DOCUMENT RESUME

ED 426 094		TM 029 324
AUTHOR	Dodds, Jeffrey	
TITLE	Understanding Interaction Effects and Type IV Errors.	
PUB DATE	1998-11-04	
NOTE	36p.; Paper presented at the Annual Meeting of the Mid-South Educational Research Association (27th, New Orleans, LA, November 4-6, 1998).	
PUB TYPE	Reports - Descriptive (141) -- Speeches/Meeting Papers (150)	
EDRS PRICE	MF01/PC02 Plus Postage.	
DESCRIPTORS	*Analysis of Variance; *Aptitude Treatment Interaction; Heuristics; *Statistical Significance	
IDENTIFIERS	Null Hypothesis; *Type IV Errors	

ABSTRACT

Aptitude-treatment interaction (ATI) studies have been used with some frequency, yet many researchers do not understand fully what interaction effects are. Because the means for interactions involve fewer persons per mean, power to detect interaction effects is typically smallest for the highest-order interaction in a given design. This phenomenon has been formalized by some methodologists as the Type IV error--the failure to detect statistical significance for the interaction null hypotheses that really should be rejected. This paper reviews the concept of the interaction effect. Small heuristic data sets are used to make the discussion more concrete. The concept of interaction is important because it links the two-way factorial designs with designs involving three or more independent variables. An appendix illustrates the analysis of variance technique. (Contains 4 figures, 5 tables, and 12 references.) (Author/SLD)

Running Head: INTERACTION EFFECTS

Understanding Interaction Effects and Type IV Errors

Jeffrey Dodds

Texas A & M University

Paper presented at the annual meeting of the Mid-South Educational Research Association, New Orleans, November 4, 1998.

Abstract

Aptitude-treatment interaction (or ATI) studies have been employed with some frequency, yet many researchers do not fully understand what interaction effects are. Because the means for interactions involve fewer persons per mean, power to detect interaction effects is typically smallest for the highest-order interaction in a given design. This phenomenon has been formalized by some methodologists as the Type IV error — the failure to detect statistical significance for interaction null hypotheses that really should be rejected. This paper reviews the concept of the interaction effect. Small heuristic data sets will be used to make the discussion more concrete.

Understanding Interaction Effects and Type IV Error

In 1957, Lee J. Cronbach, the developer of Cronbach's alpha, the Generalizability coefficient, and other important statistics, presented his American Psychological Association presidential address. In that address, Cronbach argued that too few researchers were considering the important question, "does a given educational or psychological intervention work best for everybody and, if not, what interventions work best for which types of people?"(p. 679). Cronbach labeled such inquiries aptitude-treatment interaction (or ATI) studies. In fields such as psychology or medicine, for example, treatments are designed as interventions to facilitate improvement in peoples' lives. As Snow (1991) stated, the question then becomes, "How can this treatment be made better?"

The ATI methodology was designed to systematically account for individual differences among treated subjects in the treatment evaluation of a particular study (Snow, 1991). In the ensuing years, ATI designs have been employed with some frequency because most researchers presume that few educational or psychological interventions are ideal for everyone. Thus, the interpretation of interaction effects is important in many research studies. Yet, many researchers do not fully understand what interaction effects really are.

Snow (1991) argued that a huge amount of ATI research in education has been wasted due to researchers' failure to recognize the limited statistical power of significance testing. As is so often the case, these researchers have confused practically significant findings with statistical significance. Snow stated that:

> ...every ATI report should provide descriptive statistics within treatments both for results judged significant and for those judged nonsignificant. Consistent nonsignificant trends are at least as valuable for the purposes of future research as are incoherent significant results. (p. 207)

Statistical Power Considerations in ANOVA

When selecting the most appropriate statistical methods for a study, it is important to consider not only the quality of the design but the possible relationships among the variables as well. Often, in their zeal to avoid Type I errors, researchers may be allowing a vast number of Type II errors to occur. Researchers, therefore, need to decide what size effect they want to detect and what power is needed to do so (Snow, 1991).

Controlling power is a crucial factor in research because power determines the degree to which we can detect the differences we were looking for in a study. Benton (1991) suggested researchers consider the following four conclusions with regard to this issue:

1. Researchers should think carefully about design and the possible relationships among variables to select appropriate techniques that will increase statistical power against Type II error. This involves understanding the complexities of effect size, statistical significance, error variance, and the level of significance.

2. When one or more ways in a design involve more than two levels, researchers should then consider using planned or a priori comparisons to help minimize chances of Type II error and to help locate specific sources of variance.

