Evolution of Human Nature
Exercise Workbook

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Contents

Exercise 1

Using Transposon Data to Infer Phylogenetic Trees

Figure 1.1 shows six made-up sets of transposon data, each consisting of three transposons. In this exercise, you will use each data set to infer a phylogenetic tree.

Begin by looking for transposons that are present in only two species. As explained in the text and in lecture, such a pair must have a common ancestor not shared by the other species. In other words, they occupy their own branch of the tree. To represent this fact, write the letters that identify the two species on your paper, and draw lines connecting each one with a dot, which represents their common ancestor.

Are there other transposons that unite just two species? If so, then create another branch to indicate this fact. Then continue with the other transposons, dealing first with the smaller

	Transposons		
Species	a	b	c
A	●	●	●
B	●	●	●
C	●	●	○
D	●	○	○

(a)

	Transposons		
Species	a	b	c
A	●	●	○
B	●	●	●
C	●	●	●
D	●	○	○

(b)

	Transposons		
Species	a	b	c
A	●	○	○
B	●	●	●
C	●	●	●
D	●	●	○

(c)

	Transposons		
Species	a	b	c
A	●	●	○
B	●	●	○
C	●	○	●
D	●	○	●

(d)

	Transposons		
Species	a	b	c
A	●	●	○
B	●	○	●
C	●	●	○
D	●	○	●

(e)

	Transposons		
Species	a	b	c
A	●	●	●
B	●	○	○
C	●	●	○
D	●	●	●

(f)

Figure 1.1: Dummy sets of transposon data. Key: ●,present; ○,absent
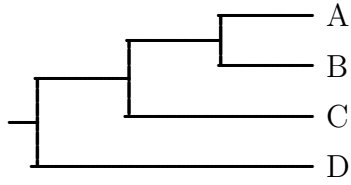
Figure 1.2: Tree implied by data set a

branches, until you have used all the transposons and have connected all the species. Using data set a, you should end up with the tree shown in figure 1.2.

Build a tree using each data set (4 in all). Be sure to label them so that we can tell which is which.

Exercise 2

The isochron method of radiometric dating

2.1 Introduction

Before doing this exercise, read the section on isochrons in the chapter named "Has there been enough time?" in reference [3]. In the exercise, you will study data describing igneous rock from southern Britain. Based on that data, you will estimate an isochron and then use the isochron to estimate the age of the rock. The data (shown in table 2.1) involve isotopes of rubidium (Rb) and strontium (Sr), rather than the uranium and lead isotopes discussed in the reading assignment. Although the isotopes are different, the principle is the same. The parent isotope (^{87}Rb) decays into the daughter isotope (^{87}Sr), with a half-life of 49.5 billion years. Because of this long half-life, the rubidium-strontium method is often used with very old rocks. The isochron is constructed from ratios of the parent and daughter isotopes to (^{86}Sr), a stable isotope.

2.2 Exercise

1. Plot each sample in Table 2.1 as a point on the graph paper provided in Fig. 2.1.

2. Using a ruler, draw a straight line through the points. Do all of the points fall on or near the line? If not, you have plotted the points incorrectly.

Table 2.1: Rb-Sr isotope data from igneous rock at Stanner Hill, England. Source: [2]

Sample	^{87}Rb/^{86}Sr	^{87}Sr/^{86}Sr
P59	1.3	0.718
P91	9.1	0.797
P62	12.2	0.828
P97	17.6	0.882

