Study of Recognition Versus Color of Emergency Vehicles

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Introduction

- During the 1980's, optometrists found that the human eye is "red-weak"
- Stephen S. Solomon and James King studied the Dallas Fire Department from 1984-1988
  - They found that fire trucks with a red livery had more accidents than the fluorescent yellow fire trucks
- FEMA conducted a study on how the color of fire engines affects the amount of intersection accidents
  - Florescent yellow vehicles were involved in less intersection accidents
  - Recognition of the vehicle is more important than the color

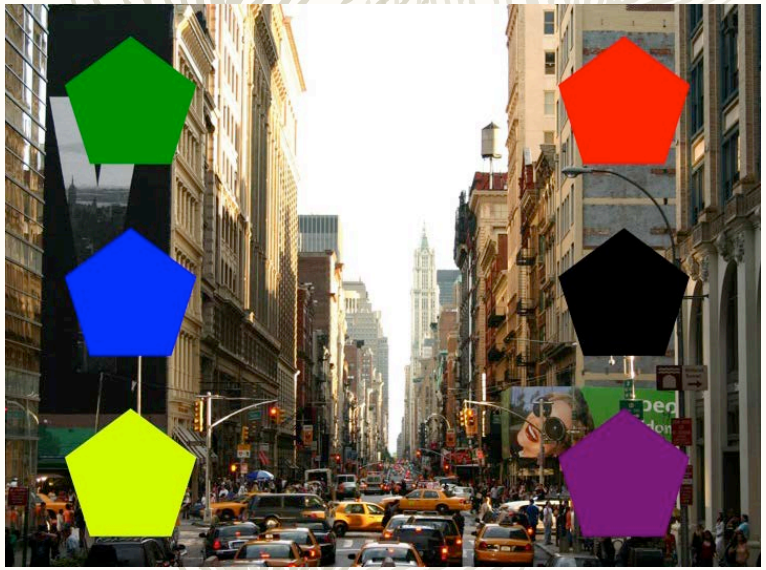
Motivation & Objective

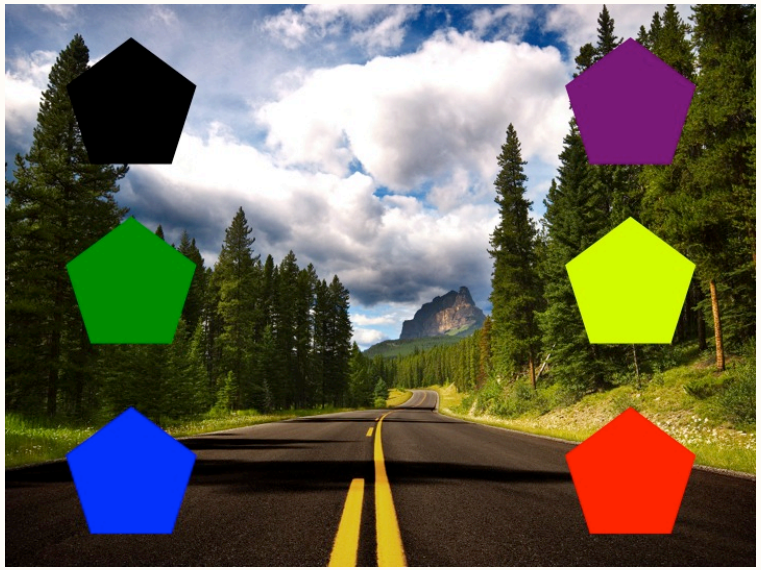
- 2008- Motor vehicle crashes were the cause of death for 29 of 114 firefighters killed on duty
- “True empirical research specific to U.S. emergency vehicle visibility is almost nonexistent”
- Goal- Quantify the importance of recognition so that engineers can design a livery that will decrease this statistic firefighter deaths

