# Research Methods and Statistics with R 3

# Week 2 – ANOVA I: One-Way ANOVAs in R

## Introduction to the session

In this session, you will perform a one-way ANOVA and compare the results to performing multiple comparisons through *t*-tests. You will also get the opportunity to practise your visualization skills in R by producing an appropriate graph(s) for a one-way experimental design.

The dataset we will use for this session is modelled after data collected as part of a previous **3rd Year BSc Neuroscience and Psychology Research Project.** As such, they are a *very good* representation of the kinds of data you might analyse next year.

## Background

The research study in question examined the effect of **response compatibility** on **The Automatic Imitation Effect [[1]](#footnote-1),** a phenomenon where people will unconsciously imitate movements, gestures, body language, etc. of individuals with whom they are interacting.

The experimental task required participants to first view a stimulus and then press either the left or right arrow key in response to an instruction cue. At the beginning of the session, the participants were instructed to place their **index finger over the left arrow key** and their **middle finger over the right arrow key**.

On each trial, the participant was presented with one of three stimuli: a distractor video of an actor pressing down their 1) index finger; 2) their middle finger, or 3) a still image of a hand. During each stimulus presentation, a prompt would appear telling the participant to press either the left or right arrow key (with their index or middle finger, respectively).

These stimuli were designed to elicit **the automatic imitation effect**, such that participants should be faster to initiate a movement when the distractor movement (the video clips) and the prompted movement (pressing left or right arrow) were **congruent** (C) as opposed to **incongruent** (I). It was hypothesised that the effect would result from **observation-induced motor activation**; that is, viewing an action evokes activation in the motor cortex necessary to produce it. The still image of the hand served as the baseline condition, where no observation-induced motor activation would occur.

The predictions in this type of design are as follows:

1. participants will produce **responses with shorter reaction times** in the congruent compared to baseline and incongruent conditions; and
2. participants will produce **responses with longer reaction times** in the incongruent trials relative to the baseline and congruent conditions.

Your task today will be to determine whether the data support the predictions. You have been provided with reaction time data for 120 participants: 40 participants per condition. Each row in the dataset represents the **mean reaction time (ms)** for all **congruent**, **incongruent**, and **baseline** trials for each of the 120 participants, one condition per participant group. N.B. This is not the usual way you would run this experiment – it would likely be run as a “within-subjects” design (where each participant was presented with each of the three conditions). However, for the purposes of this session, we are treating these data as if they are from an independent-samples (i.e., “between-subjects”) design.

## Learning Outcomes

By the end of this worksheet, you will:

1. Have performed one-way ANOVAs, including assumptions checks, using several different R functions
2. Be able to describe the difference between using multiple *t*-tests and a one-way ANOVA.
3. Have produced appropriate data visualizations for experimental designs with more than two groups.
4. Know how to report the results of an ANOVA in APA style.

## Procedure

1. We have simulated the data to be structured for an ANOVA. Load it with your favourite method, or maybe try **rio::import()**. Inspect your data to make sure they have imported appropriately. Pay particular attention to the variable types.
2. Compute descriptive statistics **for each condition (congruent vs. incongruent vs. baseline).** Here, you might find useful to look at the use of **tapply()** or **stats::aggregate()**, or to refer back to the {psych} package used last year (in which **psych::describeBy()** could be useful). What is your dependent variable? In which column is your independent variable?
3. Decide what would be an appropriate data visualization for such an experimental design with three groups and produce it. You will likely find {ggplot2} to be the most useful package for this.
4. Search for how to perform a one-way ANOVA with R and apply the method(s) you find, using the proper syntax. **Do not worry about finding the “right” one: as many things in R, there is no single way to do it.** Compute the ANOVA and save it to an object *without inspecting its output.* You should try at least three different methods.Here is a list of potential candidates to help you out. **Consult the lecture slides and Function Help for guidance on the precise syntax[[2]](#footnote-2):**
   * aov()
   * lm()
   * rstatix::anova\_test()
   * afex::aov\_ez()
   * ez::ezANOVA()
5. Investigate how you can inspect if the ANOVA assumptions are met and apply these methods on the provided dataset. This would include QQ plots and histograms, as well as the Shapiro-Wilk and Levene’s tests. You can refer back to lecture material on this.
6. Now that you have checked the assumptions, you can call your ANOVA object to see the output. You will most likely find that **summary(my\_ANOVA\_object)** is the most useful here (it works for both main ANOVA methods that we expect you to discover in your search) – though some of the other functions listed above use slightly different syntax. Again, consult the lecture slides and Function Help for guidance on the precise syntax.
7. Now, run the analyses as you did last year for the lab report, comparing each group to each other, pairwise.Take note ofthe differences between the findings with each method and refer back to the lecture material if you are not sure why such differences happen. **How many contrasts will you need? What is the corresponding family-wise error**?
8. Look up for psychology research papers reporting one-way ANOVAs and look at how they report their results. Make sure to look for papers published after 2020 to access the most up-to-date examples; journals published by the APA are also a safe bet to ensure you are seeing APA-based examples (e.g., any *Journal of Experimental Psychology: …*). Based on this, write your *F* statement in APA style. This shouldn’t require more than 2-3 sentences. Consult the lecture material for an example of how to report the results of a one-way ANOVA according to APA formatting guidelines.

## Coding/Knowledge Challenge

The dataset has been provided to you with the column for your independent variable labelled “condition” (with congruent, incongruent, and baseline). There is an additional column labelled “condition\_num”, which has condition coded by number (congruent = 1, incongruent = -1, and baseline = 0). Try running the ANOVA using this column as your independent variable. Do you get the same results? If not, why not? How can you fix the problem? *HINT*: What is one of the requirements for the independent variable in an ANOVA? Specifically with respect to the **type** **of** **variable?**

## Version History

* V1.0 (Sept 2023) – completed draft, posted to KEATS
* V1.1 (Sept 2023) – minor edits
* V.1.2 (Oct 2, 2023) – fixed Anova.test() -> anova\_test(); made clear the design is independent samples, not repeated measures

1. Catmur C. and Enns, J.T. Automatic imitation? Imitative compatibility affects responses at high perceptual load. J Exp Psychol Hum Percept Perform. 2016 Apr;42(4):530-9. doi: 10.1037/xhp0000166. Epub 2015 Nov 16. PMID: 26569336.

   Heyes C. Automatic imitation. Psychol Bull. 2011 May;137(3):463-83. doi: 10.1037/a0022288. PMID: 21280938. [↑](#footnote-ref-1)
2. “Hey! Why are you telling me to consult the lecture slides/function help and not just telling me the answer?” For two reasons: first, because you’re now skilled and experienced enough that you should be able to at least know where to look for answers to questions like this. **Two, and more importantly, one of your summative assessments will require you to learn about new R functions entirely by yourself.** This exercise will help you learn to interpret online help files, which can sometimes be a bit dense. You are, of course, welcome to ask for help interpreting what you find – but we would like you to at least try to figure it out on your own first. [↑](#footnote-ref-2)