3. Researchers should evaluate the appropriateness of factorial designs for analysis of data. Such designs can dramatically inflate Type I error rates, but paradoxically can also result in the failure to detect

statistical significance.

4. Researchers should understand the difference between statistical significance, magnitude of effect, and the importance of the research result. (pp. 128-129)

Keppel (1991) noted that in the behavioral sciences we are still locked into the convention of fixing the Type I error at a level acceptable to most researchers (viz., a=.05), which puts us in a position of allowing the Type II error rates to be higher. Thus, we have entered what Levin and Marascuilo (1972) described as "the cruel world of research," a world in which the researcher learns to live with the difficulty of deciding whether each of these errors have actually occurred.

Type IV Error

On a more positive note for the researcher, Levin and Marascuilo (1972) also found that another type of error which may arise, Type IV error, could be recognized and avoided. Marascuilo and Levin (1970) defined the Type IV error as occurring whenever a researcher performs a correct statistical test but then makes analyses and explanations that are not related to the statistical test used to decide whether the hypothesis should or should not have been rejected. For example, if a researcher concludes, on the basis of an appropriate and correctly performed statistical test, that there is a reliable source of validity in the data but then incorrectly identifies and interprets the locus of the effect, a Type IV error has been committed (Levin & Marascuilo, 1972). A researcher may also unwittingly commit a Type IV error by using post hoc multiple comparison procedures that do not test what the hypothesis originally intended or may not really fit the underlying model upon which the statistical test was based.

The preceding situation is especially problematic when it comes to interpreting interaction effects in factorial ANOVA designs (Marascuilo & Levin, 1970). When using either planned or post hoc comparisons to examine statistically significant interactions, the comparison can be evaluated in one of two ways. The comparison can be evaluated in terms of the interaction parameters of the model. Another way is to evaluate the comparison in terms of cell means that define contrasts which can then be reduced to comparisons among the interaction parameters of the model. Levin and Marascuilo (1972) suggested that the problems associated with Type IV error occur because many researchers do not have a clear understanding of what constitutes an interaction as it is defined by the mathematical ANOVA model.

Assumptions in ANOVA

There are three important assumptions relevant to ANOVA that must be met in order to use the *F* distribution as the sampling distribution for testing the null hypothesis (Hinkle, Wiersma, & Jurs, 1994). The first assumption is that the observations are random and independent samples from the population. Second, it is assumed that the samples are selected from populations that have a normal distribution. Third is the assumption of homogeniety of variance. This assumption implies that the variances of the distributions in the populations are equal (Vacha-Haase & Thompson, 1992).

Interactions in ANOVA

All ANOVA effects in a balanced designed are uncorrelated. This means that knowledge of main effects does not typically provide any information regarding the magnitudes of interaction effects, since all effects are uncorrelated in balanced designs. In a two-factor design ANOVA, an interaction between the independent variables is present when the effect of the levels of the first independent variable is not the same across the levels of the second independent variable (Hinkle et al., 1994). The interaction occurs when "the effects of one of the independent variables depend on the levels of the other independent variable" (Keppel & Zedeck, 1989, p. 187). Thus, the outcome or effectiveness of one variable varies with the level of the other variable(s).

When analyzing the results from a factorial ANOVA, there are several possible outcomes. The results may indicate a statistically significant finding for one or both of the main effects and not for the interaction effect. It is also possible to obtain results that are statistically significant for the interaction and not attain statistical significance for one or both of the main effects. Of course, all or no effects may also be statistically significant.

In the two-way ANOVA, when a significant *F* ratio is found for either or both main effects, post hoc multiple comparison tests are used to detect statistically significant differences between pairs or combinations of rows or column means (Hinkle et al., 1994). Rosnow and Rosenthal (1989) explained that row and column effects denote the size of the two main effects implicit in the researcher's designated rank ordering. They defined the row effects for each row as the mean of that row minus the grand mean; column effects for each column are defined as the mean of that column minus the grand mean.

With the presence of an interaction, we as researchers must qualify any description of the main effects of a particular independent variable. We cannot refer to the influence of one independent variable without also specifying how the second independent variable complicates the results (Keppel & Saufley, 1980). The possibility of detecting such interactions among the independent variables is, of course, one of the unique advantages of the factorial design.

