Experimental Inference

Proof reading and error rate

An investigator does a study on proofreading for typographical errors. There are three levels of the independent variable (three conditions), distinguished by the number of errors per line. In one case there is one error per every 5 lines, in another one error per every 10 lines, and in the third one error per every 20 lines. The three typescripts are exactly the same except for the typographical errors inserted. Random groups are used and the subjects are instructed to go through the script as rapidly as possible, identifying all errors with a slash. For the dependent variable (response measure), the investigator uses the mean number of failures to detect an error. For the three levels, these values are 5.0, 4.9, and 5.1. These do not differ reliably.

The investigator concludes that the error rate is independent of the number of to-be-detected errors.
This is probably an inappropriate conclusion. Why?

Learning to Learn

An investigator set about to get a definitive answer on progressive changes in learning as a function of practice (learning-to learn) for free-recall lists. He decided to study learning-to learn as a function of 2, 4, 6, 8, and 10 successive lists. Five different random groups were used, the subjects being assigned to the five conditions (2, 4,6, 8, or 10 lists) by a block-randomized schedule. In terms of method, procedure, balancing of lists, and so on, the experiment was immaculate.

However, we would have to say it was a very inefficient way to obtain the information he sought.

Why?

What is a better way of doing this study?

Infant nutrition

An investigator developed the idea that an excess of a certain chemical in the brain during infancy produced permanent mental retardation. To gather evidence germane to this notion, he used two groups of 15 newborn monkeys each. The 30 babies were assigned to the groups by a block-randomized schedule. One group, the C Group, was nursed by the mother monkeys, and it is assumed that the investigator could measure the amount of milk consumed. The other group, the E Group, was fed by bottle, but the milk was of exactly the same kind and of the same amount as that received by the naturally-fed monkeys. Of course, the baby monkeys in the E Group were separated from the mothers so that they would not nurse from them and thereby get more milk than those in the C Group. The independent variable X was given to the E Group by including the chemical in the nursing bottle. Tests of mental development were made on both groups at various points in time, even far beyond the nursing period. At every point of testing the monkeys in the E Group were found to be inferior to those the C Group. Such a finding would support the idea prompting the experiment.

a) The independent variable is confounded. How?

b) Should it be concluded that X is not responsible for the observed differences?

Antiallergenic drugs

A prominent pharmaceutical company wishes to test the effects of a new allergy drug, Drug X. They gather a sample of people with a certain minimal allergy level and randomly assign them to one of two conditions: 100 mg of X and a control group that was given no drug. They discovered that the subjects in the drug condition had a significant reduction in allergy symptoms but those in the control group did not. They concluded that Drug X is effective in fighting allergies and should be sold to the public.

Do the conclusions follow?

How could this study be improved?

Vitamin C and health

An experimenter wanted to test whether rats treated with Vitamin C were healthier than rats that received no Vitamin C. In order to test his hypothesis that Vitamin C would be beneficial to rats' health, he bought 40 random rats and placed them in a box. There were two conditions, a Vitamin C condition in which rats were given Vitamin C for several weeks and a control condition in which rats were not given Vitamin C. The researcher assigned rats to each condition by reaching into the box and randomly picking out rats. The first 20 rats picked from the box were assigned to the control condition, and the remaining 20 were assigned to the Vitamin C condition. After several weeks, the researcher discovered that the rats that received Vitamin C were on average healthier than the control rats. He concluded that Vitamin C was beneficial to rats' health.

Does the conclusion follow?

How could this study be improved? Explain.

Interactions and main effects

I. Anova framework of “Rows”, “Columns”, “Interactions”

II. Regression framework of $IV_1 + IV_2 + IV_1 * IV_2$

III. The original ANOVA design comes from agricultural studies where one was crossing (e.g.,) seeds in rows with fertilizer in columns. Each plot of land was given a different condition.

IV. The use of the interaction was to see if different fertilizers had different effects upon different seeds.

Interactions and Main Effects

	IV_2-Low	IV_2-High	Row mean
IV_1 - High	Aa	AA	A.
IV_1 - Low	aa	aA	a.
Column mean	.a	.A	Grand mean

Row effect = A. - a. = Aa + AA - aa - aA =
(Aa+AA) - (aa + aA)

Column effect = .A - .a = AA + aA - Aa - aa
(AA + aA) - (Aa+aa)

Interaction effect (do the slopes differ) =
(AA + aa) - (Aa + aA)

