Chapter 1

Introducing Statistics and the Research Process

One of the largest oil spills occurred in April, 2010, when the Deepwater Horizon oil platform experienced an explosion in the Gulf of Mexico opening a well. Approximately 4.9 million barrels of oil leaked into the Gulf before the well was capped. At its peak, 62,000 barrels a day escaped, eventually reducing to 53,000 barrels a day prior to capping the well.

In March, 2011, a 9.0 magnitude quake hit the Tōhuko region of Japan causing a tsunami, with a casualty count over 15,000. The quake was one of the largest ever measured in recorded history (the largest being the 1960 Valdivia quake in Chile measuring 9.5).

The late 2000's saw the near collapse of the U.S. economy due to poor investment strategies in risky mortgages by financial institutions. Home prices rose 124% from 1997 to 2006, and the ratio of home price to median family income increased from 3.1 in 2001 to 4.6 in 2006. The riskiest mortgages (called "subprime") were less that 10% of all mortgages financed in 2000, climbing to 20% by 2006. Subprime mortgages began to default, and the U.S. Government had to purchase a large portion of the subprime mortgages and provide monetary loan relief to a number of major financial institutions.

In covering these disasters, newspapers, TV news, on-line commentaries and blogs provided in-depth analysis of their causes and subsequent impact. Daily information was provided on injuries and casualties, economic and social impacts, rebuilding estimates, and counts of those left homeless. Estimates of oil leakage were offered, as were counts of the injured and dead for the Japan quake during the days and weeks that followed. Estimates of how much money the U.S. economy lost were offered, and we saw stock prices plummet. As these disasters illustrate, we as media consumers are constantly being exposed to information. How do we digest such information? How do we make sense of this busy world around us?

Part of the answer lies with statistics. *Statistics help us understand the world around us.* We know that Deep Water Horizon oil spill in the Gulf was one of the worst in history by comparing the total amount of oil spilled (in millions of barrels) to other spill estimates. The

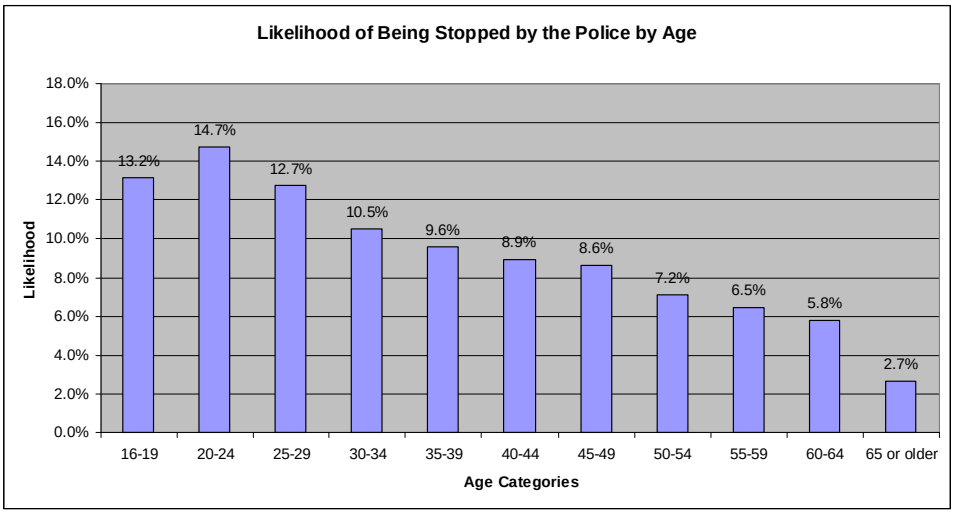
Japan earthquake was severe because quakes are measured on a moment magnitude scale (similar to the familiar Richter scale) – a 9.0 quake releases a 1000 times more energy than a 7.0 quake. The increase in subprime mortgages along with the ratio of home price to family income may be seen as predictors of the mortgage default.

