Background & Requirements

If you know little about the three-way repeated measures ANOVA, you are most likely to benefit from reading about the basic requirements that must be met to run a three-way repeated measures ANOVA, as well as the background to understanding the three-way repeated measures ANOVA.

Basic requirements when running a three-way repeated measures ANOVA

In order to run a three-way repeated measures ANOVA, there are five assumptions that need to be considered. The first two relate to your choice of study design, whilst the other three reflect the nature of your data:

- Assumption #1: You have **one dependent variable** that is measured at the **continuous** level (i.e., it is measured at the **interval** or **ratio** level). Examples of continuous variables include revision time (measured in hours), intelligence (measured using IQ score), exam performance (measured from 0 to 100), weight (measured in kg), and so forth. You can learn more about continuous variables in our article: Types of Variable.
- Assumption #2: You have **three within-subjects factors** where each within-subjects factor consists of **two or more categorical levels**. These are two particularly important terms that you will need to understand in order to work through this guide; that is, a "within-subjects factor" and "levels". Both terms are explained below:

  A **factor** is another name for an **independent variable**. However, we use the term "factor" instead of "independent variable" throughout this guide because in a repeated measures ANOVA, the independent variable is often referred to as the **within-subjects factor**. The "within-subjects" part simply means that the same cases (e.g., participants) are either: (a) measured on the same dependent variable at the same "time points"; or (b) measured on the same dependent variable whilst undergoing the same "conditions" (also known as "treatments"). For example, you might have measured 10 individuals' 100m sprint times (the dependent variable) on five occasions (i.e., five time points) during the athletics season to determine whether their sprint performance improved. Alternately, you may have measured 20 individuals' task performance (the dependent variable) when working in three different lighting conditions (e.g., red, blue and natural lighting) to determine whether task performance was affected by the colour lighting in the room. For now, all you need to know is that a within-subjects factor is another name for an independent variable in a three-way repeated measures ANOVA where the same cases (e.g., participants) are measured on the same dependent variable on two or more occasions.

  When referring to a within-subjects factor, we also talk about it having "levels". More specifically, a within-subjects factor has "categorical" levels, which means that it is measured on a **nominal**, **ordinal** or **discrete-time** scale. Such ordinal or discrete-time variables in a three-way repeated measures ANOVA are typically two or more "time points" (e.g., two time points where the dependent variable is measured "pre-intervention" and "post-intervention"; three time points where the dependent variable is measured: "pre-intervention", "post-intervention" and "6-month follow-up"; or four time points where the dependent variable is measured: at "10 secs", "20 secs", "30 secs" and "40 secs"). Such nominal variables in a two-way repeated measures ANOVA are typically two or more "conditions" (e.g., two conditions where the dependent variable is measured: a "control" and an "intervention"; three conditions where the dependent variable is measured: a "control", "intervention A" and "intervention B"; or four conditions where the dependent variable is measured: in a room with "red lighting", "blue lighting", yellow lighting" and "natural lighting"). The number of time points or conditions are referred to as "levels" of the ordinal, nominal or discrete-time variable (e.g., three time points reflects three levels). Therefore, when we refer to a "level" of a within-subjects factor in the guide, we are only referring to "one" level (e.g., the room with "red lighting" or the room with "blue lighting"). However, when we refer to "levels" of a within-subjects factor, we are referring to "two or more" levels (e.g., "red and blue" lighting, or "red, blue and yellow" lighting).

- Assumptions #3, #4 and #5: As discussed in more detail in our Assumptions I section later, a three-way repeated measures ANOVA must meet three assumptions that relate to the nature of your data in order to provide a valid result. These are that: (a) there should be no significant outliers in any cell of the design; (b) the dependent variable should be approximately normally distributed in every cell of the design; and (c) the variance of the differences between the levels of the independent variables should be equal (known as the assumption of sphericity). Since these are assumptions that you can test using SPSS Statistics, we show you how to do this in the Assumptions I section later.

Assuming that you are confident your study design meets assumptions #1 and #2 above, we explain the background to understanding the three-way repeated measures ANOVA in the section that follows.