Plotting Interaction in ANOVA

One of the basic principles of the analysis of variance (ANOVA) is that when we add a second factor to cross the first, we will generate variance associated with (a) the first factor, (b) the second fact, and (c) a third source of variance called the interaction (Rosnow & Rosenthal, 1991). An interaction between the independent variables is present in a two-factor design when the effect of the levels of the first independent variable is not the same across the levels of the second independent variable. One way we can examine an interaction is to plot the cell means (Hinkle et al., 1994). The plotting is done by placing the dependent variable on the vertical (Y) axis with the levels of one of the independent variables equally spaced along the horizontal (X) axis. The second each calculated on eight people (24 / 3 = 8), and the interaction effect involves six cell means each computed for four people (24 / 6 = 4).

Testing for Interaction

The test for interaction is of great importance because it determines whether the average effects of either independent variable (the main effects) are representative of the simple main effects of that particular variable. If the researcher finds an interaction, the next step is to analyze the individual treatment means in order to interpret the location of the statistically significant interaction. However, if the design is 2 x 2, no further inquiry is necessary, because here the interaction can only occur within this block of four cells. When designs are larger (e.g., 3 x 5) interactions may occur in several combinations of blocks of four cells.

When a statistically significant *F* ratio is obtained for the interaction in a more complex design, a post hoc procedure, called the test of simple effects, is used along with the plotted cell means when interpreting the interaction (Marascuilo & Levin, 1970). The test of simple effects allows the researcher to look at the differences among cell means within levels of the two independent

independent variable is represented by using different symbols to represent cell means that are then charted within the interaction plot.

In the two-way ANOVA, if a nonsignificant interaction is found, the lines connecting the cell means in the interaction plot will be parallel or nearly parallel. If, on the other hand, a statistically significant interaction is found, the plotting of the cell means can produce many different patterns. A pattern with non-intersecting lines is called an "ordinal" interaction. A plot that produces a pattern with intersecting lines is called a "disordinal" interaction (Hinkle et al., 1994).

Because the means for interactions involve fewer persons per mean, power to detect interaction effects is typically smallest for the highest-order interaction in a given design. This phenomenon has been formalized by some methodologists as the Type IV error — the failure to detect statistical significance for interaction null hypotheses that really should be rejected (Levin & Marascuilo, 1972). For example, in a 2 x 3 design with 4 people in each of the six cells (n = 6 x 4 = 24), the main effect for the A way tests the differences in two means each calculated on 12 people (24 / 2 = 12), the main effect for the B way tests the differences in three means variables.

Researchers must have a clear understanding of the difference between main effects and simple effects when describing interaction in the factorial design. A main effect consists of the effects of one independent variable averaged over the other. A simple effect, on the other hand, consists of the effects of one independent variable taken separately at each level of the other independent variable (Keppel & Saufley, 1980). If we find that the simple effects are not the same across levels, there is an interaction present.

The concept of interaction is important because it links the two-way factorial designs with designs involving three or more independent variables (Keppel & Saufley, 1980) in which more (and more complex) interactions can occur. The concept of interaction is also important because it enters into the theoretical thinking on which a large amount of past psychological research was based.

Heuristic Examples

To illustrate the concepts of interaction in ANOVA and its orthogonality to main effects more clearly, small hearistic data sets will be utilized. A 2 X 3 factorial ANOVA has been conducted using the data in Table 1 to illustrate four of the many possible outcomes. The four outcomes that will be discussed are (a) no main effects or interaction, (b) two main effects and an interaction, (c) two main effects and no interaction, and (d) interaction with no main effects.

INSERT TABLE 1 ABOUT HERE.

No Main Effects or Interaction

For the first example involving the Table dependent variable labelled "X1", the individual scores within each cell are the same (7,8,9) yeilding cell means that are all the same (8). Therefore, the sums of squares for the two main effects, SS_A and SS_B, and the interaction, SS_{AXB}, will all be zero, as shown in the summary table, Table 2.

INSERT TABLE 2 ABOUT HERE.

If we were to plot the cell means, the graph would show only one point, 8, identified for all three cells in both levels. The plotting of cell means in Figure 1 illustrates that there is no variance accounted for in this data.

INSERT FIGURE 1 ABOUT HERE.

Main Effects and an Interaction

In this example involving dependent variable "X2", the individual scores within each cell yield cell means that differ from one another. In looking at the summary table for the second heuristic data set, Table 2, we can see that statistical significance was reached for the A way, B way, and the two-way interaction. Therefore, the SS for all three effects are non-zero values.

INSERT TABLE 3 ABOUT HERE.

When we plot the cell means for this data set in Figure 2, because the lines intersect, we see evidence of a disordinal interaction. It is important to note that anytime the two lines connecting the plotted cell means are not parallel or approximately parallel there is an interaction. However, this does not necessarily mean that the interaction is statistically significant. In referring to Table 3, we can see that in this particular case the interaction was statistically significant.