Such disaster statistics were part of the news cycle for months, yet statistics are prevalent in everyday reporting. For example, assume that a daily edition of the newspaper *USA Today* is a good indicator of the world around us. What could you learn from statistics in a typical newspaper article? Certainly going to the sports section would yield some basic statistics, such as batting averages and earned run averages of your favorite baseball players. But let's move to a less obvious section where statistics might be found -- the front page. On the front page, we find a story about home prices, which reports that the national median home sales price is $215,300. This statistic is calculated from all reported home sales during a three-month period. The median sales price is the mid point of the home prices – half the homes sold for less than the median price and half sold above the median. The story goes on to note that median home sales in Cheyenne, Wyoming, is $175,916, noting that the median price in Cheyenne increased 7.9% from the previous year, while the national median decreased 0.9% from the previous year.

Another story centers on data in a single graph (reproduced in Figure 1.1). The graph shows a relationship between a driver's age and likelihood of being stopped by a police officer from 2005. Is there a relationship between driver's age and being stopped by police? If so, we have a greater understanding of the world around us. The graph shows the percentage of people in each age category that were stopped in 2005. The first bar in the graph shows data from 16 to 19 year-olds. We learn here that 13.2% of the people in this age group were stopped. About the

same percent applies to 20 to 29 year-olds. After that, the figure steadily decreases. There is indeed a relationship between age and likelihood of being stopped by a police officer.

Figure 1.1



Newspapers, magazines, and television programs also report statistics from scientific research in the social/behavioral sciences. For example, *USA Today* reports a story entitled "Brooding weighs on mind and body: How you handle stress could be shortening your life." Several research investigations were described. One was a study by Mroczek and Spiro (2007) that measured neuroticism in a large sample of men over 40 and then tracked their health over a period of 17 years. Neuroticism is a personality trait related to anxiety and worry about the events in your life. Over the study period, 50% of the highly neurotic men had died in contrast to only 25% of the men who were not categorized as neurotic.

In our everyday lives, whether in the media or through our everyday interactions (as we illustrate shortly for you), we are constantly exposed to statistics. To get a better sense of statistics and related issues, the following sections in this chapter offer a brief introduction to statistics, data, and the research process. But before we move forward, try Exploration Task 1.1. Its fun, and helps illustrate how statistics surround us.

Exploration Task 1.1: Finding Statistical Information in the Media

Think back to this morning after you woke up. List any news tidbits you remember reading on-line or in your local newspaper, or heard on the radio. Did you hear something about the stock market, the economy, or scores for your local sports team? You may have even heard about Lady Gaga album sales. Try and identify the statistical information presented.

The Science of Statistics

In the examples previously mentioned, a statistic was derived from some type of observation about events in the world – casualty counts, oil leak estimates, home prices, and deaths occurring in a group of men over a 17 year period. We refer to such observations as data. *Statistics help us understand and summarize data. In essence, the science of statistics incorporates the acts of data collection, data organization, data reduction or summary, and data interpretation.* When we practice statistics, we are performing one or more of these tasks.

For the examples, it is true that numeric calculations are applied to the data in order to obtain the statistics, but the calculations are not all that difficult and we have calculators and computers to do the math for us. The important thing that you will learn in your study of statistics is how to accurately interpret statistical information and apply the proper statistical techniques in various contexts.

What is Data?

We see the word *data* used frequently. A *Google* search on the phrase "the data show" reveals over 20 million search results. For example, from the website *NOLA.com*, "the data show" that in New Orleans, the number of households describing themselves as families dropped from 60% in the year 2000 to 53.9% in 2010. From *Marketwatch.com*, "the data show" the economy slowing down due to rising gasoline prices. *Mashable.com* notes that "the data show"

47% of *Facebook* walls contain profanity. And from *Oceannavigator.com*, "the data show" shark attacks have been increasing world-wide from 1900 to 2000 (sounds scary for us ocean goers, but don't panic – through 2000 there have only been 536 confirmed shark attacks world-wide). Beyond what you read on-line, data are found in everyday interactions. For example, when buying a car, the salesperson may say, "Here is a data sheet for the Subaru Outback." Or when applying for a job, many applications have sections that read "Personal Data."

