

POPCORN POPPING

A 3-WAY (BF[3]) ANOVA TEST
BY SETH HYATT



INTRODUCTION

WHY ARE WE DOING THIS?



The Best Seat In Town

- Cinemark is dedicated to providing movie-goers across the world with the best movie-going experience possible.
- One GUEST at a Time
- HOW?
 - Digital Excellence
 - Customer Service
 - Food & Beverage
 - POPCORN!

PURPOSE

- Influence Marketing & Promotions
- Cater to Guests' needs
- Analyze Butter, Salt, and Age factors



HYPOTHESES AND SAMPLE SIZE

- H_0 : Mean taste scores are the same regardless of salt content
- H_0 : Mean taste scores are the same regardless of butter topping
- H_0 : Mean taste scores are the same regardless of age

Significance defined as a difference of 1 taste score point

- 18 Groups, Detect significance in Salt
8.677065
- 18 Groups, Detect significance in Butter
7.804259
- 18 Groups, Detect significance in Age
8.677065



DESIGN & DATA COLLECTION

HOW CAN WE DO THIS?

BUTTER	SALT			AGE
	Low	Normal	High	
Odell's				<18
				18<= <50
				50<=
ButterFace				<18
				18<= <50
				50<=

Salt	Butter	Code
Low	Odell's Supur-kist	LO
Low	Butterface Real Butter	LBF
Normal	Odell's Supur-kist	NO
Normal	Butterface Real Butter	NBF
High	Odell's Supur-kist	HO
High	Butterface Real Butter	HBF

3-WAY TABLE

3 Levels of Salt

Low = $\frac{1}{2}$ tbsp

Normal = 1 tbsp

High = $1\frac{1}{2}$ tbsp

2 Levels of Butter

Odell's = Standard

“Butterface” = Cinemark

Brand 100% Real Butter

3 Levels of Age

Self-defined



GATHER DATA

Each voluntary Cinemark Guest would sample a random salt-butter combination and record their taste score 1-10 and their age.

