothesis, design and conduct an experiment to test the hypothesis, analyze the data, consider alternative explanations and draw conclusions supported by evidence from the investigation.

9.1.3.3.3. Describe how scientific investigations and engineering processes require multi-disciplinary contributions and efforts.

***Minnesota State English Language Arts Standards for Science:***

9.12.8.8. Assess the extent to which the reasoning and evidence in a text support the author’s claims.

9.13.3.3. Follow precisely a complex multi-step procedure when carrying out experiments, designing solutions, taking measurements, or technical tasks, attending to special cases (constraints) or exceptions defined in the text.

9.13.6.6. Analyze the author’s purpose in describing phenomena, providing an explanation, describing a procedure, or discussing/reporting an experiment in a text, defining the question the author seeks to address.

9.13.9.9. Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.

***Objectives:***

I will conduct an experiment, collect quantitative and qualitative data and analyze the results.

I will use proper scientific methods.

I will describe the relationship between variables.

I will analyze scientific publications and compare and contrast experimental data.

I will describe societal implications of scientific research.

***Type of Activity:***Investigation

***Duration:***60-90 minutes; probably 2 class periods, one for data collection and one for analysis

***Connection to Nobel speakers:***

# This activity can be connected with any of the following three speakers:

* Biomedical engineer **Jennifer L. West**, PhD
* Neurophilosopher **Patricia Smith Churchland**
* Neuroscientist **António Damásio**, PhD

# ***Teacher Tips:***

# This activity could be done in a shorter time frame by having students complete the article reading and/or questions as homework.

When explaining the procedure to the students in Group C who will be documenting observations on facial expression, body language and mood, help them understand how the three may be different. For example, someone can be upset and leaning forward but show no facial expression.

# ***Concepts:***

Neurotransmitters, Decision-Making, Serotonin, Ultimatum Game

# ***Description of Activity:***

An investigation that uses the Ultimatum game to learn about decision making and how neurotransmitter levels may be a factor in affecting a person’s decisions.

# ***Materials:***

* 300 individually wrapped candies that you know your students will like (e.g. Hershey’s kisses, Rolos, Starbursts, bite sized candy bars).
* Responders from another class-try to keep variables to a minimum, so try to choose students from the same age level.
* Enough copies of the survey that follows below within this lab write-up for each player of the game.
* Enough scoring rubrics for members of Groups A, B, and C.

***Activity:***

* Divide students into 3 groups:
  + Group A will time how long it takes for the responder to accept or reject the proposal
  + Group B will document whether the responder accepts or rejects the proposal
  + Group C will make and record observations of the responders facial expressions, body language, mood etc using scoring rubric (see link under materials).
* Give students a few minutes to create a data table in their science notebooks for the observations/measurements they are responsible for documenting. See examples below:
* The teacher will need to model how the experiment will work with the students that you have in your classroom. The teacher should act as the “proposer” in the game.
* Describe to your students the rules of the ultimatum game (which will follow in the subsequent bullet points) and as scientists they should not comment or react during the experiment.
* The “proposer” invites the first responder to sit across from them. On the table, put a pile of 20 candies in full view of the responder. Tell the “responder” (students playing the game); “There are 20 pieces of candy here that can be divided between us. I propose that we divide this candy 50/50.” Divide the pile in half to show the split. Continue by saying “You can accept this proposal or reject it. If you reject, we both get nothing. Do you accept or reject the offer?”
* At this time, group A will begin timing how long it takes the responder to make a decision and the observers in group C start recording body language, facial expressions etc. When the responder makes a decision, that decision is documented by group B and timing is recorded Group A.
* At the end of the data collection portion of the activity, give each responder the short survey (included at the bottom of this lab) to be completed in the hallway.
* Repeat the procedure so that all groups see three different sets of responders. (50/50; 60/40; 70/30). See subsequent bullet points.
* Then for the next group of responders, repeat the procedure but change the percentages to 60/40.
* Then repeat for the next group of responders setting the percentages at 70/30.

***Analyzing the Data:***

Have each group A, B, and C average their results and input their data into class data table, which will be displayed in the front of the classroom. See the following example of a data table below:

***Class Discussion:***

Have each group develop a claim that can be made from their data and share with the whole class.

Questions to be discussed:

* What correlations between the 3 sets of data can you see?
* Why do you think the responders answered the way they did?
* What factors might be influencing their decision to accept or reject the proposal?
* How do you think scientists study decision making by individuals?
* What kinds of scientists study decision making?

***Read and Share:***

Pair up your students and have each one read an article from below and explain to their partner. Then work together to answer the questions below. (The articles are included at the bottom of the lab.)

