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Interval scale variables

Lecture 1 Types of scales & levels of measurement Discrete and continuous variables Daniel's text distinguishes between discrete and continuous variables. These are technical distinctions that will not be all that important to us in this class. According to the text, discrete variables are variables in which there are no intermediate values possible. For instance, the number of phone calls you receive per day. You cannot receive 6.3 phone calls. Continuous variables are everything else; any variable that can theoretically have values in between points (e.g., between 153 and 154 lbs. for instance). It turns out that this is not all that useful of a distinction for our purposes. What is really more important for statistical considerations is the level of measurement used. When I say it is more important, I've really understated this. Understanding the level of measurement of a variable (or scale or measure) is the first and most important distinction one must make about a variable when doing statistics! Levels of measurement Statisticians often refer to the "levels of measurement" of a variable, a measure, or a scale to distinguish between measured variables that have different properties. There are four basic levels: nominal, ordinal, interval, and ratio. Nominal A variable measured on a "nominal" scale is a variable that does not really have any evaluative distinction. One value is really not any greater than another. A good example of a nominal variable is sex (or gender). Information in a data set on sex is usually coded as 0 or 1, 1 indicating male and 0 indicating female (or the other way around--0 for male, 1 for female). 1 in this case is an arbitrary value and it is not any greater or better than 0. There is only a nominal difference between 0 and 1. With nominal variables, there is a qualitative difference between values, not a quantitative one. Ordinal Something measured on an "ordinal" scale does have an evaluative connotation. One value is greater or larger or better than the other. Product A is preferred over product B, and therefore A receives a value of 1 and B receives a value of 2. Another example might be rating your job satisfaction on a scale from 1 to 10, with 10 representing complete satisfaction. With ordinal scales, we only know that 2 is better than 1 or 10 is better than 9; we do not know by how much. It may vary. The distance between 1 and 2 maybe shorter than between 9 and 10. Interval A variable measured on an interval scale gives information about more or betterness as ordinal scales do, but interval variables have an equal distance between each value. The distance between 1 and 2 is equal to the distance between 9 and 10. Temperature using Celsius or Fahrenheit is a good example, there is the exact same difference between 100 degrees and 90 as there is between 42 and 32. Ratio Something measured on a ratio scale has the same properties that an interval scale has except, with a ratio scaling, there is an absolute zero point. Temperature measured in Kelvin is an example. There is no value possible below 0 degrees Kelvin, it is absolute zero. Weight is another example, 0 lbs. is a meaningful absence of weight. Your bank account balance is another. Although you can have a negative or positive account balance, there is a definite and nonarbitrary meaning of an account balance of 0. One can think of nominal, ordinal, interval, and ratio as being ranked in their relation to one another. Ratio is more sophisticated than interval, interval is more sophisticated than ordinal, and ordinal is more sophisticated than nominal. I don't know if the ranks are equidistant or not, probably not. So what kind of measurement level is this ranking of measurement levels?? I'd say ordinal. In statistics, it's best to be a little conservative when in doubt. Two General Classes of Variables (Who Cares?) Ok, remember I stated that this is the first and most important distinction when using statistics? Here's why. For the most part, statisticians or researchers wind up only caring about the difference between nominal and all the others. There are generally two classes of statistics: those that deal with nominal dependent variables and those that deal with ordinal, interval, or ratio variables. (Right now we will focus on the dependent variable and later we will discuss the independent variable). When I describe these types of two general classes of variables, I (and many others) usually refer to them as "categorical" and "continuous." (Sometimes I'll use "dichotomous" instead of "categorical"). Note also, that "continuous" in this sense is not exactly the same as "continuous" used in Chapter 1 of the text when distinguishing between discrete and continuous. It's a much looser term. Categorical and dichotomous usually mean that a scale is nominal. "Continuous" variables are usually those that are ordinal or better. Ordinal scales with few categories (2,3, or possibly 