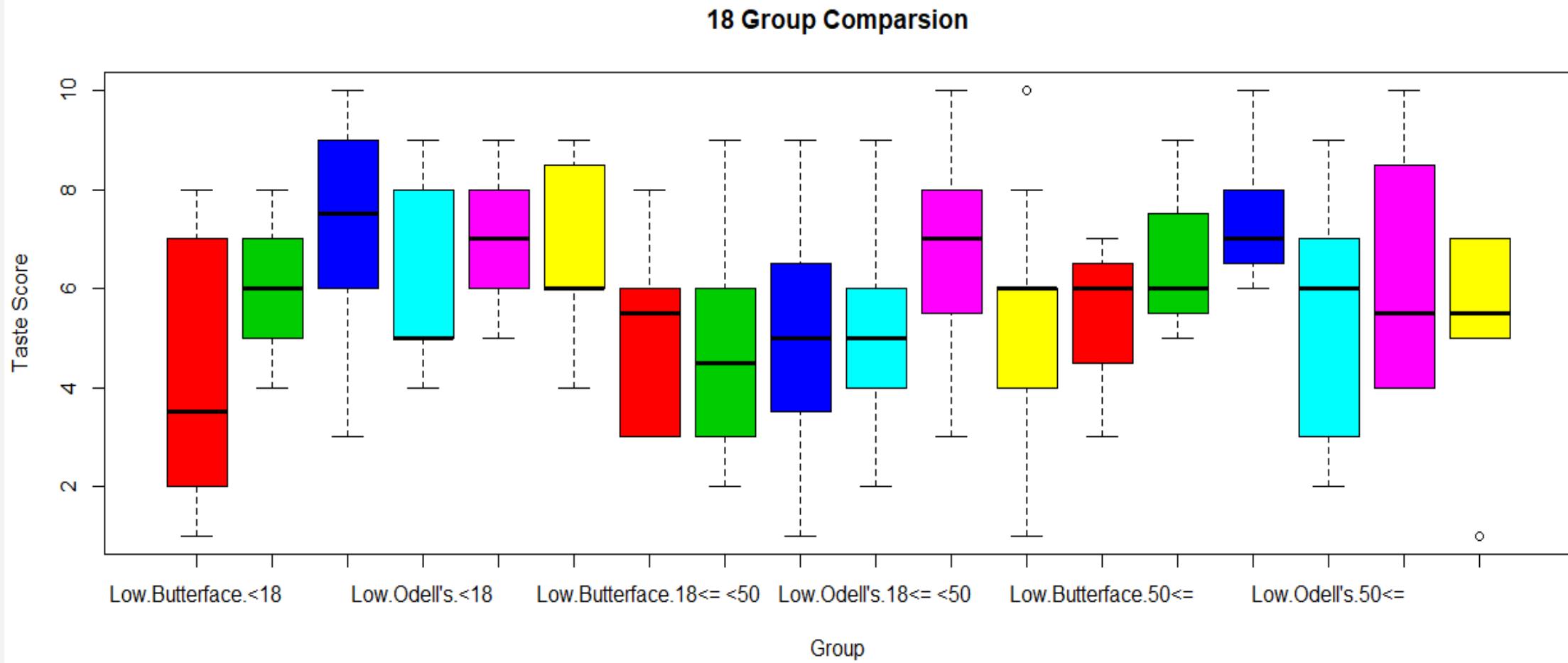
HO LBF LO

HBF NBF NO

NBF HO HBF

NO LBF LO

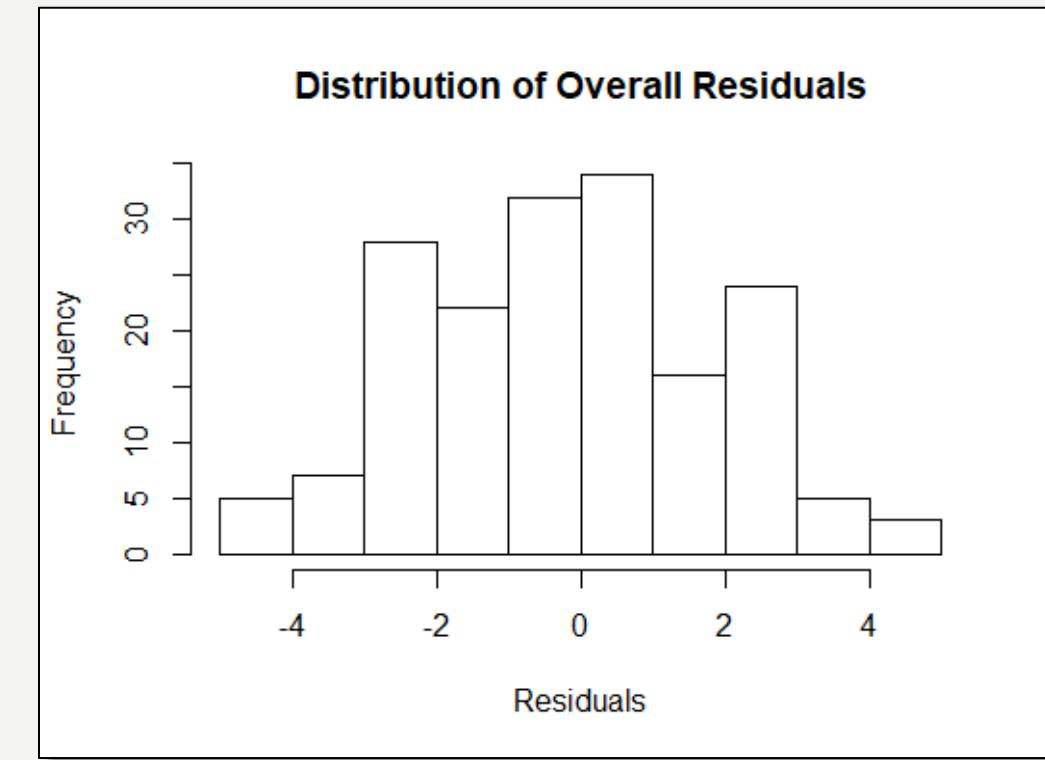
RAW DATA COMPARISON



CONDITIONS

- Independence of Results ✓
- Normality of Residuals ✓
- Equal Variance ✓-ish
 - 2.04*

