

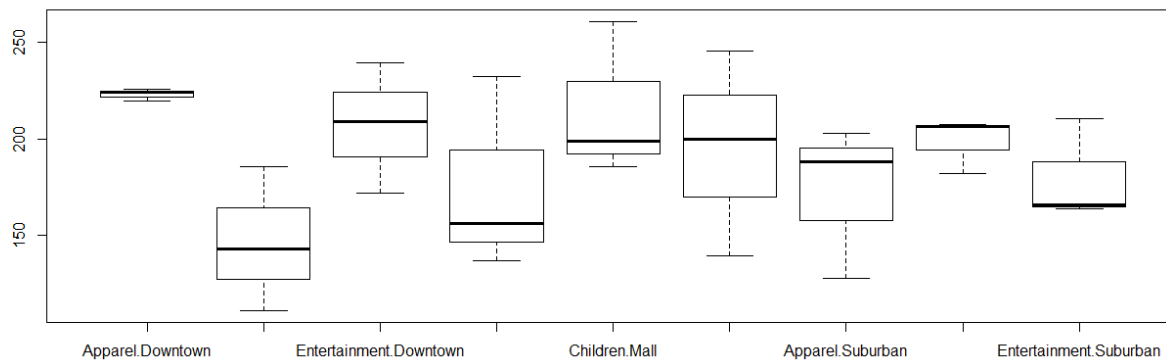
## ST 312: Ch. 13 Examples

**Example 1.** Annual Returns (in thousands of dollars) is recorded for 27 shops in three different types of locations (Downtown, Mall, and Suburban) and for three different categories (Childrens, Apparel, and Entertainment).

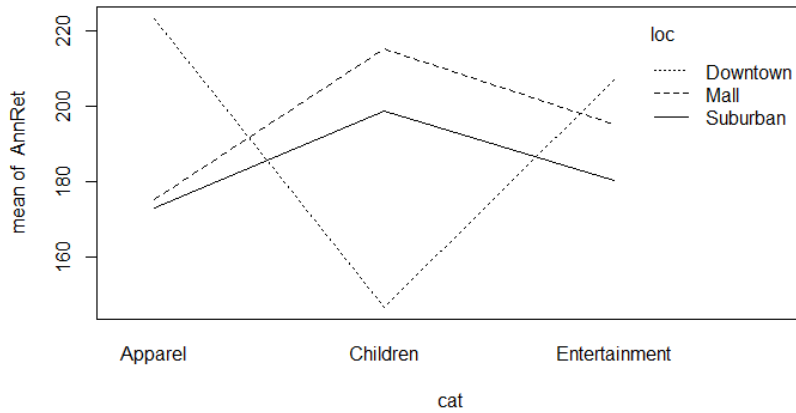
(a) The table below shows the standard deviation for each cell. Are the assumptions of ANOVA satisfied?

category	location	n	SD of AnnualReturn
Apparel	Downtown	3	3.138556
Children	Downtown	3	37.324314
Entertainment	Downtown	3	33.712904
Apparel	Mall	3	50.382694
Children	Mall	3	40.114537
Entertainment	Mall	3	53.253057
Apparel	Suburban	3	39.915186
Children	Suburban	3	14.297225
Entertainment	Suburban	3	26.202422

(b) Below are boxplots for each cell. Does this give you any indication of what outcome might be reached?



(c) If we disregard the violations above (and assume ANOVA will perform well anyway), let us look now at the interaction plot below. Discuss what you see regarding an interaction and/or main effects.



(d) Complete the ANOVA table below. State any conclusions that may be reached using an  $\alpha$  level of 0.10.

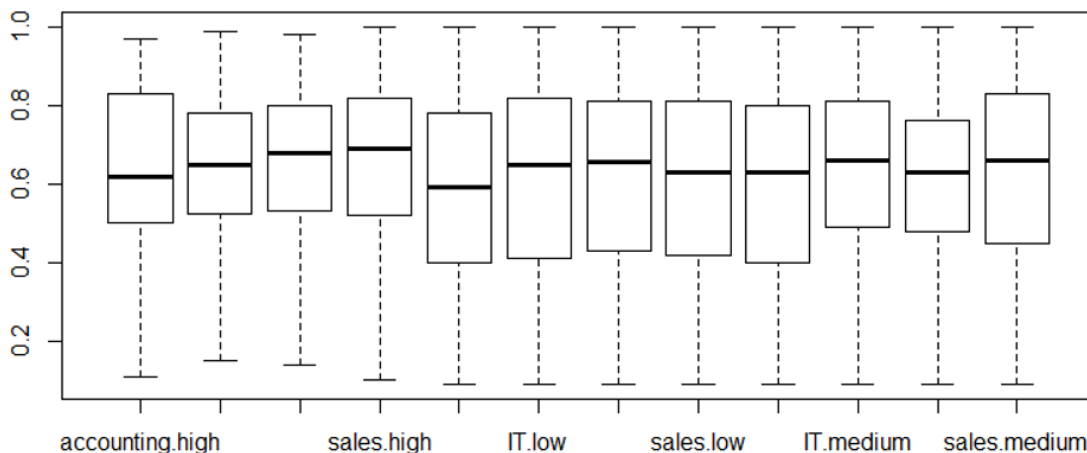
Source	Df	SS	MS	F Statistics
Category		237		
Location		613		
Category*Location				
Error		24014		
Total		37828		

