Chapter 2-Basic Concepts

2.1 Nominal: names of students in the class; Ordinal: the order in which students hand in their first exam; Interval: the student's grade on that first exam; Ratio: the amount of time that the student spent studying for that exam.

2.2 Dates are a good example of interval scales that do not have ratio properties because we do not have a zero point for dates. Even the data 0 BCE has an arbitrary zero point.. (When I came to answer this question I found that it was much more difficult that I had expected. Looking at 4 different texts, they all use temperature as their one example.)

2.3 If the rat lies down to sleep in the maze, after performing successfully for several trials, this probably says little about what the animal has learned in the task. It may say more about the animals level of motivation.

> In this exercise I am trying to get the students to see that there is often quite a difference between what you and I think our variable is measuring and what it actually measures. Just because we label something as a measure of learning does not make it so. Just because the numbers increase on a ratio scale (twice as much time in the maze) doesn't mean that what those numbers are actually measuring is ratio (twice as much learning).

2.4 The data include the child's Apgar score, gestational age, and gender, and data on the mother's weight, prenatal care, and smoking behavior.

2.5 We have to assume the following at the very least (and I am sure I left out some)

1. Mice are adequate models for human behavior.
2. Morphine tolerance effects in mice are like heroin tolerance effects in humans,
3. Time on a warm surface is in some way analogous to a human response to heroin.
4. A context shift for mice is analogous to a context shift for humans.
5. A drug overdose is analogous to pain tolerance.

> Having the whole class create a list is a useful exercise. Having them provide realistic estimates of the legitimacy of this list is even more useful. Keeping them from becoming overly cynical about any kind of research that involves such assumptions (and virtually all research does) is critical.

2.6 The mouse's paw-lick latency (dependent variable) was examined as a function of the context is which the drug was given (independent variable).

2.7 The independent variables are the sex of the subject and the sex of the other person.

2.8 The dependent variable is the amount of food eaten.

2.9 The experimenter expected to find that women would eat less in the presence of a male partner than in the presence of a female partner. Men, on the other hand, were not expected to vary the amount that they ate as a function of sex of their partner. (They're kind of clueless.)

> You might take the opportunity to point out, in a very non-technical way, that what we have predicted here is what we will later call an interaction. Ask the students if they share this prediction. If so, they are sharing in the idea of one variable (sex of subject) having a differential effect depending on the level of another variable (sex of partner). We are talking here about gender differences in response to social situations.

2.10 The major assumption is that the amount of food that a person will eat in the presence of another is somehow a measure of the person's propensity for exhibiting socially desirable behavior. We also assume that the simple presence of another person is a stimulus to elicit that socially desirable behavior.

2.11 We would treat a discrete variable as if it were continuous if it had many different levels and was at least ordinal

2.12 Discrete variables: The sex of the subject and/or the sex of the partner in the previous study; the response on a five point Likert scale; the number of trials (out of 7) on which the subjects perceives a briefly presented stimulus. Continuous variables: The grams of food that the subjects ate in the previous experiment; the number of seconds it takes a mouse to lick its paws; the time that a rat spends getting from one end of the maze to another.

2.13 When I drew 50 numbers 3 times I obtained 29, 26, and 19 even numbers, respectively. For that third drawing only 38 percent of my numbers were even, which is probably less than I might have expected—especially if I didn't have a fair amount of experience with similar exercises.

2.14 I can't give an answer for this question because it depends on the student's sequence of H and T.

2.15 Eyes level condition:

a) $X_3 = 2.03$; $X_5 = 1.05$; $X_8 = 1.86$

b) $\sum X = 14.82$

c) $\sum_{i=1}^{10} X_i = 14.82$

2.16 Eyes elevated condition:

a) $Y_1 = 1.73$; = 1.73; $Y_{10} = 1.56$

b) $\sum Y = 14.63$

2.17 Eyes level condition:

a) $(\sum X)^2 = 14.82^2 = 219.6324$; $\sum X^2 = 1.65^2 + ... + 1.73^2 = 23.22$

b) $\sum X/N = 14.82/10 = 1.482$

c) This is the mean, a type of average.

