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Preface

Teaching a research course for graduate students in communication sciences and disorders has been my privilege for several years. Only a small number of these students planned to pursue a career in research and/or higher education, and the majority anticipated working in a clinical setting as an audiologist or speech-language pathologist. At the beginning of the course I have given students an opportunity to express concerns about the topics they expected to cover. Over the years the students reported very similar concerns. Many worried that they would have difficulty understanding the content of research articles, particularly the statistical information. Others described prior frustration with their attempts to read research reports because they spent considerable time rereading material that was difficult to understand. Many students were uneasy about finding a "good" topic for their own graduate research project. A few even admitted that motivation was a concern because they expected the topics to be less than exciting.

The students and I tackled these concerns in several ways. Recognizing that the way of thinking that underlies scientific inquiry was highly similar to the way audiologists and speech-language pathologists think about assessment and treatment of persons with communication disorders was an important first step. The students found their motivation by understanding that high quality research stems from genuine curiosity and interest about a topic, and by recognizing the importance of strong evidence in providing clinical services. They discovered that research was essential for high quality clinical practice, that research in the field of communication sciences and disorders took many forms, and that audiologists and speech-language pathologists needed skills to investigate the existing research base to find good evidence to support their clinical decisions.

The concerns my students expressed about research and the strategies we developed to address those concerns were the basis for this text. The knowledge and skills one needs to engage in empirical research and to use research in clinical practice are comparable, and that is how these topics are presented in this text. Rather than treating empirical research and searching for clinical evidence as separate topics, this text presents both as different applications of a process of scientific inquiry. The order of the chapters reflects the steps a researcher or clinician might complete when conducting a scientific investigation. Chapter 1 introduces the topic of scientific inquiry and its different applications in the field of communication sciences and disorders. Because ethical practice is a primary concern for both clinicians and researchers, Chapter 2 covers ethical issues that affect the design, conduct, and utilization of research. Chapter 3 describes how researchers and clinicians might formulate questions as the starting point for their investigations. Some of these questions might be answered in

the existing literature and others might be refined based on the existing literature. Thus, Chapter 4 addresses the information you might need to conduct a good quality literature search. Chapter 5 and Chapter 6 cover the different types of research that are common in the field of communication sciences and disorders and the relationship between these types of research and the evidence audiologists and speech-language pathologists need to support their clinical endeavors. Chapter 7 discusses how researchers select persons to participate in research and issues associated with that process. Chapter 8 and Chapter 9 describe the analysis of research data using various statistical procedures. The final chapter, Chapter 10, describes how researchers and clinicians use the information gathered through their investigations. For researchers this often involves preparation of a research report to disseminate to other professionals, and for clinicians it usually leads to a decision about the most appropriate assessment and treatment approaches for their clients.

Each chapter includes examples from the field of communication sciences and disorders to illustrate important concepts. Review questions are included at the end of each chapter along with some suggestions for additional learning activities. Where appropriate, the learning activities include a list of research articles from journals in communication sciences and disorders that illustrate topics covered in the chapter. The learning activities could serve as homework assignments or in some cases as the focus of in-class discussions. In my own courses, we use the review questions in small group activities. I particularly enjoy observing students explain difficult questions to each other and doing so in a way that illustrates their own mastery of the concepts.

CHAPTER 1

Empirical and Nonempirical Research: An Overview

For many students, learning that they need to complete a research course is a cause of considerable anxiety. Perhaps you are someone who views research as a requirement to endure rather than as a topic to embrace; or perhaps you acknowledge the importance of research in communication sciences and disorders but consider it something that others with unique talents undertake. One aim of this introductory chapter is to establish the fact that research encompasses many different kinds of activities, some of which you already engage in. Further, the knowledge and skills we need to be effective researchers are not necessarily unique talents but often parallel the processes and procedures employed by audiologists and speech-language pathologists.

Systematic Inquiry

One way to view research is as a process of *systematic inquiry*. Making an inquiry involves asking a question and then engaging in a process to determine the answer to that question. Asking and answering questions is at the heart of research endeavors. Research is systematic because the approach you use to find answers has predetermined procedures, and these procedures are carried out in a regular, orderly manner.

One approach to systematic inquiry is the *scientific method*. This method involves a series of steps that lead from identifying a problem and formulating a question to discovering possible answers to that question. Peterson and Marquardt (1994, p. 26) identified the following six steps in this process:

1. Definition of the problem
2. Development of hypotheses to be tested
3. Development of a procedure for testing the hypotheses
4. Collection of data
5. Analysis of data
6. Support or rejection of hypotheses

You would expect to find the steps of the scientific method in a research text. However, Peterson and Marquardt included these steps in their appraisal and diagnosis text (*Appraisal and Diagnosis of Speech and Language Disorders*). These authors observed that diagnosis involves a way of thinking that parallels the method scientists employ in their experimental research. When faced with a clinical problem, such as a person referred for an evaluation, audiologists

and speech-language pathologists gather and analyze data to test a hypothesis. In the case of a speech, language, or hearing evaluation, the hypotheses relate to whether or not someone has a disorder, and the nature of that disorder. Although the types of questions or hypotheses differ, both clinical practice and research involve ways of thinking and problem-solving that are systematic in nature. When the process of inquiry is systematic, both clinicians and scientists have greater confidence that the information they provide is accurate and trustworthy, whether providing that information to individual clients and their families or to the scientific community.

Some Roles for Research

Scientific research has many roles in the fields of audiology and speech-language pathology. Perhaps the most basic role is to satisfy scientific curiosity. Researchers in communication sciences and disorders regularly participate in a process of identifying unanswered questions and designing information gathering procedures to answer those questions. Researchers focus on questions they regard as important for understanding the nature of human communication, the underlying physiology of speaking and hearing, the causes of speech, language, and hearing disorders, and so forth. Researchers who are motivated primarily by scientific curiosity might still include persons with speech, language, or hearing disorders in their studies and conduct research that has implications for assessing and treating communication disorders. For example, one way researchers learned about the neurological bases of speech and language was by including persons with aphasia in their studies. These types of studies provided information about the effects of brain lesions on speech and language use but did not necessarily lead directly to specific assessment or treatment recommendations.

