

# Animal Behavior

## Animal Communication

Most animals have some means of communicating with individuals of their own and sometimes other species. A **signal** is a behavior or a characteristic of an animal that causes a change in the behavior of another animal that detects it. The field of **animal communication** includes the transmission, reception, and response to a signal given by another individual. Signals may be auditory, visual, chemical, tactile, or electrical. Today in lab, we will explore some of the methods that animals use to communicate with each other.

### Human animal behavior:

**Exercise A** – Partner with one of your labmates. Sit next to each other. Stare directly at each other's eyes. Count the number of seconds it takes for one person to look away.

How many seconds did it take? \_\_\_\_\_

If you were ultra competitive and stared at each other for more than one minute without looking away, describe your feelings during this time:

Do you feel that your response to eye contact is (a) innate or (b) learned?

Is there an evolutionary adaptive significance to the human reaction to eye contact?

**Exercise B**– Your TA will test your visual, hearing, and motor coordination by leading you in a clapping exercise.

What happened? \_\_\_\_\_

How frequently do you practice clapping at home (a) daily (b) weekly (c) never?

Do you feel that your ability to clap in unison is (a) innate or (b) learned?

Is there an adaptive significance to the human ability to synchronize clapping?

**Exercise C** – Your TA will show you some pictures of human eyes. You will decide what emotion or thoughts they are showing. Mark your answer below, then compare your answers to other members in your lab group or the entire lab.

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# ⚠ Experiment: Getting Started with the SpikerBox

Did you just get a SpikerBox, and are wondering how to use it? In this lesson, you will listen to action potentials and view "spikes" in real time. This is an excellent starting point for your SpikerBox.

 Time 30 Minutes


Difficulty Beginner

 Pre-requisite Labs

None

 Equipment

[SpikerBox \(/products/spikerbox/\)](/products/spikerbox/)
[Cable: Laptop \(/products/laptopcable/\)](/products/laptopcable/)
[Phone \(/products/phone/\)](/products/phone/)
[Cockroaches \(/products/spikerbox/\)](/products/spikerbox/)

## What will you learn?

This is a great introductory experiment to get you started with spikes! By the end of this experiment, you will understand what neurons are, how they communicate, and how to record spikes using a SpikerBox!

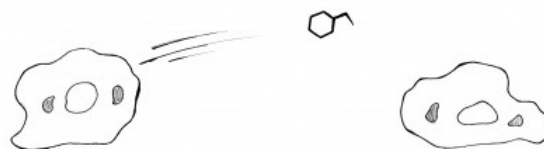
## Introduction

Your brain uses a combination of chemicals and electricity to operate. Brain cells (neurons) communicate with each other to control your body. A brain with only 1 neuron is not a brain.



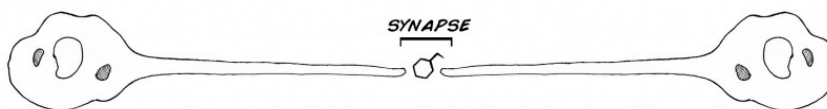
(img/Exp1\_fig01\_neurons\_together.jpg)

A brain is a network (friendship) of neurons. Your brain has and uses around one hundred billion neurons! But how do all of these neurons talk to each other? One of the first ways cells used to network was chemical communication.



(img/Exp1\_fig02\_chemical.jpg)

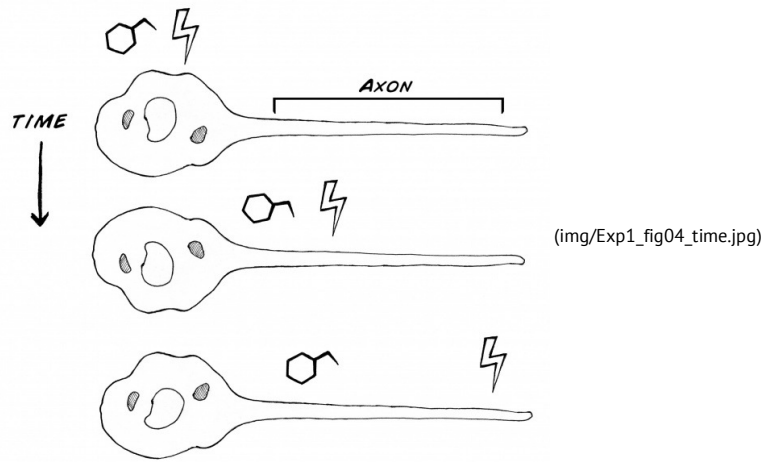
Bacteria use this method. It works well, but is limited by diffusion. For example, when you fart, how long does it take for someone on the edge of the room to smell it? There should be a faster way. One way is to bring cells closer together through stretching.



