**WHICH BETWEEN-SUBJECT ANALYSES SHOULD I USE?**

**by Simon Moss**

 Between-subject analyses are utilized to compare distinct groups of people, animals, objects, and so forth on some measure or measures. A variety of alternatives are available, such as independent t-tests, ANOVAs, ANCOVAs, MANOVAs, MANCOVAs, discriminant function analysis, chi-square test-of independence, and logistic regression analysis. To decide between these alternatives, you need to answer five questions.

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| **Number of grouping variables** |

 You first need to identify the number of grouping variables—sometimes called between-subject factors or independent variables. A grouping variable is some characteristic that differentiates the groups. To illustrate

* Suppose you want to compare the effects of three medications—A, B, and C—on the weight of individuals. Although you want to compare three medications, this design actually comprises only one grouping variable: type of medication
* Suppose you want to examine whether gender and hair color affects income. That is, you want to compare male blonds, female blondes, male brunettes, and female brunettes. This design actually comprises two grouping variables: gender and hair color.

 Research designs will tend to comprise one, two, or three grouping variables at the most.

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| **Number of levels for each grouping variable** |

 Grouping variables comprise two or more categories, often called levels. In the previous examples

* Medication comprised three levels: A, B, and C
* Gender comprised two levels—male and female—but could of course comprise more levels, such as male, female, and intersex
* Hair color comprised two levels—blond and brown—but could also comprise more levels, including red.

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| **Numerical versus categorical measures** |

 This cluster of techniques is designed to compare groups on measures such as weight, income, personality, yield, and so forth. These measures are sometimes called dependent variables—because they are dependent upon the grouping variable or independent variable.

 Imagine you ask 10 males and 10 females to specify their confidence on a scale from 1 to 10 and then to indicate whether they prefer to read online books or actual books. In this example, confidence is a numeric variable: Each person is assigned a number. In contrast, reading preference is a categorical variable: Each person is assigned a category, such as online or actual.

 Even if we coded online books as 0 and actual books as 1, reading preference would still be a categorical variable. The numbers 0 and 1 are merely symbols to represent categories. They are not true numbers. For example, actual books, or 1, are not actually higher than online books, or 0.

 You now need to reach these decisions. In particular

* Specify whether your measures are numeric or categorical
* If some measures are numeric and some measures are categorical, separate this research question into two. That is, at this time, examine only the numerical measures or only the categorical measures
* You might feel that some of your measures are rankings, sometimes called ordinal. In this instance, you probably should conduct non-parametric statistics instead.

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| **Number of measures** |

 Next, you need to ascertain the number of measures. In particular,

* Often, your analysis will include only one measure, such as confidence, weight, income, and so forth
* Sometimes, your analysis will include more than one measure.
* However, if none of your measures belong to the same category, examine each measure separately—and therefore examine one measure at a time.
* For example, suppose the measures include five personality traits, such as the degree to which individuals are extraverted, conscientious, and agreeable. In this instance, you would probably examine each measure in the same analysis
* In contrast, suppose the measures include income, weight, extraversion, and eye color. These measures are unrelated to each other—and will usually be examined in separate analyses. And each analysis might examine only measure at a time.

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| **Control variables** |

 Finally, you might want to include what are called control variables. To illustrate, suppose you want to examine whether reading actual books, rather than electronic or eBooks, enhances social skills. You generate the following results.

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| Data from this study |
|  Which books they prefer | Social skills—as measured by a special test | Age group  |
| Hard copy | 8 | Old |
| Hard copy | 8 | Old |
| Hard copy | 9 | Old |
| Hard copy | 6 | Old |
| Hard copy | 3 | Young |
| Hard copy | 4 | Young |
| Electronic | 3 | Young |
| Electronic | 2 | Young |
| Electronic | 3 | Young |
| Electronic | 5 | Young |
| Electronic | 6 | Old |
| Electronic | 5 | Old |

 In this table, each row corresponds to one person. This table generates some interesting conclusions

* If you scan the first two columns, you will conclude that people who read hard copy rather than eBooks develop greater social skills: that is, the higher scores tend to coincide with hard copy
* But another explanation is possible. Perhaps older people tend to read hard copy as well as exhibit greater social skills
* So, to assess whether reading hard copy actually enhances social skills, the researcher needs to control age. For example, the researcher needs to examine only older individuals or only younger individuals.
* Indeed, as the following table shows, if you only examine the younger individuals, whether or not social skills is greater in people who read hard copy books rather than eBooks is not as apparent
* In short, we should control variables that could affect both the grouping variable and the measure, such as age—called spurious variables