Research is also valuable in guiding clinical practice in audiology and speech-language pathology. Sometimes audiologists and speech-language pathologists are motivated to conduct research because of unanswered questions they encounter in their clinical practice. Silverman (1998) used the term *clinician-investigator* to refer to audiologists and speech-language pathologists whose primary responsibility is providing clinical services but who also engage in research in their profession. In many ways such individuals are ideally positioned to conduct research that guides the way audiologists speech-language pathologists diagnose and treat communication disorders. Clinician-investigators have firsthand knowledge regarding information that is lacking and also work with clients in their professional practice who would be most representative of children and adults with speech, language, and hearing disorders.

The notion of using research to guide clinical practice is important even for audiologists and speech-language pathologists who do not conduct their own original research. In recent years a strong movement toward use of scientific evidence to make decisions emerged in both the fields of medicine and education. Because audiologists and speech-language pathologists are employed in medical and educational settings, this movement has encompassed those fields as well. The term *evidence-based practice* refers to an approach in which clinicians use the best available scientific evidence to guide their decisions about how to evaluate and treat persons with communication disorders. According to Sacket, Rosenberg, Gray, Haynes, and Richardson (1996, p. 71 as cited in ASHA, 2004, p. 1), when clinicians engage in evidence-based practice, they are making client decisions by

" . . . integrating individual clinical expertise with the best available external evidence from systematic research."[1]

When audiologists and speech-language pathologists participate in evidence-based practice, they might do so by consulting an existing evidence review. Such reviews usually are prepared by a panel of experts. They are published in professional journals or perhaps published in electronic format on a Web site. Some examples include a review of rehabilitation for acquired brain injury (Turner-Stokes, Disler, Nair, & Wade, 2005), treatment for aphasia (Robey, 1998), the cost-effectiveness of digital hearing aids (Taylor, Paisley, & Davis, 2001), and intervention for language delays (Law, Garrett, & Nye, 2004). Many examples of evidence reviews published from 1997 through 2006 are documented by the American Speech-Language-Hearing Association (ASHA, 2007). Sometimes audiologists and speech-language pathologists conduct individual evidence searches on behalf of a particular client. Such searches begin with a client-specific question and culminate with review, evaluation, and application of existing research. Clinicians might use existing research literature when answering questions such as which of two treatment approaches produced the most improvement in the shortest time, whether a particular diagnostic procedure yields results that are accurate and reliable, or what is the most effective treatment for a client with a specific diagnosis. Evidence-based practice reflects a movement away from sole reliance on expert opinion toward an approach that relies on careful consideration of research evidence in conjunction with clinical expertise and client/family considerations (Gallagher, 2002).

Another reason audiologists and speech-language pathologists engage in research is for program evaluation and support. This type of research is conducted at a local level sometimes in response to external requirements and sometimes due to local initiatives. For example, a medical center might evaluate the quality of its programs and services by comparing them to a set of nationally recognized standards. Professionals employed in educational settings are very much aware of the use of student achievement testing to evaluate school programs. Again, such evaluation involves comparisons to state and national standards purported to reflect the quality of school programs. At other times program evaluation questions emerge from local rather than state or national initiatives. For example, a medical center might conduct consumer satisfaction research with the goal of improving its programs and services and increasing the likelihood that consumers choose that medical center as their health care provider. A school district might conduct program evaluation research after making changes to curriculum or teaching practices to determine if these changes led to improvements in student learning and achievement. Although professionals, such as audiologists, speech-language pathologists, nurses, physicians, and teachers, often debate the best approaches for program evaluation, nearly all agree that research of this type plays an important role in their professions.

Scientific research also may influence public policy, particularly policy regarding the allocation of resources. When research evidence is particularly strong, legislators and policy makers may consider this evidence in making decisions about spending public funds. An example of this is the

[1]The American Speech-Language Hearing Association (2005) position statement on evidence based practice can be found in the document, *Evidence-Based Practice in Communication Disorders* [Position Statement], available from http://www.asha.org. In this document ASHA established the position that audiologists and speech-language pathologists should engage in evidence based practice to assure provision of the highest quality clinical services.

growth of publicly funded early childhood education for all 3- and 4-year-olds. One reason for the increase in public funding is research that consistently demonstrated that children who attended good quality preschool programs performed better in school and were more successful in their later lives. The research actually demonstrated that the funds spent early in childhood were offset by savings that occurred later through reduced educational spending on special services and reduced need for public assistance in adulthood.

Research that demonstrates how a service or program impacts society is sometimes referred to as cost-effectiveness or cost-benefit research. Cost-effectiveness research looks at the cost of a program or service relative to the outcomes produced (Barnett, 2000). For example, if different treatment programs or different technology varied in cost, an audiologist or speech-language pathologist would probably want to know that the more expensive approach produced better outcomes for their clients. Cost-benefit research looks at the cost of a program or service relative to its impact on costs that occur later in life. For preschool education, the analysis included documentation of the cost of the educational program and long-term follow-up of the children who participated. The long-term follow-up revealed actual cost benefits to society in several different ways. For example, children who received early childhood education were less likely to need special education services during the school years, were less likely to need other public services such as juvenile detention, were less likely to participate in public assistance programs as adults, and typically earned more income per year as adults (Barnett, 2000). Thus, individuals who advocated for public funding of early childhood education could point to a body of research that suggested such programs produced a net financial benefit to society that greatly offset the initial cost. Audiologists and speech-language pathologists would profit from a body of research demonstrating the benefits of our programs.

Types of Research

Taking some time to peruse published research in audiology and speech-language pathology, such as that found in our professional journals, would reveal many forms of research. Generally research studies share at least one similarity—a question that needs an answer or problem that needs a solution. However, how researchers formulate their questions or how they plan and conduct their studies can be quite different. In this section we will consider some of the terminology researchers use to characterize these differences.

Most of the time when professionals in the fields of audiology and speech-language pathology use the term *research*, they are referring to *empirical* research. Empirical research involves the collection of new information or data through observation and measurement of behavior and/or physical properties (Trochim & Donnelly, 2007). Review of recent issues of professional journals in communication sciences and disorders revealed several ways that human behavior was observed and measured, such as speech samples (Sawyer & Yairi, 2006), survey responses (MacNeil, Lui, Stone, & Farrell, 2007; Skahan, Watson, & Lof, 2007), listener ratings (Spielman, Ramig, Mahler, Halpern, & Gavin, 2007), and test scores (van Kleeck, Vander Woude, & Hammett, 2006), as well as several ways of measuring physical properties, such as speaker sound pressure levels (Spielman et al., 2007), tongue strength and endurance (Stierwalt & Youmans, 2007), and electromyographic

waveform displays (Yiu, Verdolini, & Chow, 2005). Examples of research that is nonempirical might include a carefully constructed theoretical analysis or a systematic review of a body of research.