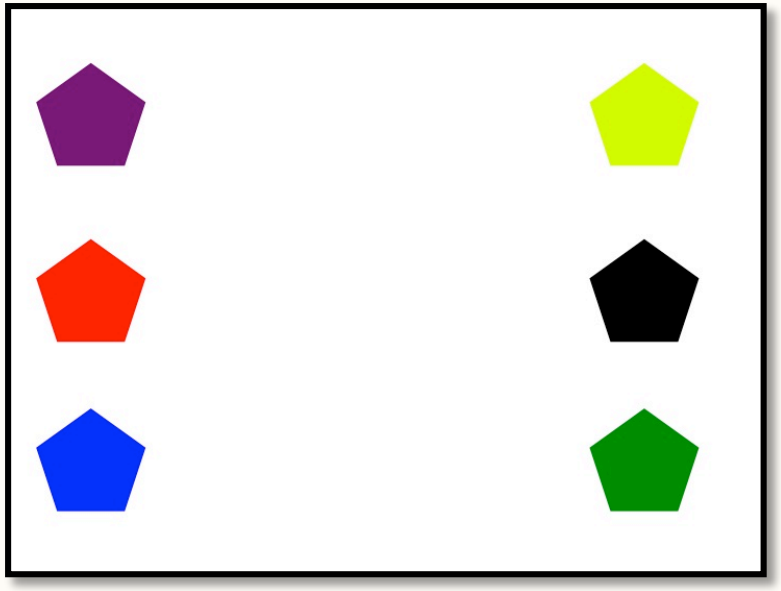
Design

- Factors Include:
  - Noise: *Police siren, ire truck siren, and no siren (ambient noise)*
  - Background: *Cityscape, countryside, and no background (white)*
  - Constant: *Colors, fire truck siren, and police siren*
- Three Replications
- 90% Confidence Level

Procedure





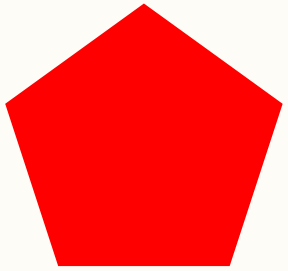


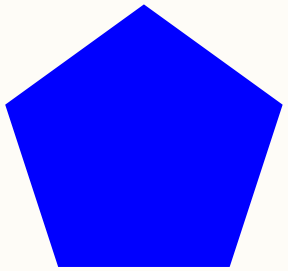
Data

		Background								
		1. Blank			2. City			3. Rural		
Noise	1. None	Yellow: 60	Yellow: 40	Yellow: 0	Yellow: 20	Yellow: 0	Yellow: 10	Yellow: 10	Yellow: 50	Yellow: 10
		Red: 10	Red: 20	Red: 20	Red: 10	Red: 70	Red: 20	Red: 30	Red: 30	Red: 20
		Blue: 20	Blue: 20	Blue: 70	Blue: 20	Blue: 30	Blue: 20	Blue: 30	Blue: 20	Blue: 10
		Red&Blue: 30	Red&Blue:40	Red&Blue: 90	Red&Blue: 30	Red&Blue: 100	Red&Blue: 40	Red&Blue: 60	Red&Blue: 50	Red&Blue: 30
		Randomization: 11	Randomization: 26	Randomization: 9	Randomization: 10	Randomization: 25	Randomization: 27	Randomization: 21	Randomization: 22	Randomization: 24
	2. Fire Siren	Yellow: 0	Yellow: 0	Yellow: 0	Yellow: 0	Yellow: 10	Yellow: 10	Yellow: 20	Yellow: 20	Yellow: 10
		Red: 10	Red: 40	Red: 20	Red: 40	Red: 70	Red: 50	Red: 10	Red: 30	Red: 20
		Blue: 30	Blue: 0	Blue: 10	Blue: 20	Blue: 20	Blue: 20	Blue: 30	Blue: 10	Blue: 30
		Red&Blue: 40	Red&Blue: 40	Red&Blue: 30	Red&Blue: 60	Red&Blue: 90	Red&Blue: 70	Red&Blue: 40	Red&Blue: 40	Red&Blue: 50
		Randomization: 3	Randomization: 4	Randomization: 17	Randomization: 1	Randomization: 5	Randomization: 19	Randomization: 2	Randomization: 6	Randomization: 20
	3. Police Siren	Yellow: 0	Yellow: 90	Yellow: 10	Yellow: 0	Yellow: 10	Yellow: 10	Yellow: 10	Yellow: 0	Yellow: 20
		Red: 10	Red: 10	Red: 10	Red: 0	Red: 10	Red: 10	Red: 50	Red: 30	Red: 10
		Blue: 30	Blue: 0	Blue: 50	Blue: 60	Blue: 20	Blue: 30	Blue: 10	Blue: 40	Blue: 20
		Red&Blue: 40	Red&Blue: 10	Red&Blue: 60	Red&Blue: 60	Red&Blue: 30	Red&Blue: 40	Red&Blue: 60	Red&Blue: 70	Red&Blue: 30
		Randomization: 7	Randomization: 14	Randomization: 18	Randomization: 23	Randomization: 13	Randomization: 16	Randomization: 8	Randomization: 12	Randomization: 15