Whether you read news on-line, shop for a car, or apply for a job, you know what such data statements mean. The data on New Orleans households and families consisted of percentages from 2000 and 2010. Data on the economy is measured using an index of economic growth, and gas prices are simply the price of gasoline -- as gas prices increase, the index of economic growth shrinks. For profanity on *Facebook*, data represent the percentage of *Facebook* walls containing profanity, and shark attacks are simply yearly counts of attacks. The Subaru data will show information on gas mileage, horsepower, time to reach 60 miles per hour, and rear cargo space, while job application data will require your name, address, phone number, and E-mail address.

The word *data* is a plural noun. The singular noun *datum* is rarely used – instead we use terms such as *data element* or *data point* to refer to a single piece of information. Data may take many forms: When you pay to see a movie on Friday night, that fact becomes part of the "weekend box office receipts" data reported in Monday's news. When you take a personality measure in your Introduction to Psychology course, your score becomes data for a study being conducted by a professor at your college. Although the word seems scientific, you are actually collecting and synthesizing data all the time. You do it in everyday life as you read a textbook

for a class, navigate through traffic, or ask some classmates to recommend a teacher for a class you want to take next semester.

Exploration Task 1.2: Discovering Data in Your Activities

Think about the path you take through campus to get to your statistics class. Why did you choose that path? Is it the fastest path? The safest? Your answers to these questions are data. Try the following – Why did you choose your statistics instructor? List a few reasons you signed up for your professor's course. For some of you, this professor's course fit your schedule best. For others, you heard through friends that this professor is the BEST (all statistics professors are like that by the way). These reasons are data – you collected data based on your current schedule or by speaking with friends to help decide to take this course. What other reasons did you list for why you signed up for this professor's course? How are these data?

Data on Eating Behavior

Data may even be discovered in the simplest situations, such as a hotdog eating contest! Let's examine a small set of data collected a few years ago at Nathan's Famous Fourth of July International Hot Dog Eating Contest held at Coney Island. Our topic is eating behavior, and we wish to study food consumption. *When researchers study specific phenomena, they must devise a specific technique to assess the variable. This is called the operational definition of the variable*. In our case, food consumption is measured with a procedure where a person is asked to eat as many hot dogs as possible during a 12-minute period. The unit of measurement is called an HDB (hot dog and bun). A fully consumed hot dog and bun is scored as 1 HDB; a partially consumed hot dog and bun is scored as 0.5 HDB. Social/behavioral researchers interested in eating behavior conduct much less spectacular research; however, their job of measuring food

consumption is much the same. They may examine the number of peanuts or ounces of ice cream consumed, for example.

The number of participants in the final hotdog eating contest was 17, chosen from regional hot dog eating contests (in case you are interested, such contests are supervised by the International Federation of Competitive Eating). Let's look at the data. The HDB scores for the 17 contestants were: 31, 21, 49, 43.5, 29, 24, 66, 21, 26, 63, 39, 35, 35, 23.5, 25, 22.5, 23. We can refer to those numbers as "raw" data – statistics have not been applied to these data, so there is no information to help us understand or summarize the data. Most data sets look like this when we begin. Note there is no information on the source of each data element, such as contestant's names. Because the contest was a public event, we could provide you with the names but this information would not tell you very much about the data. To better understand and summarize this data, we would apply statistics. Indeed, we shall see this data set again in later chapters to illustrate different statistical tests.