Figure 2.1: Isochron plot
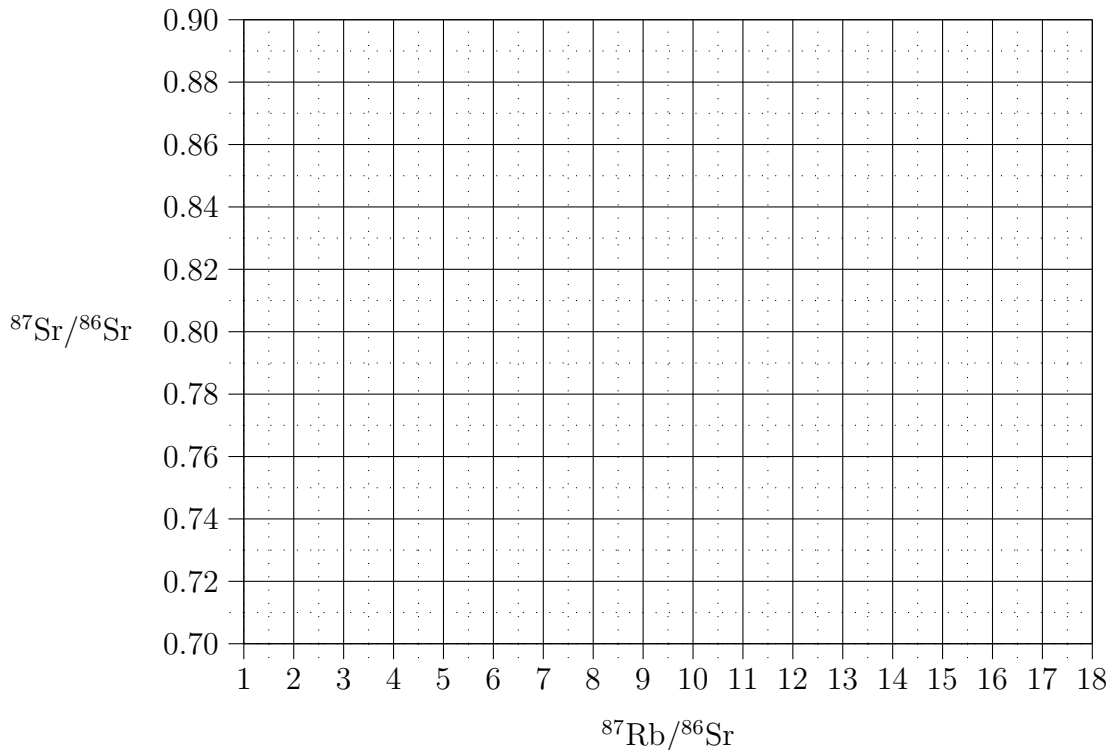
3. The straight line connecting the points is called the isochron. What can you conclude from the fact that the points fall on a straight line?

4. What is the slope of the isochron? (For details, see the appendix below.)

5. Use the slope to figure out the age of the rock. To do this, multiply the half-life (49.5) by the slope, and then divide by 0.69. This gives the age of the rock in billions of years. (This calculation is only approximate. It works well here because our slope is small.)

Your report should include (a) your graph, (b) your calculation, and (c) a sentence telling us the age of the rock.

Appendix: Calculating the slope of the isochron

This appendix is for students who do not know how to calculate the slope of a straight line.

1. Choose any two samples that fall on the straight line you have drawn. It doesn't matter much which samples you choose, but it is best to choose samples from opposite ends of the straight line. Let us call these sample A and sample B.

2. Subtract the $^{87}Sr/^{86}Sr$ value for sample A from the corresponding value for sample B.

3. Subtract the ^{87}Rb/^{86}Sr value for sample A from the corresponding value for sample B.

4. Divide the result from step 2 by the result from step 3. This is the slope of the isochron.

Exercise 3

Sexual Dimorphism and Mating Patterns of Primate Species

3.1 Introduction

When the average male of a species differs from the average female, the species is said to be *sexually dimorphic*. Humans, for example, are sexually dimorphic with respect to body size, men being on average about 10% taller than women. In this exercise you will analyze data on sexual dimorphism in non-human primates.

Sexual dimorphism can be measured in a variety of ways. In the exercise below, you will use the statistic

$$D = \log_{10}(\text{average male weight}) - \log_{10}(\text{average female weight})$$

where $\log_{10}$ is the logarithm to base 10. For a detailed discussion of this statistic and others like it, see section 3.3. If you are not interested in a detailed discussion, then just read the following paragraph.

A 1-gram difference between males and females would be more significant among mice than among elephants. It makes more sense to give equal weight to equal *percentage* differences. This is the function of the logarithms in the definition above of D. If males are 1% larger than females, then $D = 0.00995$ for mice as well as elephants.

3.2 Exercise

Answer the questions below using the data in table 3.1. At the top of the page, write your name and "Exercise 3." Be sure also to number your answers.

1. In which species is sexual dimorphism most pronounced? In other words, which species has the largest value of D?

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2. Fill in the graph in figure 3.1 (page 9). Plot each polygynous species as a plus sign (+) and each monogamous species as a circle (○). Species without sexual dimorphism should fall on the 45° line. If males are larger than females, then the species will plot above this line and the vertical distance above the line measures sexual dimorphism. As an example, the point for the Talapoin Monkey (*Miopithecus talapoin*) is already plotted for you.