Another way to characterize different forms of research is the distinction between *qualitative* and *quantitative* research. Qualitative research and quantitative research differ with regard to the way questions or problems are formulated and investigated. However, a commonly identified difference is in the type of information or data a researcher gathers. In qualitative research data often includes verbal information. This might take the form of highly detailed descriptions of a person's behavior or perhaps direct quotes of a person's statements. Quantitative research, as you might expect, relates to numerical information such as frequency counts and measures of size or other physical properties. Sometimes researchers gather both types of data and report both numerical and verbal information.

Within the category of quantitative research we often make a distinction between studies that are *experimental* and those that are *nonexperimental*. In experimental research, researchers identify one or more factors that they will manipulate or control during the experiment. For example, a researcher might be comparing different approaches for improving a person's communication abilities and could manipulate how much or what type of approach participants experience. The researcher manipulates or controls the conditions so that some participants have a different experience during the experiment than others. According to Patten (2007), a *true experiment* meets two criteria. The first is the researcher's creation of different conditions or experiences by manipulating one or more factors during the experiment, and the second is that the conditions participants experience are determined randomly. A true experiment has random assignment of the participants to different experimental groups. Experimental research that lacks random assignment to groups is sometimes referred to as *quasi-experimental* research. Generally speaking, a study that meets both standards, experimental manipulation and random assignment, provides stronger evidence than a quasi-experimental study.

One of the most common kinds of experiments is one in which a researcher compares the performance of two groups, each experiencing a different experimental manipulation or treatment. In audiology and speech-language pathology such comparison might involve traditional treatment as compared to some new treatment approach. As noted, when the participants are divided at random into groups, the study is considered a true experiment. However, sometimes researchers find it impractical or impossible to assign their participants randomly. Perhaps the researchers want to compare two different classroom-based interventions. Children in school settings are seldom assigned to their classrooms in a random manner. Therefore, if researchers decide to conduct the experiment with two existing classrooms, they are conducting quasi-experimental research rather than a true experiment.

In contrast with experimental research, nonexperimental research includes a wide variety of studies in which the researcher investigates existing conditions. Some forms of nonexperimental research are descriptive in nature. Studies that provide information about the typical communication behaviors of persons of various ages fall into this category. Such studies might include measures based on speech and language samples, measures of physical properties of speech such as fundamental frequency or intensity, as well as psychoacoustic responses to speech. Some examples of nonexperimental research include case studies, sur-

veys, studies of relationships or correlations between measures, as well as comparison studies (Patten, 2007). In comparison studies researchers include groups of persons with preexisting differences, rather than create differences via an experimental manipulation. Some examples include comparisons of 3-year-olds and 5-year-olds, persons with a particular type of hearing loss and persons with normal hearing, adults with functional voice disorders and those with normal voices, or children with specific language impairment and those with typical language.

Another important distinction for research in communication sciences and disorders is the difference between *group* and *single subject* research. This difference is not associated with the number of research participants in a literal way. That is, one might encounter a small group study with just five participants in each group, or one might encounter single subject research with several participants. Nor is single subject research the equivalent of a case study. Case studies involve nonexperimental, descriptive research, whereas single subject research is experimental in nature. The most important differences between group and single subject research concern how participants are treated during the study and how their data are reported. In single subject research, a participant experiences both the experimental and control conditions, and results for each participant are reported separately. When experimental and control conditions are compared in group research, usually the participants in one group experience the experimental condition and the participants in another group experience the control condition. The results from group research are aggregated and reported for each of the comparison groups and not for individual participants.

Variables

Two additional terms will be useful for understanding how researchers talk about their studies. Usually researchers have identified some characteristic or manipulation they want to investigate. The characteristic or manipulation the researcher wants to study is called the *independent variable*. In experimental research the independent variable might be an experience such as receiving a treatment or a way of presenting information that the researcher manipulates. In nonexperimental research the independent variable might be an existing characteristic such as the presence or absence of a communication disorder or the age of the participants. Often the independent variable has two or more categories or levels that the researcher wants to compare in some way (Patten, 2007). Keep in mind that experimental and nonexperimental studies may have more than one independent variable, and sometimes researchers study the effects of both an experimental manipulation and an existing characteristic in the same investigation. An example of this would be a researcher who studies the effects of a treatment manipulation, such as giving feedback in two different ways, for children in two different age groups. The researcher could determine in a random way which participants receive a particular type of feedback during their treatment, but the age of the children is an existing characteristic that cannot be manipulated.

When researchers want to compare the performance of their participants, they need to identify ways of measuring that performance. The measures that researchers use to determine the outcomes of their experimental or nonexperimental research are called *dependent variables*. In a sense, you might think of independent variables as

the inputs and dependent variables as the outputs of the research. If the experimental manipulation or existing characteristics made a difference, researchers will see these differences in the values of their dependent variables or outcome measures.

Getting Started with Research

One of the best ways to become familiar with the various types of research is to read the research reports published in our professional journals. Sometimes students express frustration with the notion of reading professional research. They find the articles highly detailed and confusing. When reading a research report, keep in mind that the key information in nearly any such report is a question or problem the researcher investigated and the answer(s) provided by the researcher's observations or data. Thus, the most important goal in reading a research report is to find out the research question(s) and to learn what the author(s) wrote in answering those questions.

Silverman (1998) suggested a five-part strategy for reading and taking notes on a research article. He suggested you needed to obtain complete reference information, the research question(s), a brief description of the procedures, a brief description of the outcome measures or observations, and the answer to the research question. Some examples of this question and answer format are included on pages 7–9 in Silverman's book.

One approach you might consider is to read the article in a nonlinear way. Most research reports follow a very similar structure. The articles include an introduction and review of literature, methods, results, discussion, and summary sections. Most journals require an abstract, and this is a logical place to begin reading the article. The abstract provides a brief overview of the article's contents, but because the information is a summary, you will not be able to judge the quality of the research or fully understand the theoretical basis, results, and implications without reading the full article. Some journals now use a format called a structured abstract. If you read an article in a recent volume of the *Journal of Speech-Language-Hearing Research*, for example, you will see abstracts with headings such as *purpose*, *method*, *results*, and *conclusion*. The inclusion of headings of this type allows the reader to quickly identify the question(s) addressed in the study, typically in the purpose section, and the tentative answers, typically in the results and conclusion sections.

