

Research Methods II, Spring Term 2004: Two-way ANOVA and Interactions

Your task:

Your aim this session is to design (in groups of 3-5 people) an experiment using two between-subject independent variables each with two levels. You can design any experiment you can practically run over the next month, but I will give you an example experiment to get you thinking.

The example experiment was in fact designed on this course a few years ago by a group of undergraduates, and it worked so well, I have used it for this module ever since. 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. In the original experiment, one group of men read a science fiction passage, another read a romance passage, and similarly one group of women read the science fiction passage and another read the romance. After reading the text, all subjects answered a set of comprehension questions appropriate to the text they had just read. The original students running this project found that the men understood the science fiction passage better than the women, but the women understood the romance better than the men. (The men got lost after the bit where she said "Do you love me?") The results demonstrated an interaction between gender and text type.

For your experiment, think of some text materials men may understand better than women, and some materials women may understand better than men. 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. You can measure recall by pre-determining a set of key concepts, and then scoring one point for each concept to appear in the subject's recall script. 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. For short answers, you will need to make a judgement about how much understanding each answer shows. To check how reliably you are rating the answers, it would be good for you and another member of your group to mark some of the same answers and determine how well your scores correlate with each other (this is called "inter-rater reliability").

In planning your experiment, think about whether you predict any main effects or interaction. Finalize your design in the session today, and make sure you have checked your design with a tutor before leaving. Then prepare actual materials and run subjects over the next few weeks; you should have collected all data by week 8, which is when we meet for this module again. You will analyze the data in the week 8 session. The deadline for submitting the write-up is 4pm Thursday of week 10 at the Psychology Office.

Statistical concepts:

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 (not to be confused with the factors of factor analysis): 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”.

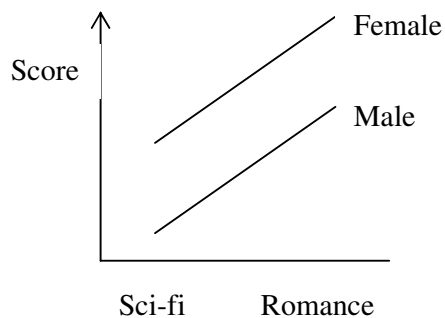
In the results of the experiment, we are interested in two main effects, which are the overall effects of gender and of text type, and in the interaction between the two factors, which is one factor having different effects depending on the level of the other factor. To find the main effect of a one 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 comprehension for just science fiction by taking the difference: (male score – female score) on just the science fiction text. Now find the effect of gender on comprehension for just 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:

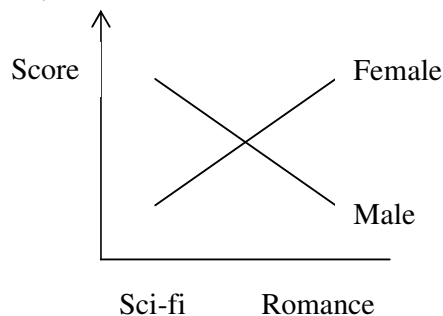
Possible results:

A.

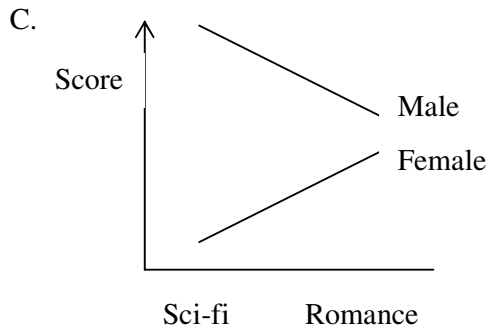


Main effect of gender: women score more than men.
Main effect of text type: romance is easier than sci-fi.
No interaction

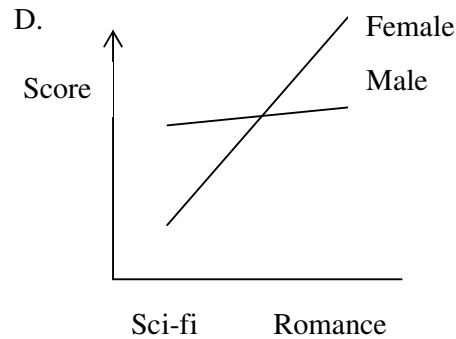
B.



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.



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.



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.

Another way of representing possible results of this experiment:

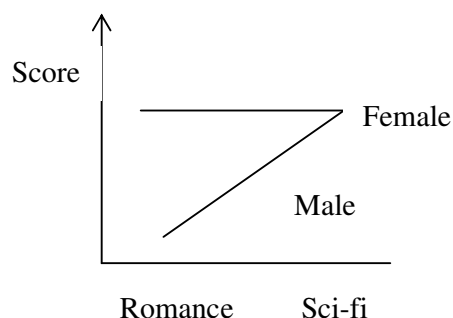
	Sci-fi	Romance	MEAN
Male	7	3	5
Female	3	7	5
MEAN	5	5	5

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.

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).



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.

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