INSERT FIGURE 2 ABOUT HERE.

Main Effects with No Interaction

The summary table for our third example, Table 3, statistically significant main effects but no statistically significant interaction effects were detected for the dependent variable "X3". Figure 3 illustrates the absence of interaction in that the lines connecting the cell means are parallel.

INSERT TABLE 4 AND FIGURE 3 ABOUT HERE.

Interaction with No Main Effects

The summary table for our final example, Table 5 for the dependent variable "X4", shows SS_A and SS_B are both zero indicating no main effects are present. SS_{AXB} however, has a non-zero value and an *F* value indicating a statistically significant interaction. As in the previous example, Figure 4 illustrates the presence of a statistically significant disordinal interaction but in this case there are no substantial main effects.

INSERT TABLE 5 AND FIGURE 4 ABOUT HERE.

Summary

In order to interpret the relationship between the factors and the interaction in ANOVA it is necessary to look at both the ANOVA summary table and the plot of the cell means. Follow-up tests of the simple effects must then be computed to identify the magnitude of the differences between the variables as well as the composition and locus of the interaction if the design is more complicated than a 2 x 2.

We have seen, through the use of heuristic data sets, that the presence of an interaction is not contingent upon the presence of one or more main effects. The interaction is an <u>orthogonal</u> and <u>unique</u> component of the factorial ANOVA. The independent variables can display unique variability in the dependent variable scores when there is interaction between them. The interaction cannot be predicted even the values of the main effects of the same independent variables involved in the interaction are known.

References

Benton, R. L., (1991). Statistical power considerations in ANOVA. In B. Thompson (Ed.). Advances in educational research: Substantive findings, methodological developments (Vol. 1, pp. 119-130). Greenwich, CT: JAI Press.

Cronbach, L. J., (1957). The two disciplines of scientific psychology. American Psychologist, 12, 671-684.

Hinkle, D. E., Wiersma, W., & Jurs, S. G., (1994). Applied statistics for the behavioral sciences (3rd ed.). Geneva, IL: Houghton Mifflin.

Keppel, G. (1991). Design and analysis: A researcher's handbook (3rd ed.). Englewood Cliffs, NJ: Prentice Hall.

Keppel, G., & Saufley, W. H. (1980). Introduction to design and analysis: A student's handbook. San Francisco: W. H. Freeman.

Keppel, G., & Zedeck, S. (1989). Data analysis for research designs: Analysis of variance and multiple regression/correlation approaches. New York: W. H. Freeman.

Levin, J. R., & Marascuilo, L. A. (1972). Type IV errors and interactions. Psychological Bulletin, 78, 368-374.

Marascuilo, L. A., & Levin, J. R. (1970). Appropriate post hoc comparisons for interaction and nested hypotheses in analysis of variance designs: The elimination of Type IV errors. American Educational Research Journal, 7, 397-421.

Rosnow, R. L., & Rosenthal, R. (1989). Definition and interpretation of interaction effects. Psychological Bulletin, 105, 143-146.

Rosnow, R. L., & Rosenthal, R. (1991). If you're looking at the cell means, you're not looking at *only* the interaction (unless all main effects are zero). Psychological Bulletin, 110, 574-576.

Snow, R. E., (1991). Aptitude-treatment interaction as a framework for research on individual differences in psychotherapy, Journal of Consulting and Clinical Psychology, 2, 205-216.

Vacha-Haase, T., & Thompson, B. (1992, January). The homogeniety of variance assumption in ANOVA: What it is and why it is required. Paper presented at the annual meeting of the Southwest Educational Research Association, Houston.

Table 1

Heuristic Data

ID	A_WAY	B_WAY	DV X1	X2	X3	X4
1	1	1	7	3	4	7
2	1	1	8	4	5	8
3	1	1	9	5	6	9
4	1	2	7	2	5	8
5	1	2	8	3	6	9
6	1	2	9	4	7	10
7	1	3	7	1	6	9
8	1	3	8	2	7	10
9	1	3	9	3	8	11
10	2	1	7	5	6	9
11	2	1	8	6	7	10
12	2	1	9	7	8	11
13	2	2	7	6	7	8
14	2	2	8	7	8	9
15	2	2	9	8	9	10
16	2	3	7	1	8	7
17	2	3	8	2	9	8
18	2	3	9	3	10	9

Note. X1= DV with all effects zero; X2= DV with all three effects non-zero; X3= DV with only main effects; and X4= DV with only interaction.