3. In a sentence or two of prose, summarize the pattern that you see in the graph. How do polygynous and monogamous primates differ?

3.3 Appendix: Details about Measuring sexual dimorphism

[This appendix is optional.]

How does one measure sexual dimorphism? To make this question concrete, let us take two species:

| | Body Weight | |
| | Male | Female |
Species	(kg)	(kg)
Agile gibbon *(Hylobates agilis)*	5.82	5.5
Talapoin Monkey *(Miopithecus talapoin)*	1.4	1.1

Which species is most dimorphic? The answer to this question depends on how we measure sexual dimorphism. One possibility is to use the difference between male and female character values. Using this measure, the gibbon is most dimorphic since males of that species are (on average) 0.32 kg larger than females whereas male talapoin monkeys are only 0.3 kg larger than their females. This measure of dimorphism is unsatisfactory, however, because it ignores the overall difference in size between the two species. Surely a 1 gram difference is more important in comparisons among mice than in comparisons among elephants.

To incorporate the effect of overall body size, we must use a different measure of dimorphism. One possibility is the ratio, R, of male to female size. For the gibbon in our example,

$$R = \frac{\text{male weight}}{\text{female weight}} = \frac{5.82}{5.5} = 1.058$$

For the talapoin monkey, $R = 1.27$. Thus, male agile gibbons are only 5.8% larger than females, but male talapoin monkeys are 27% larger. By this measure, the monkey is more dimorphic than the gibbon. This seems a more natural measure of sexual dimorphism since it automatically scales the result to body size.

There is one remaining problem, which arises when we try to make a graph of sexual dimorphism against body size. If the horizontal axis of our graph were measured in (say) kilograms, then two animals that differed by 1 gram would be separated by the same distance

Table 3.1: Sizes and mating systems of primate species

Species	Mating system*	Log10 Male weight (kg)	Log10 Female weight (kg)
Lemur mongoz	P	0.26	0.26
Propithecus verreauxi	P	0.57	0.54
Galago alleni	P	–1.22	–1.22
Tarsus bancanus	P	0.08	0.04
Alouatta villosa	P	0.87	0.76
Callicebus moloch	M	–0.17	–0.17
Ateles geoffroyi	P	0.87	0.88
Cercopithecus aethiops	P	0.65	0.56
Cercopithecus neglectus	P	0.85	0.60
Cercopithecus ascanius	P	0.96	0.81
Miopithecus talapoin	P	0.15	0.04
Cercocebus albigena	P	0.95	0.81
Macaca nemestrina	P	1.00	0.85
Papio hamadryas	P	1.26	0.97
Colobus badius	P	1.02	0.85
Presbytis entellus	P	1.18	1.02
Presbytis obscurus	P	0.80	0.78
Presbytis senex	P	0.93	0.89
Hylobates agilis	M	0.76	0.74
Hylobates hoolock	M	0.84	0.79
Hylobates lar	M	0.76	0.72
Symphalangus syndactylus	M	1.05	1.01
Pongo pygmaeus	P	1.84	1.57
Pan troglodytes	P	1.69	1.61
Gorilla gorilla	P	2.20	1.97