4) and nominal measures are often classified as categorical and are analyzed using binomial class of statistical tests, whereas ordinal scales with many categories (5 or more), interval, and ratio, are usually analyzed with the normal theory class of statistical tests. Although the distinction is a somewhat fuzzy one, it is often a very useful distinction for choosing the correct statistical test. There are a number of special statistics that have been developed to deal with ordinal variables with just a few possible values, but we are not going to cover them in this class (see Agresti, 1984, 1990; O'Connell, 2006; Wickens, 1989 for more information on analysis of ordinal variables). General Classes of Statistics (Oh, I Guess I Do Care) Ok, so we have these two general categories (i.e., continuous and categorical), what next...? Well this distinction (as fuzzy as it may sound) has very important implications for the type of statistical procedure used and we will be making decisions based on this distinction all through the course. There are two general classes of statistics: those based on binomial theory and those based on normal theory. Chi-square and logistic regression deal with binomial theory or binomial distributions, and t-tests, ANOVA, correlation, and regression deal with normal theory. So here's a table to summarize. Type of Dependent Variable (or Scale) Level of Measurement General Class of Statistic (Binomial or Normal Theory) Examples of Statistical Procedures Categorical (or dichotomous) nominal, ordinal with 2, 3, or 4 levels binomial chi-square, logistic regression Continuous ordinal with more than 4 categories normal ANOVA, regression, correlation, t-tests Survey Questions and Measures: Some Common Examples In actual practice, researchers and real life research problems do not tell you how the dependent variable should be categorized, so I will outline a few types of survey questions or other measures that are commonly used. Yes/No Questions Any question on a survey that has yes or no as a possible response is nominal, and so binomial statistics will be applied whenever a single yes/no question serves as the dependent variable or one of the dependent variables in an analysis. Likert Scales A special kind of survey question uses a set of responses that are ordered so that one response is greater than another. The term Likert scale is named after the inventor, Rensis Likert, whose name is pronounced "Lickert." Generally, this term is used for any question that has about 5 or more possible options. An example might be: "How would you rate your department administrator?" 1=very incompetent, 2=somewhat incompetent, 3=neither competent, 4=somewhat competent, or 5=very competent. Likert scales are either ordinal or interval, and many psychometricians would argue that they are interval scales because, when well constructed, there is equal distance between each value. So if a Likert scale is used as a dependent variable in an analysis, normal theory statistics are used such as ANOVA or regression would be used. Physical Measures Most physical measures, such as height, weight, systolic blood pressure, distance etc., are interval or ratio scales, so they fall into the general "continuous " category. Therefore, normal theory type statistics are also used when a such a measure serves as the dependent variable in an analysis. Counts Counts are tricky. If a variable is measured by counting, such as the case if a researcher is counting the number of days a hospital patient has been hospitalized, the variable is on a ratio scale and is treated as a continuous variable. Special statistics are often recommended, however, because count variables often have a very skewed distribution with a large number of cases with a zero count (see Agresti, 1990, p. 125; Cohen, Cohen, West, & Aiken, 2003, Chapter 13). If a researcher is counting the number of subjects in an experiment (or number of cases in the data set), a continuous type measure is not really being used. Counting in this instance is really examining the frequency that some value of a variable occurs. For example, counting the number of subjects in the data set that report having been hospitalized in the last year, relies on a dichotomous variable in the data set that stands for being hospitalized or not being hospitalized (e.g., from a question such as "have you been hospitalized in the last year?"). Even if one were to count the number of cases based on the question "how many days in the past year have you been hospitalized," which is a continuous measure, the variable being used in the analysis is really not this continuous variable. Instead, the researcher would actually be analyzing a dichotomous variable by counting the number of people who had not been hospitalized in the past year (0 days) vs. those that had been (1 or more days). In economics, utility can be considered to be on interval scale. There is some disagreement whether utility should be ordinal or cardinal, but in the case of