Three Analyses

Noise	Background	RepsYellow	RepsRed
1	1	60	10
1	1	40	20
1	1	0	20
1	2	20	10
1	2	0	70
1	2	10	20
1	3	10	30
1	3	50	30
1	3	10	20
2	1	0	10
2	1	0	40
2	1	0	20
2	2	0	40
2	2	10	70
2	2	10	50
2	3	20	10
2	3	20	30
2	3	10	20
3	1	0	10
3	1	90	10
3	1	10	10
3	2	0	0
3	2	10	10
3	2	10	10
3	3	10	50
3	3	0	30
3	3	20	10





- Red Response: Uses only the red percentage responses in order to analyze recognition
- Yellow Response: Uses only fluorescent yellow percentage responses in order to analyze the subject's tendency to chose the color that irritates the eye the most
- Blue Response: Uses only the blue percentage responses in order to analyze if recognition of police cars applies to experiment as well

Red Response: Analysis of Variance

Analysis of Variance

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
Noise	2	1266.7	14.29%	1266.7	633.3	2.71	0.093
Background	2	955.6	10.78%	955.6	477.8	2.05	0.158
Noise*Background	4	2444.4	27.57%	2444.4	611.1	2.62	0.069
Error	18	4200.0	47.37%	4200.0	233.3		
Total	26	8866.7	100.00%				