Table 2

DV With All Effects Zero

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects					
A_WAY	.000	1	.000	.000	1.00
B_WAY	.000	2	.000	.000	1.00
2-Way Interactions					
A_WAY B_WAY	.000	2	.000	.000	1.00
Explained	.000	5	.000	.000	1.00
Residual	12.000	12	1.000		
Total	12.000	17	.706		

Table 3

DV with All 3 Effects Non-Zero

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects					
A_WAY	18.000	1	18.000	18.000	.001
B_WAY	36.000	2	18.000	18.000	.000
2-Way Interactions					
A_WAY B_WAY	12.000	2	6.000	6.000	.016
Explained	66.000	5	13.200	13.200	.000
Residual	12.000	12	1.000		
Total	78.000	17	4.588		

TABLE 4

DV With Only Main Effects

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects					
A_WAY	18.000	1	18.000	18.000	.001
B_WAY	12.000	2	6.000	6.000	.016
2-Way Interactions					
A_WAY B_WAY	.000	2	.000	.000	1.00
Explained	30.000	5	6.000	6.000	.005
Residual	12.000	12	1.000		
Total	42.000	17	2.471		

Table 5

DV With Only Interaction

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects					
A_WAY	.000	1	.000	.000	1.00
B_WAY	.000	2	.000	.000	1.00
2-Way Interactions					
A_WAY B_WAY	12.000	2	6.000	6.000	.016
Explained	12.000	5	2.400	2.400	.099
Residual	12.000	12	1.000		
Total	24.000	17	1.412		

Figure 1. Plotted cell means for no main effects or interaction.

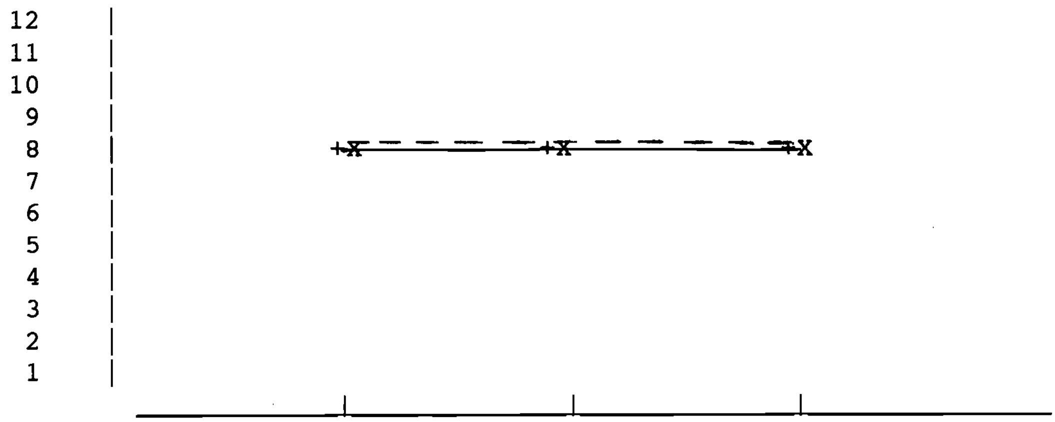
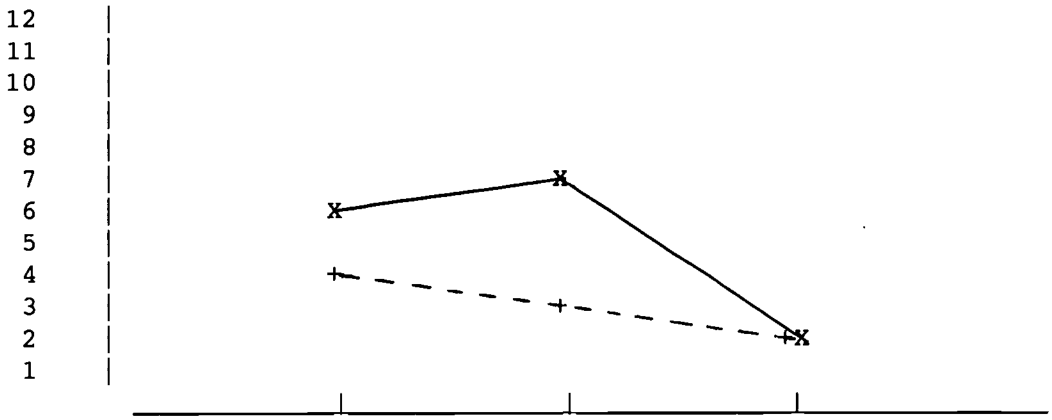


Figure 2. Plotted cell means for two main effects and an interaction.