*Attempted Log Transform



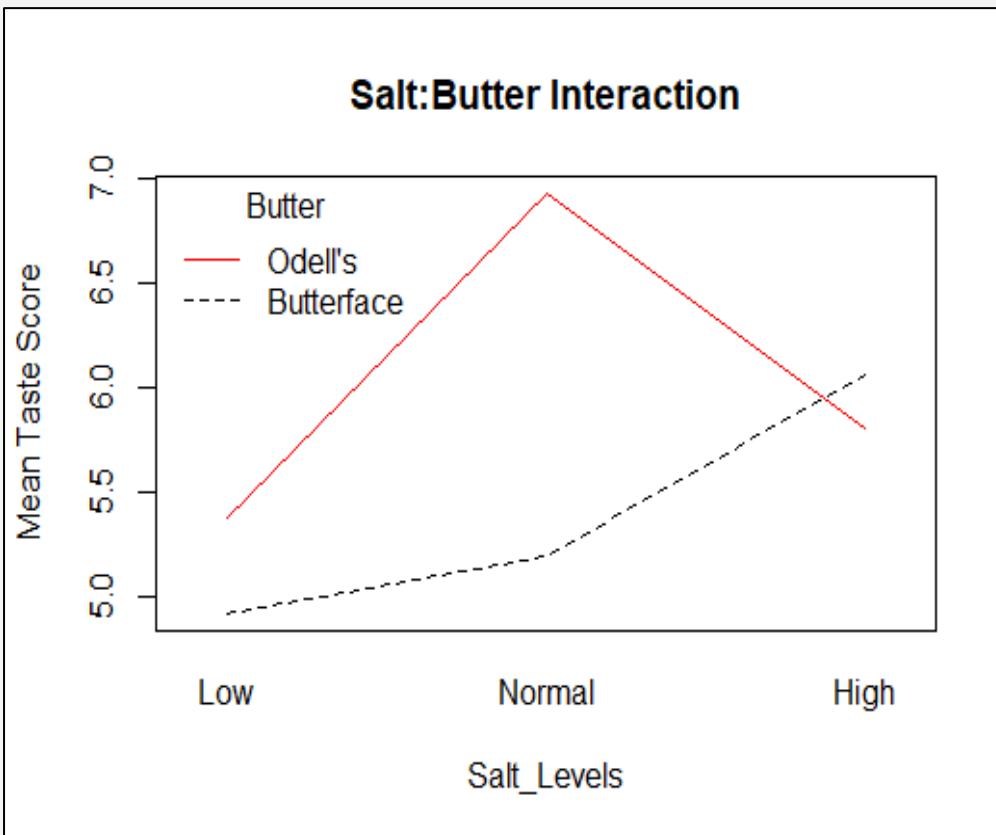


ANALYSIS

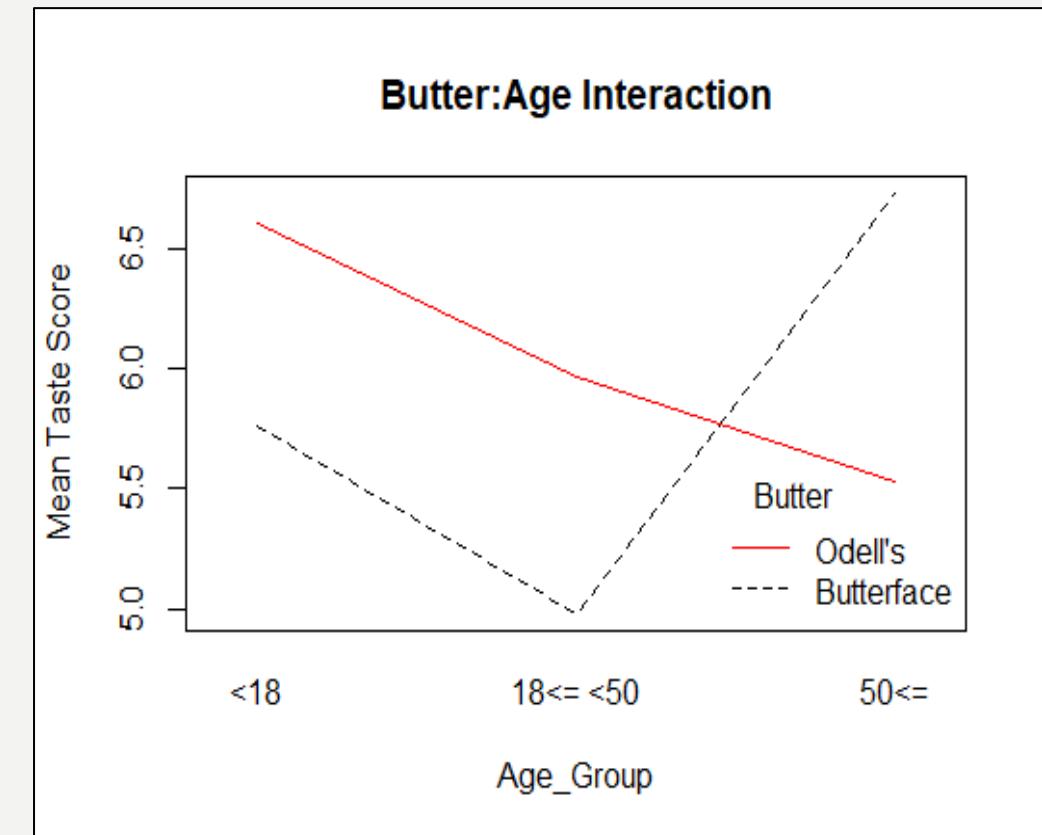
WHAT CAN WE SAY ABOUT THIS?

