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Empirical Measurement

*Variables and Constants
Measurement Types
Operationalization*

Scientific knowing stands or falls on the precision of its empirical observations. Whether these observations are made by a microscope, or a telescope, or stop watch, or pencil and paper test, the scientist strives for an accurate, numerical representation of the phenomena he is studying.

The first step is to define the phenomenon under study in terms of the way you intend to measure it. This process is called *operationalization*. In order to understand the process, you will need to understand the terms “variable” and “measurement.” If you do not determine a clear way to measure what you intend to study, you will eventually bog down in the confusion of instrument design and statistical procedures. Now, not “sometime later in your studies,” is the time to decide *specifically* how you will measure the variables you intend to study.



Variables and Constants

A “constant” is a specific number which remains the same under all conditions. For example, water freezes (at sea level) at 32 degrees fahrenheit or 0 degrees centigrade. The number of seconds in a minute is 60. An object dropped from an airplane will accelerate at 32 feet per second per second (32 ft/sec²). These are constants.

A “variable” is an entity which can take different values. If we were to weigh each member of this class, we would find the numbers (“weight”) varying from subject to subject. “Weight” is a variable. So is eye color, IQ, gender, education level, level of anxiety, marital satisfaction, and so on.

Research design and statistical analysis focus on the study of variables. As you think about subjects you would like to study, you will determine what “variables” you will study. Some of you are interested in counseling technique. Others are interested in learning style. Still others in administrative effectiveness. But what will you measure to determine which counseling technique is “best?” What will you measure to determine the effects of differing learning styles? What will you measure in order to gain a better picture of productive administration? Answers to these questions involve

an understanding of independent and dependent variables.

Independent Variables

An independent variable is one that you control or manipulate. You decide to study three different teaching methods. "Teaching Method" is an independent variable. Or you want to compare four approaches to counseling abused children. "Counseling Approach" is the independent variable.

Dependent Variables

A dependent variable is the variable you measure to demonstrate the effects of the independent variable. If you are studying "Teaching Method" you might measure "achievement" or "attitude toward the class." If you are studying "counseling approach" you might measure "anxiety level" or "overt aggression."

Measurement Types

Nominal
Ordinal
Interval
Ratio

Before a dependent variable can be analyzed statistically, it must be measured or classified in some manner. There are four major ways we measure variables. These measurement types are called nominal, ordinal, interval and ratio.

Nominal Measurement

"Nominal" data refers to variables which are categorized into discrete groups. Subjects are grouped or classified into categories on the basis of some particular characteristic. Examples of nominal variables include all of the following: gender, college major, religious denomination, hair color, residence in a certain geographic region, staff position.

Ordinal Measurement

"Ordinal" data refers to variables which are rank ordered. Notice that nominal variables have no "order" to them. "Males" and "Females" imply nothing more than two different groups of subjects. but ordinal data orders subjects from high to low on some variable. An example of this data type would be the rank ordering of ten priorities for Christian education in the local church.

Interval Measurement

An ordinal scale only reports 1st, 2nd, 3rd places in a set of data. It cannot tell us whether the distance between 1st and 2nd is greater than or less than the distance between 2nd and 3rd. In order to measure distances between data points, we need a scale of equal, fixed gradations. This is precisely what an interval scale is. Numbers are associated with these fixed gradations, or intervals. One of the most common examples of an interval scale is temperature. The difference between 50 and 60 degrees F. is the same as the difference between 100 and 110 degrees F. Another example is an attitude scale which has 20 items. Each item can have a value of 1, 2, 3, or 4. That means a subject can make a score between 20 and 80. The scores on this scale fall at regular one-point intervals from 20 to 80.

Ratio Measurement

Interval data does not, however, lend itself to ratios. We cannot say, for example, that 100 degrees is twice as hot as 50 degrees. The zero point on an interval scale is arbitrary; that is, it does not represent the total absence of the measured characteristic. A temperature reading of 0 degrees F. does not mean there is “no heat.” (The Kelvin scale was invented for this. A temperature of 0 degrees Kelvin, about -485 degrees F., is absolute zero temperature.)

Ratio measurement differs from interval measurement only in the fact that the ratio scale contains a meaningful zero point. Zero weight means that the object weighs nothing. Zero elapsed time means that no time has passed since the beginning of the experiment (it has yet to begin!). A true zero point means that observations can be compared as ratios or percentages. It is meaningful to say that a 60-year-old is twice the age of a 30-year-old. Or that a 90-pound weakling weighs half as much as a 180-pound bully. In most types of studies, interval and ratio data are treated the same for purposes of selecting the proper statistical procedure.