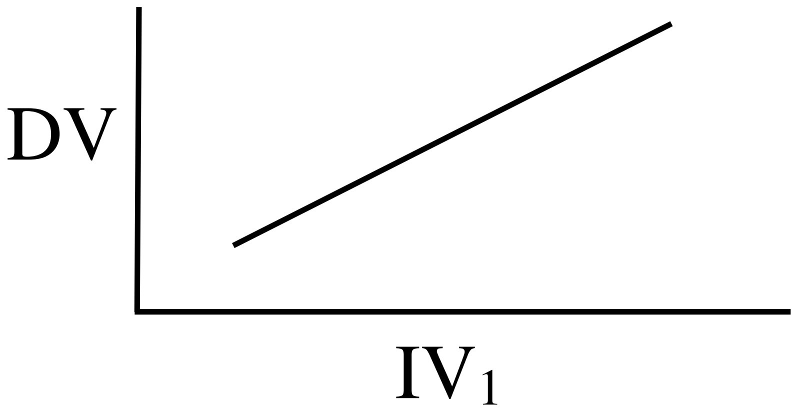
Anova as multiple t-tests

	IV_2-Low	IV_2-High	Row mean
IV_1 - High	Aa	AA	A.
IV_1 - Low	aa	aA	a.
Column mean	.a	.A	Grand mean

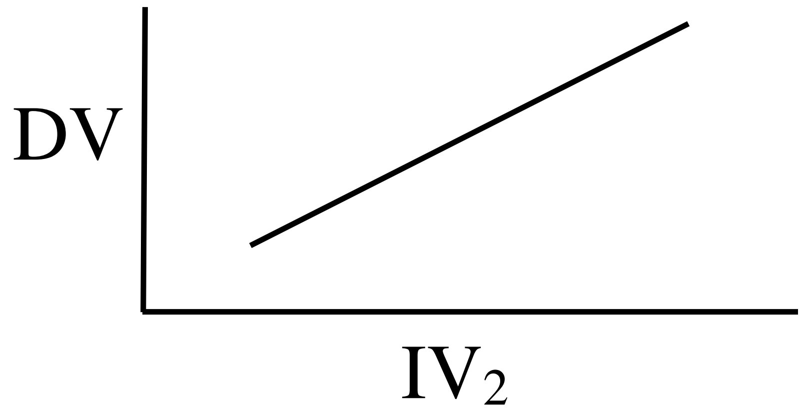
Cells	Aa	AA	aa	aA
rows	-1	1	-1	1
columns	-1	-1	1	1
interaction	1	-1	-1	1