<u>Figure 3</u>. Plotted cell means for two main effects only.

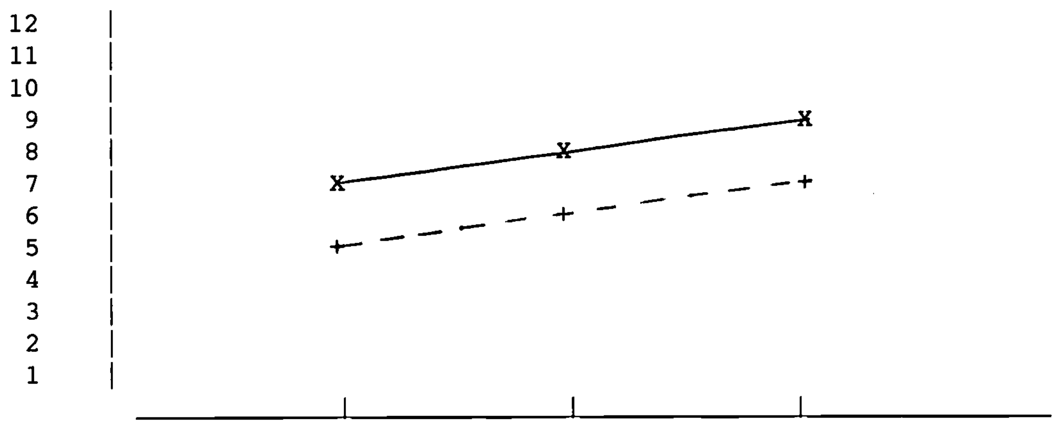
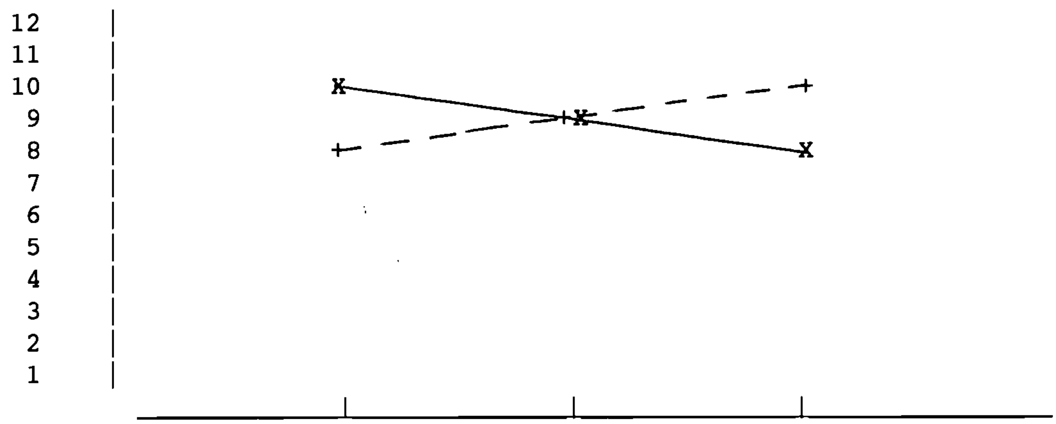


Figure 4. Plotted cell means for interaction only.



APPENDIX

```
-> DATA LIST
->   FILE='a:msera.dat' FIXED RECORDS=1 TABLE
->   /1 id 1-2 a_way 4 b_way 6 x1 7-9 x2 10-12 x3 13-15 x4 16-18 .

-> variable labels
->   x1 DV with all effects zero
->   x2 DV with all 3 effects non-zero
->   x3 DV with only main effects
->   x4 DV with only interaction .

-> list variables=all/cases=99/ .
```