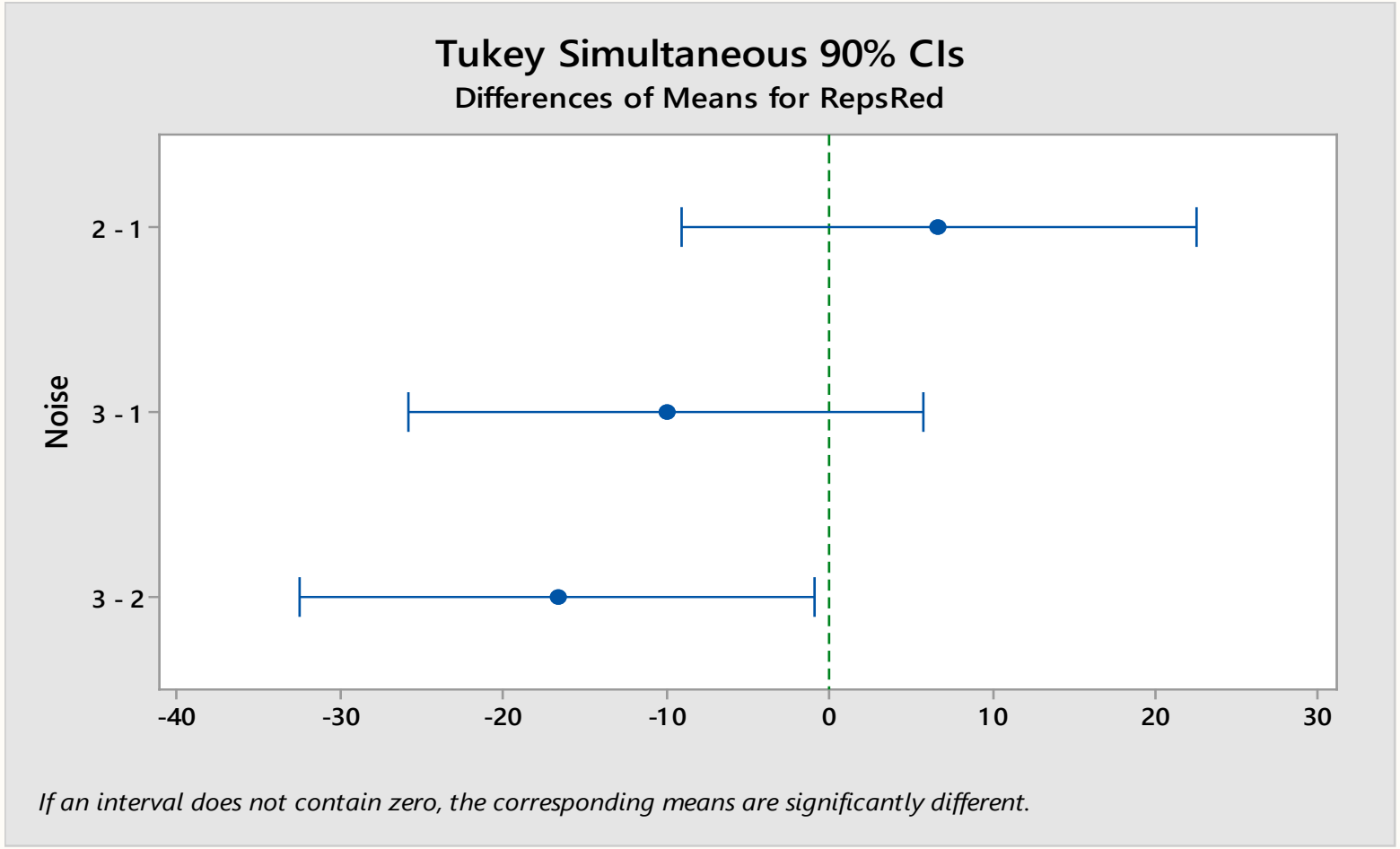
$$\begin{cases} H'_0: \alpha_1 = \alpha_2 = \alpha_3 = 0 \\ H'_1: At\ least\ one\ \alpha_i \neq 0 \end{cases} \quad (1)$$

$$\begin{cases} H''_0: \beta_1 = \beta_2 = \beta_3 = 0 \\ H''_1: At\ least\ one\ \beta_i \neq 0 \end{cases} \quad (2)$$

