

Week 3, Lecture 2: Types of Data, Internal and External Validity

Observation and measurement are the foundations of empirical research. Observations can either be done by a human or an apparatus. Each method has its own advantages and disadvantages. Humans performing manual observations in notebooks are low in cost and are flexible. However, human error and tediousness of the task can be disadvantageous. Using apparatuses to record observations will be faster, more convenient and accurate than a human observer. They also can be costly for the experimenter.

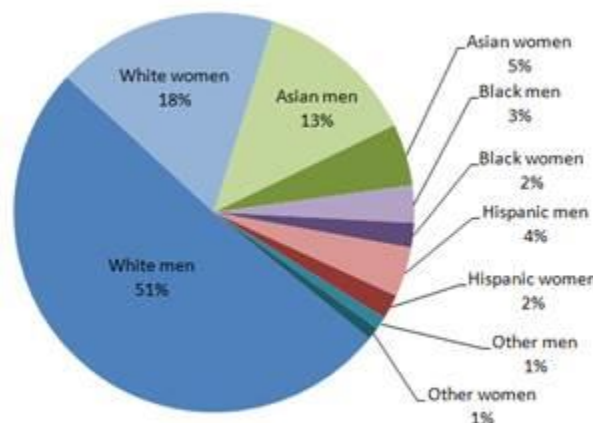
Measurement and Data Types

Measurements are facts or data collected from the experiment. There are four data types: nominal, ordinal, interval and ratio. The data types are listed in order of their sophistication, with nominal being the crudest and ratio being the most sophisticated.

1) Nominal (categorical): This type of qualitative data assigns numerical or non-numerical codes to attributes. Statistical analysis cannot be performed on nominal data, but offers a count that is useful in comparisons between codes.

Ex. Each color (non-numerical code) represents a different demographic. With this chart, one can accurately state that there were more White woman scientists and engineers than there were Asian men.

Demographic characteristics of scientists and engineers: 2010



Source: NSF & NCSES. (2013). *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2013*

2) Ordinal: This type of data assigns a rank or order to an attribute. Comparison of greater than or less than are possible with this data, however it is not sophisticated enough to develop ratios.

Ex. Movie ratings: 1-5 stars

3) Interval: This type of data features equal distances between values and no measurement of absolute zero. While ratios still cannot be developed, statistical means can be found.

Ex. Time of day (the difference between 12pm and 1pm is the same as the difference between 2pm and 3pm); Likert scales

4) Ratio: This is the most preferred and sophisticated data type. The presence of an absolute zero allows for any type of numerical computation and strengthened comparisons. The normalization of ratio data allows for effective experimental validation. It enhances counts provided by nominal data.

Ex. 10 words recorded in 30 seconds -> ratio of 20 words per minute

Internal and External Validity

Weak research questions can be improved upon by narrowing in on the exact variable to be tested. However, improving the accuracy of an answer often results in a question of low breadth. The high accuracy of an answer usually depends on having an experiment with high internal validity. Internal validity is the extent to which the effects observed are due to the test conditions. To achieve high validity, an experiment will be very controlled. The high level of control will often cause the external validity to be low. External validity is the extent to which the results of the experiment are generalizable to people and situation. Experiments with high external validity not only have participants that are representative of a broad population, but the testing environment is demonstrative of a real-world setting. The more the testing environment simulates a real-world situation, the higher the probability of uncontrolled variance.

Scenario: The testing of two interfaces for a car's audio/entertainment system.

The interfaces are tested on a tablet in a usability study room with a driving simulator wheel. The controlled experiment in a non-moving area poses compromises the external validity. In the real world, the user would have to use the system with other possible distractions: kids fighting in the background, a cell phone ringing, concentrating on the traffic. However, conducting the experiment in a more realistic environment, the mentioned distractions would divert the user from choosing which interface they truly liked, lowering the internal validity.

Project Related In-Class Discussions:

Each group was given the opportunity to state and, if necessary, refine the research question for their project. Also, the groups met briefly and discussed with the class the threats to the internal and external validity of their study and how they could be resolved.