Once you have a broad understanding of the content of an article from reading the abstract, you have some idea that the article is one that is relevant to the topic you are researching. When you read the full article, I suggest you begin by identifying the research question or problem the author(s) were studying. In almost every research article you read, the research question(s) will appear in the paragraph or two immediately preceding the methods section. Sometimes you will see a series of actual questions listed in these paragraphs, although at other times you might read a statement of purpose. We will learn more about the various forms a research question or problem might take in Chapter 3. Once I know the question(s), I typically want to know the tentative answers next. Usually, in a well-written article, the authors will provide their interpretation of results and the possible answers to their research questions in the discussion section of the article. You might even find that the various questions or purposes of the research are clearly identified with subheadings in the discussion section. Once

you have a general understanding of the research questions and possible answers, you are better prepared to read the full article. You will begin with the introduction and review of literature, and because you know the questions addressed in the study, you will have a good understanding why the author included certain topics in this review. As you read the methods section, you should be considering whether the way the researchers designed the study and the way they collected their data gives you confidence in the results of the study. A course in research methods should provide you with the knowledge you need to critically evaluate the articles you read. Finally, as you read the results section you will be able to judge how the numerical (quantitative) or verbal (qualitative) information reported there related to the interpretation and conclusions the authors presented in their discussion section.

Summary

As noted previously, research is an essential component of the professional practice of audiologists and speech-language pathologists. In your clinical practice you will utilize research on a regular basis because our professional research is the basis of our clinical practice from decisions about diagnosis and etiology to the approaches we use in treatment. Further, speech-language pathologists and audiologists might need to directly consult existing research on behalf of specific clients. This might occur when these professionals are required, perhaps by a funding agency, to document the effectiveness of a proposed treatment, or perhaps when the audiologist or speech-language pathologist needs additional information to decide on the best course of treatment.

Professionals who investigate the existing research literature on behalf of their clients or for their own professional development are acting in the role of a consumer of research. However, audiologists and speech-language pathologists working in clinical settings have many good reasons to participate in designing and conducting original research as well. Some of the skills associated with the diagnosis and treatment of communication disorders could transfer to the research setting. Professionals already engage in a scientific approach to problem-solving and regularly participate in observation and measurement of communication behaviors to document the effectiveness of their services (ASHA, 2003). Using these skills to generate new information for the professions could be a natural extension for some audiologists and speech-language pathologists. The motivation for such work might come from unanswered questions encountered in the clinical setting, as well as the need for research generated in an ecologically valid setting—the work settings of audiologists and speech-language pathologists. For some types of research, particularly assessment or treatment research, audiologists or speech-language pathologists working regularly in the field might obtain higher quality data because of their clinical skills and experience.

Review Questions

1. What is the first step in the scientific method?

2. What phrase refers to the use of scientific evidence to guide clinical decisions?
   a. systematic inquiry
   b. hypothesis testing

c. evidence-based practice
d. single subject research

3. Define cost effectiveness research.

4. Which of the following statements is true?
   a. Empirical research involves the collection of new information through observation and measurement.
   b. Empirical research involves a systematic review of existing information identified through a literature search.

5. In _____ research, data often includes verbal information such as a detailed description of behavior or a direct quote.

6. What are the two characteristics of a *true* experiment?

7. Match the following terms.
   _____ independent variable
   _____ dependent variable
   _____ true experiment
   a. outcome measure
   b. random assignment
   c. experimental manipulation

8. What kind of research includes case studies, surveys, studies of correlations between measures, or studies of preexisting differences?

9. Which of the following statements is true?
   a. Single subject research is descriptive research in which a researcher provides a detailed report on the characteristics of an individual participant.
   b. Single subject research is experimental research in which a participant experiences both the experimental and control conditions.

10. When reading a research report, where are you most likely to find the research questions or statement of purpose?

11. List the typical parts of a research report. When you start reading a research report, which part would you read first?

12. Which of the following statements is true?
   a. Some of the skills associated with the diagnosis and treatment of communication disorders are similar to the skills required to conduct scientific research.
   b. The skills required to conduct scientific research are entirely different from the skills associated with the diagnosis and treatment of communication disorders.

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CHAPTER 7

Research Participants and Sampling

When planning a study, researchers usually have a group of persons in mind who are the focal point of the study. These groups can be quite large, such as all persons in the United States who are age 65 and older, or all children between the ages of 2 and 4; or the groups can be somewhat smaller, such as all persons between the ages of 45 and 65 with sensorineural hearing loss, 5-year-old children with specific language impairment, or adults between the ages of 18 and 25 with a traumatic brain injury. Even when a group is relatively small, studying everyone who is a member of the group is usually impractical. As an alternative, researchers try to identify a representative sample of individuals from the group to participate in their research. The strategies researchers use to select participants and criteria for obtaining a representative sample are topics covered in this chapter.

Populations and Samples

Ordinarily, researchers expect the findings from their studies to apply to a fairly large group of individuals and certainly to a larger group than actually participated in the study. Researchers use the term *population* to refer to all of the persons of interest for a particular study (Patten, 2007; Pyrczak, 2006). This population is defined in the planning phase of the study and all the members have one or more predetermined characteristics. For example, researchers might define the population of a study as all 4- and 5-year-old children who are bilingual Spanish-English speakers, all adults ages 45 to 65 who are native English speakers with no known medical conditions, or adults with a sensorineural hearing loss with an onset after age 50. Although the population of interest often is relatively large, this is not always the case. For example, audiologists and speech-language pathologists might conduct a study of the persons served in a particular speech-language-hearing center to determine how satisfied they were with the services provided. One of the criteria for establishing the population for a study is that all members have at least one characteristic in common.

The persons who actually participate in a study usually are a *sample* from a larger population. Sometimes authors refer to research participants as the subjects of a study. However, recent guidelines from the

American Psychological Association (APA, 2001; 2005) suggest authors should refer to their participants in a way that either describes who they are (e.g., the first grade children, the high school students, the parents, the teachers), or their role in the study (e.g., the participants, the listeners). One goal in identifying persons to participate in a study is to recruit a sample that represents the population well. This means all members of the population should have an equal chance of being recruited to participate (Patten, 2007). Researchers particularly try to avoid systematically excluding some members of the intended population when they identify participants. Let's consider the example of a research team that wants to recruit preschool children for a study. The team obtains the names and telephone numbers of potential volunteers by leaving a description of their study and a sign-up sheet at locations in their community frequented by parents and their children. They follow up by calling each of the families; however, because the researchers call between 9:00 A.M. and 5:00 P.M., they inadvertently exclude many families with working parents. This is an example in which some members of a population do not have an equal opportunity to take part in a study.