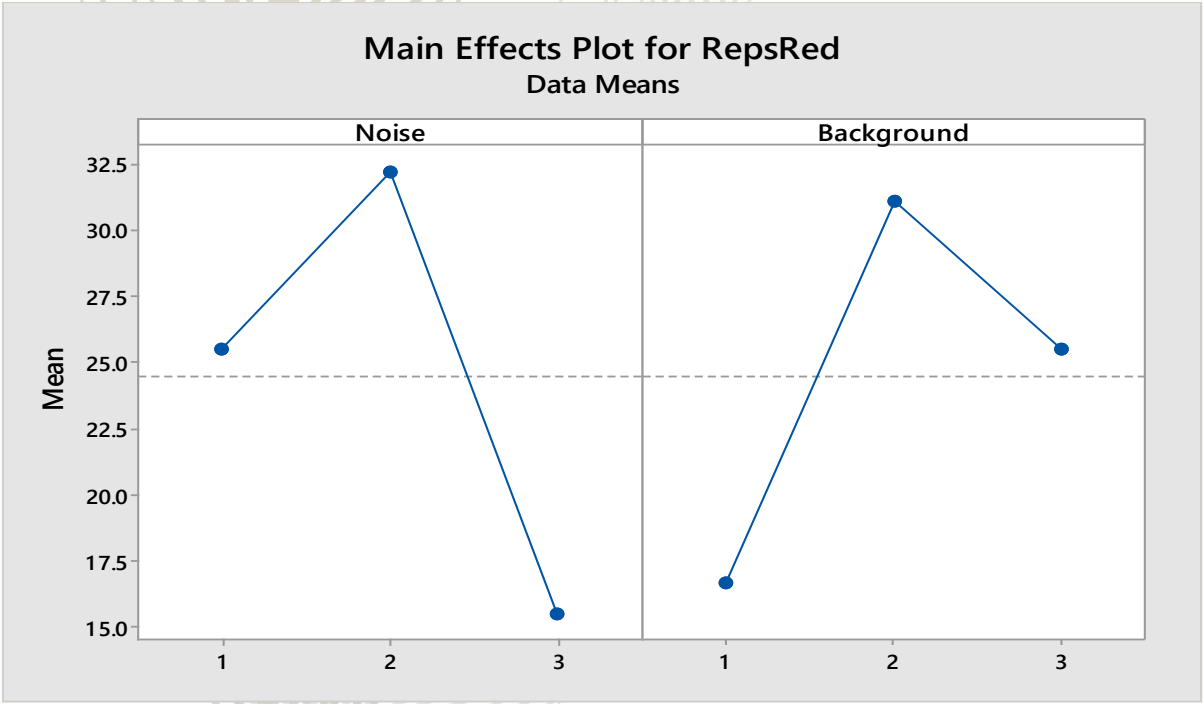
$$\begin{cases} H'''_0: (\alpha\beta)_{11} = (\alpha\beta)_{12} = \cdots = (\alpha\beta)_{33} = 0 \\ H'''_1: At\ least\ one\ (\alpha\beta)_{ij} \neq 0 \end{cases} \quad (3)$$

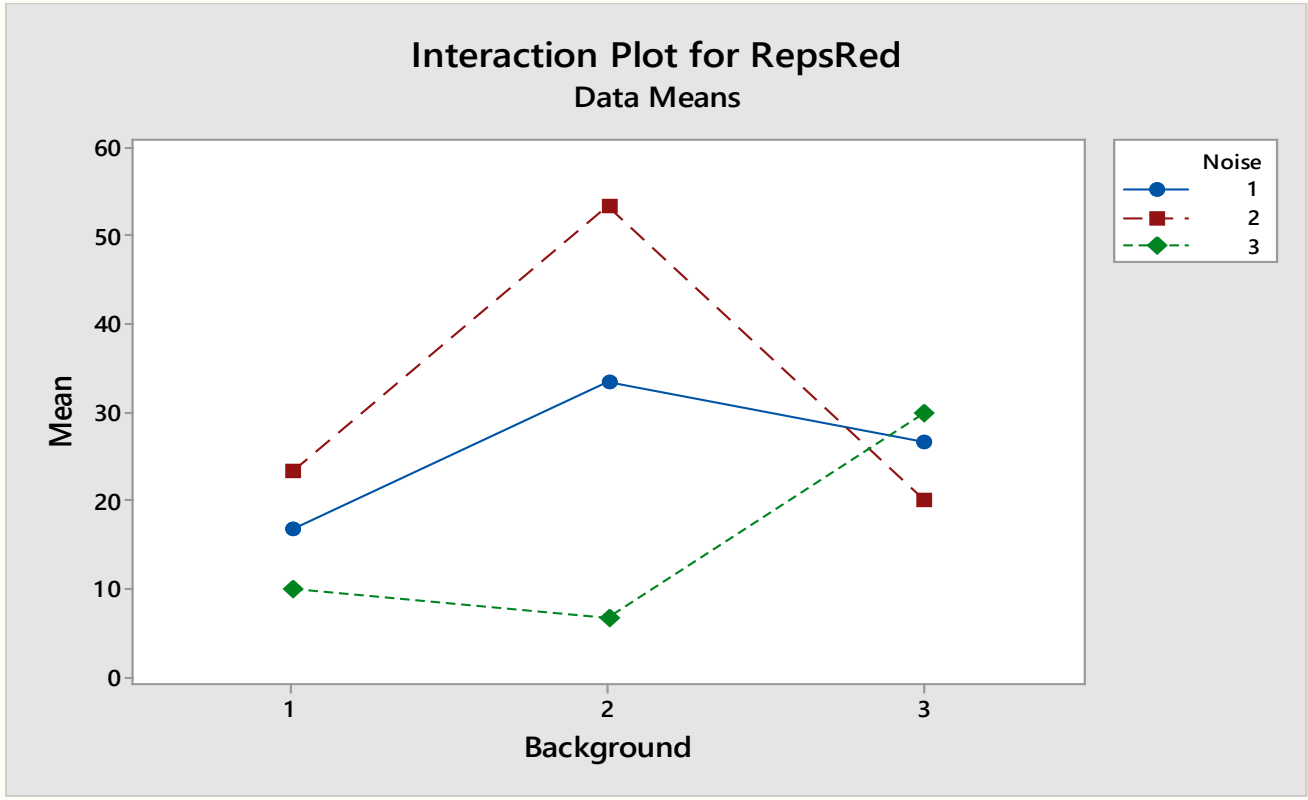
- Noise- Significant
- Background- Insignificant
- Interaction- Significant