(e) Was this data from an observational study or an experiment?

**Example 2.** Job satisfaction level is recorded for 6764 employees at a large corporation in several departments (this study is *not* balanced). The employee's salary is categorized into three levels: low, medium, and high. Use two-way ANOVA to determine if department and/or salary have significant effects on job satisfaction.

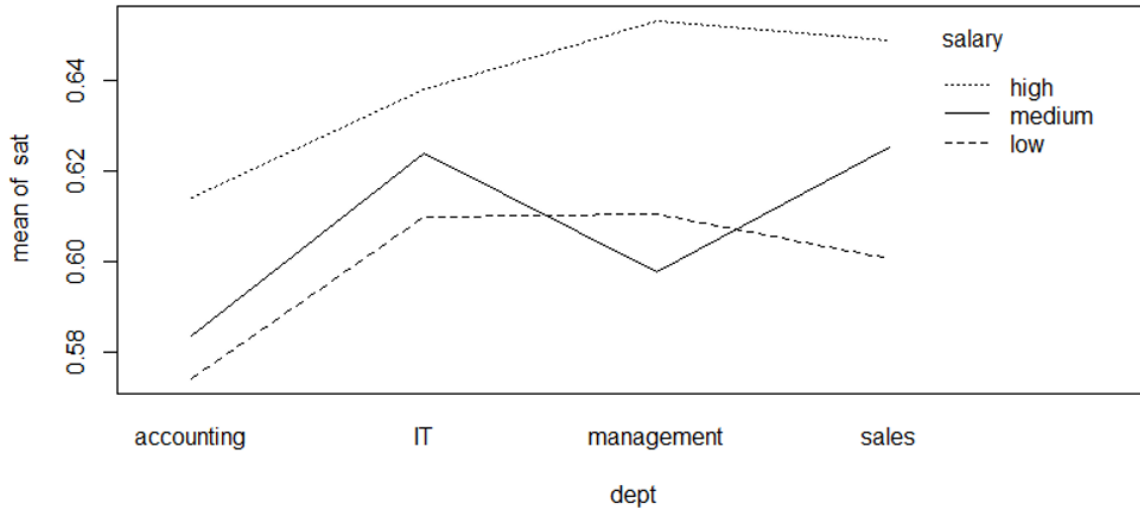
(a) Below is a table of standard deviations, and side-by-side boxplots. Discuss the necessary conditions for two-way ANOVA.

	high	low	medium
accounting	0.237	0.252	0.262
IT	0.224	0.259	0.243
management	0.194	0.255	0.233
sales	0.236	0.252	0.250



(b) Based on the boxplots above, do you expect to find differences in the means? Explain.

(c) Analyze the interaction plot shown below.



(d) Complete the two-way ANOVA to determine if department and/or salary have significant effects on job satisfaction. Use a 5% significance level.

Source	Df	SS	MS	F Statistics
Department		0.80949		
Salary		1.2846		
Interaction		0.1998		
Error		416.598		
Total		418.8922		

(e) The Tukey Honest Significant Differences post-hoc test can be used to test pairwise comparisons between levels of a factor. Below is the output for a Tukey HSD test for the Department variable.

Each line describes the comparison, the estimate of the difference, a confidence interval for the difference (lwr = lower limit, upr = upper limit), and an adjusted p-value (adjusted for the number of comparisons made).

Look at the confidence intervals and p-values to determine which departments have significantly different mean job satisfaction.

	diff	lwr	upr	p adj
IT-accounting	0.035990571	0.006602216	0.06537893	0.0089909
management-accounting	0.039197968	0.004868829	0.07352711	0.0176592
sales-accounting	0.032295621	0.007197406	0.05739384	0.0052495
management-IT	0.003207397	-0.028085521	0.03450031	0.9936051
sales-IT	-0.003694949	-0.024447716	0.01705782	0.9681752
sales-management	-0.006902346	-0.034206040	0.02040135	0.9157195