ID	A_WAY	B_WAY	X1	X2	X3	X4
1	1	1	7	3	4	7
2	1	1	8	4	5	8
3	1	1	9	5	6	9
4	1	2	7	2	5	8
5	1	2	8	3	6	9
6	1	2	9	4	7	10
7	1	3	7	1	6	9
8	1	3	8	2	7	10
9	1	3	9	3	8	11
10	2	1	7	5	6	9
11	2	1	8	6	7	10
12	2	1	9	7	8	11
13	2	2	7	6	7	8
14	2	2	8	7	8	9
15	2	2	9	8	9	10
16	2	3	7	1	8	7
17	2	3	8	2	9	8
18	2	3	9	3	10	9

```
Number of cases read:  18    Number of cases listed:  18

-> subtitle '1  ALL EFFECTS ZERO ***********************'.

-> execute .

-> anova x1 by a_way(1,2) b_way(1,3)/statistics=all .

>Note # 10728.  Command name: ANOVA
>Unique sums of squares is now the default method in ANOVA.

>Warning # 10729.  Command name: ANOVA
>MCA is not available with the unique sums of squares method.

>Warning # 10739.  Command name: ANOVA
>MEAN statistic is not available with the unique sums of squares method.


            * * *  A N A L Y S I S   O F   V A R I A N C E  * * *

                  X1        DV with all effects zero
            by    A_WAY
                  B_WAY

                  UNIQUE sums of squares
                  All effects entered simultaneously
```

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	.000	3	.000	.000	1.00
A_WAY	.000	1	.000	.000	1.00
B_WAY	.000	2	.000	.000	1.00
2-Way Interactions	.000	2	.000	.000	1.00
A_WAY B_WAY	.000	2	.000	.000	1.00

Explained	.000	5	.000	.000	1.00
Residual	12.000	12	1.000		
Total	12.000	17	.706		

```
18 cases were processed.
0 cases (.0 pct) were missing.

-> subtitle '2  ALL EFFECTS NON-ZERO ##################'.

-> execute .

-> anova x2 by a_way(1,2) b_way(1,3)/statistics=all .

>Note # 10728.  Command name: ANOVA
>Unique sums of squares is now the default method in ANOVA.

>Warning # 10729.  Command name: ANOVA
>MCA is not available with the unique sums of squares method.

>Warning # 10739.  Command name: ANOVA
>MEAN statistic is not available with the unique sums of squares method.
```

* * * A N A L Y S I S   O F   V A R I A N C E * * *

```
     X2        DV with all 3 effects non-zero
by   A_WAY
     B_WAY

     UNIQUE sums of squares
     All effects entered simultaneously
```

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	54.000	3	18.000	18.000	.000
A_WAY	18.000	1	18.000	18.000	.001
B_WAY	36.000	2	18.000	18.000	.000
2-Way Interactions	12.000	2	6.000	6.000	.016
A_WAY B_WAY	12.000	2	6.000	6.000	.016
Explained	66.000	5	13.200	13.200	.000
Residual	12.000	12	1.000		
Total	78.000	17	4.588		

18 cases were processed.
0 cases (.0 pct) were missing.

```
-> subtitle '3  ONLY MAIN EFFECTS $$$$$$$$$$$$$$$$$$$$$$'.

-> execute .

-> anova x3 by a_way(1,2) b_way(1,3)/statistics=all .

>Note # 10728.  Command name: ANOVA
>Unique sums of squares is now the default method in ANOVA.


>Warning # 10729.  Command name: ANOVA
>MCA is not available with the unique sums of squares method.


>Warning # 10739.  Command name: ANOVA
>MEAN statistic is not available with the unique sums of squares method.
```

* * * A N A L Y S I S   O F   V A R I A N C E * * *

```
     X3        DV with only main effects
by   A_WAY
     B_WAY

     UNIQUE sums of squares
     All effects entered simultaneously
```

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	30.000	3	10.000	10.000	.001
A_WAY	18.000	1	18.000	18.000	.001
B_WAY	12.000	2	6.000	6.000	.016
2-Way Interactions	.000	2	.000	.000	1.00
A_WAY B_WAY	.000	2	.000	.000	1.00
Explained	30.000	5	6.000	6.000	.005
Residual	12.000	12	1.000		
Total	42.000	17	2.471		

18 cases were processed.
0 cases (.0 pct) were missing.

```
-> subtitle '4  ONLY INTERACTION EFFECTS @@@@@@@@@@@@@@@@'.

-> execute .

-> anova x4 by a_way(1,2) b_way(1,3)/statistics=all .

>Note # 10728.  Command name: ANOVA
>Unique sums of squares is now the default method in ANOVA.


>Warning # 10729.  Command name: ANOVA
>MCA is not available with the unique sums of squares method.


>Warning # 10739.  Command name: ANOVA
>MEAN statistic is not available with the unique sums of squares method.


          * * * A N A L Y S I S   O F   V A R I A N C E * * *

               X4        DV with only interaction
          by   A_WAY
               B_WAY

               UNIQUE sums of squares
               All effects entered simultaneously
```