INTERACTION PLOTS

SALT & BUTTER



BUTTER & AGE



ANOVA TABLE

SS I - SALT

Main Effect	Df	Sum Sq	Mean Sq	F Value	Pr(>F)	Sig
Salt_Levels	2	27.04	13.5224	2.9821	0.05355	.
Butter_Type	1	14.82	14.8199	3.2682	0.07254	.
Age_Group	2	21.29	10.643	2.3471	0.09897	.
Salt_Levels:Butter_Type	2	29.59	14.796	3.263	0.04087	*
Butter_Type:Age_Group	2	23.68	11.8404	2.6112	0.07662	.
Salt_Levels:Age_Group	4	11.94	2.9858	0.6585	0.62177	
Salt_Levels:Butter_Type:Age_Group	4	15.67	3.918	0.864	0.487	
Residuals	158	716.46	4.5345			

ANOVA TABLE

SS III - SALT

Main Effect	Df	Sum Sq	Mean Sq	Fvalue	Pr(>F)	Sig
Age_Group	2	17.7	8.849	1.9515	0.14548	
Butter_Type	1	14.95	14.9464	3.2961	0.07134	.
Salt_Levels	2	30.51	15.2532	3.3638	0.0371	*
Age_Group:Salt_Levels	4	12.91	3.2282	0.7119	0.58493	
Butter_Type:Salt_Levels	2	29.4	14.7011	3.242	0.0417	*
Age_Group:Butter_Type	2	22.9	11.4504	2.5252	0.08327	.
Age_Group:Butter_Type:Salt_Levels	4	15.67	3.918	0.864	0.487	
Residuals	158	716.46	4.5345			

ANOVA TABLE

SS I - BUTTER:AGE

Main Effect	Df	Sum Sq	Mean Sq	F value	Pr(>F)	Sig
Butter_Type	1	13.93	13.9349	3.0731	0.08154	.
Salt_Levels	2	27.93	13.9649	3.0797	0.04874	*
Age_Group	2	21.29	10.643	2.3471	0.09897	.
Butter_Type:Age_Group	2	28.54	14.2719	3.1474	0.04567	*
Butter_Type:Salt_Levels	2	24.73	12.3645	2.7267	0.06851	.
Salt_Levels:Age_Group	4	11.94	2.9858	0.6585	0.62177	
Butter_Type:Salt_Levels:Age_Group	4	15.67	3.918	0.864	0.487	
Residuals	158	716.46	4.5345			



ANALYSIS PT. 2

WHAT CAN WE REALLY SAY?

SAMPLE SIZE REVISITED

**UNFORTUNATELY,
INSUFFICIENT GUESTS (<9)**

Overall #Obs	SALT			AGE
	Low	Normal	High	
BUTTER				
Odell's	6.00	5.00	7.00	<18
Odell's	18.00	20.00	22.00	18<= <50
Odell's	5.00	4.00	6.00	50<=
ButterFace	6.00	5.00	6.00	<18
ButterFace	14.00	18.00	19.00	18<= <50
ButterFace	4.00	3.00	8.00	50<=

**YIELD INSUFFICIENT
POWER (<.80)**

Overall Powers	SALT			AGE
	Low	Normal	High	
BUTTER				
Odell's	0.731	0.609	0.825	<18
Odell's	0.999	0.999	0.999	18<= <50
Odell's	0.609	0.463	0.731	50<=
ButterFace	0.731	0.609	0.731	<18
ButterFace	0.997	0.999	0.999	18<= <50
ButterFace	0.463	0.307	0.891	50<=

BASIC MODELS

Basic Model 1		SALT		
BUTTER	Low	Normal	High	
Odell's				
Butterface				

Basic Model 2		AGE		
AGE	Low	Normal	High	
<18				
18<= <50				
50<=				

Basic Model 3		AGE		
BUTTER	<18	18<= <50	50<=	
Odell's				
Butterface				

Main Effect	Df	Sum Sq	Mean Sq	F value	Pr(>F)	Sig
Butter_Type	1	13.93	13.9349	3.0061	0.0848	.
Salt_Levels	2	27.93	13.9649	3.0126	0.0518	.
Butter_Type:Salt_Levels	2	30.59	15.2947	3.2994	0.0393	*
Residuals	170	788.04	4.6355			