Trochim and Donnelly (2007) make a distinction between the intended population for a study and the "accessible" population (p. 37). The intended population includes all persons to whom the researchers want to apply their results, and the accessible population represents the group from which the researchers actually recruit their participants. One reason for the difference between the intended and actual populations could be geographic proximity. The researchers might want to apply their findings to all persons in the United States with a particular speech, language, or hearing disorder, but the accessible population might only include those persons who live near the research facility. The accessible population might be a good representation of the intended population but in some instances could be systematically different. For example, researchers in a university setting could have more families with highly educated parents than would be the case in the general population. Sometimes researchers address issues such as geographic proximity by developing cooperative projects with researchers in other locations.

On occasion, researchers conduct a study in which they gather information from an entire population. When researchers attempt to gather data from all members of a population, the study is called a *census* (Patten, 2007; Trochim & Donnelly, 2007). Perhaps the most familiar census is the U. S. Census that is conducted every decade by the United States Census Bureau (2000). Another example of a census would be research conducted on all members of a small population. Examples of these types of census studies would be research on persons served at a particular rehabilitation facility or on all first grade children in a particular school district.

When researchers study a sample from a large population, they still want to draw conclusions about the population as a whole. However, instead of knowing the characteristics of the population, as they would if they conducted a census, researchers make *inferences* about the population based on the data they gather from their sample. An inference is a conclusion we draw in an indirect way. When researchers develop conclusions about a population based on data from a sample, their conclusions about the population are indirect and not based on actual observations of the entire population. Furthermore, the accuracy of these conclusions depends on how well the sample represents the population.

Usually researchers want to study a population of persons, and the sample is a

group of persons selected from that population. However, sometimes the population is defined in a different way, such as all first grade classrooms in the United States or all utterances produced by a particular child (Woods, Fletcher, & Hughes, 1986), and the units sampled will be different as well (e.g., a sample of first grade classrooms or a sample of utterances).

Often in group studies researchers report their findings as numerical summaries (Pyrczak, 2006). If these numbers come from observations on the entire population, they are called *parameters*. If these numbers come from observations on a sample, they are called *statistics*. In Chapter 8 and Chapter 9, we discuss how researchers use statistics to describe their findings and to make accurate inferences about the populations of interest in their investigations.

Sample Characteristics

As noted earlier, the most common approach to group research is to study a sample and to infer characteristics of the population as a whole from the results of the sample. The value of this kind of research depends on how well the sample represents the population of interest. Thus, researchers want to know about sample characteristics, such as what population a sample represents and whether the sample is biased or unbiased.

A sample is representative if the characteristics of the sample are a good match for the characteristics of the population. One aspect of this is to understand the actual population from which you draw your sample. Sometimes it is difficult if not impossible to access the intended population. Perhaps researchers want to recruit 4-year-old children to participate in a study. However, they do not have a readily available list of 4-year-olds and their parents. Instead, they have access to 4-year-olds who attend preschool programs in the community. If the researchers draw their sample from the preschool programs, this sample might not be an ideal match for the general population of preschoolers.

In addition to concerns about differences between the intended and accessible populations, researchers also need to avoid bias in selecting a sample. An unbiased sample is one in which all members of a population have an equal opportunity of being selected, whereas a biased sample is one in which some members of a population have an unequal opportunity, or perhaps no opportunity, of being selected (Patten, 2007; Pyrczak, 2006). One source of bias in sampling is *failing to identify all members* of a population (Patten, 2007), either because of differences in the accessible and intended populations or because the researchers used a sampling method that introduced a bias. For example, researchers might issue a call for participants in an ad in a newspaper and in fliers distributed throughout the community. If they select as their participants the first 50 persons who respond, it would be a biased way of selecting a sample. Persons who respond quickly to such an ad could be systematically different from those who take more time to respond.

Another source of bias is using a *sample of convenience*. This refers to using a group of participants who are easy to access (Pyrczak, 2006). A common example is research with college students, and particularly research with students in introductory psychology courses. University professors often conduct research in their areas of professional interest, and if young adults are an appropriate population for the research, students in introductory courses are a readily available source of participants. Some professors might offer credit toward the course grade to students who volunteer for their research. However, from an ethical

standpoint professors should not require participation in research, nor should they offer such opportunities as the only way to earn extra credit.

Sometimes researchers recruit participants from existing community programs because contacting persons through these programs is less of an invasion of privacy. For example, researchers might make initial contact with a group of persons age 65 and older through a community activity center. The initial contact could be low key, perhaps through a flier distributed at the community center, and potential participants could provide their contact information voluntarily without undue pressure. However, a sample recruited in this way might not be representative of the general population of persons age 65 and older. One might speculate that persons who attend the community programs might be more outgoing socially or in better general health than those who do not attend. If researchers wanted to apply their findings to all persons in this age group, they would need to develop ways to contact and sample from all members of the population of interest.

Another reason a sample could be biased is through *volunteerism*. This is a source of bias that cannot be avoided, because the process of informed consent specifies that all persons who participate in research should do so on a voluntary basis. However, persons who volunteer to participate in research might differ from the general population in some systematic way. They might have a special interest in the topic of the research because of their own or a family member's experiences. They might have greater interest than usual in research because they have conducted studies of their own. These are just a few of the many ways research volunteers could differ from the overall population. To address this issue, researchers sometimes resort to incentives to increase the number who agree to participate, such as payments, extra credit points, and so forth.

Sampling Methods

Although certain types of problems in selecting a sample are difficult to avoid, particularly volunteerism, researchers prefer random sampling methods when they want to avoid systematic biases in choosing research participants. In this section, we cover some of the most common sampling methods.

Simple Random Sampling

The procedure researchers usually use to obtain an unbiased sample is *simple random sampling.* An important feature of this sampling approach is that every member of a population has an equal chance of being selected for the study (Patten, 2007; Pyrczak, 2006; Trochim & Donnelly, 2007). Theoretically, you could generate a random sample by writing participant identifiers on separate pieces of paper, placing them all in a hat, and drawing them out one at a time until you have the target number of participants. However, researchers often use random numbers to choose participants. One approach is to assign all participants an identifying number. The researchers might start with a list of potential participants, for example, a list of 100 volunteers. Each person on the list is assigned a three-digit number from 101 to 200, and then the researchers could consult a table of random numbers and select participants in the order their numbers appear in the table. Example 1 is a series of random numbers representing the first 10 participants.

