

Scaling

PSYC3302: Psychological Measurement and Its Applications

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Week 1

Learning Objectives

Psychological
Measurement

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Scaling

Properties of
Numbers

Identity
Order

Quantity
Meaning of 0

Properties of
Measurement

Measurement
Scales

Nominal
Ordinal
Interval
Ratio

Measurement
Scales in
Psychology

References

- Introduction to scaling
- The meaning of numbers
- How numbers can be used to represent psychological attributes
- Problems with using numbers to represent psychological attributes

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References

- Psychological measurement is the process by which numbers are assigned to represent the amounts of psychological attributes
- Psychologists assume that these psychological attributes exist in some quantity that can be measured
- This is true even if it is not directly observable
- Scaling refers to how numerical values are assigned to psychological attributes
- It is a fundamental issue in psychometrics

Properties of Numbers

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References

- In psychological measurement, numbers are used to represent the amount of a psychological attribute (e.g., intelligence, working memory) an individual possesses
- How these amounts are represented depends on the properties of the numeral used to represent the attribute
- There are three key properties of numbers:
 - 1 the property of identity
 - 2 the property of order
 - 3 the property of quantity

The Property of Identity

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References

- The most basic form of measurement
- Represents "sameness" vs. "differentness" by sorting people into categories based on similarity of psychological features
 - for example, a teacher classifies children in her class as either having behavioural problems or not
- Rules for sorting individuals into categories:
 - 1 individuals within a category must satisfy the property of "identity"
 - 2 the categories must be *mutually exclusive*
 - 3 the categories must be *exhaustive*

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References

- Different categories can be represented by different numbers
- e.g., 1 = "No Behavioural Problem"; 2 = "Behavioural Problem"
- But the numbers are arbitrary—they have no quantity significance
- The categories could just as easily be labelled with letters or names
- This form of measurement represents differences in kind or quality, but not differences in amount

The Property of Order

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References

- The property of order conveys more information than the property of identity
- It represents information about the relative amount of an attribute people possess
- When numerals have this property, they indicate the rank order of individuals on some psychological attribute
- For example, a teacher may be asked to rank all of the students with respect to their interest in learning
- The most interested child could be given a value of 1, the next most interested child could be given a value of 2, and so on

The Property of Order

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References

- As for the property of identity, the numbers assigned are merely labels—they have no inherent meaning
- We could just as easily assign letters as numerals to indicate ranks
- Although it conveys more information than the property of identity, the property of order is still limited
- It informs us about the relative differences between individuals in an attribute, but nothing about the degree of those differences
- For example, the child ranked 1 has more interest in learning than the child ranked 2, but we do not know *how much* more

The Property of Quantity

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References

- The property of quantity provides more information than the property of order
- It conveys information about the magnitude of differences between individuals
- Numerals with this property are *real numbers*:
 - 1 the number 1 defines the size of the basic *unit* on any scale
 - 2 all other values are multiples of 1 or fractions of 1
 - 3 each numeral represents a count of basic units

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References

- Real numbers can be used to represent the quantity of an attribute
- Also, you can compare cases with each other in a meaningful and informative way
 - e.g., if person A has a brain weight of 1084 grams and person B has a brain weight of 1254 grams, we can say that person B has a brain 15.7% larger than person A
- Psychologists frequently assume that test scores have the property of quantity
- However, this is rarely true

The Meaning of 0

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References

- The number zero can have different meanings
- Sometimes it means the absence of an attribute—known as *absolute zero*
- A good example in psychology of a measure with an absolute zero is reaction time
- Sometimes it is an arbitrary quantity of an attribute—known as *arbitrary zero*
- A temperature of 0 on the Celsius scale does not indicate the absence of temperature

The Property of 0

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- In psychology, many attributes are likely to have arbitrary zero points
- For example, a child who scored zero on a spelling test is unlikely to have zero spelling ability
- It is more likely that the spelling items were too hard to index low levels of this competency
- In this case, we should probably treat a test score of zero as arbitrary
- The interpretation of psychological test scores is influenced by the type of zero associated with a test

Units of Measurement

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Scaling

Properties of Numbers

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References

- The property of quantity requires that measurement units be clearly defined
- Measurement depends critically on our ability to count these units to obtain a score for our measurement

Counting and Additivity

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References

- There is an important assumption related to counting that should be satisfied known as *additivity*
- This requires that the measurement unit size should not change—all units being counted should be equal
- For example, the difference between 4 and 5 inches in length should be identical to the difference between 9 and 10 inches in length
- Thus, additivity requires unit size to remain constant

Counting and Additivity

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References

- However, in psychological measurement this assumption is rarely satisfied
- For example, the questions on an exam developed to tap knowledge of psychometrics will differ in their difficulty level
- Accordingly, a score of 60 out of 100 does not imply that a person has 60 units of knowledge of psychometrics
- Even if we tried to devise ways to give more difficult questions more marks, we still would not satisfy the assumption of additivity

Counting and Additivity

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References

- Simply counting various *things* is not necessarily construed as measurement
- For example, if you counted the pebbles by the river, would you be measuring something or simply counting?
- However, if you count the number of correct responses on a student's exam, the total sum is construed to represent some sort of attribute (e.g., knowledge or competence)
- Counting is a necessary but not sufficient condition for measurement

Four Scales of Measurement

Psychological Measurement

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Measurement Scales in Psychology