(img/Exp1\_fig03\_synapse.jpg)

But there is still a problem. The signal still needs to travel a long way through the cell. Is there a way to

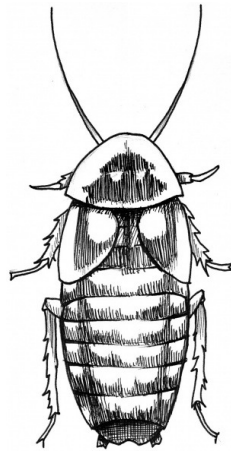
make this faster? What is very fast & important today?



Electricity! Notice how fast the lights in your house turn on when you flick the switch. Neurons use electricity as well; electrical pulses travel down the neurons This pulse is called the:



We at Backyard Brains have dedicated our lives to studying spikes, and you can too! But first, some biology. 380 million years of evolution bring you the cockroach. We will use the Discoid cockroach (*Blaberus discoidalis*), or false death's head. They live in the Amazon rainforest of South America under the bark of rotting trees.



(img/Exp1\_fig06\_cockroach.jpg)

Like all multicellular animals (beyond creatures like sea sponges), cockroaches' bodies are filled with nerves to control movement & sensation. Let's begin.

## Video

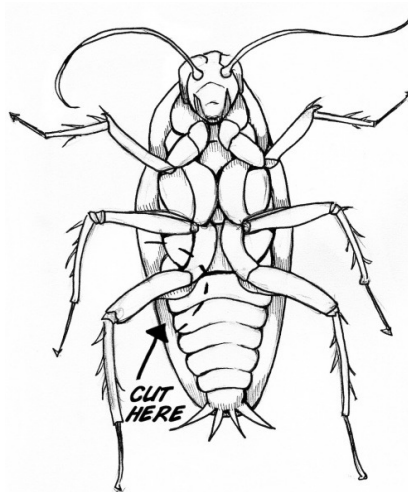
## Procedures

1. Take a cockroach & put it in a jar of ice water. Wait a few minutes until it stops moving.



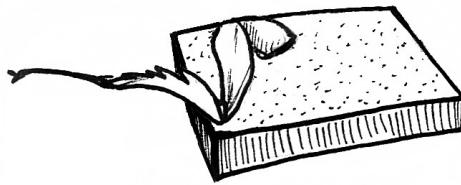
(img/Exp1\_exp01\_cockroachhoodie.jpg)

2. Remove the cockroach, and cut off one of his legs near the body, so that you end up with a leg like this:



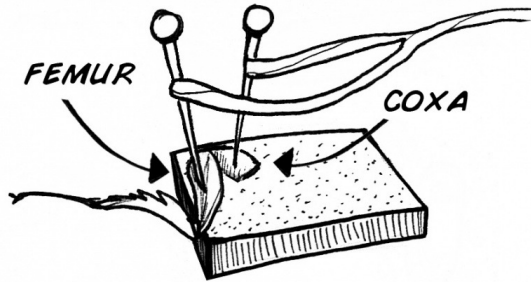
(img/Exp1\_exp02\_cut\_leg\_cockroach.jpg)

3. Return the cockroach to its house. It'll be fine, the leg will grow back if the cockroach is not a full grown adult yet (Adults have wings, nymphs don't).
4. Place the leg on the cork of your SpikerBox, allowing a bit of the leg to overhang, like this:



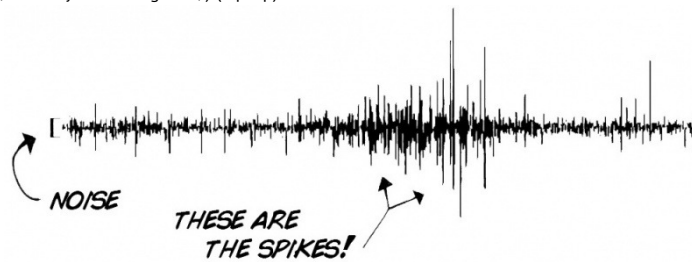
(img/Exp1\_exp03\_legprep.jpg)

5. And put the two electrodes in:



(img/Exp1\_exp04\_legprep\_pins.jpg)

6. Turn your SpikerBox on! If you hear a popcorn sound, congratulations, you have just heard your first neurons! Now let's see what the electrical discharge looks like. Plug your sound cable from the SpikerBox into your smartphone or into the microphone input of your computer. Turn on our free "Backyard Brains" app (Android (<https://play.google.com/store/apps/details?id=com.backyardbrains>) or iPhone (<https://itunes.apple.com/gb/app/backyard-brains/id367151200?mt=8>)) or Audacity (<http://audacity.sourceforge.net/>) (laptop). You should see:



(img/Exp1\_exp05\_spiketrain.jpg)

7. Zoom in, & the spikes look like:




(img/Exp1\_exp06\_closeupspike.jpg)

This is due to ion channels opening and closing in the neurons, causing the pulse.

Note: You can also do this experiment on crickets if you do not have access to cockroaches. You can usually buy crickets at local pet stores. See video:

## ⚠ Anuradha Rao Memorial Experiment: Effect of Nicotine and MSG on Neurons

It's 2 AM, your linear algebra final is in 6 hours, and you gulp down another espresso. You start thinking: "I wonder how this espresso and other drugs actually work?" We are here to lead you through an interesting experiment where you will use drugs, such as glutamate and nicotine, to change the firing rate of the cricket cerci system's neurons.

 Time 45 Minutes


Difficulty Advanced

### What will you learn?

In this experiment you will learn how different drugs and chemical agents affect the nervous system using the cricket cercal system. You will also learn how to create a few different chemical solutions.

### ⚠ Pre-requisite Labs

SpikerBox (spikerbox) - You should become familiar with how to use your SpikerBox.

### 🔧 Equipment

SpikerBox (/products/spikerbox)

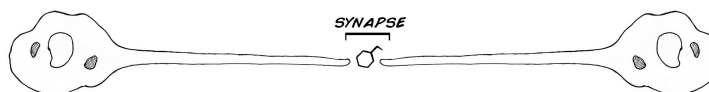
Cable: Laptop (/products/laptopcable)

Phone (/products/smartphone)

## Background

We have been studying "spikes" in the last couple experiments, and we will continue to do so here, but now we are also going to study the synapse! Recall experiment 1, where we explained that neurons communicate with a combination of electricity and chemicals. Consider two neurons:

Once a spike reaches the end of the first neuron, it can cause the neuron to release "neurotransmitters" across the small distance between the two neurons called the "synapse." These neurotransmitters bind to receptors on the second neuron, which then cause the second neuron to begin firing spikes (or stop firing spikes, but let's keep it simple for now). These receptors are very sensitive to electrical activity and certain chemicals. In fact, the very sensitivity of these receptors is how neurons, and ultimately you, learn!

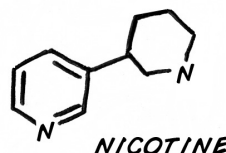


(img/Exp1\_fig3.jpeg)

In this experiment we will test the effect of neuroactive compounds on central nervous system neurons. Obtaining drugs that affect neurons can be quite difficult, as they are often very dangerous (like the Batrachotoxins of poison dart frogs or the tetrodotoxins of Fugu Puffer Fish, both of which block sodium channels) or are drugs of abuse (like cocaine, which allows dopamine to stay in synapses longer than normal). But, we have access to two types of drugs we can use on our insects.

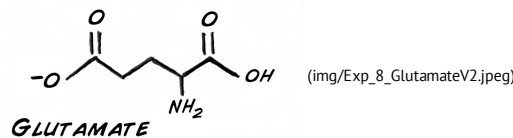
### Nicotine and Monosodium glutamate!