[Deal or No Deal?](http://news.sciencemag.org/2008/06/deal-or-no-deal?rss=1)

[The chemistry of choice: How serotonin affects decision-making](https://docs.google.com/a/isd507.k12.mn.us/document/d/1A-C9kO2F1Uhf_yOkB30ajK_1FoU6spadlopKw2lIUqQ/edit)

***Questions:***

1. What is serotonin?

2. How do neurologists use the Ultimatum game to study the effects of serotonin on decision

making?

3. How does lowering serotonin levels affect decision making?

4. Does our experimental evidence support your claim? Explain.

5. What societal issues could benefit from this type of research?

***Extension and Follow-up Activity:***

To extend the investigation, students could come up with a new experiment that tests different variables within the confines of the Ultimatum Game, for example, male vs. female response times, testing responses of different age groups, time of day, etc. (Don’t forget to adjust your Responder Survey accordingly).

Require students to present experimental design and results.

Show this [interview](http://thesciencenetwork.org/programs/the-science-studio/patricia-smith-churchland-and-molly-crockett) with Dr. Churchland and Dr. Crockett.

***Sources:***

1.<http://thesciencenetwork.org/programs/the-science-studio/patricia-smith-churchland-and-molly-crockett> Interview with Dr. Patricia Churchland and Dr. Molly Crockett.

2. [www.mollycrockett.com](http://www.mollycrockett.com) Dr. Molly Crockett’s website.

3. <http://news.sciencemag.org/2008/06/deal-or-no-deal?rss=1> Deal or No Deal Article, Scientific American.

**The chemistry of choice: How serotonin affects decision-making**

By Dr. Molly Crockett

Runner-up, New Scientist/Wellcome Trust essay competition, 2008

It should have been so easy. All I wanted to do end my phone contract, but Angus, the customer loyalty agent, wasn't having it. Why did I want to cancel my service? What would make me reconsider? As his barrage of questions rose in pitch, I felt a hot lump of anger rise in my throat, drowning my last shred of patience. In a fit of indignation, I hung up. But later, as I waded through the endless maze of phone menus all over again, I regretted my emotional decision.

Why did I make that costly choice? Maybe if Angus had caught me on a lazy Sunday I would have been more relaxed, but I was in a rush and late for lunch and it's possible that my brain chemistry was not as tolerant as it might have been after a good meal. I certainly was not thinking about it then, but our brain chemistry influences how well we control our emotions and, in turn, the decisions we make in the heat of our emotions. Understanding how our variable brain chemistry affects our decisions might someday help us make better ones.

Scientists who study decision-making have discovered that most human decisions are not exactly ‘rational’, but do follow ‘predictably irrational’ patterns1. In particular, we stray from our long- term goals when emotions interfere with our brain’s tools for self-control. For instance, at the start of a meal we may resolve to stick to our diet, but when the dessert trolley rolls by, our feelings of desire overwhelm us and we order the tiramisu.

To study how decisions go wrong in the brain, researchers have looked at the brain chemistry of patients who have made particularly egregious decisions—much worse than ordering tiramisu. They have found that alcoholics, suicide attempters, and violent criminals have unusually low levels of the neurotransmitter serotonin2. Since this brain chemical is involved in emotional disorders like depression, researchers suspect that serotonin is also critical for regulating emotions. Could serotonin play a role in how emotions influence decision-making? In my work, I investigate this question by temporarily lowering serotonin levels in healthy volunteers whilst they’re faced with choices between ‘rational’ and ‘emotional’ decisions.

My conversation with Angus was eerily similar to a decision-making scenario I use in my experiments, called the Ultimatum Game. In this game, one player proposes a way to split money with a partner. If the partner accepts the offer, both players collect the proposed sums. If he rejects the offer, neither player gets any money. People tend to reject offers that offend their emotional sense of fairness, despite the fact that it costs them money- like when I hung up on Angus at the expense of my time. If serotonin is necessary for making ‘rational’ decisions, then lowering serotonin levels should unleash emotions, making people more ‘predictably irrational.’ Sure enough, when I artificially lowered serotonin levels in volunteers, they rejected more unfair offers than they would in a normal state. By tinkering with a few grams of a single chemical, I reliably provoked irrational, emotionally-driven decisions!

It turns out that serotonin affects more than our sense of injustice—it also may help us overcome the fear of making the wrong decision. In a game where volunteers could win more money if they made snap decisions based on less information, artificially lowered serotonin levels made people less willing to tolerate uncertainty—and cost them money. Just as lowering serotonin increased angry decisions in the Ultimatum Game, lowering serotonin in this experiment resulted in fearful decision-making.

So what does all of this mean for the everyday decision-maker? We’re beginning to establish that artificially lowering serotonin levels lets our emotions influence more of our decision- making. But in order to make sense of, and improve, our decisions out in the real world, we’ll need to figure out what in our environment changes serotonin levels naturally—and we’re not quite there yet. Until then, Angus will have to cross his fingers and hope that his next customer is in a better chemical state than I was.