Example 1

154, 196, 191, 108, 157, 143, 188, 152, 183, 140

Another way to use random numbers to select a sample is to use the random number function in a spreadsheet program. First, you would list all possible participants in one column of a spreadsheet. Next, you would use the random number function to generate a random number for each participant in a second column, and then you would sort the participants using the random number column as the basis of your sort. Look at Table 7–1 for an example of this approach. The first column shows the potential participants listed by their participant identifier. The second column shows the random numbers generated for each participant. The last two columns show the participants and numbers after they were sorted. If the researchers in this example wanted a sample of 15 participants, they simply would take the first 15 persons in the sorted list (e.g., QQ through NN). This example only includes 26 possible participants, but the list often would be much longer.

Systematic Sampling

Another approach that generally yields a sample that is free from intentional bias is *systematic sampling*. In systematic sampling you start with a list of potential participants, establish a sampling interval, and then select every so many participants according to the number representing your sampling interval (Patten, 2007; Pyrczak, 2006; Trochim & Donnelly, 2007). To illustrate, let's consider the case of a group of researchers who have a list of 2500 potential participants. They want to select a sample of 125 actual participants from this list. To determine the sampling interval, they divide 2500 by 125, resulting in a sampling interval of 20. This means that the researchers will choose every 20th person from their list. Often, researchers using systematic sampling establish their starting point with a random number. For example, these researchers might have determined at random that participant 110 would be the first selected. They would start at 110 and continue through their list choosing every 20th person until they have a sample of 125 persons (110, 130, 150, 170, 190).

Stratified Random Sampling

When researchers want to increase the likelihood that their sample accurately represents the population of interest, they might use a strategy called stratified random sampling. In this approach researchers identify one or more criteria or *strata* that characterize the population of interest. Examples include the percentage of men and women in the population, the distribution of persons by age group, family income levels, parent education levels, and whether the person lives in an urban, suburban, or rural area. Often, the goal is to include a similar percentage of persons in the sample as was present in the population. For example, if the population percentages were 60% women and 40% men, and researchers want to match these percentages in a 125 person sample, they would include 75 women and 50 men. Speech-language pathology is an example of a field where including an equal number of men and women in a sample would not be representative of the population. Occasionally, the goal in stratified random sampling is to select an equal number of participants across the levels of a stratum. This is often true with sampling across age levels.

Table 7–1. Illustration of the use of a spreadsheet to generate a randomized list of research participants

Participant Identifier	*Random Numbers*	*Sorted Participants*	*Sorted Numbers*
AA	87	QQ	10
BB	21	GG	11
CC	71	EE	14
DD	83	HH	18
EE	14	BB	21
FF	43	PP	23
GG	11	XX	26
HH	18	RR	29
II	40	JJ	32
JJ	32	UU	36
KK	52	YY	37
LL	99	II	40
MM	42	MM	42
NN	47	FF	43
OO	79	NN	47
PP	23	KK	52
QQ	10	ZZ	53
RR	29	VV	59
SS	60	SS	60
TT	61	TT	61
UU	36	CC	71
VV	59	OO	79
WW	97	DD	83
XX	26	AA	87
YY	37	WW	97
ZZ	53	LL	99

Variations on stratified random sampling are often employed in generating samples for test norms (e.g., Dunn & Dunn, 2007; Goldman & Fristoe, 2000; Newcomer & Hammill, 1997; Reynolds & BigIer, 1994; Zimmerman, Steiner, & Pond, 2002) and less frequently in research reports (e.g., Smit, Hand, Freilinger, Bernthal, & Bird, 1990; Trulove & Fitch, 1998; Wilson, Beckett, Bennett, Albert, & Evans, 1999). Usually the goal of

stratified sampling is not to make comparisons across the subgroups but to generate a sample that represents the diversity present in the population of interest.

Cluster Sampling

One additional sampling approach that yields a random sample is *cluster sampling*. In this sampling approach researchers begin by obtaining a random sample of predefined groups such as medical centers, classrooms, or communities. An example would be a random sample of all the kindergarten classrooms in a particular state. Sometimes cluster sampling is combined with simple random sampling in a procedure called *multistage sampling* (Patten, 2007). In this procedure, researchers begin with a random sample from the previously identified clusters. They could start with a list such as a list of all communities in the United States with a population greater than 100,000, or a list of all universities that offer audiology and/or speech-language pathology graduate programs. Then they would select a certain number of clusters at random from this list. Perhaps they could use random numbers to select 50 communities or 50 high schools. After selecting communities or high schools to investigate, the researchers could follow up by selecting actual participants from each high school or community using simple random sampling.

Patten (2007) noted that predefined groups or clusters tend to be more similar to one another than the population as a whole. Therefore, researchers usually use cluster sampling in studies with relatively large numbers of participants. Such studies often include many clusters so that no single cluster will overly influence the research results. Tomblin et al. (1997) conducted a study in which they used a variation on cluster sampling, stratified cluster sampling. The clusters in this example were kindergarten children in previously identified elementary schools. The strata were schools classified as being in urban, suburban, and rural areas. These researchers sampled elementary schools or clusters from a group of urban, suburban, and rural schools, and then completed their research by testing the kindergarten children from each school who were eligible for the study.

The various options for random sampling are regarded as the best way to obtain a sample that is free from systematic bias. However, that does not mean that all random samples represent their populations well. On occasion researchers obtain a sample that either overrepresents or underrepresents some aspect of the population. For example, the population might include fairly equal percentages of men and women, but after random sampling researchers could end up with a sample that has 60% women and 40% men; or perhaps the researchers end up with a sample that include a disproportionate percentage of children with college-educated parents compared to those whose parents have a high school education. When these kinds of variances occur by chance, and not through some bias in the sampling method, the errors that occur are less damaging than systematic errors such as failing to identify all members of a population or using a sample of convenience (Patten, 2007).

Purposive Sampling

In some research the goal is not to generalize findings to a larger population but rather to obtain an expert opinion or the perspectives of persons who have had a unique experience. Researchers use *purposive sampling* when they need to recruit participants

they think will be the best source of information for a particular issue (Patten, 2007). Professional expertise could encompass many areas of audiology, speech-language pathology, as well as speech, language, and hearing science. Perhaps researchers are interested in studying recommendations for feeding infants with a palatal cleft, services provided by speech-language pathologists in neonatal intensive care units, or industrial audiology services provided to a specific industry. The number of professionals who could provide meaningful information on topics such as these might be relatively small, and researchers would need to make a special effort to identify and recruit them as participants.