Nicotine comes from the tobacco plant. Tobacco evolved nicotine to prevent insects from eating its leaves. Nicotine is a powerful acetylcholine receptor agonist; it amplifies the effect of acetylcholine binding to its receptors in synapses, causing a neuron to fire more (due to increased sodium ion influx).



(img/Exp\_8\_NicotineV2.jpeg)

Whereas nicotine is a drug that acts on receptors that neurotransmitters bind to, Monosodium glutamate itself is a neurotransmitter. Once dissolved in water, it turns into positively charged sodium ions and negatively charged glutamate ions. Glutamate is normally part of the metabolic pathway of glycolysis (breakdown of sugar) and is readily available from the foods you eat.



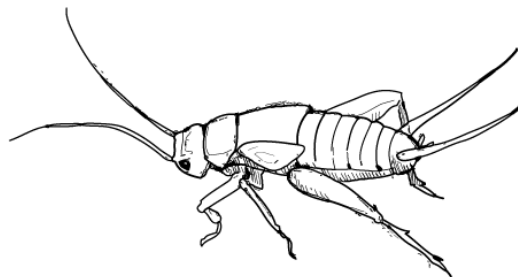
In fact, over 80% of the synapses in your brain use glutamate as its excitatory neurotransmitter. In insects, is it excitatory as well? Let's find out!

## Procedure

To create your nicotine solution, take a cigarette or small cigar, remove all the shredded tobacco leaves, and place them in a small container (a clear pill bottle, for example). Fill the container with water, put the cap on, shake up the mixture, and allow it to sit for a couple days to extract the nicotine. Over time the solution should turn yellowish-brown. If you are in high school ask your teacher or parent to help you prepare this solution.

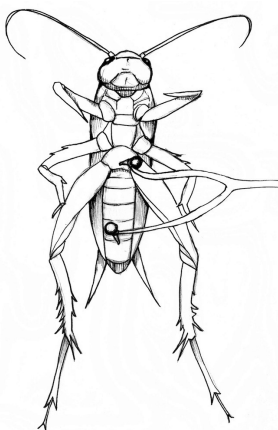
To create your glutamate solution, you need to find some monosodium glutamate! You can often find it at your friendly neighborhood Asian import grocery store. A pound should cost a couple dollars. Fill up a clear pill bottle about a quarter full of the MSG salt crystals, fill the remainder of the bottle with water, and shake thoroughly to dissolve the MSG. Note that not all of the MSG will dissolve, as you are making a saturated solution. Do some online research or ask your teacher to find out what a saturated solution is.

For reasons we haven't figured out (or really worked hard enough on yet), the cockroach leg preparation does not lend itself well to neuropharmacology experiments. Maybe you can prove us wrong, but for now, we are going to switch to a new species, the cricket cercal system!



(img/Exp\_8\_Cricket\_new.png)

Crickets are readily available for local pet stores (<http://www.petco.com/product/12680/Live-Crickets.aspx>) as feeder insects for lizards and frogs; they are a \$1/dozen. Place your crickets on ice when you are ready to do an experiment. Take your two needles from your electrode and place them along the central axis of the insect, like the figure below:



(img/Exp\_8\_Cricket\_electrodesV2.jpeg)

Wait about 2-4 minutes for the neurons to "warm up" and then blow gently on the rear of the insect. You should see the cerci move from the pressure of your air puff. The cerci are sensing organs on the rear of the cricket that are sensitive to wind vibration. You should also hear an increase in the spiking activity on your SpikerBox. Note that these spikes are not as loud as the spikes you are used to hearing with the cockroach leg prep, but if you are lucky you should hear them.

Now take a small syringe (you can also buy this at local pharmacy over the counter) and inject a tiny bit of each solution into the cricket near one of the electrodes. What do you notice with the two different solutions. Can you explain any peculiar effects you hear with regards to spiking rate?

## About Anuradha Rao

This experiment is dedicated to Anuradha Rao, a neuroscientist who studied pharmacology and enjoyed educational outreach. Her memorial fund generously allowed Backyard Brains to present experiments and prototypes at the 2010 Society for Neuroscience Conference in San Diego, CA.