References

- According to Stevens (1946), measurement may be defined as “the assignment of numerals to objects or events according to rules”
- This definition of measurement is not universally accepted
- Some experts disagree with it and have proposed alternative definitions
- However, it is the prevailing view and a discussion of alternative approaches is beyond the scope of this lecture

Four Scales of Measurement

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References

- Steven's (1946) proposed four scales of measurement
- The rules in Steven's definition of measurement correspond to the four levels of measurement
- The four scales are:
 - 1 Nominal
 - 2 Ordinal
 - 3 Interval
 - 4 Ratio

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Four Scales of Measurement

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References

Table: Association Between Numerical Principles and Levels of Measurement

Principle	Level of Measurement			
	Nominal	Ordinal	Interval	Ratio
Identity	✓	✓	✓	✓
Order		✓	✓	✓
Quantity			✓	✓
Absolute zero				✓

Nominal

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References

- Nominal scales are the most basic form of measurement
- These scales involve categorising based on one or more attribute into mutually exclusive and exhaustive categories
- A good example is the *Diagnostic and Statistical Manual of Mental Disorders* in which every disorder is assigned its own number
- Number 303 is alcohol intoxication and number 307 is stuttering
- The numbers are used for classification purposes—they cannot be added, subtracted, or averaged
- Hence, the middle code (305) does not identify an intoxicated stutterer!!

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References

- Individual test items may also employ nominal scaling, including (but not restricted to) *yes/no* responses
- Consider the following items:

Instructions: Answer either yes or no:

Are you a psychology student? _____

Do you enjoy statistics? _____

Do you think Mark's lecture is dull? _____

- In each case, a *yes* or *no* response results in placement into one of a set of mutually exclusive groups

Ordinal

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References

- Like nominal scales, ordinal scales allow classification
- However, in addition, rank ordering on some characteristic is also possible
- In business and organisational settings, job applicants may be rank-ordered according to their suitability for a position
- In clinical settings, people on a waiting list for treatment may be rank-ordered according to their need for treatment
- In these examples, individuals are compared with others and assigned a rank

Ordinal

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Measurement Scales in Psychology

References

- Assessment items can also use an ordinal form of measurement
- The Rokeach Value Survey uses such an approach
- In this test, a list of personal values—such as freedom, happiness, and wisdom—are rank-ordered according to their perceived importance by the test-taker (Rokeach, 1973)
- Ordinal scales say nothing about how much greater one ranking is than another
- Although they use numbers or scores to indicate rank ordering, the numbers do not indicate units of measurement
- Ordinal scales do not have an absolute zero point

Interval

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References

- Interval scales contain the same features as nominal and ordinal scales but in addition such scales contain equal intervals between numbers
- Each unit on the scale is exactly equal to any other unit on the scale
- Like ordinal scales, interval scales do not have an absolute zero point
- With interval scales it is possible to average a set of measurements and obtain a meaningful result

Interval

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References

- Scores on many tests, such as intelligence, are analysed statistically in ways appropriate for data at the interval level of measurement
- The difference in intellectual ability represented by IQs of 80 and 100, for example, is thought to be similar to that existing between IQs of 100 and 120
- However, if an individual obtained an IQ of zero (something that isn't even possible), that would *not* indicate that they possess zero intelligence
- This is because ordinal scales have an arbitrary zero point

Ratio

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References

- Ratio scales have all the properties of nominal, ordinal, and interval scales in addition to an absolute zero point
- Accordingly, all mathematical operations can be meaningfully performed because:
 - there exist equal intervals between numbers on the scale
 - there is an absolute zero point

Psychological Tests

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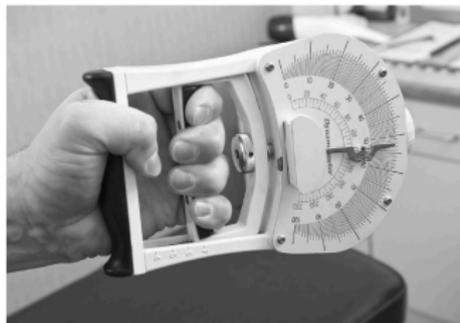
Interval

Ratio

Measurement Scales in Psychology

References

- In psychology, ratio level measurement is employed in some types of tests:
 - a test of hand grip
 - a timed test of perceptual-motor ability
- In these examples it is meaningful to speak of a true zero point—but in theory only!



A *dynamometer* used to measure hand grip

Measurement Scales in Psychology

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Measurement Scales in Psychology

References

- The ordinal level of measurement is most frequently used in psychology
- Intelligence, aptitude, and personality test scores are ordinal in nature
- These tests indicate not the amount of intelligence, aptitude, and personality traits, but rather the rank order of individuals
- However, most psychological scales approximate the interval level of measurement fairly well

Measurement Scales in Psychology

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- Psychologists prefer to think of their data as interval because of the flexibility with which such data can be manipulated and analysed
- One can compute the average if the data is interval- or ratio-level in nature but not if they are ordinal- or nominal-level
- Crucially, one can apply parametric tests (e.g., ANOVA, regression) with interval- or ratio-level data but not with ordinal- or nominal-level data
- So long as ordinal measures contain equal intervals between numbers, these tests will *generally* work fine with ordinal data

In Next Week's Lab ...

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References

- ... You will:
 - 1 Learn about scaling methods and item formats in psychological measurement
 - 2 Develop your first psychological test—exciting!!
 - 3 Critique a measure

In Next Week's Lecture ...

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References

- ... To deliver you from the provisional terrors:
 - Statistics refresher—variance, covariance, correlation etc.
 - Bring your stats hat
 - See you then!!

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