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| Data from this study |
|  Which books they prefer | Social skills—as measured by a special test | Age group  |
| Hard copy | 8 | Old |
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| Hard copy | 9 | Old |
| Hard copy | 6 | Old |
| Hard copy | 3 | Young |
| Hard copy | 4 | Young |
| Electronic | 3 | Young |
| Electronic | 2 | Young |
| Electronic | 3 | Young |
| Electronic | 5 | Young |
| Electronic | 6 | Old |
| Electronic | 5 | Old |

 Besides spurious variables, researchers might also want control variables for other reasons. In particular, the measures or manipulations are sometimes contaminated or confounded with other variables. To illustrate, perhaps the measure of social skills is confounded with language. That is

* People who speak English fluently, might perform well on this test, even if their social skills are only modest
* People who do not speak English fluently might perform inadequately on this test, even if their social skills are actually good.

Consequently, as the table below shows

* If you scan the first two columns, you will conclude that people who read hard copy rather than eBooks develop greater social skills: that is, the higher scores tend to coincide with hard copy
* But if you now orient your attention only to the individuals who speak English fluently, the conclusion is not as obvious.

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| Data from this study |
|  Which books they prefer | Social skills—as measured by a special test | English  |
| Hard copy | 8 | Fluent |
| Hard copy | 8 | Fluent |
| Hard copy | 9 | Fluent |
| Hard copy | 6 | Fluent |
| Hard copy | 3 | Not fluent |
| Hard copy | 4 | Not fluent |
| Electronic | 3 | Not fluent |
| Electronic | 2 | Not fluent |
| Electronic | 3 | Not fluent |
| Electronic | 5 | Not fluent |
| Electronic | 6 | Fluent |
| Electronic | 5 | Fluent |

 In short, at times, you might want to control variables, such as age or fluency in English. You can apply two approaches to control variables:

* You can examine only a subset of participants, such as the people who are young or the people who speak English fluently
* Or you can utilize statistical tests to predict what the results would be if you controlled variables—such as if the participants were average on age.

 So, when should you control variables? You should control variables whenever you have collected information about a variable, such as age, that is likely to be strongly associated with the measures. Age is likely to be associated with social skills—that is, older people have often developed better social skills—so age should be controlled. Height is not as likely to be associated with social skills, so height might not need to be controlled.

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| **Table of alternatives** |

 Once you have answered the previous questions, you should utilize the following table to ascertain which technique to utilize.

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| Table to decide which test to utilize |
| Number of grouping variables  | Number of levels in grouping variables  | Numerical or categorical measures | Number of measures | Do you want to control variables as well |  Technique |
| 1 | 2  | Numerical  | 1 | No  | Independent samples t-test |
| 1 | More than 2 | Numerical  | 1 | No | One-way ANOVA |
| 1 | Does not matter | Numerical  | 1 | Yes | One-way ANCOVA |
| 1 | Does not matter | Numerical  | More than 1 | No | One-way MANOVA |
| 1 | Does not matter | Numerical  | More than 1 | Yes | One-way MANCOVA |
| 1 | More than 2 | Numerical  | More than 1 | No | Discriminant function analysis |
| 1 | Does not matter | Categorical | 1 | No | Chi-square test of independence |
| 1 | 2 | Categorical | 1 | Yes | Binary logistic regression |
| 2 | Does not matter | Numerical  | 1 | No | Two-way ANOVA |
| 2 | Does not matter | Numerical  | 1 | Yes | Two-way ANCOVA |
| 2 | Does not matter | Numerical  | More than 1 | No | Two-way MANOVA |
| 2 | Does not matter | Numerical  | More than 1 | Yes | Two-way MANCOVA |
| 3 | Does not matter | Numerical  | 1 | No | Three-way ANOVA |
| 3 | Does not matter | Numerical  | 1 | Yes | Three-way ANCOVA |
| 3 | Does not matter | Numerical  | More than 1 | No | Three-way MANOVA |
| 3 | Does not matter | Numerical  | More than 1 | Yes | Three-way MANCOVA |
| 1 | 2 | Numerical, categorical, or both | More than 1 | Does not matter | Binary logistic regression |