Exploration Task 1.3: Create Your Own Small Dataset

Yesterday, how many glasses of water did you drink? How many sodas? How many french fries, or how many chips did you consume? Pick a few of your favorite foods or drinks, and write down how many you consumed. Ask your friends too! Create a small dataset with this information. Just like a hot dog eating contest, you can see who won the "tortilla chip" eating contest amongst your friends!

Contrasting Quantitative and Qualitative Data

Statistics are applied to numeric data for summary and interpretive purposes. Another term for numeric data is *quantitative data* – statistics deal with quantities. So far in this chapter, we described quantities such as median sales price of homes, and number of hot dogs consumed in a contest.

You should also know data may be qualitative. *Qualitative data* are not numeric, nor are statistics generally applied to qualitative data. The observations gathered with qualitative research focus on qualities rather than quantities. *Qualitative data can consist of observations of behavior (e.g., nonverbal flirting behaviors; how physicians interact with their patients; pedestrian traffic on a college campus), and can also be verbal descriptions of thoughts and behaviors which must then be analyzed through an analysis of text.* For example, Rosenblatt (2006) studied the sleeping patterns of married couples. He conducted interviews with 42 couples. Each interview lasted approximately two hours. His data were qualitative because he asked such things as "Do you talk in bed? About what? Who talks more?" and "Tell me about your sleeping together last night." The data consist of the answers provided by the individuals interviewed, e.g., "We talk the most about stressors; something's bothering me…" This research resulted in a book in which Rosenblatt analyzed the interview transcripts and made sense of the data as a couples phenomenon; two individuals have a social system where they learn to sleep together, make compromises, and deal with issues such as having pets in bed or watching television before going to sleep.

The distinction between quantitative and qualitative data becomes especially clear when the two approaches are applied to understanding the same phenomenon. Consider the case of the 1986 Challenger space shuttle, which exploded 73 seconds into flight killing all seven people aboard. A video of the liftoff and explosion may be viewed on YouTube (**http://tinyurl.com/y8s525g**). After the initial shock and media frenzy surrounding the disaster, a search was on for the cause of the explosion. What had happened?

Both quantitative and qualitative data were used to explain the accident, ultimately concluding both mechanical and human led to the disaster. Using *quantitative* data and statistical

analysis, the cause of the explosion was found to be a faulty O-ring seal that separated two parts of one of the rocket boosters. The O-ring failed due to extreme cold, which allowed gasses to escape and ignite. Data were collected and analyzed by a Presidential committee to investigate the disaster, and the characteristics of actual O-rings were carefully evaluated under many different temperature conditions. These data and subsequent statistics applied to the data showed an increased probability of failure under colder launch temperatures. For example, O-ring performance data from 23 previous shuttle flights (with launch temperatures between 53 and 81 degrees Fahrenheit) showed that at colder temperatures, O-rings performed poorly, loosing their resilience to expand and contract (a demonstration of this resiliency may be found on YouTube by Cal Tech physicist Richard Feynman - **http://tinyurl.com/7a4zx9**). On the day of the Challenger launch in 1986, the temperature was below 30 degrees Fahrenheit.

Knowing the exact mechanical cause of the disaster was one piece of the puzzle – O-ring failure due to extreme cold. However, human error was also a cause. NASA gave the okay to launch even though they knew that O-ring failure could occur in cold temperatures. Indeed, engineers who designed the rocket booster O-rings were aware that the rings perform poorly in cold temperatures, and meetings were held prior to launch to discuss the issue. Why did NASA decide to launch Challenger given these conditions? To answer this question, Diane Vaughan (1996) conducted *qualitative* research on the Challenger disaster by interviewing personnel from both NASA and the engineering firm of Morton Thiokol who designed the rocket boosters, and examined numerous archival records such as internal memos and explored the history of the shuttle program. *Vaughan's qualitative research used these verbatim quotes from interviews and other information to weave an explanation for why the Challenger disaster occurred.* One conclusion from her research was that the organizational culture within the shuttle group at

NASA caused the scientists and engineers to unconsciously view risks as a normal part of program.