Main Effect	Df	Sum Sq	Mean Sq	F value	Pr(>F)	Sig
Age_Group	2	17.7	8.849	1.8469	0.16093	
Salt_Levels	2	29.51	14.7566	3.08	0.04858	*
Age_Group:Salt_Levels	2	3.16	1.58	3.2889	0.6864	0.60229
Residuals	167	800.13	4.7912			

Main Effect	Df	Sum Sq	Mean Sq	F value	Pr(>F)	Sig
Butter_Type	1	13.93	13.9349	2.9652	0.08689	.
Age_Group	2	18.71	9.3547	1.9906	0.13979	
Butter_Type:Age_Group	2	28.93	14.4665	3.0783	0.04861	*
Residuals	170	798.92	4.6995			

BASIC POWERS

SALT:BUTTER INTERACTION

SUFFICIENT GUESTS (>17)

Overall #Obs	SALT		
	BUTTER	Low	Normal
Odell's	29.00	29.00	35.00
Butterface	24.00	26.00	33.00

SUFFICIENT POWER

Overall Powers	SALT		
	BUTTER	Low	Normal
Odell's	0.888	0.888	0.945
Butterface	0.809	0.845	0.930

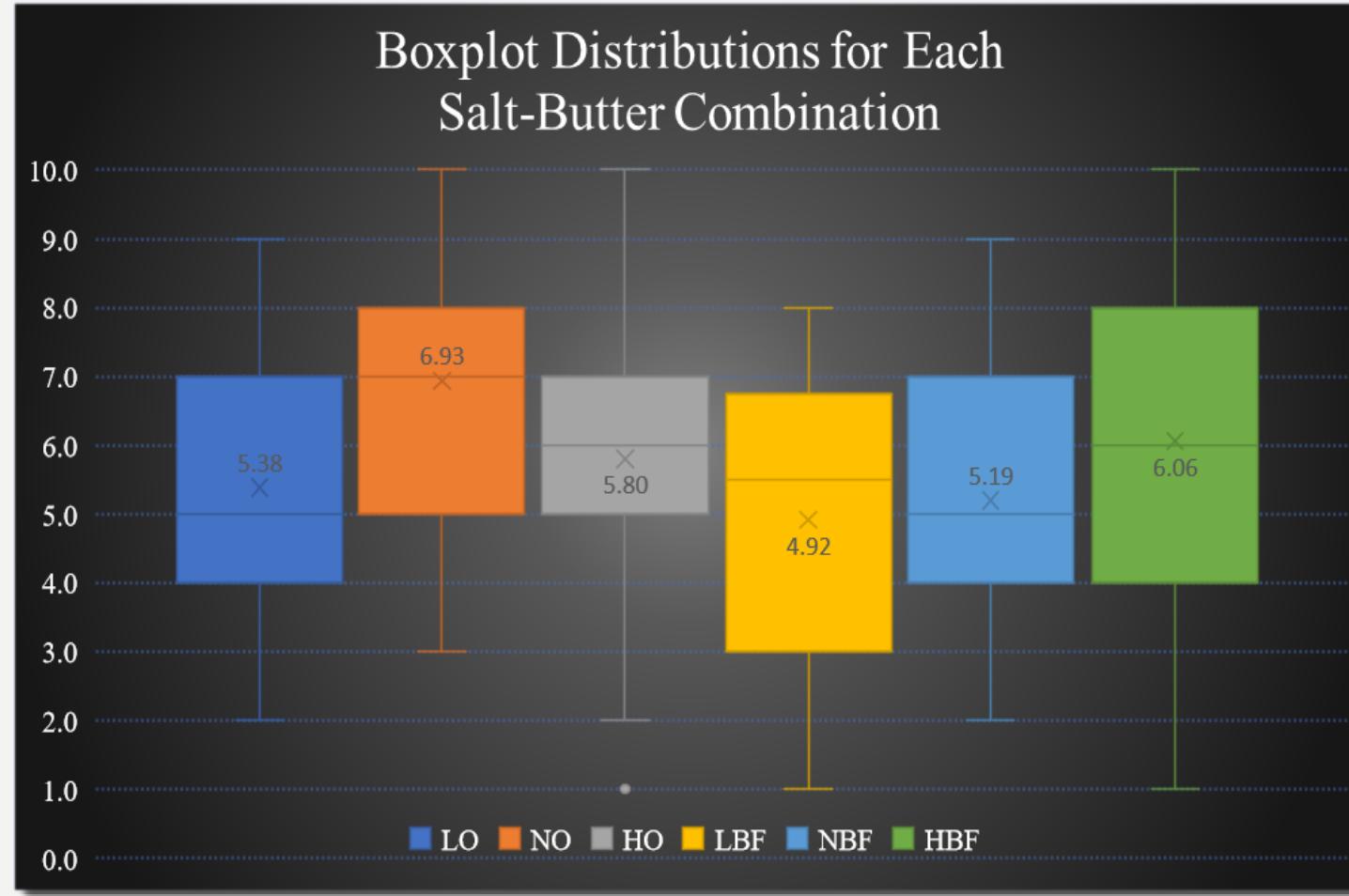


ANALYSIS PT. 3

WHAT CAN WE REALLY REALLY SAY?