Understanding the three-way repeated measures ANOVA

It is most often the case that the primary reason for running a three-way repeated measures ANOVA is to establish whether there is an interaction effect between three independent variables, sometimes called a three-way interaction effect. We explain in more detail below what is meant by an interaction effect and what it tells us about our data.

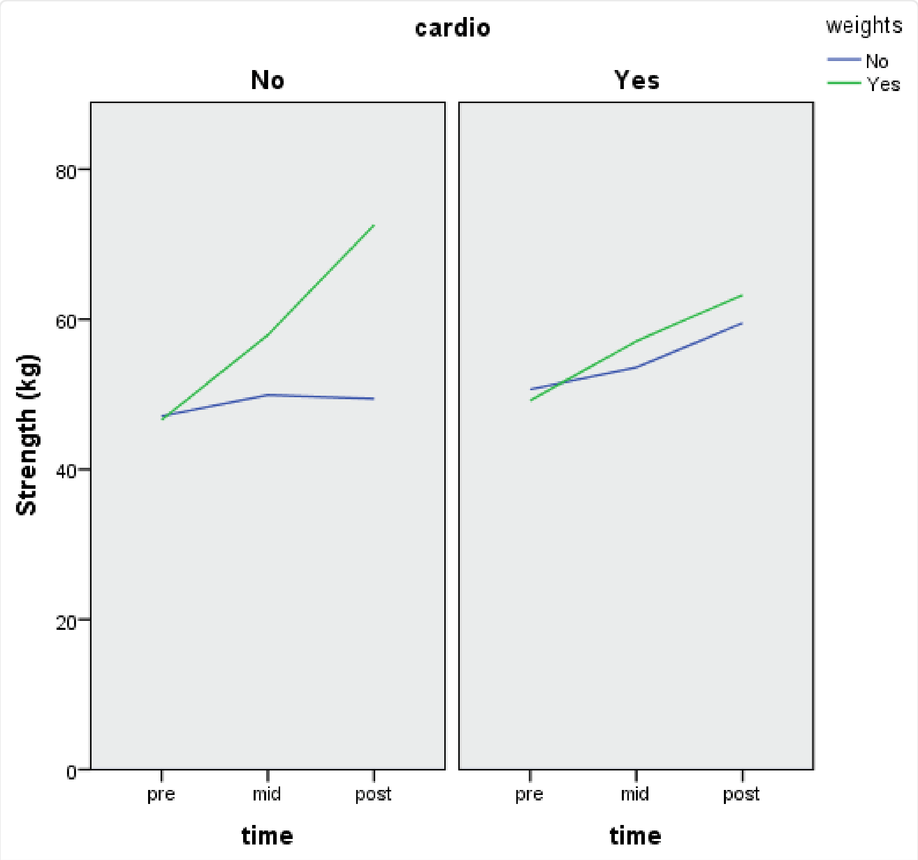
An interaction effect

In the simpler two-way repeated measures ANOVA, an interaction term between two independent variables is added to the effects of the independent variables alone to predict the dependent variable. This interaction is also referred to as a two-way interaction or two-way interaction effect. It allows the effect of one of the independent variables on the dependent variable to be dependent on the value of the other independent variable. For example, the effect of weight training (in a gym) on strength was tested in sedentary participants over a six week period with participants performing both the control (no weight training) and the weight training trial. The dependent variable is "strength" and the two independent variables are "weight training" (i.e., yes or no) and "time" (i.e., pre-, mid- and post-trial). In the two-way repeated measures ANOVA, not only is the effect of "weight training" and "time" calculated, but also the effect of their interaction (i.e., "weigh training*time"). If a statistically significant interaction is found, you can conclude that the effect of "weight training" on "strength" is dependent on the value of "time" (i.e., dependent on how long the trial has been running) and vice versa (i.e., the effect of "time" is dependent on the value of "weight training"; that is, whether weight training has been performed or not).

