Experiments: Within-Subjects Designs

- Basic Within-Subjects (Repeated-Measures) Design.
- More than 1 IV: Within-Subjects Factorial Designs.
  - Example: The Simon Effect.
- Both Within- & Between-S IVs: Mixed Designs.
  - Example: Implicit vs. Explicit Memory in Amnesics vs. Controls.
- Advantages & Disadvantages of Wi-Subjects Designs.
- Counterbalancing.
  - Subject-by-Subject Counterbalancing.
  - Reverse Counterbalancing & Block Randomization.
  - Across-Subjects Counterbalancing.
    - Complete vs. Partial Counterbalancing.
      - Randomized Partial Counterbalancing.
      - Latin Square & Balanced Latin Square Counterbalancing.
    - Counterbalance order as a between-Subjects IV.

Basic Within-Subjects Design

Within-Subjects (Repeated-Measures) Designs are similar to Between-Subjects Designs, except that each subject experiences all experimental conditions.

```
+----------------------+
| Population           |
+----------------------+
| Population (external validity) |
| x number of subjects (n) |
| Condition A           |
| Condition B           |
| x.x  x.x             |
| x.x  x.x             |
| x.x  x.x             |
| x.x  x.x             |
| x.x  x.x             |
| M  M                 |
| different?           |
| M  M                 |
| sd  sd               |
| Infer. Stat (t, F, etc.) = Systematic + Error / Error = Diff Btw Conditions / Diff Btw Subjects |
| Conditions are often mixed together rather then sequential. |
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不同的
**Within-Subjects Factorial Designs**

- Same as Between-Subjects Factorial except that all subjects get all conditions.
- Same issues with respect to the interpretation of main effects and interactions, as well as increased complexity as additional IVs are added.

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**The Simon Task (Toth et al. 1995)**

![Brain Diagram]

**Congruent**

**Incongruent**

The goal is to respond to the arrow's direction, not its location.

**IV1:** Direction of Arrow (Pointing Left vs. Right)

**IV2:** Location of Arrow (Left vs. Right Side of Screen).

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**Correct responses for left- and right-pointing arrows as a function of arrow location in pc50**

![Graph]

- **Left pointing**
- **Right pointing**

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Toth et al. (1995)
Mixed Factorial Designs

Mixed designs have at least one within- & one between-subjects factor.

Example: Implicit vs. Explicit Memory in Amnesia

Within-Subjects Factor: Type of Memory Test (Explicit vs. Implicit).
Between-Subjects Factor: Population (Healthy Control, Alcoholic, Amnesic).

Procedure:
Subjects read a list of words (e.g., truck, computer, infant, apple, etc.) and then were asked to (a) recall as many words as possible; and (b) provide the first word that came to mind when given a category cue (e.g., Vehicle - ?; Baby - ?).

Advantages & Disadvantages of Within-Subjects Designs

- Advantages.
  - Increased statistical Power.
  - Reduced time & effort for experimenter in collecting data.
  - More efficient data collecting (fewer subjects to train).
  - Experiments can better mimic real-life conditions.

- Disadvantages.
  - Increased time & effort for subject in collecting data.
  - Progressive error (aka. Order Effects; Carry-over effects): A change in performance over the course of an experiment.
    - May involve a non-specific change in performance affecting all conditions; or specific interference between conditions.
    - Possible causes include fatigue, relaxation, learning, practice, development of strategies, figuring out the purpose of the experiment; habituation, sensitization, contrast, & adaptation.
  - 3 Solutions: (1) Eliminate Error; (2) Counterbalance; (3) Order as IV.
**Subject-by-Subject Counterbalancing**

In this method, each subject receives all of the condition-orders used in the experiment. This could thus be called "Within-Subjects Counterbalancing" because all of the various orders occur "within" each subject.

- **Reverse Counterbalancing.**
  - Each subject receives all conditions in one order and also in the reverse order: A then B then B then A (ABBA).
  - Not very useful when there are more than 2 conditions (and may not even eliminate progressive error with 2 conditions).

- **Block Randomization.**
  - Used when there are many conditions (e.g., 4, which yields 24 orders).
  - Implemented by presenting each subject with a number of "blocks", with each block containing a different random order of conditions.
  - Works best when blocks are chosen such that each condition appears equally often in each location.
  - For example: ABCD, DABC, CDAB, BCDA, DCBA, ADCB, BADC, CBAD.

**Across-Subject Counterbalancing**

In this method, each subject receives just a subset of the condition orders used. This could be thus called "Between-Subjects Counterbalancing".

- **Complete Counterbalancing.**
  - All possible orders are used but each subject only gets one order.
  - For 2 conditions: Subject 1 gets AB; Subject 2 gets BA.
  - For 3 conditions: S1 gets ABC; S2 gets BCA; S3 gets CAB; S4 gets ACB; S5 gets BAC; S6 gets CBA.
  - Note that the number of possible orders (and thus the number of subjects required) is \( N! \). Thus, 4 conditions yields 24 orders & thus requires 24 subjects, 5 yields/requires 120, and 6 yields/requires 720!

- **Partial Counterbalancing.**
  - Used when there are many conditions or trials within a condition.
  - Only a subset of possible orders are used; S gets one or more subset.
  - Three main types: Randomized Partial, Latin Square, Balanced Latin Square.
Across-Subject Partial Counterbalancing

- Randomized Partial Counterbalancing.
  - Each subject is given a different random order of conditions or trials.
  - Used when the number of conditions (or trial orders) is far larger than the number of subjects.

- Latin Square Counterbalancing.
  - Presenting a subset of conditions orders such that each condition appears once and only once in each position.
  - The number of subjects required is equal to the number of conditions (in this case, 5).

- Balanced Latin Square Counterbalancing.
  - Same as the above with the additional restriction that any condition comes before or after any other condition an equal number of times.
  - Balanced Latin Square can only be created when there are an even number of conditions.

Making Order a (Between-Subject) IV

<table>
<thead>
<tr>
<th>Population (external validity)</th>
<th>Within Subject IV</th>
<th>Between Subject IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition A</td>
<td>Condition B</td>
<td></td>
</tr>
<tr>
<td>Condition B</td>
<td>Condition A</td>
<td></td>
</tr>
</tbody>
</table>

Condition Order (Between Subjects)

<table>
<thead>
<tr>
<th>AB</th>
<th>BA</th>
</tr>
</thead>
<tbody>
<tr>
<td>.40</td>
<td>.60</td>
</tr>
<tr>
<td>.60</td>
<td>.80</td>
</tr>
</tbody>
</table>

Learning Method (Within Subjects)

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>.50</td>
<td>.70</td>
</tr>
</tbody>
</table>