Exploration Task 1.4: Comparing Quantitative and Qualitative Data

Describe today's weather in a few sentences. Is it cold out? Warm? Windy or rainy? Gloomy or happy? Provide a good description. Viola! You now have qualitative data. After doing this, collect some quantitative data. Check on-line your local weather conditions (try http://weatherunderground.com, or in Google search just type "weather"). What is the temperature out? What is the wind speed? Humidity? Is it sunny out? Compare and contrast your two sets of data – your personal account of the weather, and the reported numbers. Which do you prefer? Which provides a better assessment of the weather?

The Research Process

So far, you know that statistics are used to help organize, summarize, and interpret numeric data. Further, you now see the difference between numeric or *quantitative* data, and data that are *qualitative* such as the interviews conducted by Diane Vaughan on the Challenger disaster. Quantitative and qualitative data are analyzed in social/behavioral research – with statistics applied when the data are quantitative.

Whether we look at the *USA Today* articles described earlier, the study on sleeping patterns of married couples, or the Challenger Shuttle disaster, all of these results were derived from published research reports, articles, or books. *Behind these works rests a research process, which may be defined as the process by which research is conducted and data are collected for scientific inquiry*. Some students find it surprising the amount of forethought and effort that goes into published reports and articles. Such effort by researchers insures the study results are reliable and valid.

We provide next a brief overview of two research approaches that illustrate the research process; deductive research and inductive research. Here, our goal is to provide basic information on how data are generated, which ultimately will help you make good choices regarding how to statistically analyze the data. The research approach adopted – deductive or inductive -- is based on your research goals and expected outcomes of the phenomena being studied.

Deductive Research

Deductive research involves studying a phenomena without any preconceived causes or explanations of the phenomena. In many cases, this type of research is exploratory. A phenomena is chosen for study, and general questions are written regarding the phenomena. Then, an open-approach research method such as observations or open-ended personal interviews are used for data collection. These data are then evaluated and conclusions are drawn about the phenomena being studied. This research approach is very open, meaning there are no limitations set on the information collected. *In most instances, the data collected using deductive research will be qualitative.*

Inductive Research

Inductive research involves studying a phenomena using extensive planning before data are collected. After a phenomenon is chosen for study, a theory is adopted to help explain the phenomena. *Theories organize and explain how phenomena work.* For example, social interactions between individuals may be explained through "social exchange theory" which states that individuals are reward-driven and willing to incur "costs" in order to obtain those rewards.

After a theory is chosen, hypotheses are written to guide the research. *Hypotheses are formal statements about a phenomena, and are written as predictions that reflect the interplay between the phenomena and related variables*. For example, the hypothesis for the study noted earlier on neuroticism and increased death-rate was, "Risk of mortality should be lowered among persons who show a long-term decline in neuroticism or a long-term increase in extraversion" (Mroczek & Spiro, 2007, p. 372). Hypotheses and how they are formed will be fully addressed in Chapter 4. A final step before collecting data is to operationalize the phenomena and related variables. *When we operationalize a variable, it means we must figure out a way to measure or assess the variable*. For example, to study eating behavior, we decided to use hotdog/bun combinations taken from Nathan's Famous Hotdog Eating Contest. Eating behavior was the phenomena, and we operationalized it as hotdog/bun combinations eaten.

Once the above steps have been completed, data collection may begin. Note that the deductive research process is very controlled, and only the variables "planned" to be investigated are evaluated. *In general the data collected using inductive research will be quantitative.*

Deciding on a Research Approach

The research approach you choose to investigate phenomena -- inductive or deductive -- is linked to your research goals and to the expected outcomes of your study. Let's examine a possible research project you might undertake and see how each approach could be applied. Suppose you are curious about how healthcare providers such as doctors and nurses make patient treatment decisions. Perhaps this interest stemmed from visiting your campus health clinic. How do healthcare providers make decisions about how to treat patients?