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
Main Effects	.000	3	.000	.000	1.00
A_WAY	.000	1	.000	.000	1.00
B_WAY	.000	2	.000	.000	1.00
2-Way Interactions	12.000	2	6.000	6.000	.016
A_WAY B_WAY	12.000	2	6.000	6.000	.016
Explained	12.000	5	2.400	2.400	.099
Residual	12.000	12	1.000		
Total	24.000	17	1.412		

```
18 cases were processed.
0 cases (.0 pct) were missing.
```

```
TITLE 'Jeff Dodds *************************************'.
SET BLANKS=SYSMIS UNDEFINED=WARN printback=listing.
DATALIST
 FILE='a:msera.dat' FIXED RECORDS=1 TABLE
 /1 id 1-2 a_way 4 b_way 6 x1 7-9 x2 10-12 x3 13-15 x4 16-18 .
variable labels
 x1 DV with all effects zero
 x2 DV with all 3 effects non-zero
 x3 DV with only main effects
 x4 DV with only interaction .
list variables=all/cases=99/ .
subtitle '1  ALL EFFECTS ZERO ************************'.
execute .
anova x1 by a_way(1,2) b_way(1,3)/statistics=all .
subtitle '2  ALL EFFECTS NON-ZERO ####################'.
execute .
anova x2 by a_way(1,2) b_way(1,3)/statistics=all .
subtitle '3  ONLY MAIN EFFECTS $$$$$$$$$$$$$$$$$$$$$$$'.
execute .
anova x3 by a_way(1,2) b_way(1,3)/statistics=all .
subtitle '4 ONLY INTERACTION EFFECTS @@@@@@@@@@@@@@@'.
execute .
anova x4 by a_way(1,2) b_way(1,3)/statistics=all .
```

1	1	1	7	3	4	7
2	1	1	8	4	5	8
3	1	1	9	5	6	9
4	1	2	7	2	5	8
5	1	2	8	3	6	9
6	1	2	9	4	7	10
7	1	3	7	1	6	9
8	1	3	8	2	7	10
9	1	3	9	3	8	11
10	2	1	7	5	6	9
11	2	1	8	6	7	10
12	2	1	9	7	8	11
13	2	2	7	6	7	8
14	2	2	8	7	8	9
15	2	2	9	8	9	10
16	2	3	7	1	8	7
17	2	3	8	2	9	8
18	2	3	9	3	10	9

TM029324

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement (OERI)
Educational Resources Information Center (ERIC)

REPRODUCTION RELEASE
(Specific Document)

I. DOCUMENT IDENTIFICATION:

Title: UNDERSTANDING INTERACTION EFFECTS AND TYPE IV ERRORS

Author(s): JEFFREY DODDS

Corporate Source:

Publication Date: 11/4/98

II. REPRODUCTION RELEASE:

In order to disseminate as widely as possible timely and significant materials of interest to the educational community, documents announced in the monthly abstract journal of the ERIC system, *Resources in Education* (RIE), are usually made available to users in microfiche, reproduced paper copy, and electronic/optical media, and sold through the ERIC Document Reproduction Service (EDRS) or other ERIC vendors. Credit is given to the source of each document, and, if reproduction release is granted, one of the following notices is affixed to the document.

If permission is granted to reproduce the identified document, please CHECK ONE of the following options and sign the release below.

[X] Sample sticker to be affixed to document

Check here Permitting microfiche (4"x 6" film), paper copy, electronic, and optical media reproduction

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY
JEFFREY DODDS
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

Level 1

Sample sticker to be affixed to document [ ]

"PERMISSION TO REPRODUCE THIS MATERIAL IN OTHER THAN PAPER COPY HAS BEEN GRANTED BY
Sample
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

or here Permitting reproduction in other than paper copy.

Level 2

Sign Here, Please

Documents will be processed as indicated provided reproduction quality permits. If permission to reproduce is granted, but neither box is checked, documents will be processed at Level 1.

"I hereby grant to the Educational Resources Information Center (ERIC) nonexclusive permission to reproduce this document as indicated above. Reproduction from the ERIC microfiche or electronic/optical media by persons other than ERIC employees and its system contractors requires permission from the copyright holder. Exception is made for non-profit reproduction by libraries and other service agencies to satisfy information needs of educators in response to discrete inquiries."

Signature:	Position: RES ASSOCIATE
Printed Name: JEFFREY DODDS	Organization: TEXAS A&M UNIVERSITY
Address: TAMU DEPT EDUC PSYC COLLEGE STATION, TX 77843-4225	Telephone Number: (409) 845-1831
	Date: 10/25/98