

# FMS1203S: Randomness in scientific thinking

Week 3

Observational study and Experiment Design

# Observational study vs. Experiment design

- ▶ Data can be collected either by observation or through designed experiments.
- ▶ In designed experiments the experimenter can control the values of some of the variables in the system being observed.
- ▶ In observational studies the experimenter observes the system passively.
- ▶ Designed experiments are best for proving cause-effect relationship, but observational studies might be used for this purpose only under some circumstances.

# Observational study

## Prospective study

- ▶ We are studying a certain disease say. A group of individuals without the disease is obtained and characteristics which may be risk factors for the disease (exposure variables) are measured.
- ▶ The group is followed forward in time and we look for differences in the exposure variables between the participants in the study who develop the disease and those who don't.
- ▶ Some disadvantages
  - ▶ Time consuming and expensive.
  - ▶ Large study populations are required, and it may be hard to generalize from the study population to the general population.
  - ▶ It may take a long time for enough disease cases to arise to allow for sensible analysis.

# Observational study (cont.)

## Retrospective study

- ▶ A group of individuals with the disease is identified. Then we attempt to match the diseased individuals with similar disease free individuals (similar in terms of characteristics like age, sex, etc.)
- ▶ Look at whether there are differences in exposure variables between the diseased and disease free individuals.
- ▶ Some disadvantages
  - ▶ It may be difficult to find participants for the disease free controls matching the disease cases.
  - ▶ To measure the exposure variables we rely on the recall and honesty of the participants.
  - ▶ Prone to selection bias (in taking a sample of disease cases, for example, those who die quickly from the disease may not be properly represented).

# Designed experiments

## Fundamental ideas

- ▶ **Randomization.** Assign treatments to individuals at random. Without randomization, the experiment could be biased and misleading.
- ▶ **Blocking.** Other than the treatments, there are usually factors of the experiment units which have potential influence on the measured results. The experiment units must be blocked according to those factors and treatments be assigned at random within each block.
- ▶ For factors which can be controlled, blocking; for factors which cannot be controlled, randomizing.

## Designed experiments (cont.)

### An example — Lady testing tea

- ▶ During a Summer afternoon in Cambridge, England, in the late 1920s, a lady claimed that she can tell whether the milk was poured into the cup first or after the tea had been poured.
- ▶ To verify whether the lady's claim is true, R. A. Fisher, proposed an experiment.
- ▶ In the experiment eight cups of tea were made with four of the cups being made with milk in first and four with tea in first.
- ▶ The cups were presented to the lady in a random order. The lady identified perfectly all the 8 cups. If this is by chance, the probability is only  $1/70$ .
- ▶ This was the introductory example Fisher used in his textbook entitled "The Design of Experiments".

## Readings for next week

Group one: Young, Stanley S. and Karr, Alan (2011). Deming, data and observational studies: A process out of control and needing fixing. *Significance*, 8 (3), 116–120.

Group two: Salsburg, David (2001). *The Lady Tasting Tea: How Statistics Revolutionized Science in the Twentieth Century*, W.H. Freeman (Chapter 18, Does smoking cause lung cancer?)

Group three: Salsburg, David (2001). *The Lady Tasting Tea: How Statistics Revolutionized Science in the Twentieth Century*, W.H. Freeman (Chapter 27, The intent to treat).

Group four: Group four: Read “Digit Ratio” in Wikipedia (and its references if necessary) [http://en.wikipedia.org/wiki/Digit\\_ratio](http://en.wikipedia.org/wiki/Digit_ratio)

Group five: Sulloway, F.J. (1995). Birth order and evolutionary psychology: a meta-analytic overview. *Psychological Inquiry*, Vol. 6, No.1, 75-80.