1. Ariely, D. (2008). Predictably Irrational. New York, HarperCollins.

2. Linnoila, V. M. and M. Virkkunen (1992). "Aggression, suicidality, and serotonin." J Clin

Psychiatry 53 Suppl: 46-51.

# **Deal or No Deal?**

By

[Constance Holden](http://news.sciencemag.org/author/constance-holden)

What if your friend had a large apple pie but gave you only a sliver? Would you throw the piece on the floor in protest? Maybe, depending on your brain chemistry. New research suggests that such emotional decisions can be influenced by a shortage of the neurotransmitter serotonin.

Researchers have linked low levels of serotonin in the brain to various mental states, including depression and impulsive, irrational behavior. A team headed by neuroscience Ph.D. student Molly Crockett of the University of Cambridge in the U.K. wondered whether the neurotransmitter would affect how people play the ultimatum game, an experiment used by economists that shows how people's economic decisions are sometimes irrational.

In the game, a "proposer" is given a sum of money, part of which he or she offers to share with a "responder." If a responder turns down the offer as too low, then neither player gets any money. What the ultimatum game reveals is that even though a responder would always gain by accepting the offered share, he will sometimes cut off his own nose to spite his face, as it were, punishing a proposer by rejecting an unfair offer.

In the current study, the researchers recruited 20 volunteers and asked them to fast the evening before the game. The next morning, some of the volunteers were given a drink chock-full of every amino acid the body needs to make protein, save tryptophan, an amino acid from which serotonin is manufactured. The result, says Crockett, is that the amino acids rush to the brain, "crowding out" any residual tryptophan and creating a temporary shortage of tryptophan and therefore serotonin. Control subjects were given drinks that contained tryptophan.

Both groups then played the ultimatum game as responders. The lack of tryptophan did not affect the subjects' general moods or their perceptions of the fairness of an offer, the team reports online today in [*Science*](http://www.sciencemag.org/cgi/content/abstract/1155577). It did, however, appear to make people more likely to reject unfair offers. For example, when they knew that they were being offered only 20% of the pot, 82% of the acute tryptophan depletion group rejected the offer over multiple trials, whereas only 67% of the placebo group did.

The research bolsters the view that rejection of an unfair offer is "an emotionally driven impulse," says Crockett. To heed more rational monetary considerations in the face of an unfair offer, she says, requires that you "swallow your pride"--or the sliver of pie--which is a form of emotional control.

The new work is "a significant advance" in understanding the neural mechanisms of how emotions impact decision-making, says neuroscientist Michael Koenigs of the National Institute of Neurological Disorders and Stroke in Bethesda, Maryland. Psychologist Ernst Fehr of the University of Zürich, Switzerland, cautions, however, that the paper doesn't really address which behavior is rational or irrational. Rejecting low offers, he says, could be the result of a rational calculation about the value of fairness rather than an angry impulse.

Ultimatum Game Scoring Rubric

**Facial Expression:**

1 2 3

Stressed/Angry/Dissatisfied Neutral Smiling/Agreeable/Satisfied

**Body Language:**

1 2 3

Dissatisfied Neutral Satisfied

Leaning Forward Neutral Leaning Back

Arms Crossed/Hands on Hips Open Body

Aggressive Relaxed

**Mood:**

1 2 3

Dissatisfied Neutral Satisfied

Ultimatum Game Survey

Please circle a number on the scale below to rate how satisfied you are with the outcome of the proposal.

1 2 3

Dissatisfied Neutral Satisfied

**Possible Data Tables**

Group A-Time to Decide

|  |  |  |  |
| --- | --- | --- | --- |
| Group name | 50/50  time to decide | 60/40  time to decide | 70/30  time to decide |
| Jenny’s Group |  |  |  |
| Joe’s Group |  |  |  |
| Seth’s Group |  |  |  |
|  |  |  |  |
|  | Average: | Average: | Average: |

Group B-Accept or Reject

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Group name | 50/50  accept | 50/50  reject | 60/40  accept | 60/40  reject | 70/30  accept | 70/30  reject |
| Jenny’s Group |  |  |  |  |  |  |
| Joe’s Group |  |  |  |  |  |  |
| Seth’s Group |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  | total: | total: | total: | total: | total: | total: |

Group C- Body Reaction

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 50/50  Facial  Exp. | 50/50  Body Lang. | 50/50  Mood | 60/40  Facial  Exp. | 60/40  Body Lang. | 60/40  Mood | 70/30  Facial  Exp. | 70/30  Body Lang. | 70/30  Mood |
| Jenny’s Group |  |  |  |  |  |  |  |  |  |
| Joes’ Group |  |  |  |  |  |  |  |  |  |
| Seth’s Group |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Avg: |  |  |  |  |  |  |  |  |  |