1.4.3: Scales of Measurement

Look at the Figure 1.4.3.1:

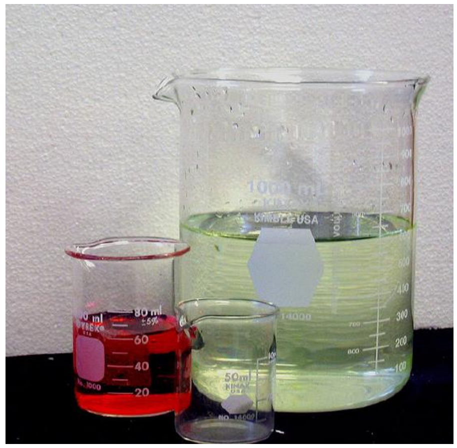

Figure 1.4.3.1: 3 Beakers. (CC-BY-SA Photo by Jaeger5432. The file was originally uploaded to English Wikipedia. This file is licensed under the Creative Commons Attribution-Share Alike 2.5 Generic license.)

Example 1.4.3.1

List three ways that the beakers in Figure 1.4.3.1 can be described.

Solution

Some examples include: by color, by size (bigger, smaller), and measurement (ounces, milligrams, etc). Your descriptions probably map pretty well onto the different Scales of Measurement.

Scales of Measurement

A very useful concept for distinguishing between different types of variables is what's known as ***scales of measurement***.

Note

Scales of Measurement

- Ratio: true numerical measurement
- Interval: created numerical scale
- Ordinal: variables with an order
- Nominal: Named variable

Table 1.4.3.1 - Description & Examples of Each Scale of Measurement

Scale of Measurement	Description of Scale of Measurement	Example from Figure 1.3.1	Another Example
Ratio Scale	A type of variables that is measured, and zero means that there is none of it.	Ounces of liquid (and you could have no liquid)	Liters of ice cream (you could have zero liters of ice cream)
Interval Scale	A type of variable that is measured, and the intervals between each measurement are equal (but zero does not mean the absence of the measured item).	[There are no variables with an interval scale in the image.]	A satisfaction scale in which -5 means "very unsatisfied", 0 means "neutral," and +5 means "very satisfied."

Scale of Measurement	Description of Scale of Measurement	Example from Figure 1.3.1	Another Example
Ordinal Scale	A type of variables that can be put in numerical order, but the difference between any pair is not the same as the difference between any other pair. The variables are in ranks (first, second, third, etc.).	You could order these from biggest to smallest; the difference between the biggest and the middle might be much larger than the difference between the middle and the smallest.	The medals earned in the Olympics; the difference between the person who wins the gold medal and the person who wins the silver medal might be much larger than the difference between the person who wins the silver medal compared to the person who wins the bronze medal.
Nominal Scale	Type of variable that has quality or name, but not a number that means something. “Nom” means “name,” so it’s just a name, not anything that is measured. This variable is counted, rather than measured.	Color of the liquids	Your major in college.

Things that are measured use some sort of tool (like a ruler, weight scale, or survey scale), which differs from things that can only be counted.

If you're still a little lost (which is fine, these types of variables are confusing and a little squishy), keep reading. If you're good, skip down to the last section in this page, then make sure to read the section on Qualitative and Quantitative variables!

Ratio Scale

The fourth and final type of variable to consider is a ratio scale variable, in which zero really means zero, and it’s okay to multiply and divide. A good example of a ratio scale variable is response time (RT). In a lot of tasks it’s very common to record the amount of time somebody takes to solve a problem or answer a question, because it’s an indicator of how difficult the task is. Suppose that Amar takes 2.3 seconds to respond to a question, whereas Becky takes 3.1 seconds. As with an interval scale variable, addition and subtraction are both meaningful here. Becky really did take 3.1 - 2.3 = 0.8 seconds longer than Amar did. However, notice that multiplication and division also make sense here too: Becky took 3.1 / 2.3 = 1.35 times as long as Amar did to answer the question. And the reason why you can do this is that, for a ratio scale variable such as RT, “zero seconds” really does mean “no time at all”.

Interval Scale

In contrast to nominal and ordinal scale variables, ***interval scale*** and ratio scale variables are variables for which the numerical value is genuinely meaningful. In the case of interval scale variables, the *differences* between the numbers are interpretable, but the variable doesn’t have a “natural” zero value. A good example of an interval scale variable is measuring temperature in degrees celsius. For instance, if it was 15^o yesterday and 18° today, then the 3^o difference between the two is genuinely meaningful. Moreover, that 3^o difference is *exactly the same* as the 3^o difference between 7^o and 10^o. In short, addition and subtraction are meaningful for interval scale variables.[8]

However, notice that the 0^o does not mean “no temperature at all”: it actually means “the temperature at which fresh water freezes”, which is pretty arbitrary. As a consequence, it becomes pointless to try to multiply and divide temperatures. It is wrong to say that 20^o is *twice as hot* as 10^o, just as it is weird and meaningless to try to claim that 20^o is negative two times as hot as -10^o.

Again, lets look at a more psychological example. Suppose I’m interested in looking at how the attitudes of first-year university students have changed over time. Obviously, I’m going to want to record the year in which each student started. This is an interval scale variable. A student who started in 2003 did arrive 5 years before a student who started in 2008. However, it would be completely insane for me to divide 2008 by 2003 and say that the second student started “1.0024 times later” than the first one. That doesn’t make any sense at all.