Anova as regression

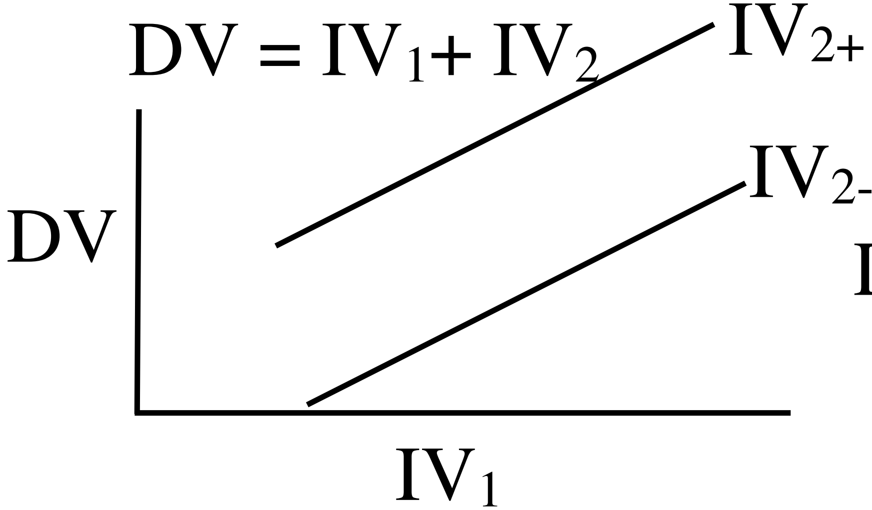
$DV = IV_1$



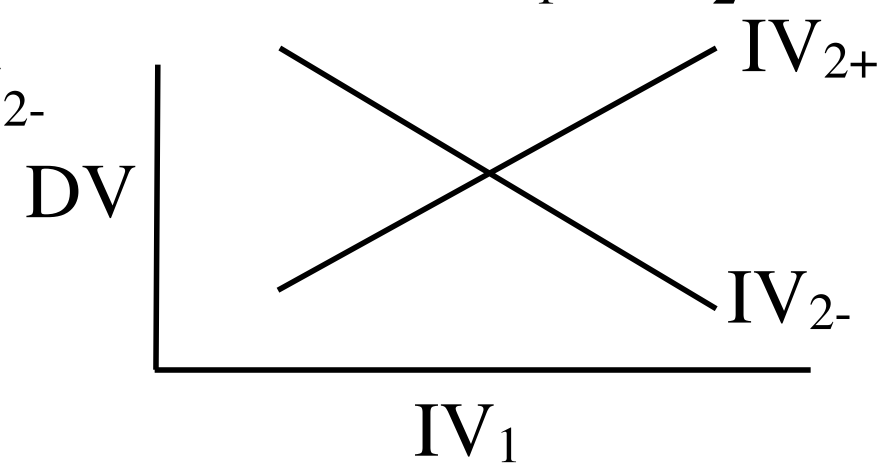
$DV = IV_2$



$DV = IV_1 + IV_2$



$DV = IV_1 * IV_2$



Anova and regression: The importance of graphics

```
 my.data <- read.clipboard.tab()
> my.data
           DV IV1 IV2
        1  -3   L   L
        2  -1   L   L
        3   1   L   L
        4  -5   L   H
        5  -3   L   H
        6  -1   L   H
        7  -3   H   L
        8  -1   H   L
        9   1   H   L
        10  3   H   H
        11  5   H   H
        12  7   H   H
```

Anova does 3 comparisons

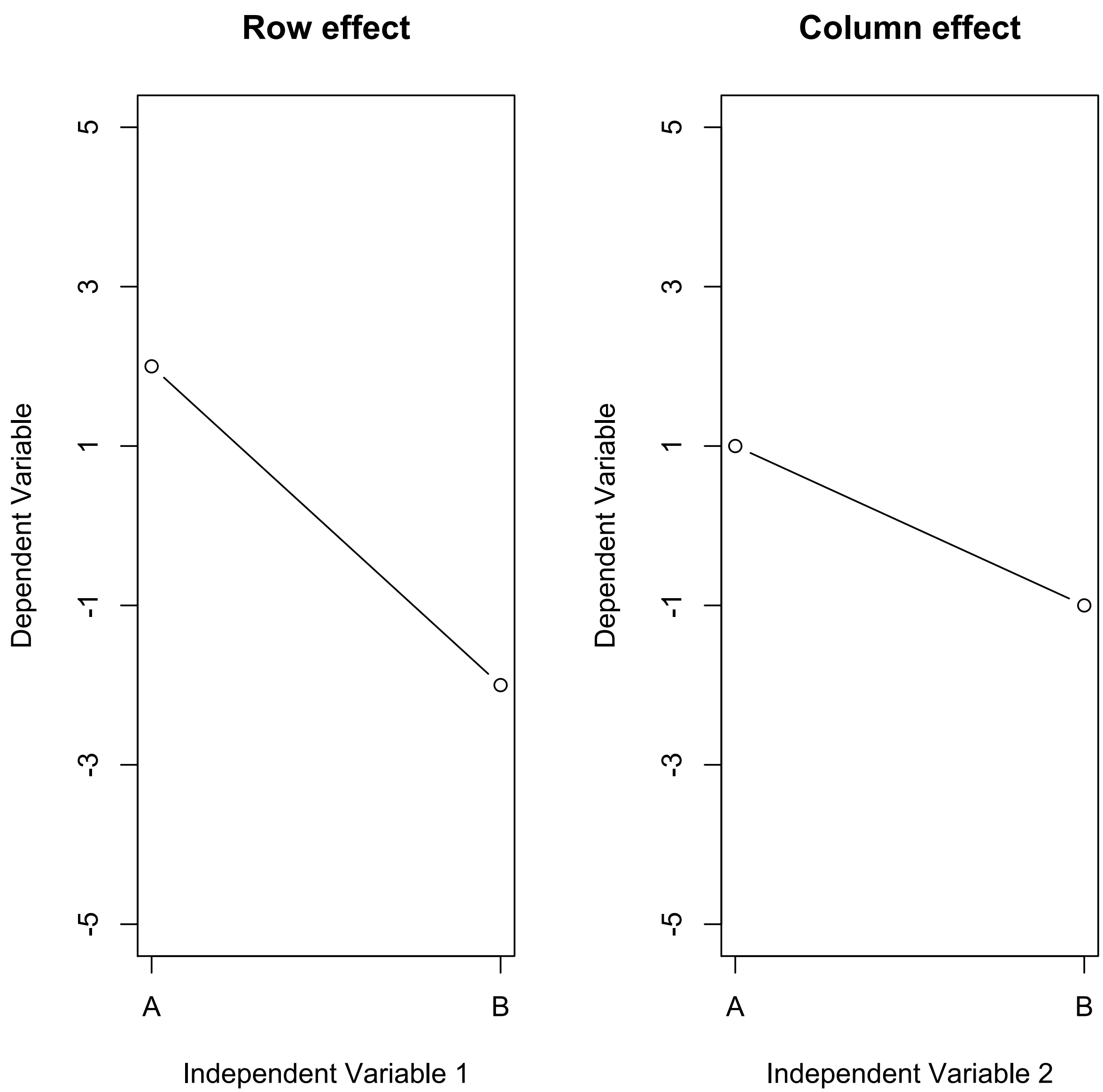
```
summary(aov(DV ~IV1 + IV2 + IV1*IV2,data=my.data))

            Df Sum Sq Mean Sq F value   Pr(>F)
IV1          1     48      48      12 0.008516 **
IV2          1     12      12       3 0.121503
IV1:IV2      1     48      48      12 0.008516 **
Residuals    8     32       4
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