## Exercise 1 - Honeybee Waggle Dance

One of the best-studied cases of animal communication is that of the honeybee. Through a combination of tactile and chemical cues, honeybee scouts can quickly communicate to a large group of workers in the hive the location and nature of a new food source (nectar and pollen from flowers). We know the scout does not have to physically lead other bees to the food. Researchers have found that worker bees can find the site even when not accompanied by the scout. So how does the scout communicate the location of the food source?

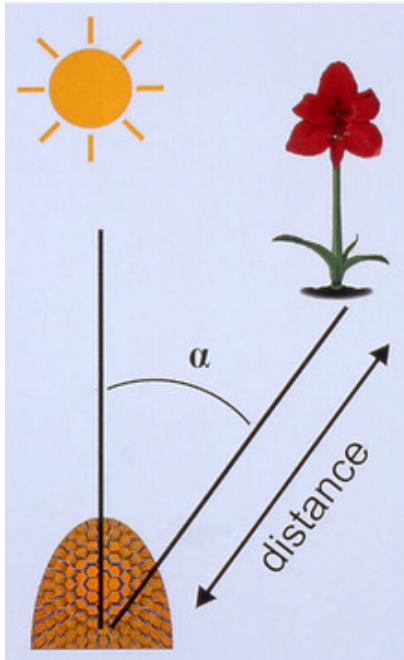
When a bee locates a new source of flowers in the field, she takes a sip of the nectar and then marks the site with a chemical secreted from a gland at the tip of her abdomen, called the *Nasonoff's gland*. When the scout returns to the hive, worker bees gather around her. The scout regurgitates a sample of the nectar for others to taste. The workers can also detect traces of pollen and odors of the food locale on the scout's body.

If the food source is more than 150m from the hive, the scout will perform a special dance, called a **waggle dance**, to communicate the distance and direction to the food. This dance is performed on the vertical surface of the honeycomb within the hive. During the waggle dance, the scout moves in a figure-8 shape. In the central straight run of the figure-8, the scout vibrates, or waggles, her abdomen and produces a low frequency buzz. Since it is dark in the hive, the other worker bees must follow the scout's movements with their antennae.



The number of waggles in the straight segment of the figure-8 conveys the distance to the food source. The more waggles in the straight run and the longer the buzzing, the farther away the food source is located.

The direction of the waggle portion of the dance indicates the direction to the food site. Keep in mind, the waggle dance is performed on a vertical surface in the hive. In the dance, straight up represents the direction of the sun in relation to the hive entrance. If the bee moves straight up during the waggle portion of the dance, this indicates that the food source is in the direction of the sun from the hive entrance. If the waggle portion of the dance points 30 degrees to the right of vertical, this indicates that the food source is 30 degrees to the right of the sun from the hive entrance.



Within the hive, straight up corresponds to the sun. Thus, if the food source is at an angle alpha from the sun, then the bee will orient the dance at angle alpha off from vertical.

A scout is also able to take into account the apparent movement of the sun during the day. If it takes a scout one hour to return to the hive, she will adjust her dance by subtracting 15 degrees from the angle so that workers will fly to the correct spot even though the sun has moved.

The waggle dance guides bees to the general area of a food source. Then, olfactory cues, such as the molecules adhering to the body of the scout and the marking chemical left behind, help the forager bees to find the exact location.

