Terminology I

- **Factor**: independent variable(s) are often called factor(s).
- **Level**: A particular value of an independent variable/factor esp. if it is discrete is called a **level**.
- **Treatment**: the set of independent variable(s)/factor(s) value(s) that identify a particular instance of the experiment that characterize a group of subjects who are part of the experiment. So, a treatment is characaterized by a level for each independent variable/factor.
- **Experimental unit**: the unit on which an experiment is conducted. This is the actual unit on which a treatment is applied. This can be a group of subjects.

Terminology II

- **Measurement unit**: the unit on which the response/dependent variable is actually measured. This may be the same as an experimental unit or different - for example a subject in a group with the same treatment.
- **Responses**: the outcomes of the treatment. Typically, dependent variable(s) values for a treatment elicited from a measurement unit and possibly aggregated for an experimental unit if the measurement unit is different from an experimental unit.
- **Experimental error**: random variation that is present in experimental units, treatments, other conditions that result in variations in the response variable(s) even when input conditions are replicated.

Terminology III

- **Control**: three meanings - i) ability to manipulate independent variable(s) ii) freedom to decide treatments, create groups of experimental units, assign subjects to groups iii) a reference or base group for comparison - most often in clinical trials.
- **Single blind, Double blind**: i) in single blind the subject does not know the treatment being given ii) in double blind experiments both subject and experimenter do not know the treatment being given.
- **Placebo**: null treatment. Used when applying a treatment is expected to have an effect. Used in clinical settings. The placebo group is also the control group in such settings.

Terminology IV

- **Confounds/ confounding variables**: when one or more independent variable(s) that can influence the response (i.e. can be the cause of an effect) are not controlled for or distinuished in an experiment.
- **Randomization**: a well defined probabilistic method for assignments. For example assigning subjects to treatments, assigning a sequence of items in an experiment or any situation where choice is involved.
- An **experiment**: has i) a set of treatments, ii) a set of experimental units iii) a way to assign experimental units to treatments and iv) the response measurements of the dependent variable(s) for each experimental unit, v) knowledge and an estimate of possible causes of random error, vi) ethical implications and ethical clearance for the experiment. All this together makes up **experimental design**.

Between subjects, within subjects study designs I

BSD - between subjects design; WSD - within subjects design.

- At the top level an experiment can be **between subjects** or **within subject**.
- In BSD a group (or subject or experimental unit) is assigned a single treatment. In WSD a group (or subject or experimental unit) is assigned multiple (typically all) treatments.
- The choice of the design is dictated by multiple factors:
  - Availability of subjects. A BSD will require many more subjects since each experimental unit is assigned just one treatment while WSD requires just one group.
  - Order and transfer effects. These are not a concern in a BSD. For WSD a) the order of treatments can matter, b) transfer/ learning/ practice effects may be present when different treatments have similarity or overlaps in some components c) starting states can differ between treatments in WSD.

Between subjects, within subjects study designs II

- Random noise. Enviromental and other factors that cannot be controlled (or more often are not identified a priori) can have an effect on subjects and therefore on their responses during an experiment. In BSD there is likely to be more random noise since more measurement units are involved and therefore there is more variability in uncontrolled factors.
- Experiment duration, fatigue. WSD experiments will necessarily be longer and responses can be affected by fatigue. Some times experiment duration may rule out WSD. In BSD groups can be run concurrently. In WSD we cannot.

Randomization

- Proper randomization is one of the most important aspects of experiment design. Improper randomization is also the most common weakness in experiments. It guards against bias both selection and accidential bias.
- In most experiments (esp. with human subjects) achieving theoretically sound randomization may be impossible or extremely hard.
- Randomization is needed in:
  - Selecting a sample from a population. Example: simple random sampling.
  - Assigning treatments to experimental units.
  - Exposure of items to subjects.
  - Order of treatments in WSD.
- Randomization$\neq$Arbitrary. It must be a probabilistically sound replicable procedure.

What does randomization achieve?

- Inference to population parameters.
- Cancel out effects of uncontrolled and enviromental variables that may have an effect on the response. Reduces/ eliminates confounds.