cardinal utility, it is measured on the interval scale. The following is a quote from Wikipedia's article on Cardinal utility, section Measurability: It is helpful to consider the same problem as it appears in the construction of scales of measurement in the natural sciences. In the case of temperature there are two degrees of freedom for its measurement - the choice of unit and the zero. Different temperature scales map its intensity in different ways. In the celsius scale the zero is chosen to be the point where water freezes, and likewise, in cardinal utility theory one would be tempted to think that the choice of zero would correspond to a good or service that brings exactly 0 utils. However this is not necessarily true. The mathematical index remains cardinal, even if the zero gets moved arbitrarily to another point, or if the choice of scale is changed, or if both the scale and the zero are changed. Every measurable entity maps into a cardinal function but not every cardinal function is the result of the mapping of a measurable entity. The point of this example was used to prove that (as with temperature) it is still possible to predict something about the combination of two values of some utility function, even if the utils get transformed into entirely different numbers, as long as it remains a linear transformation. See also Wakker "Explaining the characteristics of the power (CRRA) utility family" (2008). Look again at the variables (columns) and values (individual entries in each column) in Table 2.1. If you were asked to summarize these data, how would you do it? First, notice that for certain variables, the values are numeric; for others, the values are descriptive. The type of values influence the way in which the variables can be summarized. Variables can be classified into one of four types, depending on the type of scale used to characterize their values (Table 2.2). Table 2.2 Types of Variables Scale Example Values "categorical" or "qualitative" disease status ovarian cancer yes / no Stage I, II, III, or IV "continuous" or "quantitative" date of birth tuberculin skin test any date from recorded time to current 0 – ??? of induration A nominal-scale variable is one whose values are categories without any numerical ranking, such as county of residence. In epidemiology, nominal variables with only two categories are very common: alive or dead, ill or well, vaccinated or unvaccinated, or did or did not eat the potato salad. A nominal variable with two mutually exclusive categories is sometimes called a dichotomous variable. An ordinal-scale variable has values that can be ranked but are not necessarily evenly spaced, such as stage of cancer (see Table 2.3). An interval-scale variable is measured on a scale of equally spaced units, but without a true zero point, such as date of birth. A ratio-scale variable is an interval variable with a true zero point, such as height in centimeters or duration of illness. Nominal- and ordinal-scale variables are considered qualitative or categorical variables, whereas interval- and ratio-scale variables are considered quantitative or continuous variables. Sometimes the same variable can be measured using both a nominal scale and a ratio scale. For example, the tuberculin skin tests of a group of persons potentially exposed to a co-worker with tuberculosis can be measured as "positive" or "negative" (nominal scale) or in millimeters of induration (ratio scale). Table 2.3 Example of Ordinal-Scale Variable: Stages of Breast Cancer Stage Tumor Size Lymph Node Involvement Metastasis (Spread) I Less than 2 cm No No II Between 2 and 5 cm No or in same side of breast No III More than 5 cm Yes, on same side of breast No IV Not applicable Not applicable Yes For each of the variables listed below from the line listing in Table 2.1, identify what type of variable it is. Nominal Ordinal Interval Ratio ____ Date of diagnosis ____ Town of residence ____ Age (years) ____ Sex ____ Highest alanine aminotransferase (ALT) Check your answer. As you create a plan for analyzing quantitative data from your surveys, chances are you've come across the phrase "interval scale." But what is the interval scale, and how does it differ from commonly associated terms like "nominal scale" and "ordinal scale"? We'll cover the definition, describe key characteristics, and provide interval scale examples that could be especially useful for your survey strategy. Interval Scale: Definition The interval scale is a quantitative measurement scale where there is order, the difference between the two variables is meaningful and equal, and the presence of zero is arbitrary. It measures variables that exist along a common scale at equal intervals. The measures used to calculate the distance between the variables are highly reliable. The interval scale is the third level of measurement after the nominal scale and the ordinal scale. Understanding the first two levels will help you differentiate interval measurements. A nominal scale is used when variables do not have a natural order or ranking. You can include numbered or unnumbered variables, but common survey examples include gender, location, political party, pets, and so on. In contrast, on an ordinal scale, the rank of variables matters, but the difference or distance between the variables doesn't. Think about price range filters for online shopping. You can select "less than $25," "$26 up to $50," and so forth, but the difference between them is not relevant. Likewise, the ranking of variables such as "Would not recommend" and "Would highly recommend" matters, but the difference between them does not unless that difference is represented by another variable.   