*P: polygynous; M: monogamous
Note: Data are from [1].
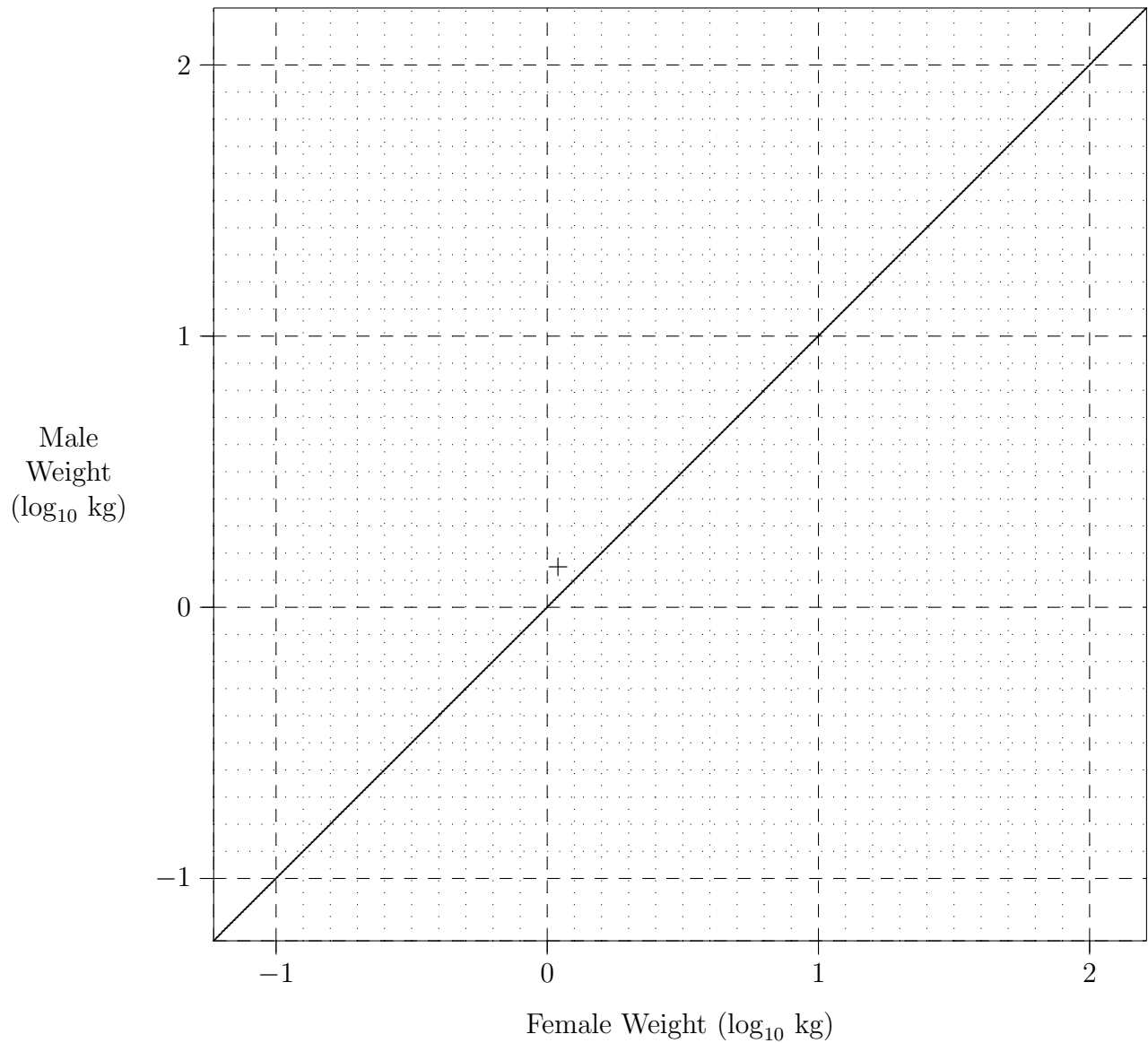
Figure 3.1: Log male weight versus log female weight for primate species. Polygynous species are indicated by plus signs and monogamous species by circles. The Talapoin Monkey (*Miopithecus talapoin*) is already plotted for you.

on our graph, whether they were mice or elephants. Yet as we argued above, a 1-gram difference is more significant among small animals than among large ones. By plotting dimorphism against raw body size, we would exaggerate differences among large animals and obscure those among small ones.

To avoid this difficulty, we work with logarithms. (If you are not sure what a logarithm is, see appendix A, page 16.) In the exercise above, you were asked to make a graph with the logarithm of average female weight on the horizontal axis and the logarithm of average male weight on the vertical axis. If the average male and female weights are equal, then species will fall on a line that is drawn from the origin at an angle of 45°. If males are larger than females, then that species will plot above the 45° line. The vertical distance, D, from the 45° line to a species's point on the graph is equal to

$$D = \log_{10}(\text{average male weight}) - \log_{10}(\text{average female weight})$$

For example, in the case of the agile gibbon, this is

$$D_{\text{gibbon}} = \log_{10} 5.82 - \log_{10} 5.5 = 0.765 - 0.740 = 0.025$$

In the case of the talapoin monkey, the vertical distance to the 45° degree line is

$$D_{\text{monkey}} = \log_{10} 1.4 - \log_{10} 1.1 = 0.146 - 0.041 = 0.105$$

This new quantity, D, is another way to measure sexual dimorphism. Since it is based on logarithms, it is automatically scaled to body size and will not obscure differences within small species or exaggerate those within large ones.

