Popping Popcorn

By Allison Upchurch and Charles Hwang

How do brand and flavor affect the number of unpopped kernels?

Materials

- Standard microwave
- Two boxes of Pop Secret popcorn (6 bags each)
- Two boxes of Orville Redenbacher’s popcorn (6 bags each)
- Flavors: Movie theater butter and regular butter

Design

We used a two-level factorial design:

Factors:

- Brand
  - Pop Secret & Orville Redenbacher
- Flavor
  - Butter & Movie Theater

The experimental units were the individual bags of popcorn, and the response was the number of unpopped kernels.

Procedure

1. Open the box and remove a bag of popcorn.
2. Microwave the bag of popcorn by pressing the popcorn button (2 minutes 45 seconds).
3. Count the number of unpopped kernels in the bag of popcorn.
4. Repeat steps 1-3 for 3 bags in each brand and flavor, letting the microwave cool for 1 minute between bags because my microwave sucks.
5. Compare the numbers of unpopped kernels between the different brands and flavors.

Results

We randomized the order of the treatments and got the following results:

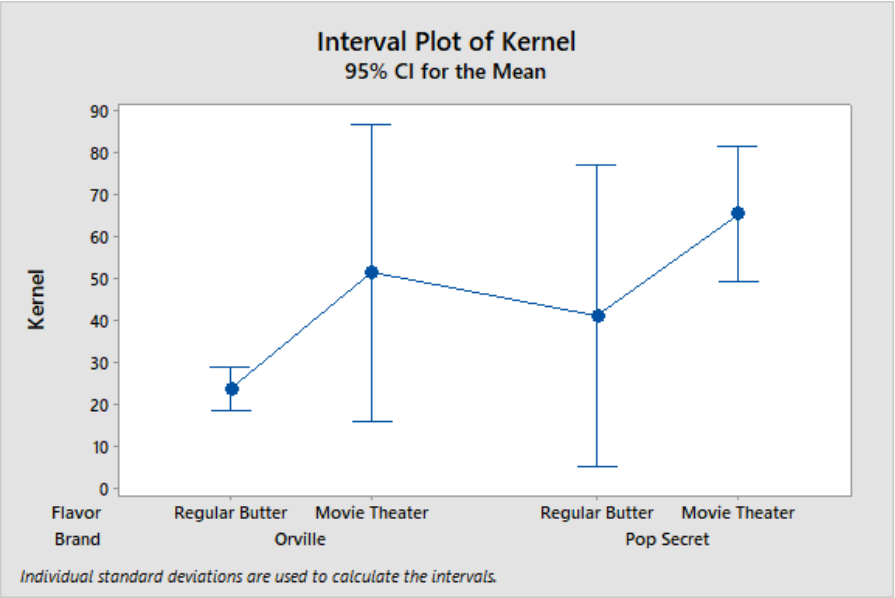
Observation	Treatment	Number of Unpopped Kernels
1	Pop Secret Movie Theater	70
2	Orville’s Regular Butter	23
3	Pop Secret Regular Butter	37
4	Pop Secret Movie Theater	58
5	Pop Secret Movie Theater	68
6	Orville’s Movie Theater	54
7	Orville’s Movie Theater	36
8	Orville’s Regular Butter	26
9	Pop Secret Regular Butter	57
10	Orville’s Regular Butter	22
11	Pop Secret Regular Butter	29
12	Orville’s Movie Theater	64

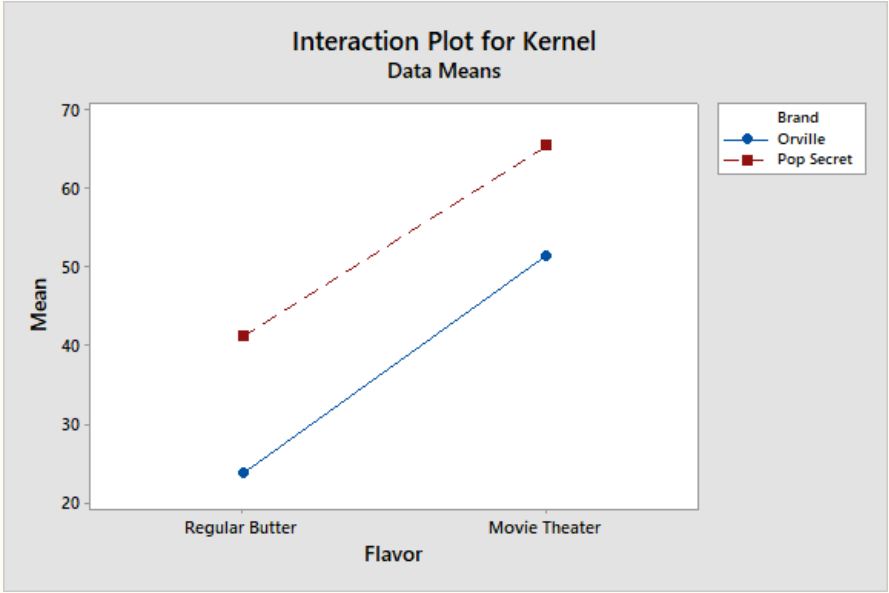
Hypotheses (α = .05)