Data Type Summary

Perhaps one final example will help you see how these four data types differ from each other. Study the table below.

The students listed below have class attitude scores (interval: 20-80), test scores (ratio: 0-100), test rankings (ordinal: 1-11), grade classifications (nominal; A, B, C) and gender classifications (nominal: M,F).

	Attitude Scores (20-80)	Test Scores (0-100)	Test Rank (1-11)	Test Grade (A-F)	Gender (M-F)
Barb	80	100	1	A	F
Chris	48	96	2.5	A	M
Bonnie	74	96	2.5	A	F
Robert	35	93	4	A	M
Jim	79	92	5	A	M
Tina	60	89	7	B	F
Ron	55	89	7	B	M
Jeff	56	89	7	B	M
Brenda	74	88	9	B	F
Mark	56	82	10	B	M
Mike	65	75	11	C	M
Type:	interval	ratio	ordinal	nominal	nominal

test scores. Notice that **equal test scores** received the **same average rank** (e.g., 96 and 96 both ranked '2.5', the average of ranks 2 and 3. These are called 'tied ranks'. "89" is ranked 7, 7, and 7 -- the average of 6, 7, 8). The first nominal scale (“test grade”) identifies students by grade categories and the second (“gender”) identifies them “m” or “f.”

These four measurement types require *three different sets of statistical procedures*: one set for interval/ratio, another for ordinal, and still another for nominal. We'll look at some of the major procedures in a statistical flow chart in Chapter 5.

Operationalization

Our research design describes how we plan to measure selected variables. Statistical analysis describes how we plan to reduce these measurements to a meaningful (numerical) form. In both cases, the variables in the study must be defined in terms of measurement.

Definition
An Example
Another Example
Questions to Answer

Definitions

An operational definition indicates the operations¹ or activities that are performed to measure or manipulate a variable.² The purpose of an operational definition is to help scientists speak the same language when reporting research. Since one of the primary characteristics of science is precision, we must begin with precise definitions of the variables we plan to study. Operational definitions force us to think concretely and specifically about the terms we use. Some of my students struggle with this. In one of my Principles of Teaching classes, a student was attempting to describe the fruit of the Spirit (Gal. 5:22-23). He defined "love" as "God's kind of love." But what kind of love is that? "Joy" was defined as "joy that you feel deeply, the joy we'll experience in heaven." But what *is* joy? These are non-definitions. They are empty. They are useless in teaching because they convey nothing but semantic fluff. I call this kind of definition "word magic," for it deceives teachers into thinking they are explaining words and phrases when in fact the definitions are little more than puffs of smoke in the air. Defining terms in precise terms of measurement avoids this kind of imprecision in research.

Secondly, operational definitions provide a common base for communication of terms with others. When terms are operationally defined, readers know exactly how we are using our terms.

For example, what does *hunger* mean? In one research study the operational definition for hunger was

...the state of animals kept at 90% of their normal body weight.

This is certainly not the definition people use when they reach for their third chocolate-covered doughnut, saying, "I'm really hungry!!" The goal is to *precisely* understand the terms we use in research, and to convey that meaning clearly to others.

An Example

Years ago, General Motors used the slogan "We Build *Excitement* –PONTIAC!" Suppose we wanted to study that. What does General Motors mean by "excitement?" We need to operationalize the term. There are several ways to do it.

Have trained raters follow selected owners of Pontiacs, Fords and Chryslers and count the number of times they behave in an excited, agitated or exuberant manner. "Excitement" means the number of such behaviors per day. Is there a significant difference among the owners of these three makes of cars?

Or, tally the number of dates selected car owners have per week. "Excitement" means the number of dates per week. This definition assumes that dates are exciting.

Or, ask the owners: "How excited does your car make you?" Have them respond by marking a scale from 0 (no excitement) to 10 (excited all the time because of the car). Here "excitement" is a self-reported feeling, measured by a number on a scale.

Or, ask two acquaintances of each selected subject to rate them on a "car excitement" scale. With this definition, "excitement" is the average scale score of impres-

¹Meriam Lewin, *Understanding Psychological Research* (New York: John Wiley & Sons, 1979), 75.

²Walter R. Borg and Meredith D. Gall, *Educational Research: An Introduction*, 4th ed. (New York: Longman, 1983), 22

sions of the two acquaintances.