2.18 Eyes elevated condition:

a) $(\sum Y)^2 = 14.63^2 = 214.0369$; $\sum Y^2 = 22.4483$

b) $$\frac{\Sigma Y^2 - \frac{(\Sigma Y)^2}{N}}{N-1} = \frac{22.4483 - \frac{14.63^2}{10}}{9} = \frac{22.4483 - \frac{214.0369}{10}}{9} = 0.1161$$

c) $\sqrt{b} = \sqrt{0.1161} = .3407$

You could point out that the above answers are the variance and standard deviation of *Y*. You could also point out that they really aren't going to do much more calculation that this.

2.19 Putting the two sets of data together:

a) Multiply pairwise

b) $\sum XY = 22.27496$

c) $\sum X \sum Y = 14.82 * 14.63 = 216.82$

d) $\Sigma XY \neq \Sigma X \Sigma Y$. They do differ, as you would expect.

e) $$\frac{\sum XY - \frac{\sum X \sum Y}{N}}{N-1} = \frac{22.7496 - \frac{14.82*14.63}{10}}{9} = \frac{1.0679}{9} = .1187$$

2.20 Demonstrations:

a) $\sum(X + Y) = 29.45 = 14.82 + 14.63 = \sum X + \sum Y$

b) $\sum XY = 22.7496 \neq 216.82 = \sum X \times \sum Y$

c) $\sum 5X = 74.10 = 5 \times 14.82 = 5\sum X$

d) $\sum X^2 = 23.2238 \neq 219.63 = 14.82^2 = (\sum X)^2$

2.21							
	X	5	7	3	6	3	$\sum X = 24$
	X + 4	9	11	7	10	7	$\sum(X + 4) = 44 = (24 + 5*4)$

2.22 Hairs on a goat only come in whole numbers. How could a goat have 3/4 of a hair? (It may only be 3/4 as long as most hairs, but it still counts as a hair.) However for all practical purposes any sensible person would *treat* that variable as if it were continuous.

2.23 In the text I spoke about room temperature as an ordinal scale of comfort (at least up to some point). Room temperature is a continuous measure, even though with respect to comfort it only measures at an ordinal level.

> Here is a good place to beat home the idea again that the scale of measurement doesn't depend on the numbers themselves, but on what we think they are measuring.

2.24 I would look at the distribution of scores for both measures. Is one more neatly distributed than the other? Does one show more systematic changes over time? Is there a logical reason to think that one measure is somehow more appropriate to the phenomenon under study than another.

> I have found that students are very distrustful of any transformation on data, even when the original units of measurement are purely arbitrary. They somehow think that time, since it is measured in the units we are familiar with, is more appropriate for whatever phenomenon than some other measure. In fact, a logarithmic transformation would have a disproportionate effect on longer times, which might make the transformed data a lot more reasonable in terms of the relationship between sensitivity and time.

2.25 The Beth Perez story:

a) The dependent variable is the weekly allowance, measured in dollars and cents, and the independent variable is the sex of the child.
b) We are dealing with a selected sample—the children in her class.
c) The age of the students would influence the overall mean. The fact that these children are classmates could easily lead to socially appropriate responses—or what the children deem to be socially appropriate in their setting.
d) At least within her school, Beth could randomly sample by taking a student roster, assigning each student a number, and matching those up with numbers drawn from a random number table. Random assignment to Sex would obviously be impossible.
e) I don't see negative aspects of the lack of random assignment here because that is the nature of the variable under consideration. It would be better if we could randomly assign a child to a sex and see the result, but we clearly can't.
f) The outcome of the study could be influenced by the desire of some children to exaggerate their allowance, or to minimize it so as not to appear too different from their peers. I would suspect that boys would be likely to exaggerate, and the data are consistent with that expectation.
g) The descriptive features of the study are her statements that the boys in her class received $3.18 per week in allowance, on average, while the girls received an average of $2.63. The inferential aspects are the inferences to the population of all children, concluding that "boys" get more than "girls."