BASIC DATA COMPARISON

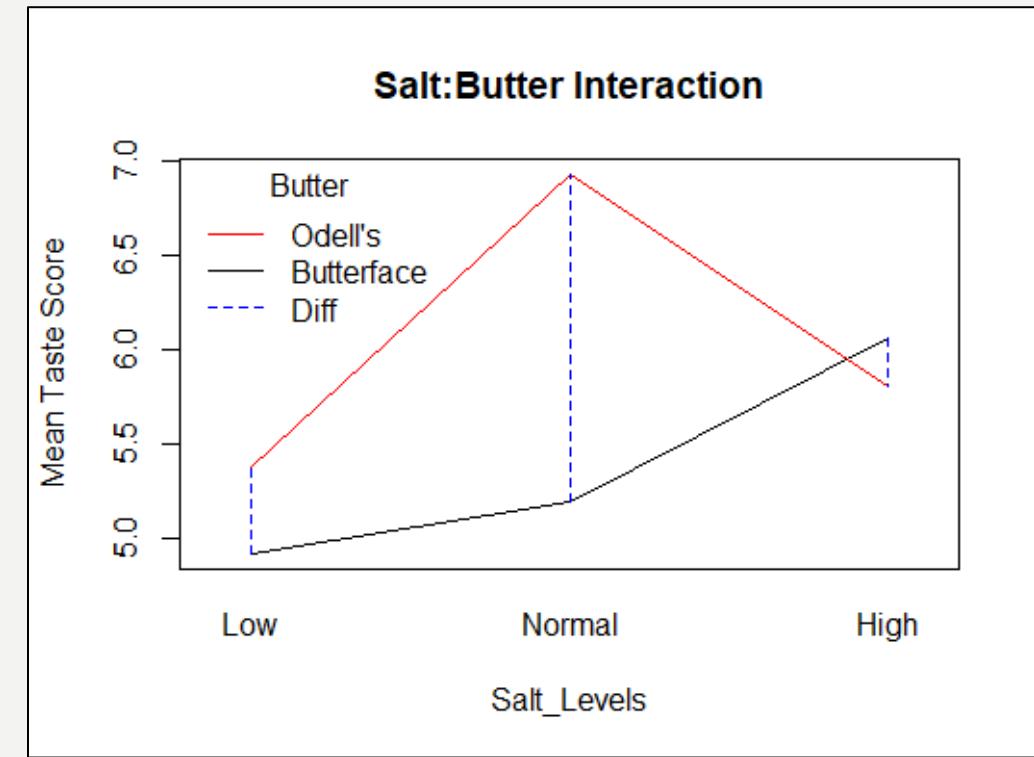
Equal Variance:
1.12