As you plan the research to address this question, you need to decide whether your answer is intended to be exploratory, or an attempt to investigate a clear hypothesis. In exploratory research, you want to evaluate how healthcare providers make treatment decisions, but do not have any preconceived ideas regarding how the decisions are made. Exploratory research often focuses on a *deductive research approach* and qualitative data collection. If this is the approach you wish to take, you might consider interviewing healthcare providers after they see patients, gather healthcare providers in a room for discussion of these issues, or follow a group of medical students as they are trained by healthcare providers in hospital settings.

In Diane Vaughan's research on why the Challenger disaster occurred, a decision was made to focus on personal interviews to weave an explanation for why the Challenger disaster occurred. In a similar fashion, you might decide to use the qualitative approach of personal interviews for your study of healthcare decision making. These interviews would be tape recorded and then transcripts would be made of the recordings. You could then see if there are any common themes across the interviews. These themes could then be summarized into understanding how treatment decisions are made.

In contrast, you might approach the research question from a more narrow perspective and apply an *inductive research approach*. You may have a theory and a set of well-defined hypotheses regarding medical decisions. Data would then be collected and analyzed to evaluate the hypotheses. For example, you might be concerned with one particular type of medical decision that you hypothesize differs depending on whether a patient is male or female. In this case, it is more likely that you will be collecting quantitative data. You might present health care providers with a description of a male or a female with the same symptoms and ask them to choose among several possible treatments. Or, if the medical data have been recorded in a

computer, you could examine the actual treatment outcomes for males and females with the same diagnosis. To make your comparisons between males and females regarding their treatment outcomes, you would use statistics on the collected data.

Exploration Task 1.5: Investigating Romantic Love

Romantic love abounds! But what goes into romantic love? What research approach, inductive or deductive, would best serve understanding romantic love? If you were to take a deductive research approach, you might start by making a brief list of statements regarding romantic love. Try writing 5 statements to address romantic love, "Romantic love is _____." Have a friend do the same thing, listing 5 "Romantic love is _____" statements. From these statements, what conclusions can you draw about romantic love? For an inductive research approach to romantic love, you would start by adopting a theory that explains romantic love. And lucky for you, there is one! In Robert Sternberg's Triangular Theory of Love (1986), romantic love is the combination of passion and intimacy. Your research study would measure both passion and intimacy to assess romantic love. Looking back at your romantic love statements, would you say passion and intimacy define romantic love per Sternberg's theory, or is romantic love more than passion and intimacy? What research approach do you think is best for assessing romantic love?

Moving Forward with Statistics: The Structure of this Book

Why study statistics? It must be an important topic because a course in statistics is required for majors in such diverse fields as psychology, sociology, political science, education, criminal justice, biology, business, economics, health, and kinesiology. One reason why it is so important is that all of these fields advance through research. Research is conducted to address basic and applied research questions about learning and memory, relationships, health, crime, and human performance. Statistics are used to understand the results of such research.

So far, we have provided you an overview of statistics, and a brief summary of the research process including deductive and inductive research approaches. Numeric or

quantitative data were introduced as was qualitative data. Statistics and statistical analyses are the "endpoint" of the deductive research approach – they help us organize, summarize, and interpret numeric data.

One of the major goals of this textbook is to help guide you in choosing an appropriate statistical test for your data. Certain statistical tests are used for assessing associations between variables, while other statistical tests are used for group comparisons. A second goal is to make you proficient in calculating the test statistics by hand, and also to perform these same calculations using a computer. A third goal is to make you comfortable writing and discussing the statistical test results. In other words, once the data have been analyzed, you will be able to write-up and interpret the findings. Are the findings important? Are these findings beyond what would be expected by chance occurrence? What do the findings mean?

