**Week 4 Lecture 1**

A first step to making your experiment testable is defining your variables. There are four (4) types of variables:

**Independent variable** is the characteristic that you want to study or test. It is also known as a factor or as a manipulated variable. An experiment should have at least one (1) independent variable and each independent variable must have at least two (2) conditions or levels.

**Example:** If you were studying an input device, “input device” is your independent variable and the levels could be mouse, keyboard and joystick.

**Example:** If you are studying visualization type, “visualization” is your independent variable and, 2d, 3d, and augmented reality are the different levels.

There are two different types of effects associated with the independent variable:

**Main effect:** the effect that the independent variable has on the dependent variable (described below). There could possible be one main effect for each independent variable.

**Interaction Effect:** the effect that the combination of independent variables has on the dependent variable (described below). The total number of possible interaction effects is equal to the number of combinations where n is the number of independent variables and r is the number of variables you wish to test for interaction. The number of possible interaction effects = NcN+NcN-1+NcN-2+…+Nc2

The more independent variables, the more effects you will have.

**Example:** If one (1) independent variable is input device (mouse, keyboard and joystick) and another independent variable is the usage scenario (navigating a map or playing a game) there are two main effects and 1 (2c2) interaction effects. The main effects are change in dependent variable based on input device and change in dependent variable based on usage scenario. The interaction effects are change in the dependent variable based on both independent variables. This interaction is a 3x2 (read three by two) interaction. The number of numbers (2) tells you how many independent variables are involved. The first number (3) tells you how many levels there are for the first independent variable. The second number tells you how many levels there are for the second independent variable.

**Example:** If an experiment has 4 independent variables, there could possibly be 4c2+4c3+4c4 =11 interaction effects. An experiment with 6 independent variables could have up to 57 interaction effects.
The **dependent variable** is the measured response to the independent variable. The more clearly the dependent variable is defined, the more precise and reproducible the experiment. It’s the data that will be collected. Dependent variables can be quantitative or qualitative.

**Examples:** task time completion, error rate, and satisfaction.

The **control variable** is everything you keep constant in the experiment. The more things you control, you are increasing internal validity and decreasing the amount of randomness (described below). On the other hand, the more you control, the less external validity, the less generalizable. When looking for variables to control, you must strike a balance between what you control and what you allow to be random. If you control too many variables, the experiment might not be generalizable. However, if you allow too many variables to be random, it may impact your ability to determine if your independent variable had any affect.

**Example:** The purpose of one experiment is to test the effect of font color on reading comprehension. The independent variable is font color and the dependent variable is reading comprehension measured by the number of correct responses to questions about the text. Some control variables could be size of font, font family, screen brightness etc.

Finally, the **random variables** are variables you can’t (or don’t) control for.

**Example:** An experimenter asks: Does stance affect performance on Guitar hero? The independent variable would be stance (sitting or standing). The dependent variable would be performance measured by score. The control variable could be, among others, the songs the user performs/plays. One random variable could be the participant’s experience on guitar hero. This would mean that you accept users who are new to the game as well as those who have been playing for years. The tradeoff is that while the experiment is realistic and reproducible but including first time users could be an issue. Was performance affected by stance or by the user’s lack of experience? Another random variable could be ambient noise. If you allow ambient noise to be random, you are not conducting the experiment in a sound proof room. This makes the experiment more realistic but could the noises outside your experiment room be distracting to users, affecting their performance?

When redesigning an experiment, one thing to do is to go back and determine what random variables should be controlled. What you control and leave random could possibly impact your experiment differently.
## Summary

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Definition</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Independent Variable</td>
<td>The variable that you are studying or testing. Also known as the manipulated variable. Must have at least one with at least 2 levels.</td>
<td>Size of laptop (13 inch, 15 inch, 17 inch)</td>
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<tr>
<td>Dependent Variable</td>
<td>The data that is collected. It is the measured response to the independent variable.</td>
<td>Number of mistakes made when typing a passage.</td>
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<tr>
<td>Control Variable</td>
<td>The value(s)/variables/settings that you keep constant in an experiment.</td>
<td>The passage being typed, the lighting in the room, the brightness of the screen, the text editor used.</td>
</tr>
<tr>
<td>Random Variable</td>
<td>The value(s)/variables/settings that you don’t or can’t control.</td>
<td>Size of participant’s hand, the speed at which participants type, familiarity with the passage, familiarity with typing</td>
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</tbody>
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