### Procedure:

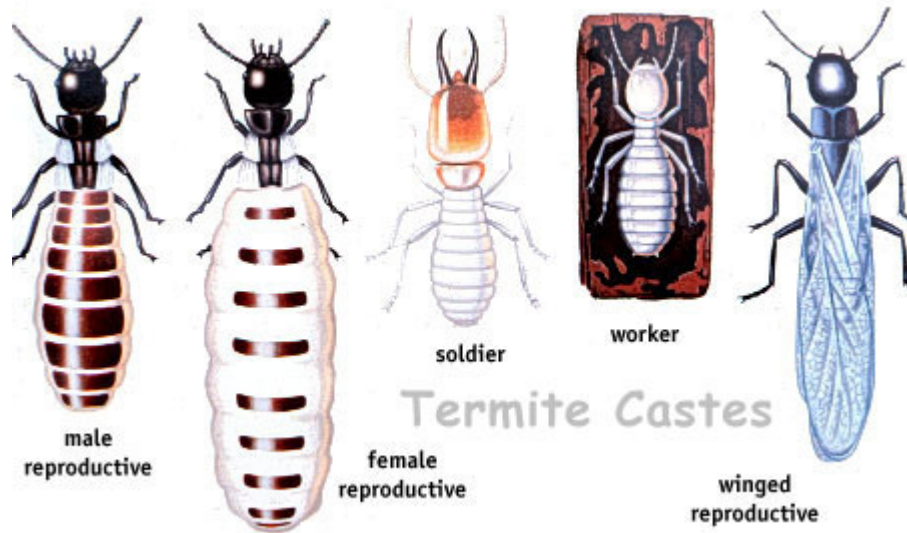
Now it is your turn. You and the students at your table are a group of worker bees who have scouted out a new source of food (your TA will tell you where). You will receive a map of campus with concentric rings around Abelson Hall. The building entrance represents the entrance to your “hive”.

1. Draw a line from the building entrance to the new food source.
2. Draw a line from the building entrance in the direction of the sun (determine this by observation, or your TA may assign this direction).
3. Draw a waggle dance to indicate the direction and distance to the food source. Let each waggle (~) be equivalent to one concentric ring on your map (or whatever number of waggles your TA assigns).
4. Draw your waggle dance on the white board and see if the rest of the class can identify the location of the food source.

### Exercise 2 - Termite Communication

Termites are highly social animals and some of their most interesting behavior is centered on communication within a termite colony. The colony is composed of one family produced by a

reproductive female, the queen, and a reproductive male, the king. The progeny are organized into castes, or types of termites, including workers, soldiers, and winged reproductive individuals.



It is dark inside a termite mound or inside of wood where they feed, so termites communicate by tactile or chemical means. Termites produce different chemicals, called pheromones, which are used for communicating alarm, aggregation, etc. Worker termites also produce a trail-marking pheromone to lead other workers to food sources. Interestingly, a component of some ballpoint pen inks has been found to resemble the trail-marking pheromone. Termites have been observed to follow lines drawn with pens that contain this attractant. In the next exercise, you will explore this phenomenon and training behavior in termites.

### Exercise 2a - Which lines will termites follow?

On a sheet of paper, draw a line about 10 inches long with one of the ballpoint pens provided.

Use a paintbrush to gently place a termite on the paper at the end of the line. (Note: termites are easily squished! Be very gentle!)

Observe the termite's behavior. If the termite follows the line, it has probably detected a pheromone-like chemical. If the termite wanders off randomly, re-place it on the beginning of the line. Repeat several times. If after several tries the termite does not follow the line, it is likely that the termite does not detect a trail-marking pheromone. For tests with other lines, draw parallel lines at least 1½ inches apart.

Form a hypothesis and design an experiment related to this phenomenon using the materials provided in lab. Among the questions you might address: Do termites prefer certain colors or brands of pen? Will they follow lines made by other writing implements, such as pencils or gel pens?

Write your hypothesis here:

Carry out the experiment and record the results. Did you get consistent results upon repeating the experiment? Was your hypothesis supported by the results?

### **Exercise 2b - What shape of trail can termites follow?**

Now do an experiment to see how well termites can follow certain shapes or patterns. Some examples of how you might test this:

Draw a trail with a fork in the path and make one side of the fork at a more acute angle than the other, or curve rather than a sharp angle, and determine which path termites take more often.

Draw paths of the same length, one straight, another with a gentle curve, and a third with a sharp angle, and measure how fast termites navigate the three paths.

Will termites follow the same line repeatedly or continue to follow a circle of figure-8? Will termites follow an interrupted line?

Write your hypothesis here:

Design an experiment to test your hypothesis and make a prediction for the result of the experiment.

What conclusion can you draw from your experiment? Can you think of how this behavior fits in with the termite's way of life?

## **Predation and the Benefits of Group Living**

modified from Theodore E. Burk

Sociobiologists (scientists who study group-living animals) have concluded that in some cases, the benefits of group living, such as foraging advantages and anti-predator benefits, outweigh costs, such as increased competition among group members and increased risk of disease and parasite transmission.