The textbook is divided into five parts. Part I includes this chapter, and the remaining two chapters address the types of numeric data you may encounter, summary statistics, and data distributions. Part II addresses null hypothesis testing and why we use statistics to formally test hypotheses. The starting point for this section is basic probability and its association with the normal curve and hypothesis testing. Here, Type I and Type II error will be covered, along with issues associated with sample size, power and effect size.

Parts III, IV, and V are our formal presentations of various introductory statistical tests. Part III presents various measures of association, including the chi-square test, Fisher's exact test, odds ratios, and correlation. Part IV examines statistics for evaluating group differences when data are grouped. These tests include the independent sample t-test and one-way ANOVA. Part V, the final section, and addresses group differences in dependent samples, including paired sample t-tests and repeated measures ANOVA.

Throughout the remaining chapters, we will also show you how to calculate the various test statistics by hand (of course, have a calculator ready too). In addition, we will provide additional analysis examples using two computer programs – IBM SPSS (SPSS stands for Statistical Package for the Social Sciences), and SAS (which stands for Statistical Analysis System). Both programs are widely used in the social/behavioral sciences and in applied settings.

Welcome to the world of statistics!

Summary of Important Chapter Points

1. Statistics help us understand the world around us.

2. The science of statistics incorporates the acts of data collection, data organization, data reduction or summary, and data interpretation.

3. Data can be derived from anything, and takes two forms – quantitative and qualitative. *Quantitative* data is another term for numeric data. *Qualitative* data are based on qualities, consisting of observations of behavior or verbal descriptions of thoughts and behaviors.

4. The *research process* is the procedure used to conduct research and collect data for scientific inquiry, and may be either deductive or inductive.

5. *Deductive research* involves studying phenomena without any preconceived causes or explanations of the phenomena.

6. *Inductive research* involves studying phenomena using extensive planning before data are collected. After a phenomena is chosen for study, a *theory* is adopted which helps to organize and explain how phenomena work. An *operational definition* is derived to allow the phenomena to be scientifically assessed (e.g., earlier we operationally defined the phenomena

"eating behavior" as the number of hotdog/bun combinations consumed). *Hypotheses* are written which are formal predictive statements that reflect the interplay between the phenomena and related variables.

7. Data collected using deductive research generally are *qualitative*, while data collected using inductive research generally are *quantitative*.

8. The research approach chosen to investigate phenomena -- inductive or deductive – is based on your research goals and to the expected outcomes of your study.

9. Statistics are applied to quantitative data (i.e., numeric data) for summary and interpretive purposes.

Key Terms

Statistics	Science of Statistics	Data
Quantitative Data	Qualitative Data	Research Process
Inductive Research	Deductive Research	Theory
Operational Definition		
Hypotheses		

Web Resources

- For a daily shot of science in the news, try http://www.sciencedaily.com/

- George Mason University's http://stats.org/ is a helpful website addressing statistics in the media, including on-going commentaries on how the media misinterprets statistics

- http://www.factcheck.org/ helps to verify statistical claims and interpretations made by politicians and those in the media

- A dating website with statistics? Indeed, the dating website OKCUPID.com has an interesting blog on face profiles that are rated attractive, and uses graphs to display some basic statistical information. It's really interesting! You will be very surprised by the findings. http://tinyurl.com/2cklscj

- A 10 minute video from YouTube of the 2010 Nathan's Famous Hotdog Eating Contest (because you are curious aren't you!) – watch the counts soar -- http://tinyurl.com/2bl4on7

References

Mroczak, D.K., & Spiro, A. (2007). Personality change influences mortality in older men. *Psychological Science, 18,* 371-376.

Rosenblatt, P.C. (2006). *Two in a bed: The social system of couple bed sharing*. NY: State University of New York Press.

Vaughan, D. (1997). *The Challenger launch decision: Risky technology, culture, and deviance at NASA.* University of Chicago Press.

Sternberg, R. J. (1986). A triangular theory of love. *Psychological Review,* 93, 119–135.

Exercises (to be developed)