Each of these definitions provides a different measure of the general term “excitement.” In fact, we actually have four concepts of the term. But each definition is clear in its meaning.³

Another Example

Let’s illustrate the operationalization process with a practical example. Read this example carefully, noting each step in the process. John is considering several topics for his research proposal. He is drawn toward the problem of adolescent “bail-out” of church attendance when they leave home. Putting his first thoughts down on paper, he writes:

“Church attendance decreases when young people leave home”

Writing out your thoughts is important! Almost anything can “sound logical” as you play with ideas in your mind. Putting these thoughts down on paper is a first real step toward constructing a workable topic. I’ve heard students complain, “I know what I want to study, but I just can’t put it down on paper!” Well, they “feel” like they know what they want to study, but their ideas are only wisps of fantasy. To put your idea down on paper is to grasp it, refine it, put shape to it, and bring it into the real world where the rest of us live. Do you have an idea for your study? Write it down. Then work on it, as a sculptor on granite, and bring out the essence of your creation. Nothing of value comes easy.

As John reflects on his statement, he asks as many questions about it as he can. He steps away from his idea and objectively critiques it. You must separate your ego from your statement. Otherwise you will find yourself *defending* your work rather than *refining* it. Here are some of his questions:

Whose church attendance decreases?

This statement could refer to parents or friends. It is not specific on this point. The statement seeks to measure a change in behavior. This requires before-and-after measurements. Is this possible to do?

What is church attendance?

What does this term imply? Worship? Bible Study? Church softball league?

What is “home”?

What does it mean to “leave home”?

After writing down these questions and considering alternative ways to express what he wants to study, he rewrites his statement like this:

“Young people living away from home will have a lower rate of attendance at worship services than young people living at home.”

First, this statement is better because it clarifies “attendance” as the young people’s attendance at worship services.

Second, this statement is better because it indicates measuring attendance of

³See Earl Babbie, *The Practice of Social Research*, 3rd ed. (Belmont, CA: Wadsworth Publishing Company, 1983), 130-131

two groups and comparing them, rather than a before-and-after measurement of a selected group of subjects.

The term “young people” is still fuzzy, however. How young is “young”? What does “living away from home” mean? Or “living at home”? *Answers to these questions would be placed in the Definitions section of the proposal.*

In John's case, he defined these terms as follows: “Young people” is defined as persons aged 18-25. “Home” is defined as the residence of the subjects’ parents and where he or she lived as a child. “Living at home” is defined as the continued full-time residence of the subject at “home”. “Leaving home” is defined as the subject taking up residence away from “home” for at least three months.

In order to do this study, John needs to define two populations: “young people living at home” and “young people living away from home.” He will need to sample two study groups from these populations. He will need to gather four pieces of data from each subject: (1) age, (2) residence, (3) attendance at worship services, and (4) how long away from home.

You have just walked through a process of operationalization. It is a process essential for clear problem-solving. Begin now to operationalize the variables you are considering for your study.

Operationalization Questions

As you consider the measurement of variables for your study, there are two basic questions you must answer. The first is *“Are my variables measurable?”* If they are not, you cannot study them -- not statistically, that is. Some students have difficulty answering this question because they have too limited an understanding of what “measurement” entails. We will be looking at several approaches to measurement in the chapters ahead: direct observation, survey, testing, attitude measurement, and experimentation. Once you have settled on what kind of data you need for your study, begin looking in research texts and journal articles for ways to gather that data. Don’t overlook the guidelines in later chapters of this text!

The second question is *“How will I measure these variables?”* Define each of your variables in terms of how you will measure them [“operational definitions”]. I suggest you work on the statement for a while and then put it aside for several hours. When you come back to it, you’ll be able to look at it more objectively. It is difficult to avoid rationalization and self-defense of your work. But you will excel in writing your proposal only if you can critique yourself clearly and objectively. It is better if you find the weaknesses before others do! Once you have operationalized your draft statement, you will be ready to write the Statement of the Problem and the Research Hypothesis. We will get into these two sections of the proposal in the next chapter.

Summary

This chapter has introduced you to the concept of **variables**, four data types (**nominal, ordinal, interval, and ratio**), as well as the process of **operationalization**: defining selected variables in terms of measurement.