Living in a group can increase one's safety against predators in several ways. Among these are what have come to be called the "dilution effect" and the "confusion effect."

In the **dilution effect**, an individual's chance of being captured by a predator decreases as group size increases, often because the predator takes only a single or a limited number of prey on each attack. Well-studied examples of animals that benefit from a dilution effect include monarch butterflies, preyed upon by birds in their overwintering roosts, and mud-puddle frogs, preyed upon by frog-eating bats.

In the **confusion effect**, predators find it difficult to focus their concentration and pursuit on a specific individual prey animal when a large number of prey are escaping from them at the same time, going in different directions, making a lot of noise, etc. A behavioral physiologist might say that the predator finds it difficult to focus on stimuli coming from one prey because of interference from all the stimuli coming

from the other escaping prey. This confusion may slow the predator down sufficiently so that all of the prey are beyond successful pursuit distance before the predator is able to concentrate its efforts on any one prey animal; at the least, it may lower the risk of capture for each prey individual in the group. Examples include fish escaping from predatory fish or squid and ground squirrels escaping from eagles. Human quail hunters are also likely to be familiar with this phenomenon.

Another phenomenon that influences predator and prey interactions is the “**odd prey effect.**” In this case, any prey that differs in a conspicuous way from the others in its group is more likely to draw a predator’s notice, leading to an increased chance of its being attacked and captured. The odd prey effect may in some part negate the confusion effect, making it easier for a predator to single out a single escaping prey - the odd one.

**Exercise 3a – Dilution and Confusion Effect**

In this exercise you will examine the influence of the dilution and confusion effect on the ability of predators to capture prey. First, you must determine what hypotheses you are testing. Recall that a null hypothesis indicates that the variable of interest has no effect on the outcome.

Read the procedure below and determine what, for this experiment, is the null hypothesis? What are the alternative hypotheses? Write these here:

**Procedure:**

Using the ping-pong balls provided, test for the confusion and dilution effects in the following way. One student is the predator. He or she should stand in a relaxed manner. Another student, standing about eight feet away, will toss a ball(s) (i.e., the prey) at the predator’s chest. The ball(s) should be tossed underhanded and at a speed that is not impossible to follow, but that at the same time, requires the predator’s concentration to catch. The predator should catch the prey with the hands; “basket catches” - trapping the ball against the chest or with the forearms - are not allowed.

In the table below, record how many balls the predator catches and how many successful hunts the predator has (# of times at least one ball was caught). Conduct 5 trials for each treatment. After 5 trials, predator and ball-thrower switch places for 5 more trials.

Prey Group Size: (# Balls Tossed at once)	# Balls captured for each of 10 trials										% Balls captured for each of 10 trials										# Successful hunts (at least 1 ball captured)	% Successful hunts
1																						

2																				
3																				
4																				
5																				

Did the probability of capture for each individual prey animal (ball) decline as a function of group size? Which hypothesis does this finding lend support for or lead you to reject, and why?

How did the percentage of successful hunts change as a function of group size? Which hypothesis does this finding lend support for or lead you to reject, and why?

**Exercise 3b – Odd Prey Effect**

Now examine the odd prey effect by adding a colorful ping-pong ball to the prey group. The procedure is the same as above, except this time, make one of the balls tossed a colorful one. In addition to recording the total number of balls caught, record how many of the captured prey were the colorful balls. Toss each combination of balls 5 times, then switch roles and toss each combination an additional 5 times.

For this experiment, what is the null hypothesis?

# Balls Tossed at once	# Balls captured for each of 10 trials	# Colorful balls captured for each of 10 trials	% colorful balls tossed	% colorful balls captured
1 w + 1c				
2 w +				

1 c																				
3 w + 1 c																				
4 w + 1 c																				
5 w + 1 c																				

Calculate the percentage of colorful balls captured and the percentage of colorful balls that were present in each toss (i.e., if 1 white and 1 colorful ball are tossed, then the percentage of colorful balls is 50%).

Was the percentage of colorful balls captured by the predator greater than its rate of occurrence in the population?

How did the size of the group influence the percentage of colorful balls captured compared to the percentage of available prey that were colorful?

Which hypothesis does this finding lend support for or lead you to reject, and why?