1. H_0: There is no difference between the numbers of unpopped kernels among brands
2. H_0: There is no difference between the numbers of unpopped kernels among flavors
3. H_0: There is no interaction between brand and flavor (B*F)

1-2. H_A: There is a difference between the numbers of unpopped kernels among the two groups

3. H_A: There is interaction between brand and flavor


Interval Plot of Kernel
95% CI for the Mean
Kernel
90
80
70
60
50
40
30
20
10
0
Flavor
Brand
Regular Butter
Movie Theater
Regular Butter
Movie Theater
Orville
Pop Secret
Individual standard deviations are used to calculate the intervals.


Interaction Plot for Kernel
Data Means
Mean
70
60
50
40
30
20
Regular Butter
Movie Theater
Flavor
Brand
Orville
Pop Secret

General Linear Model: Kernel versus Brand, Flavor

Method

Factor coding (-1, 0, +1)

Factor Information

Factor	Type	Levels	Values
Brand	Fixed	2	Orville, Pop Secret
Flavor	Fixed	2	Regular Butter, Movie Theater

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Brand	1	736.33	736.33	6.47	0.034
Flavor	1	2028.00	2028.00	17.83	0.003
Brand*Flavor	1	8.33	8.33	0.07	0.794
Error	8	910.00	113.75		
Total	11	3682.67			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
10.6654	75.29%	66.02%	44.40%

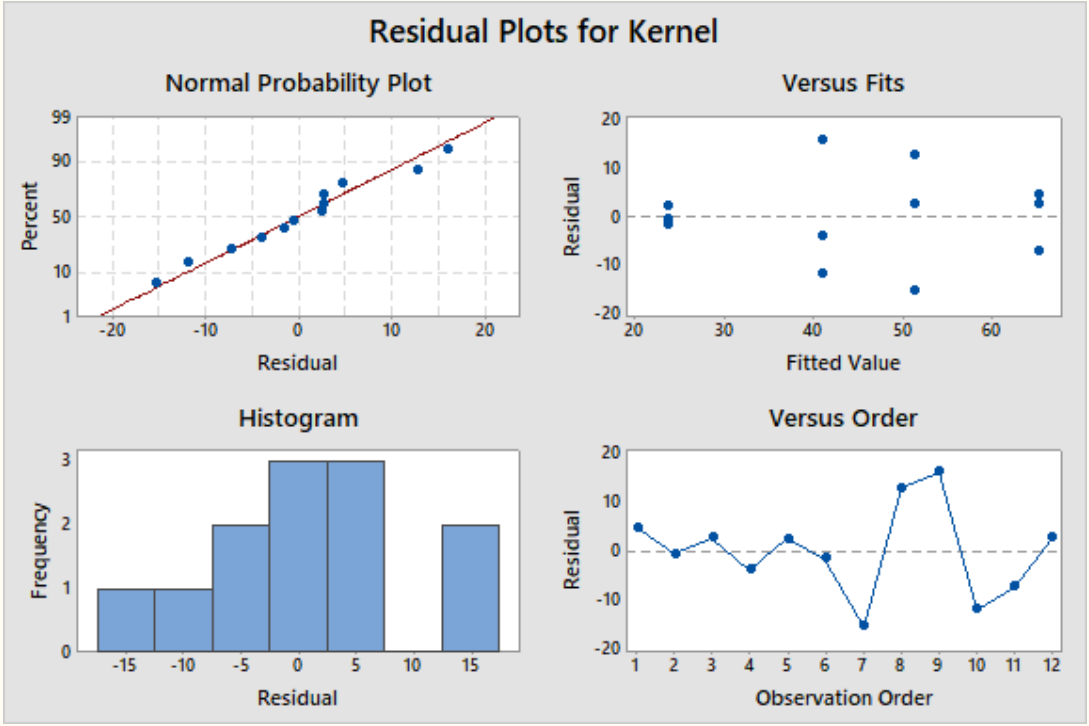
Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	45.33	3.08	14.72	0.000	
Brand					
Orville	-7.83	3.08	-2.54	0.034	1.00
Flavor					
Regular Butter	-13.00	3.08	-4.22	0.003	1.00
Brand*Flavor					
Orville Regular Butter	-0.83	3.08	-0.27	0.794	1.00