2.26 Smoking and health:

a) The sampling could have been limited to those countries because the health statistics for those countries are more extensive and reliable.
b) Both of these could be taken to be ratio scales, because we are specifically measuring the incidence of each behavior. For example, 40 cigarettes is clearly twice as many as 20, and 184 cases of heart disease is twice as many as 92. If coronary heart disease were being used as a measure of "national health," I would certainly not claim that it is a ratio measure.
c) These data relate to one (very important) health effect of smoking, but only one.
d) The level of health care, the amount of fat in the diet, the degree of exercise people get, and the age of the populations all have to be taken into account.
e) A health psychologist would be out there right now, identifying a very large sample of women and noting their health characteristics. She would check on these subjects periodically, recording smoking behaviors, other health risks, and general demographic variables. She would then track changes in health in an attempt to test for an association with changes in smoking behaviors, after controlling for other variables.
f) The articles that I found show a clear and consistent relationship between second hand smoke and coronary heart disease. These are the kinds of statistics that lie behind recent societal efforts to ban smoking in public places.

> This question could lead to an excellent discussion of experimental design. Students should be able to phrase a set of questions they would like to ask, and a number of competing hypotheses they would like to eliminate. It would be very useful if they could lay out the kinds of analyses they might like to think about *before* they learn any more about analytical procedures. This sets the stage for much of what follows.

2.27 I would record the sequence number of each song that is played and then plot them on a graph. I can't tell if they are *truly* random, but if I see a pattern to the points I can be quite sure that they are not random.

2.28 This is an Internet question without a specific answer.

> I think that it is important to get the students involved with the Internet early on. There is so much material out there that will be helpful to them, that they have to start finding it now. I find it impossible to believe that my explanations of concepts are always the best explanations that could be given and that they serve each student equally well. They need to learn that if one explanation doesn't make sense, they can find others that may.

Examples, Data Sets, and Suggestions

2.1 In Exercise 2.13 I ask the students to draw 3 random samples and calculate their means. These data could be collected from all members of the class and form the basis for a discussion of sampling and a discussion of the distribution of means.

2.2 Students often have trouble understanding the basic issues behind measurement. It is helpful to engage them in a class discussion of how they might measure something as vague as physical attractiveness of houses, babies, or males, (but please not women). They quickly come to see the difficulty in measurement, and the meaning of the underlying scale. They find "intelligence" much easier to think about than "attractiveness."

2.3 The paper by Lord (1953) on football numbers leads to an interesting discussion. Without reading the paper themselves, students can often come to terms with several of the issues involved.

2.4 Several problems in this book deal with the moon illusion. I think that I am justified in assuming that students know what it is, but perhaps they have never thought about possible explanations. A very short discussion of that illusion might make the exercises and examples more interesting.

A great web site provides a discussion of the illusion and a couple of simple demonstrations can be found at http://www.grand-illusions.com/opticalillusions/moon/ .

2.5 It is often difficult to get across the basic ideas behind summation notation. In particular, students have a difficult time understanding why ΣX^2 is different from $(\Sigma X)^2$. I found that having a small group of students invent data on a hypothetical study of their own choosing, and then demonstrating the meaning of different notational symbols helps to bring the idea home.

2.6 If you want to devote a fair amount of time to having students think about a set of data, a good source is an article by Robert Dawson entitled "The 'Unusual Episode' Data Revisited" in the online *Journal of Statistics Education*. The article can be found at http://www.amstat.org/publications/jse/v3n3/datasets.dawson.html , and concerns the sinking of the Titanic, which is a topic that students know something about. It is not particularly related to the behavioral sciences, but it should engage their attention and make for an interesting, and useful class.