We now have two measures of sexual dimorphism, R and D, both of which take body size into account in a natural fashion. It turns out (trust me on this) that $D = \log_{10} R$. For example, in the case of the gibbon,

$$D_{\text{gibbon}} = \log_{10} R_{\text{gibbon}} = \log_{10} 1.058 = 0.025$$

We can calculate D either as the log of the ratio of male and female sizes or as the difference of the logs. The answer is the same in either case. The two measures of dimorphism, R and D, will never disagree: if species A is more dimorphic than species B according to R, then it is also more dimorphic according to D. Thus, both statistics provide the same information and it does not matter much which we use. In this exercise you have been asked to use D rather than R because this makes it easier to interpret the graph.

Exercise 4

Prisoners' Dilemma

Read this section and do the warm-up exercises before coming to class for this experiment.

Joe and Jack rob a grocery store and are arrested shortly thereafter. The evidence against them is weak, however, so the police want to encourage confession. Each prisoner is interrogated in a separate room. Each knows that if neither of them confess, then their sentences will be light—6 months in jail. If just one confesses (implicating the other), then the one who confesses will be released while the other will serve 10 years in jail. If both confess, both will serve 8-year sentences.

The payoffs to Joe are as follows:

		Jack	
		Mum	Fink
Joe	Mum	−0.5	−10
	Fink	0	−8

4.1 Warm-up exercises

To be completed before you come to class for this experiment.

1. If Joe plays Fink and Jack plays Mum, Joe's payoff is _____ and Jack's is _____.

2. If Jack and Joe both play Mum, the payoff to each is _____.

3. If Jack and Joe both play Fink, the payoff to each of _____.

4.2 Instructions

4.2.1 Game 1

1. Form groups of three.

2. Within each group, one student will be the "interrogator" and will keep records. The other two will be "prisoners." Decide for yourselves who will play each role.

3. Each player will need a sheet of paper and should write numbers 1–15 on separate lines. Game 1 will consist of 15 repetitions, and you will record your play for each repetition on a separate line.

4. In the first repetition, each prisoner chooses between playing Fink or Mum and then writes this choice on line 1. Cover your choice with another sheet of paper so that no one can see.

5. After both prisoners have recorded their choices, each prisoner reveals his or her choice to the other two. Together, the three decide on the payoff to each prisoner.

6. The interrogator keeps a tally of the number of times Mum and Fink are played during each turn.

7. Repeat for lines 2–15. Play the game one round at a time—don't fill in choices for later rounds until you get to them.

8. When your group has finished, your interrogator should go to the board and write down your group's results in a column like this:

Group 1		
	Prisoner	
Turn	1	2
1	F	F
2	F	M
⋮	⋮	⋮
15	M	M

where "F" indicates Fink and "M" indicates Mum.

We will post the data on the class web site (`http://www.anthro.utah.edu/~rogers/courses.html`).

4.3   Theory

(I will explain the game-theoretic analysis of this game in class. If you missed class, you will need to get someone's notes. Most of what I say in this lecture is covered in Ridley's chapter 3.)

4.4 Assignment

In this exercise you will summarize the data from the Prisoner's Dilemma experiment in a form that is easy to understand. We will be discussing the results for the rest of the semester. The data include (i) what each pair did on each round of the game, (ii) mean payoff to Fink on each round, (iii) mean payoff to Mum on each round, and (iv) overall mean payoff on each round. The exercise involves making two graphs and writing three paragraphs discussing them. Space for the answers is provided here. Your answers to questions 5 and 6 should be typed. The report is due at the first class following experiment 4. If you have trouble understanding the assignment, consult section 4.4.1 below.