Learn more: Interval Data- Definition and Example Characteristics of interval scale Now that you're familiar with the first two scales of measurement, it's much easier to understand the interval scale. In a sense, it's the combination of the other scales. The trickiest part about the interval scale is probably the fact that there is no true zero. But when you think about it, some variables do not have a universally constant zero. Consider this interval scale example: temperature in degrees Fahrenheit. If you're analyzing temperatures in degrees Fahrenheit, say 20-40 degrees and 40-60 degrees, there is order and difference between variables is meaningful, but the presence of zero is arbitrary. How is zero arbitrary? Zero degrees on the Fahrenheit (and Celsius) scale is not a universal constant but instead assigned to represent the temperature at which brine made from equal parts of ice, water, and salt freezes. Let's not get too wrapped up in the particulars of temperature, though. Your surveys will likely focus on other variables. It is easy to remember the objective of this scale because "interval" refers to the interval (or distance) between two variables. Another way to remember the interval scale is that the data between two variables can be added or subtracted, but not multiplied or divided. This is unlike the ratio scale, where division is defined between two variables. Want an easy guide to the interval scale and its data? We've listed key characteristics here: The interval scale is preferred to nominal scale or ordinal scale because the latter two are qualitative scales. The interval scale is quantitative in the sense that it can quantify the difference between values. Interval data can be discrete with whole numbers like 8 degrees, 4 years, 2 months, etc., or continuous with fractional numbers like 12.2 degrees, 3.5 weeks or 4.2 miles. You can subtract values between two variables that help understand the difference between two variables. Interval measurement allows you to calculate the mean and median of variables. Interval data is especially useful in business, social, and scientific analysis and strategy because it is straightforward and quantitative. This is a preferred scale in statistics because you can assign a numerical value to any arbitrary assessment, such as feelings and sentiments. Now that you know how to spot the interval scale when you see it, let's take a look at some useful interval scale examples. Interval scale examples Questions that can be measured on the interval scale are the most commonly used question types in research studies. To receive answers in the form of interval data, you need to limit feedback options to variables that can be assigned a numerical value where the difference between the two variables is equal. You have probably seen the following scales used in a research study: agreement, satisfaction levels, or likelihood. The survey needs to be scaled so variables can meet the criteria of interval measurement. Otherwise, the data you receive in feedback will be difficult to quantify. Consider these questions as you write your next survey. They are all compatible with the interval scale and offer actionable data: One of the most commonly used interval scale questions is arranged on a five-point Likert Scale question, where each emotion is denoted with a number, and the variables range from extremely dissatisfied to extremely satisfied. In a Net Promoter Score (NPS) question, the respondents reply on a scale of 1-10 rating how likely they are to refer a company/product/service to a peer. When you include this type of question, participants assess an object on a bipolar matrix table using a five-point rating scale that helps you quantify sentiments by creating a ranking system. Conclusion The interval scale gives survey strategists the ability to quantify and differentiate between options so your feedback can contribute to meaningful goals and results. It's often more effective for most businesses and scientific studies than the nominal scale or ordinal scale, as it can account for quantitative outcomes. QuestionPro makes it easy to write, share, and analyze surveys to gather deep insights. Use this article to select the best interval scale question-answer types for your next study.

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