

Research Methods II, Module 2, Autumn 2002: Two-way ANOVA and Interactions

The experiment used in this module is on text comprehension. The purpose of the experiment is to compare men and women's comprehension of two different types of text, for example science fiction and romance. One group of men reads a science fiction passage, another reads a romance passage, and similarly one group of women reads the science fiction passage and another reads the romance. After reading the text, all subjects answer a set of comprehension questions appropriate to the text they have just read.

Comprehension can be measured using recall or questions about the text. Recall can be used as an indirect measure of comprehension because according to research on levels of processing, the better subjects understand the text in the first place (the deeper their processing of it), the better their recall will be. Questions can be multiple choice or short answers. Think about the sort of issues your questions are about: stated facts or inferences? Peripheral details or central issues? Try to balance the different types of questions across the texts.

Some terminology:

The dependent variable (what is measured) in this experiment is score on the comprehension questions.

There are two independent variables (set by the experimenter), also called factors: gender and text type.

The factors have levels, in this case each factor has two levels: male vs. female and sci.-fi. vs. romance, respectively.

This makes a 2x2 design (each number refers to the number of levels of each factor), to be analysed using a 2-way ANOVA (an n-way ANOVA has n factors).

There are four conditions which consist of all the possible combinations of the two levels of each of the two factors, i.e. male-sci.-fi., female-sci.-fi., male-romance and female-romance. Because all combinations are used the design is called "fully factorial".

In the results of the experiment, we are interested in two main effects, which are the overall effects of gender and of text type, and in the interaction between the two factors, which is one factor having different effects depending on the level of the other factor. To find the main effect of a one variable – for example, text type – you average over all levels of the other variable, e.g. gender. So find the average score for romance (averaging over males and females) and the average score for science fiction (averaging over males and females). If there is a significant difference between the average romance score and the average science fiction score, then there is a main effect of text type. The interaction is NOT "the combined effect of both variables", it is a different effect of one variable according to the level of the other variable. For example, find the effect of gender on science fiction by taking the difference: (male score – female score) on just the science fiction text. Now find the effect of gender on romance by taking the difference: (male score – female score) on just the romance text. If these effects are different then there is an interaction. In other words, an interaction is a difference of differences: (male score on romance – female score on romance) - (male score on science fiction – female score on science fiction).

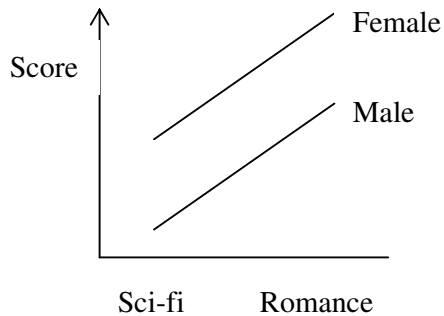
These effects can be interpreted geometrically, as illustrated in the graphs below (treat the graphs as graphs of population means). To find a main effect of gender, find the point half way along the male line and the point half way along the

female line. If these points are different in height there is a main effect of gender. To find the main effect of text type, find the point midway between men and women for romance, and the point midway between men and women for science fiction. If these points are different in height, there is a main effect of text type. If the lines are parallel, there is no interaction. Any way in which the lines are not parallel indicates an interaction.

These are illustrated below:

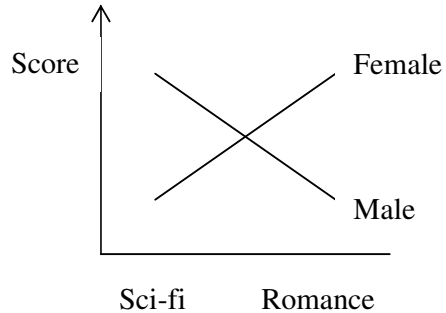
Possible results:

A.



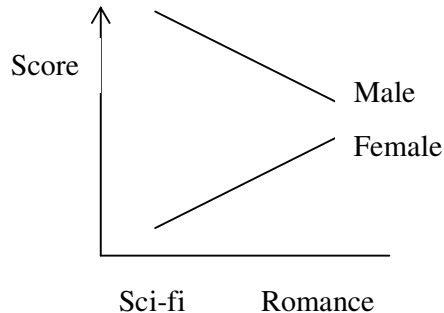
Main effect of gender: women score more than men.
Main effect of text type: romance is easier than sci-fi.
No interaction

B.