Ordinal Scale

Ordinal scale variables have a bit more structure than nominal scale variables, but not by a lot. An ordinal scale variable is one in which there is a natural, meaningful way to order the different possibilities, but you can't do anything else. The usual example given of an ordinal variable is "finishing position in a race". You *can* say that the person who finished first was faster than the person who finished second, but you *don't* know how much faster. As a consequence we know that 1st > 2nd, and we know that 2nd > 3rd, but the difference between 1st and 2nd might be much larger than the difference between 2nd and 3rd.

I accidently found an ordinal scale when trying to find an example of a nominal scale: highest degree earned. I was looking for categories, but there is definitely an order to level of education!

1. Did not finish high school
2. High school degree only
3. Some college
4. Certificate
5. Associate's degree
6. Bachelor's degree
7. Graduate degree

Since there is a natural order to education level, it would be very weird to list the options like this…

1. Did not finish high school
2. Graduate degree
3. High school degree only
4. Some college
5. Certificate
6. Bachelor's degree
7. Associate's degree

… because it seems against the natural "structure" to the question. Notice that while we *can* use the natural ordering of these items to construct sensible groupings, what we *can't* do is average them. The #1 doesn't have any meaningful numerical value, and is not really related to the #7 in any measurable way. If you can tell me what the mean of these categories might mean, I'd love to know. Because that sounds like gibberish to me!

Nominal Scale

A ***nominal scale*** variable (also referred to as a ***categorical*** variable) is one in which there is no particular relationship between the different possibilities: for these kinds of variables it doesn't make any sense to say that one of them is "bigger' or"better" than any other one, and it absolutely doesn't make any sense to average them. The classic example for this is "eye color". Eyes can be blue, green and brown, among other possibilities, but none of them is any "better" than any other one. As a result, it would feel really weird to talk about an "average eye colour". In short, nominal scale variables are those for which the only thing you can say about the different possibilities is that they are different. That's it.

Let's take a slightly closer look at this. Suppose I was doing research on how students studied. This "study" variable could have quite a few possible values,but for now, let's suppose that these four are the only possibilities, and suppose that when I ask 100 students what they did the last time that they studied, and I get this:

Table 1.4.3.2.1 - Example of Nominal Variable

Method of Studying	Number of people
(1) Read the whole chapter	12
(2) Skimmed the whole chapter, read some sections	30
(3) Watched YouTube videos on class content	48
(4) Took notes on the chapter	10

So, what's the average way that students studied? The answer here is that there isn't one. It's a silly question to ask. You can say that watching YouTube is the most popular method, and taking notes is the least popular method, but that's about all. Similarly, notice that the order in which I list the options isn't very interesting. I could have chosen to display the data like this

Table 1.4.3.2.2 - Example of Nominal Variable

Method of Studying	Number of people
(3) Watched YouTube videos on class content	48
(2) Skimmed the whole chapter, read some sections	30
(1) Read the whole chapter	12
(4) Took notes on the chapter	10

and it doesn't matter.

Some Complexities

Okay, I know you're going to be shocked to hear this, but … the real world is much messier than this little classification scheme suggests. Very few variables in real life actually fall into these nice neat categories, so you need to be kind of careful not to treat the scales of measurement as if they were hard and fast rules. It doesn't work like that: they're guidelines, intended to help you think about the situations in which you should treat different variables differently. Nothing more.

So let's take a classic example, maybe *the* classic example, of a psychological measurement tool: the ***Likert scale***. The humble Likert scale is the bread and butter tool of all survey design. You yourself have filled out hundreds, maybe thousands of them, and odds are you've even used one yourself. Suppose we have a survey question that looks like this:

Which of the following best describes your opinion of the statement that "all pirates are freaking awesome" …

and then the options presented to the participant are these:

(1) Strongly disagree
(2) Disagree
(3) Neither agree nor disagree
(4) Agree
(5) Strongly agree

This set of items is an example of a 5-point Likert scale: people are asked to choose among one of several (in this case 5) clearly ordered possibilities, generally with a verbal descriptor given in each case. However, it's not necessary that all items be explicitly described. This is a perfectly good example of a 5-point Likert scale too:

(1) Strongly disagree
(2)
(3)
(4)
(5) Strongly agree

Likert scales are very handy, if somewhat limited, tools. The question is, what kind of variable are they? They're obviously discrete, since you can't give a response of 2.5. They're obviously not nominal scale, since the items are ordered; and they're not ratio scale either, since there's no natural zero.

But are they ordinal scale or interval scale? One argument says that we can't really prove that the difference between "strongly agree" and "agree" is of the same size as the difference between "agree" and "neither agree nor disagree". In fact, in everyday life it's pretty obvious that they're not the same at all. So this suggests that we ought to treat Likert scales as ordinal variables. On the other hand, in practice most participants do seem to take the whole "on a scale from 1 to 5" part fairly seriously, and they tend to act as if the differences between the five response options were fairly similar to one another. As a consequence, a lot of researchers treat Likert scale data as if it were interval scale. It's not interval scale, but in practice it's close enough that we usually think of it as being quasi-interval scale.

These different Scales of Measurement are important because they determine which statistical analysis to use on your data. We'll talk about choosing the correct statistical analysis when we know more specific statistical analyses, but that's why we care about what kind of variables we have so much.

Contributors and Attributions

- Danielle Navarro (University of New South Wales)
- Dr. MO (Taft College)
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