1. Calculate the relative frequency of Fink in each turn (for the class as a whole), and plot these numbers on Graph 1.

Graph 1
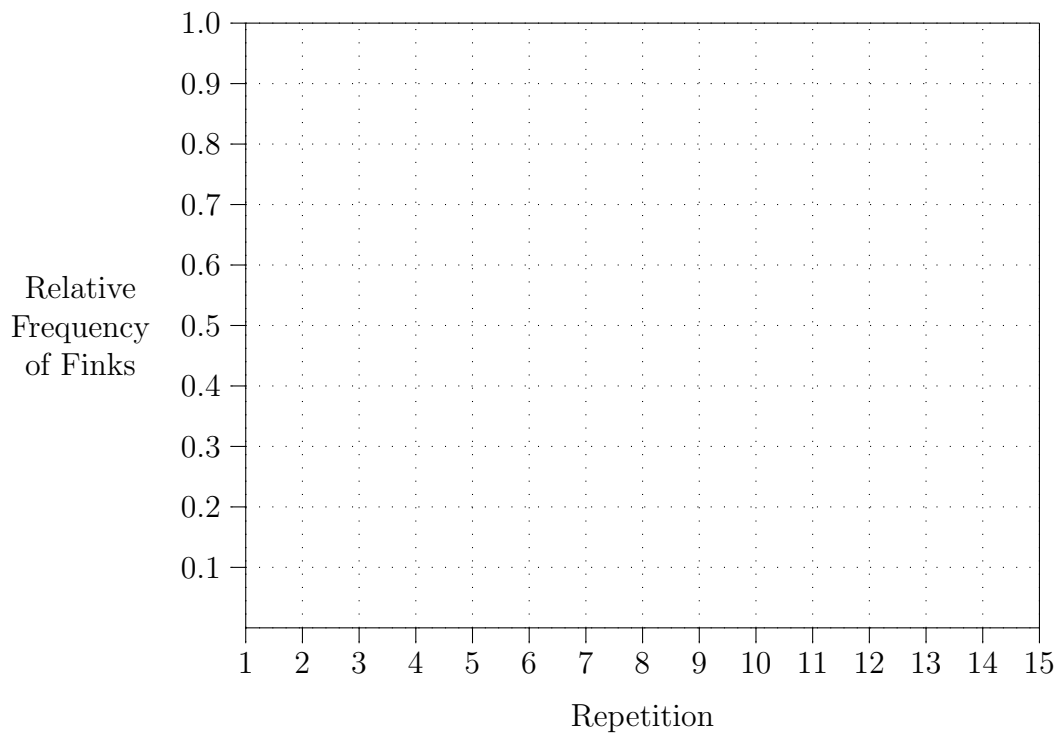
No calculations are involved in the next three exercises. The values to be plotted are all provided on the web page.

2. On graph 2, plot the average payoff to members of the class on each round. Label this line "A" (for Average).

3. On the same graph, plot the average payoff to those who played Fink, and label this line "F" (for Fink).

4. On the same graph, plot the average payoff to those who played Mum, and label this line "M" (for Mum).

Graph 2
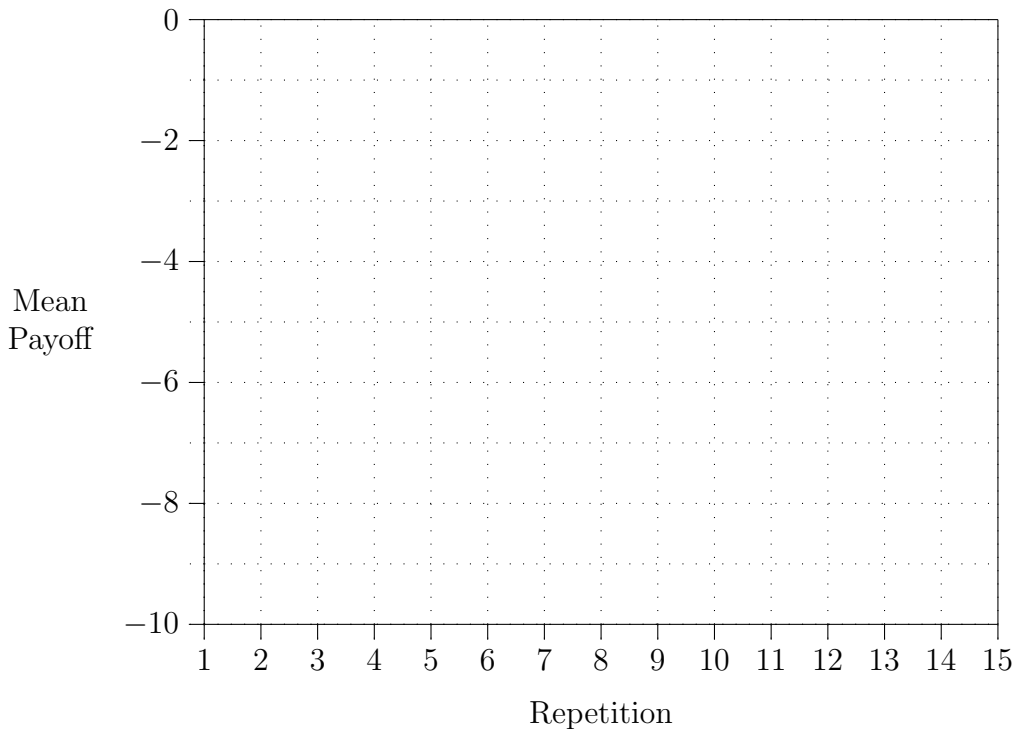
5. In class, I summarized the conventional game-theoretic analysis, which predicts the outcome of a Prisoner's Dilemma game that is repeated a fixed number of times. Use the results from our in-class game to evaluate this theory. Under a new heading, write a paragraph discussing the following issues: (a) What does the conventional theory predict? (b) Did your class behave as predicted by the theory? (c) If not, then how did the class's responses differ? Did class-members co-operate with each other more or less than the theory predicts? (d) As the class gained more experience with the game, was there any tendency to converge toward the theoretical prediction?