Regression Equation

Kernel = 45.33 - 7.83 Brand_Orville + 7.83 Brand_Pop Secret - 13.00 Flavor_Regular Butter + 13.00 Flavor_Movie Theater - 0.83 Brand*Flavor_Orville Regular Butter + 0.83 Brand*Flavor_Orville Movie Theater + 0.83 Brand*Flavor_Pop Secret Regular Butter - 0.83 Brand*Flavor_Pop Secret Movie Theater

- Brand p-value: 0.034
- Flavor p-value: 0.003



Grouping Information Using the Tukey Method and 95% Confidence

Brand	N	Mean	Grouping
Pop Secret	6	53.1667	A
Orville	6	37.5000	B

Means that do not share a letter are significantly different.

Tukey Pairwise Comparisons: Flavor

Grouping Information Using the Tukey Method and 95% Confidence

Flavor	N	Mean	Grouping
Movie Theater	6	58.3333	A
Regular Butter	6	32.3333	B

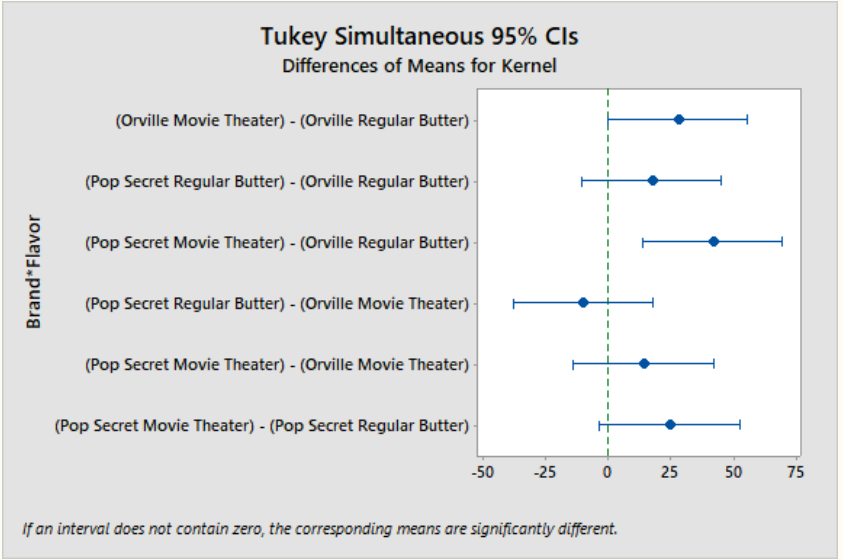
Means that do not share a letter are significantly different.

Tukey Pairwise Comparisons: Brand*Flavor

Grouping Information Using the Tukey Method and 95% Confidence

Brand*Flavor	N	Mean	Grouping	
Pop Secret Movie Theater	3	65.3333	A	
Orville Movie Theater	3	51.3333	A	B
Pop Secret Regular Butter	3	41.0000	A	B
Orville Regular Butter	3	23.6667		B

Means that do not share a letter are significantly different.



Conclusion

- We reject H_0 #1-2 at α = .05 and can conclude that the difference between the two brands is significant and the difference between the two flavors is significant
    - However, Tukey's HSD test shows the only two individual types that are significantly different are Pop Secret Movie Theater Butter and Orville's Regular Butter
- We fail to reject H_0 #3 at α = .05 and can conclude that there is no interaction
- Do brand or flavor affect the number of unpopped kernels? ¯_(ツ)_/¯
    - P-value for difference between Orville's Movie and Orville's Regular was 0.0518365
- Larger sample size may prove these differences to be significant

Potential Future Experiment Variations

- Microwave wattage and microwave time
- Cooling time between trials
- Other brands and flavors
- Finding the percentage of unpopped kernels per bag

Questions?