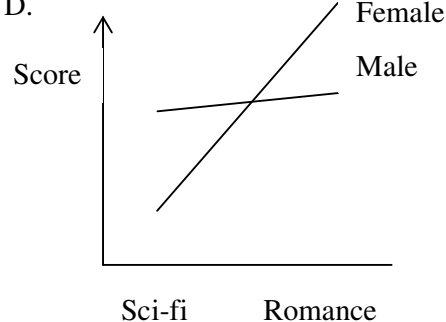
No main effect of gender: male and female scores equal overall.
No main effect of text type: sci-fi and romance equally easy.
Interaction: men score more on sci-fi than romance and women score more on romance than sci-fi.

C.



Main effect of gender: men score more than women overall.
No main effect of text type: sci-fi and romance equally easy.
Interaction: men score more on sci-fi than romance and women score more on romance than sci-fi.

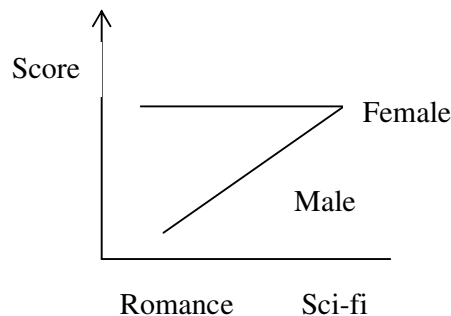
D.



Main effect of gender: no difference between men and women overall.
Main effect of text type: romance easier than sci-fi.
Interaction: romance easier for women than men and sci-fi easier for men than women

These graphs don't show all the possible results that you could get from this experiment, but they illustrate four patterns, showing various combinations of the two main effects and the interaction between them. Make sure you can draw other patterns, including graphs which show just one effect and no others, for each of the effects.

If you obtain a significant interaction, you can analyse it further with simple effects. A simple effect means the effect of one independent variable at just one level of another independent variable. So the simple effect of gender at each level of text is the difference between men and women for just the romance text; and the difference between men and women for just the sci fi text. The simple effects of text are the difference between sci-fi and romance for each gender. You must always be clear which simple effect you are describing. Consider the statement: “The men were better at sci-fi”. That is incomplete by itself. The graph below shows that the men were better at sci-fi than romance (simple effect of text). But the men were NOT better at sci-fi than the women (simple effect of gender).



Another way of representing possible results of this experiment:

	Sci-fi	Romance	MEAN
Male	7	3	5
Female	3	7	5
MEAN	5	5	5

Gender: No main effect ($5-5 = 0$).
 Text type: No main effect ($5-5 = 0$).
 There is an interaction: The simple effect of text type for males is ($7-3 = 4$); the simple effect of text type for females is ($3-7 = -4$). These effects are different ($4 - -4 = 8$).

	Sci-fi	Romance	MEAN
Male	7	5	6
Female	3	9	6
MEAN	5	7	6

Gender: No main effect ($6-6=0$).
 Text type: There is a main effect ($5-7 = -2$).
 There is an interaction: The simple effect of text type for males is 2; the simple effect for females is -6 . These effects are different.

The two-way ANOVA tests each of the three effects (two main effects and one interaction). Whereas the one-way ANOVA summary table had three rows: Treatment, error and total, the two-way ANOVA summary table has five rows: Main effect of gender, main effect of text type, interaction, error and total. Each of the first three of these is equivalent to the treatment row of the one-way ANOVA, so instead of one result to read off, there are three, which is done in exactly the same way as for the one-way ANOVA. The three effects are independent of each other, so, for example, whether the interaction is significant or not doesn't depend on whether the main effects are significant. The logic is just the same as a one-way ANOVA for each effect: For the main effect of gender, is the variability between the overall male mean and the overall female mean more than would be expected given the within-group variability? For the interaction, is the difference between the differences more than would be expected given the within-group variability?

References

- McKelvie, S.J., Standing, L., St. Jean, D. and Law, J. (1993). Gender differences recognition memory for faces and cars: Evidence for the interest hypothesis. *Bulletin of the Psychonomic Society*, **31**, 447-448.
- Spilich, G. J., Vesonder, G. T., Chiesi, H. L., & Voss, J. F. (1979). Text processing of domain related information for individuals with high and low domain knowledge. *Journal of Verbal Learning and Verbal Behaviour*, **18**, 275-290.