```
mod1 <-aov(DV ~IV1 + IV2 + IV1*IV2,data=my.data)
 print(model.tables(mod1,"means"))
Tables of means
Grand mean
-2.56395e-16

 IV1
IV1
H  L
2 -2

 IV2
IV2
H  L
1 -1

 IV1:IV2
   IV2
IV1 H  L
  H  5 -1
  L -3 -1
>
```

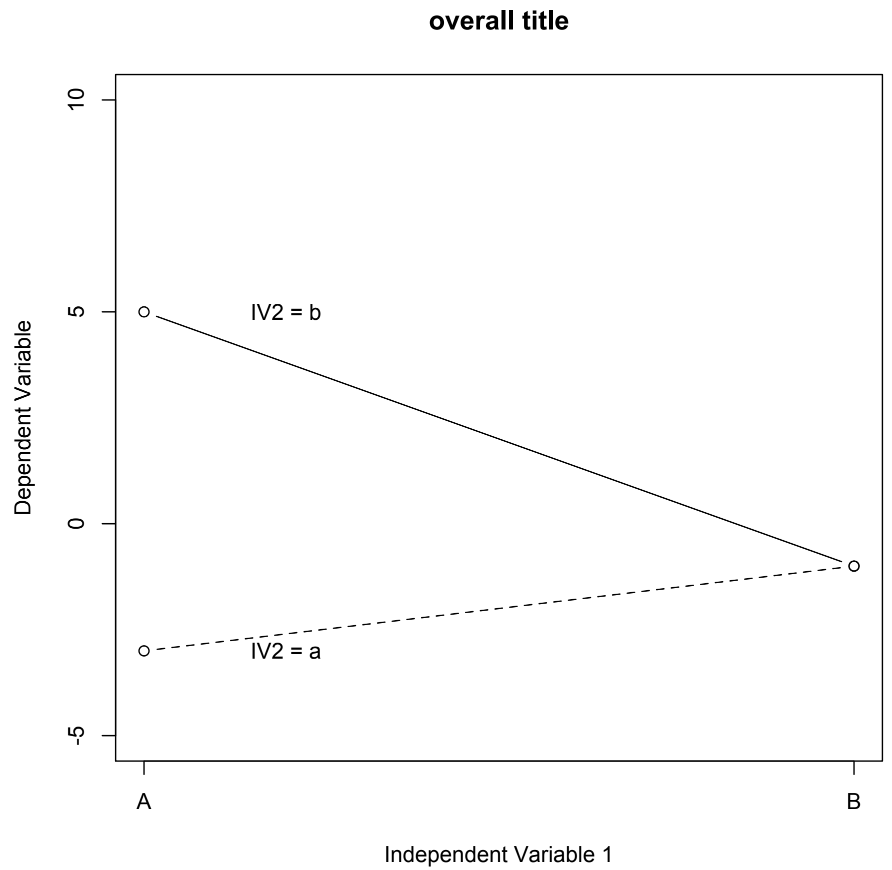
Mean squares are variances associated with particular effects

Fs are comparisons of variances

Two Main Effects



Main effects difficult (impossible?) to interpret in presence of interaction




```
plot(my.means[1,],ylab= "Dependent Variable", xlab="Independent Variable 1",ylim=c
(low,high),main= "overall title",typ= "b", axes=FALSE)
axis(1,c(1,2),c("A","B")) #x axis
axis(2,seq(low,high,step)) #y axis
box()
points(my.means[2,],typ="b",lty="dashed")
text(1.2,-3,"IV2 = a")
text(1.2,5,"IV2 = b")
```