Qualitative researchers often are interested in studying persons or organizations that have had unique experiences and may employ purposive sampling to find appropriate participants. For example, they might be interested in how persons in a clinical or medical center react to an experience such as implementation of new regulations, how persons who faced a sudden onset speech, language, or hearing impairment reacted and adjusted to the changes in their communication abilities, or how an adult who recently received a cochlear implant experienced the preparation for and follow-up to the surgery. When the answer to a research question requires input from special persons, researchers have to make a purposeful effort to identify those individuals.

Random Assignment

For some studies researchers have to divide the participants into two or more groups. This is the case in any true experiment with treatment and no treatment control groups or experimental and alternate treatment groups. The preferred method for generating groups is *random assignment* of participants to groups. Although both random assignment and random selection involve procedures such as a table of random numbers or the random number function of a spreadsheet, the two are different processes that serve different roles in research. The purpose of random selection is to identify a sample of individuals who will participate in the study from a larger population. The purpose of random assignment is to divide all the participants into different treatment groups. Sometimes in research, using random selection to choose participants is impractical (Woods, Fletcher, & Hughes, 1986). This could be the case in audiology and speech-language pathology if the research involves persons with very specific diagnostic characteristics. For example, speech-language pathologists might want to conduct intervention research with 4-year-old children who have a moderate-to-severe phonological disorder and age-appropriate expressive and receptive language, or audiologists might want to conduct research with persons with bilateral sensorineural hearing loss with an onset after age 40 with certain audiogram characteristics. The number of individuals who fit these descriptions might be relatively small, particularly if the researchers are limited to working with individuals who live relatively close to their research site. In situations like this you could begin with purposive sampling to identify as many individuals as possible that fit your criteria and were willing to participate in your study. After identifying your sample, you could use random assignment to divide the participants into different groups.

In the example in Table 7–2, the researchers identified 30 participants using purposive sampling. Each participant received a random number using the random number function in a spreadsheet program.

Table 7–2. Illustration of the use of a spreadsheet to generate two treatment groups using random assignment

Participant Identifier	*Random Numbers*	*Sorted Participants*	*Sorted Numbers*	*Treatment Group*
P01	271	P26	006	A
P02	231	P20	058	A
P03	489	P07	068	A
P04	420	P14	079	A
P05	091	P05	091	A
P06	289	P19	095	A
P07	068	P15	098	A
P08	329	P17	107	A
P09	311	P10	114	A
P10	114	P18	125	A
P11	421	P23	151	A
P12	373	P24	181	A
P13	188	P13	188	A
P14	079	P28	194	A
P15	098	P30	198	A
P16	434	P02	231	B
P17	107	P21	245	B
P18	125	P22	251	B
P19	095	P01	271	B
P20	058	P06	289	B
P21	245	P09	311	B
P22	251	P29	317	B
P23	151	P08	329	B
P24	181	P12	373	B
P25	454	P27	386	B
P26	006	P04	420	B
P27	386	P11	421	B
P28	194	P16	434	B
P29	317	P25	454	B
P30	198	P03	489	B

The researchers sorted the list using the random numbers and then assigned the first 15 participants in the random list to treatment group A and the next 15 to treatment group B. This procedure would yield two treatment groups created at random that should be free of any systematic bias in the assignment of participants.

Sample Size

One additional thing to consider about the sample is the number of participants to include. In some types of research, such as single subject designs or qualitative case studies, a single participant might be adequate. However, having a sample that is too small could affect the validity of the conclusions obtained from group studies. Even with random sampling methods researchers might end up with a sample that does not represent their population well, and this problem is more likely if the sample is very small. Pyrczak (2006) noted that increasing sample size should increase how well a sample represents a population, sometimes referred to as *sample precision*. On the other hand, increasing sample size does not decrease systematic bias. If researchers use a sample of convenience or fail to identify all members of a population, for example, increasing sample size does not reduce the bias associated with these sampling problems. Thus, researchers recruiting 4-year-old children from local preschool programs will fail to include children who do not attend preschool in their sample, and even doubling the size of the sample does not reduce this source of bias.

Several factors affect decisions about sample size. When conducting a study to estimate characteristics of a population, such as a typical level of performance on some skill or the percentage of persons exhibiting a certain trait, these factors include the size of the population of interest, how variable the levels of performance are, and how frequent the trait is in the overall population (Patten, 2007; Pyrczak, 2006). If a population is small (e.g., 50 members), the best strategy is to recruit all or nearly all members as participants. For moderately sized populations (such as 1000 members), the recommended sample is approximately 28% or about 280 participants, and for larger populations (100,000 members), the recommended sample size is approximately 0.4% or about 400 participants (Patten, 2007). These sample size recommendations are not absolute and need to be modified to accommodate other factors such as population variability and high or low prevalence of the trait under study. Generally, the more variable a population is for a behavior, the larger the sample should be, and the rarer a particular trait, the larger the sample should be (Patten, 2007; Pyrczak, 2006).

When conducting a study to investigate the difference between groups, such as between treatment and control groups, the factors that affect decisions about sample size include how large the group differences might be, variability of scores on the outcome measures, and how certain researchers want to be about detecting group differences (Bland, 2000; Pyrczak, 2006). If a sample is too small, a study has a low probability of detecting a difference that actually occurs in the population.

Let's compare two hypothetical intervention studies. In this example, a group of researchers investigated two different language intervention approaches. Previous experience with the approaches suggested that intervention A was slightly superior to intervention B at the end of 3 weeks of treatment. The researchers expect participants receiving intervention A to score on

average about 2 points higher than those receiving intervention B. Variability in performance would also be a factor, and in this example, the researchers expect 95% of the participants' scores to fall within ± 12 points. The researchers found they would need to recruit approximately 400 participants for each intervention group to be reasonably sure of detecting this small difference. The researchers realized that recruiting 800 participants who fit their criteria was impractical.[1] One solution the researchers considered was to extend the treatment time to 15 weeks. Their previous experience suggested that participants receiving intervention A would score on average about 5 points higher than those receiving intervention B after 15 weeks of treatment. Assuming the same amount of variability in participant scores, the researchers would only need to recruit approximately 25 to 30 participants for each intervention group to be reasonably sure of detecting this larger difference.