6. What reasons can you think of that might account for the differences between the results of the experiment and the results that the theory predicts?

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Hand in only the pages containing your answers—not the entire Prisoner's Dilemma handout. Please staple all the pages together.

4.4.1 More detail

The relative frequency of Finks is the number of Finks divided by the number of students playing the game. Here is a partially worked example. Suppose that we had data like this:

	Group			
Turn	1	2	3	4
1	MM	MF	MF	MM
2	FF	FF	MF	MM

In the first round, 2 of the 8 players played F. The relative frequency of Fs is thus $2/8 = 0.25$. In the second round, it was $5/8 = 0.625$. These are relative frequencies of Finks within the class taken as a whole.

You do not need to calculate mean payoffs, since these values are provided on the web site. Nonetheless, you may be curious about how these values are calculated. Here's how:

To calculate the mean payoff, first calculate the payoff of each player using the payoff matrix on page 11. With the toy data set above, the payoffs are:

	Group							
Round	1		2		3		4	
1	–0.5	–0.5	–10	0	–10	0	–0.5	–0.5
2	–8	–8	–8	–8	–10	0	–0.5	–0.5

Next, average the payoffs from each row. For the first round, the average payoff is

$$(-0.5 - 0.5 - 10 + 0 - 10 + 0 - 0.5 - 0.5)/8 = -2.75$$

For the second, the average payoff is –5.375.

To calculate the average payoff for those who played Fink, use the same procedure but include only the payoffs for those individuals that played Fink. In the first turn of the example, the mean payoff to those who played Fink was

$$(0 + 0)/2 = 0$$

The mean payoff to those who played Mum was

$$(-0.5 - 0.5 - 10 - 10 - 0.5 - 0.5)/6 = -3.67$$

Appendix A

What is a logarithm?

We all know that
$$10^2 = 100$$

This same fact can also be expressed by writing

$$\log_{10} 100 = 2$$

In words, this reads "the logarithm to base 10 of 100 equals 2." Both equations mean the same thing: if you raise 10 to the 2nd power you get 100.

Similarly, $10^3 = 1000$, so $\log_{10} 1000 = 3$. Here are some other numbers and their logs:

x	$\log_{10} x$
1	0
10	1
100	2
1000	3
10000	4
1000000000000000000000	21

Notice the pattern. As x grows, $\log_{10} x$ grows too, but much more slowly.

Logarithms are useful when we are more interested in proportional differences than in absolute ones. For example, a one-ounce difference is large if we are comparing mice but small if we are comparing elephants. Thus, we would not want to use "ounces" as the horizontal axis of a graph that included values for animals ranging in size from mouse to elephant. The graph is easier to interpret if we use "log ounces" instead, because a proportional difference of (say) 10% between mice occupies the same space on the graph as a 10% difference between elephants. This is why logarithmic scales are used so often in illustrations.

Bibliography

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