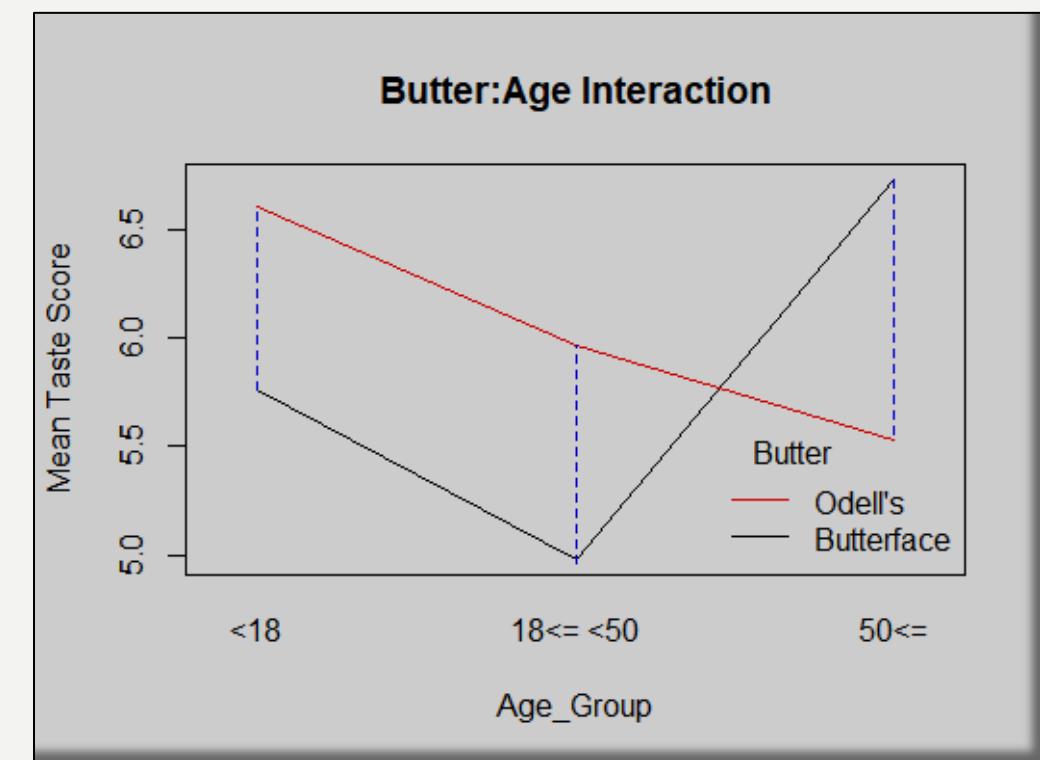
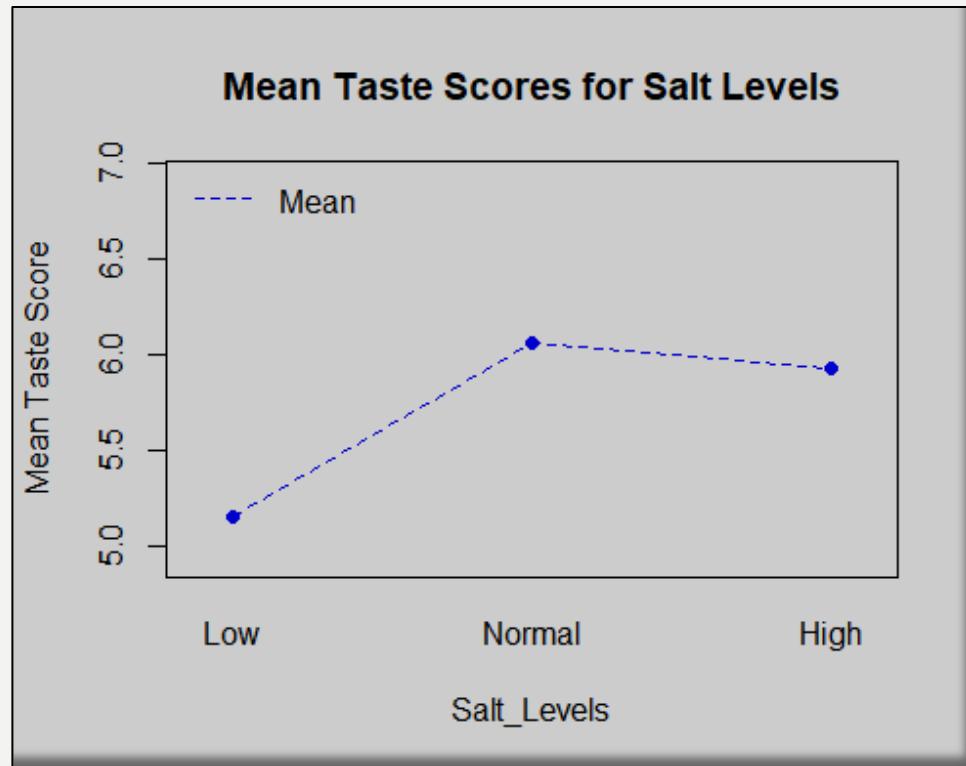
T-TESTS