Vocabulary

arbitrary zero	an arbitrary 'zero value' -- does not mean absence of the variable (e.g. 0°F)
category	a class or group of subjects (e.g. male/female on variable GENDER)
constant	a numerical value which does not change (e.g. the freezing point of water: 32°F)
dependent variable	a variable which is MEASURED by the researcher
independent variable	a variable which is MANIPULATED by the researcher
interval	equi-distant markings on a scale (e.g. degrees on a thermometer)
interval data	a measurement which reflects a position on an interval scale (e.g. 54°F)
measurement type	a specific kind of measurement (<i>nominal, ordinal, interval, ratio</i>)
measurement	the process of assigning a number value to a variable
nominal data	a measurement which reflects <i>counts</i> in a group (e.g. 15 males in Research class)
operational definition	describing a variable by it's measurement (e.g. 'adult' means 18+ years old)
operationalization	the process of <i>defining variables by their measurement</i>
ordinal data	a measurement which reflects <i>rank order</i> within a group
rank	"the relative <i>position</i> in a group (e.g. <i>1st, 2nd, 3rd</i>)"
ratio data	a measurement which reflects a position on a ratio scale (e.g. 93 on Exam 1)
true zero	the complete absence of a variable (e.g. <i>0 pounds = no weight</i>)
variable	"an element that can have many values (e.g. 'weight' can be 120 or 210 or 5)"

Study Questions

- List and define four kinds of measurement. Give an example of each kind.
- Define "constant" and "variable." Give two examples of each.
- Operationalize the "fuzzies" below.
 - "Staff members who work with autocratic pastors are less happy than those who work with democratic pastors."
 - "Teaching Sunday School with discussion will result in better feelings than teaching with lecture."
 - "Group counseling is better than individual counseling."

Sample Test Questions

- Identify the following kinds of data by writing **Nominal**, **Ordinal**, **Interval**, or **Ratio** in the blank provided.

___ Birth Year	___ °C or °F	___ Class rank
___ Test score	___ Nationality	___ Body Weight
- Which of the following is not a characteristic of an operational definition?
 - helps researchers communicate clearly
 - uses global, abstract terminology
 - specifies activities used to measure a variable
 - addresses science's desire for precision

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3. Which of the following is the best operational definition?
- An attitude of forgiveness
 - Aggressive facial expressions
 - Immoral behavior
 - Anxiety test score
4. Identify the type of data expressed in the statements below by writing the appropriate letter in the blank provided.

Nominal Ordinal Interval Ratio

___ Statistical Aptitude will be measured by scores obtained on the STAT2 (0-20)¹

___ My current feelings toward my father could be characterized as:²

Very Warm and Tender	Good	Unsure	Unfavorable	Very Distant and Cold
1	2	3	4	5

___ Employment Status: Full-Time Part-Time Not Employed³

___ Study Habits: Sum of Delay Avoidance (DA) and Work Methods (WM) Scores on the Survey of Study Habits and Attitudes Inventory (Max: 100)⁴

___ Critical Thinking Ability: score on the Watson-Glaser Critical Thinking Appraisal⁵

___ Leadership Style: "9,9" "5,5" "9,1" "1,9" "1,1"⁶

___ Reasons for Dropping Out of a Christian College: Ranking of 50 Attrition Factors⁷

___ Child Density: Computed by dividing the number of children in a family by the number of years married⁸

¹"0" means no aptitude for statistics.

²*Ibid.*, 86

³James Scott Floyd, "The Interaction Between Employment Status and Life Stage on Marital Adjustment of Southern Baptist Women in Tarrant County, Texas," (Ed.D. diss., Southwestern Baptist Theological Seminary, 1990), 45

⁴Steven Keith Mullen, "A Study of the Difference in Study Habits and Study Attitudes Between College Students Participating in an Experiential Learning Program Using the Portfolio Assessment Method of Evaluation and Students Not Participating in Experiential Learning," (Ph.D. diss., Southwestern Baptist Theological Seminary, 1995), 51

⁵Bradley Dale Williamson, "An Examination of the Critical Thinking Abilities of Students Enrolled in a Masters Degree Program at Selected Theological Seminaries," (Ph.D. diss., Southwestern Baptist Theological Seminary, 1995), 23

⁶Helen C. Ang, "An Analytical Study of the Leadership Style of Selected Academic Administrators in Christian Colleges and Universities as Related to Their Educational Philosophy Profile," (Ed.D. diss., Southwestern Baptist Theological Seminary, 1984), 28-29

⁷Judith N. Doyle, "A Critical Analysis of Factors Influencing Student Attrition at Four Selected Christian Colleges," (Ed.D. diss., Southwestern Baptist Theological Seminary, 1984), 98

⁸Martha Sue Bessac, "The Relationship of Marital Satisfaction to Selected Individual, Relational, and Institutional Variables of Student Couples at Southwestern Baptist Theological Seminary," (Ed.D. diss., Southwestern Baptist Theological Seminary, 1986), 23