Theoretically, you might consider one of the independent variables as a **focal variable** and the other independent variable as a **moderator variable**. In this situation, the effect of the focal variable is your primary concern, but you think that its effect on the dependent variable depends on the value of the moderator variable. In our weight training example, the effect of time might be considered the focal variable. However, it is thought that the effect of time on strength will be different if weight training is performed or not. Hence, we think that "time" moderates the effect of "weight training" on "strength". We will see that this principle can be extended to the three-way repeated measures ANOVA.

A three-way repeated measures ANOVA extends the two-way repeated measures ANOVA by increasing the number of independent variables from two to three. In the two-way repeated measures ANOVA, both independent variables were allowed to interact (i.e., there was a two-way interaction). Likewise, in the three-way repeated measures ANOVA, all three independent variables are allowed to interact (i.e., there is a **three-way interaction**). The principles remain the same, only now you have to also account for the values of the third independent variable. Let us extend our weight training example by adding "cardio training" as a third independent variable. Let us, for the sake of understanding, consider this to be a second moderator variable. Having a (statistically significant) three-way interaction means that the effect of one independent variable on the dependent variable is dependent on the values of the two other independent variables. So, the effect of "time" on "strength" depends not only on "weight training", but also on "cardio training". Stated another way, the only way to accurately predict the effect of "time" on "strength" is to know if an individual performs "weight training" and/or "cardio training". Essentially, we are having to qualify our statements. So, if we are asked whether time has an effect of strength, we would have to answer, "it depends", and then qualify the effect based on whether weight training and/or cardio training were being performed. Continuing with our concept of moderation, "time" is still the focal variable, but there are now two moderator variables: "cardio training" and "weight training". The effect of "time" on "strength" is said to be moderated by "cardio training" and "weight training" combined.

Although the paragraphs above should give you a feel for a three-way interaction, a three-way interaction is more formally considered a difference in two-way interactions between the levels of a third independent variable. So, in our training example, a three-way interaction would be considered to exist if the two-way interactions between "weight training" and "time" are different for "cardio training" (i.e., different if cardio training is also undertaken). We can plot this situation below:



You can see above that there is a two-way interaction between "weight training" and "time" when either cardio training is performed or not (i.e., the levels of the third independent variable, "cardio training"). When a two-way interaction is considered at a specific level of a third independent variable, it is called a **simple two-way interaction**. If these two simple two-way interactions are different, you have a three-way interaction. Discovering whether you have a three-way interaction is generally considered the primary goal of a three-way repeated measures ANOVA. If these two simple two-way interactions are not different, you do not have a three-way interaction.

You should note that it does not matter which two variables are part of the simple two-way interactions and which is the third independent variable. The tests are symmetrical and the decision will most likely be based on any hypotheses or theoretical considerations you have.

Follow-up tests

Whilst determining whether you have a three-way repeated measures ANOVA is relatively straightforward, the follow-up analyses can be complicated and a pattern of testing is often required that examines the effects of variables and their interactions in a "hierarchical" manner. This can take considerable time and it is easy to get lost making a great number of tests. However, all follow-up tests revolve around a general principle that you might have learned with the two-way repeated measures ANOVA: if there is an interaction effect, the main effects are "compromised" and simple main effect must be run, but if an interaction effect does not exist, main effects would be reported. We explain the pattern of testing throughout the guide.

Error term

As you work through this guide, you will discover the importance of the error term in a three-way repeated measures ANOVA analysis. The reason is that the error term is different for the various statistical terms (e.g., the three-way interaction) and post hoc tests (e.g., simple two-way interactions) of the three-way repeated measures ANOVA. You will discover that to run post hoc tests with the separate error terms (aka restricted error terms) you simply treat each post hoc test as having come from a simpler design (Keppel & Wickens, 2004). Broadly speaking, the use of a restricted error term is "safer" from any violations of the assumption of sphericity whereas the pooled error terms have greater power – particularly with small sample sizes – but are susceptible to problems if there are is a violation of the assumption of sphericity. Again, this is something that we explain as you move through the guide.

Moving forward

After setting up your data in SPSS Statistics in the Example & Data Setup section, we will return to idea of testing the assumptions of the three-way repeated measures ANOVA in the Assumptions I, Procedure and Assumptions II sections of this guide. If you are working through this guide step-by-step, you should now read the next page.