SALT:BUTTER INTERACTION

- LBF < LO
 - $4.917 < 5.379$
 - $p = 0.2161$
- NBF < NO
 - $5.192 < 6.931$
 - $p = 0.0015 **$
 - $(-0.598, -2.880)$
- HBF > HO
 - $6.061 > 5.800$
 - 0.3073



CONTRAST: NOT ENOUGH POWER TO MATTER

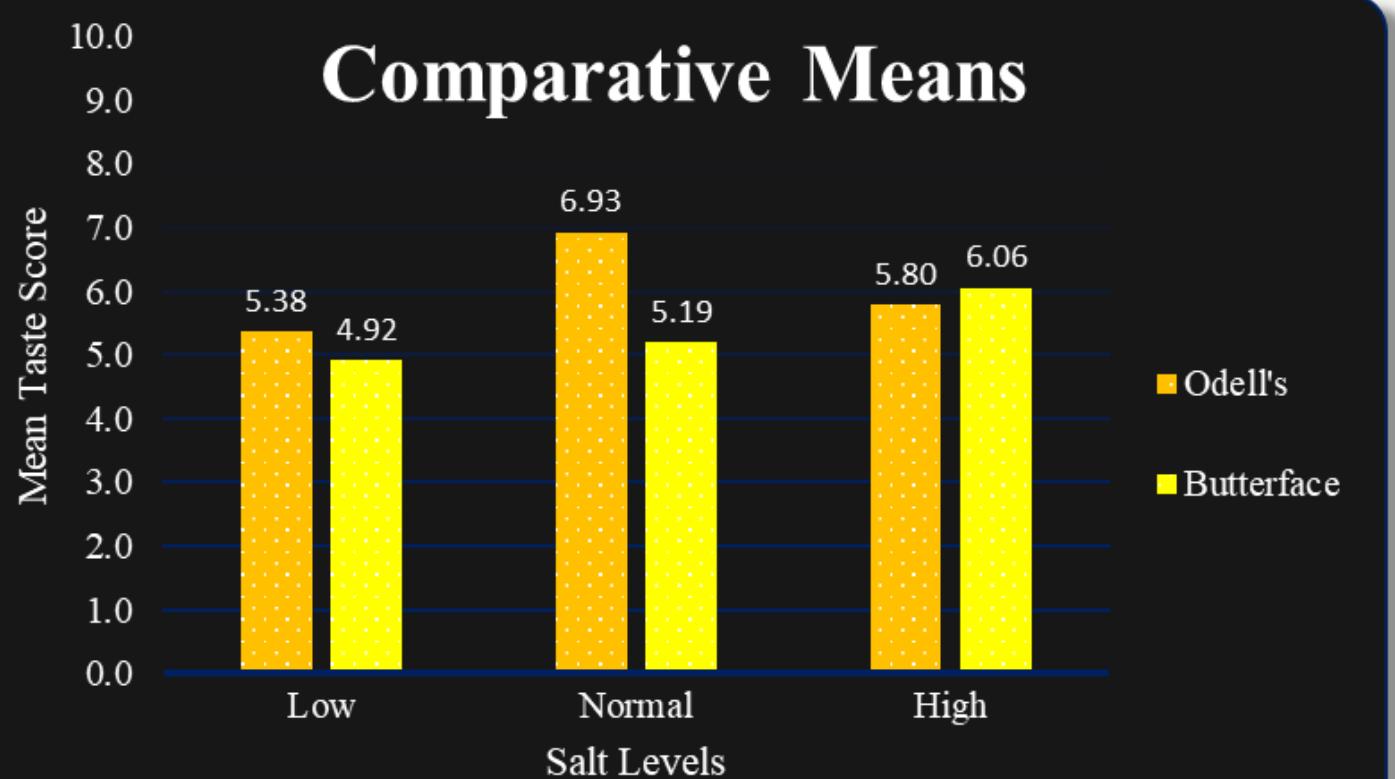




CONCLUSION

WHAT WAS THIS ALL ABOUT AGAIN?

ONLY ONE SIGNIFICANCE



Salt:Butter Interaction

Normal Salt

Odell's > Butterface

80.88% Power

p-value = 0.0015

LIMITATIONS

- Voluntary Sample => limited inference
 - Only Cinemark University Mall Guests
- Confounding Variables
 - Chewing Gum or Brushed Teeth
 - Comparisons
- Times and Days were not randomly assigned

FUTURE RECOMMENDATIONS

- Alter or Add Age Groups
- More Time => Greater Power => Possibly Increased Significance