Let's also consider how differences in variability would affect sample size requirements. In the example above, the researchers needed 25 to 30 participants for each intervention group if the expected difference was approximately 5 points and variability was such that 95% of the participants' scores to fell within ± 12 points. How many participants would be needed if variability is greater and 95% of the participants' scores fall within ± 18 points? The answer is that sample size requirements would increase and the researchers might need to recruit as many as 65 participants for each group. Rosenthal and Rosnow (2008) noted that researchers need to attend to sample size requirements or run the risk of reaching conclusions that are inaccurate or invalid. When researchers have too few participants, they are less likely to detect differences that would actually exist if they could study the entire population. Using a sample that is too small might lead researchers to discard a new intervention that actually could have improved professional practice.

A challenge in planning research is finding the information you need to make decisions about appropriate sample sizes. Conducting a pilot study is one of the best ways to determine how much difference to expect between groups or how variable participants will be on outcome measures. In a pilot study researchers recruit a small number of participants and employ their research design with those participants. Through this procedure they have an opportunity to identify any problems with their experimental procedures, determine how much change participants might make, and determine the amount of variability that occurs on their outcome measures. Although having data from a pilot study is extremely valuable in planning research, conducting one is not always feasible. As an alternative, Trochim and Donnelly (2007) suggest careful review of published research that employed procedures and/or outcome measures similar to the ones you plan to use. The previous research should provide some guidance regarding how much variability to expect in performance on outcome measures and how much change to expect after a certain amount of treatment.

In an ideal world, researchers would always be able to conduct studies with an adequate number of participants. However, with many of the populations served by audiologists and speech-language pathologists, recruiting a large sample for a study is

[1]These sample size estimates are based on Table 12.4 in Rosenthal and Rosnow (2008). The initial assumptions were that the outcome measure had a standard deviation (SD) of 6 and that this SD was the same for both intervention groups.

very challenging. Rather than settle for only a small chance of detecting differences that actually exist in a population, researchers in communication sciences and disorders might consider other ways to improve their research. As we saw in our first example above, even a relatively small sample would be adequate if the effect of a treatment is large. One way to increase the effectiveness of a treatment is to assure that it is executed in a precise and accurate way, such as through extensive training of the person(s) who will provide the treatment (Trochim & Donnelly, 2007). The second example above illustrated how variability in performance affected sample size requirements. Thus, another way to improve the likelihood that you will be able to detect important differences is to reduce the variability associated with your outcome measures (Trochim & Donnelly, 2007). If you have a choice of outcome measures, using the one with a high degree of reliability or measurement consistency is important. If you are using a self-constructed measure, ways to increase reliability include increasing the number of items or trials and possibly improving the instruction for those who administer and score the measure. More reliable outcome measures could reduce the amount of variability researchers sometimes consider noise in their data relative to the systematic differences associated with the experimental manipulations.

Summary

One aspect of planning research is to define the population or group of persons who are potential participants. If this population is relatively large, a second aspect of planning is to consider how to obtain a representative, unbiased sample from this population. An unbiased sample is one in which all members of a population have an equal chance of being selected. A biased sample comes about when some members of a population are systematically excluded, such as when researchers fail to recruit some segment of a population or when they rely on a sample of convenience. Generating a sample in a random way using methods such as simple random sampling, systematic sampling, or stratified random sampling generally is the best way to obtain samples that are free of systematic bias.

In the field of communication sciences and disorders, researchers often engage in extensive, purposeful recruiting just to generate a sample of sufficient size. Samples generated in this way are not random samples, but researchers still could use random assignment to divide the participants into groups. Participants might receive their group assignment based on a series of random numbers, and thus each participant has an equal opportunity of being included in the various experimental and control groups.

Determining an adequate sample size is an issue that sometimes receives too little emphasis in research planning. A sample that is sufficiently large generally represents the characteristics of a population better than a sample that is too small. Further, in intervention research larger samples are more likely to reveal differences associated with treatment and control groups than samples that are relatively small. The appropriate sample size for research is not an absolute number but rather a variable number determined by factors such as how large the population is, how variable the population is for the characteristics under study, how frequent the trait is in the overall population, how large group differences might be, and how certain researchers want to be about detecting differences (Bland, 2000; Pyrczak, 2006). If researchers use

samples that are too small, their findings are less likely to provide a true picture of the population as a whole and less likely to reveal differences that actually occur in the population.

Review Questions

1. What term refers to all persons of interest to researchers when they conduct a study? What term refers to the group of persons who actually participate in a study?

2. If all members of a population have an equal chance of being selected to participate in a study, is the sample biased or unbiased?

3. What is one reason that the intended population for a study and the accessible population could be different?

4. How could each of the following sources of bias affect the findings from a study?
   a. Failing to identify all members of a population
   b. Sample of convenience
   c. Volunteerism

5. Explain the procedures a researcher would use for each of the following approaches to random sampling.
   a. Systematic sampling
   b. Simple random sampling
   c. Stratified random sampling
   d. Cluster sampling

6. Which of the sampling approaches in question 5 is often used in obtaining normative data for our clinical tests?

7. Explain the difference between random sampling and random assignment of subjects to groups.

8. Identify each of the following statements as true or false.
   a. You can reduce the potential errors from using a biased sample by selecting a very large sample.
   b. Generally speaking, a larger sample yields more precise results because the sample is more likely to be representative.

9. The following example illustrates the use of random numbers to select participants for a study. The potential participants, listed by identification letter in column one, each received a random number as shown in column two. If a researcher selected participants by random number from lowest to highest, who would be the first five participants selected?

Column 1	Column 2
AB	105
CD	170
EF	129
GH	141
IJ	187
KL	158
MN	177
OP	121
QR	106
ST	131

10. Assuming all other factors are equal, which of the follow would require a larger sample?
    a. A behavior with high variability or a behavior with low variability

b. A group difference of 10 points or a group difference of 20 points
c. A trait that occurs rarely or a trait that occurs frequently in a population

Learning Activities

1. Use random assignment to divide your classmates into small discussion groups. You might use a spreadsheet application for this task. Start by listing all students in one column, and then assign each student a random number in a second column using the random number function. Finally, sort the students using the random numbers as your sort key. Once you have a randomized list you can divide the class by grouping every three or every four students.

2. Read a published report on some form of group research. What was the intended population for the research and what was the accessible population? How did the researchers generate their sample?

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