Red Response: Tukey's Plot



Red Response:
Main Effects and Interaction Plot





Yellow Response: Analysis of Variance

Analysis of Variance

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
Noise	2	955.6	8.05%	955.6	477.8	1.02	0.379
Background	2	955.6	8.05%	955.6	477.8	1.02	0.379
Noise*Background	4	1555.6	13.11%	1555.6	388.9	0.83	0.522
Error	18	8400.0	70.79%	8400.0	466.7		
Total	26	11866.7	100.00%				

$$\begin{cases} H'_0: \alpha_1 = \alpha_2 = \alpha_3 = 0 \\ H'_1: At\ least\ one\ \alpha_i \neq 0 \end{cases} \quad (1)$$

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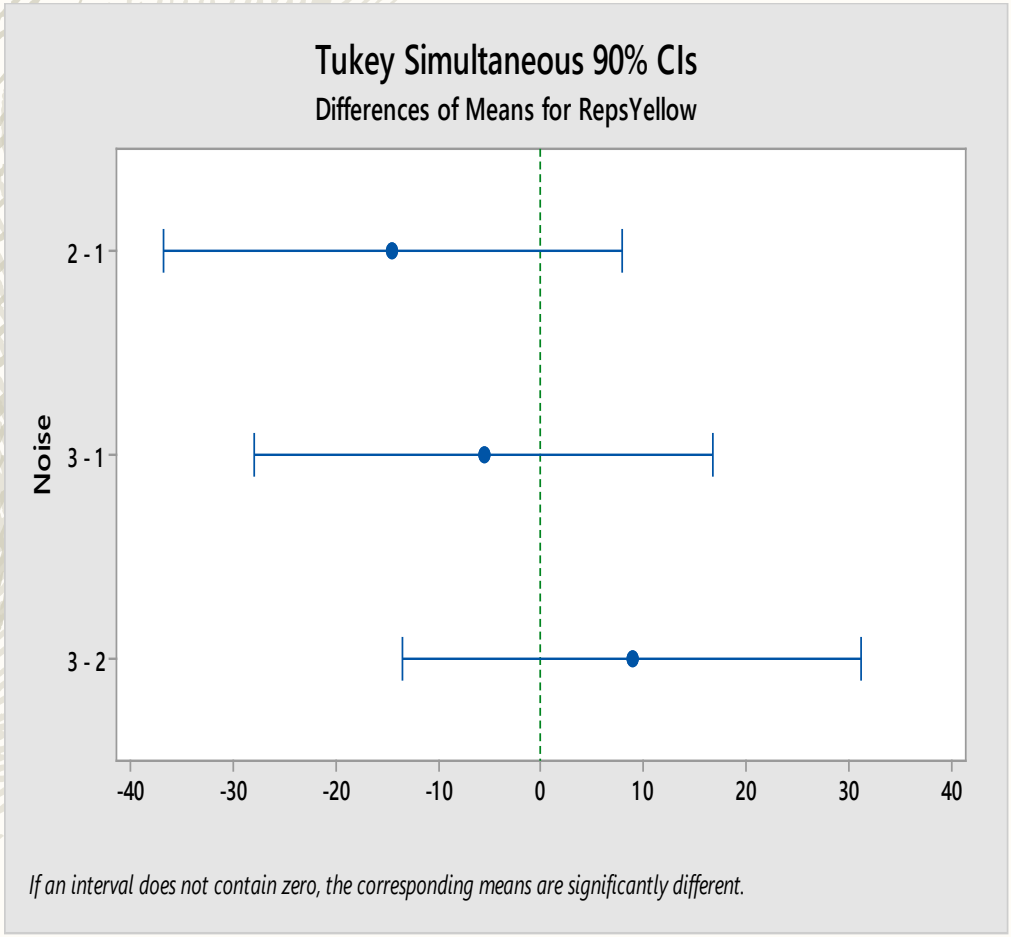
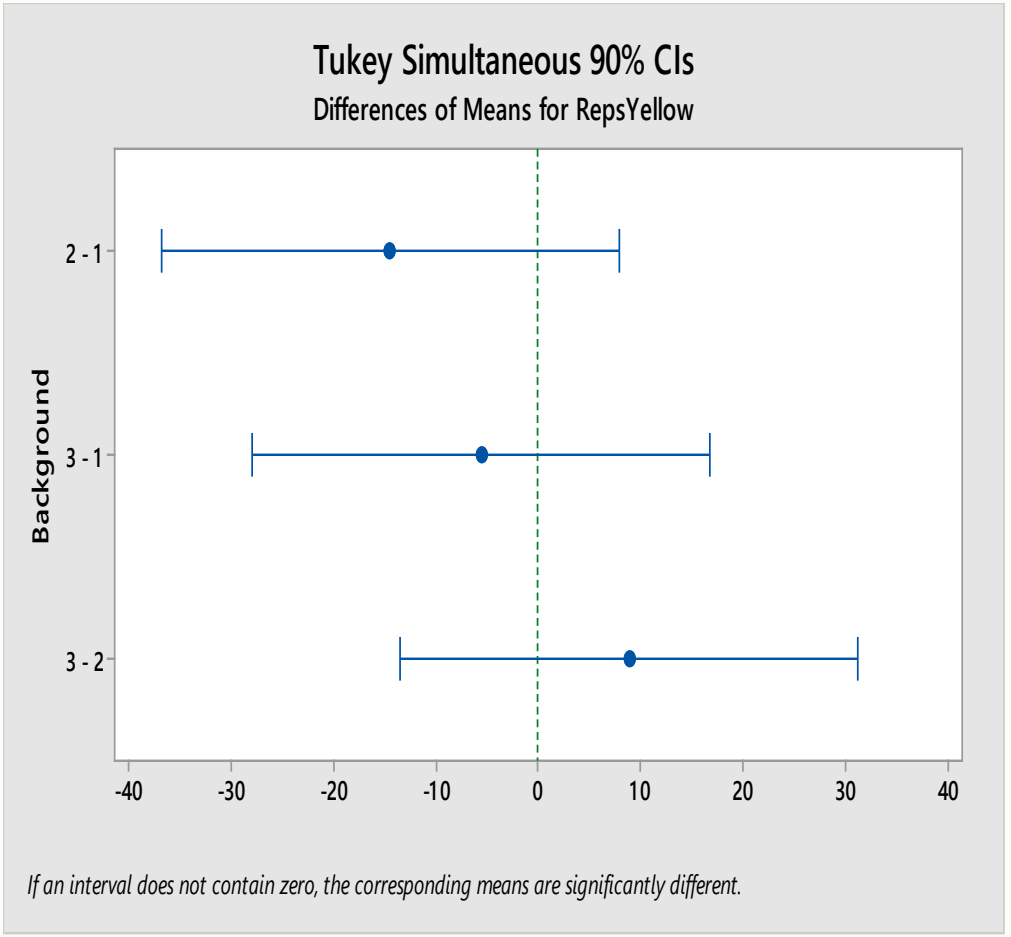
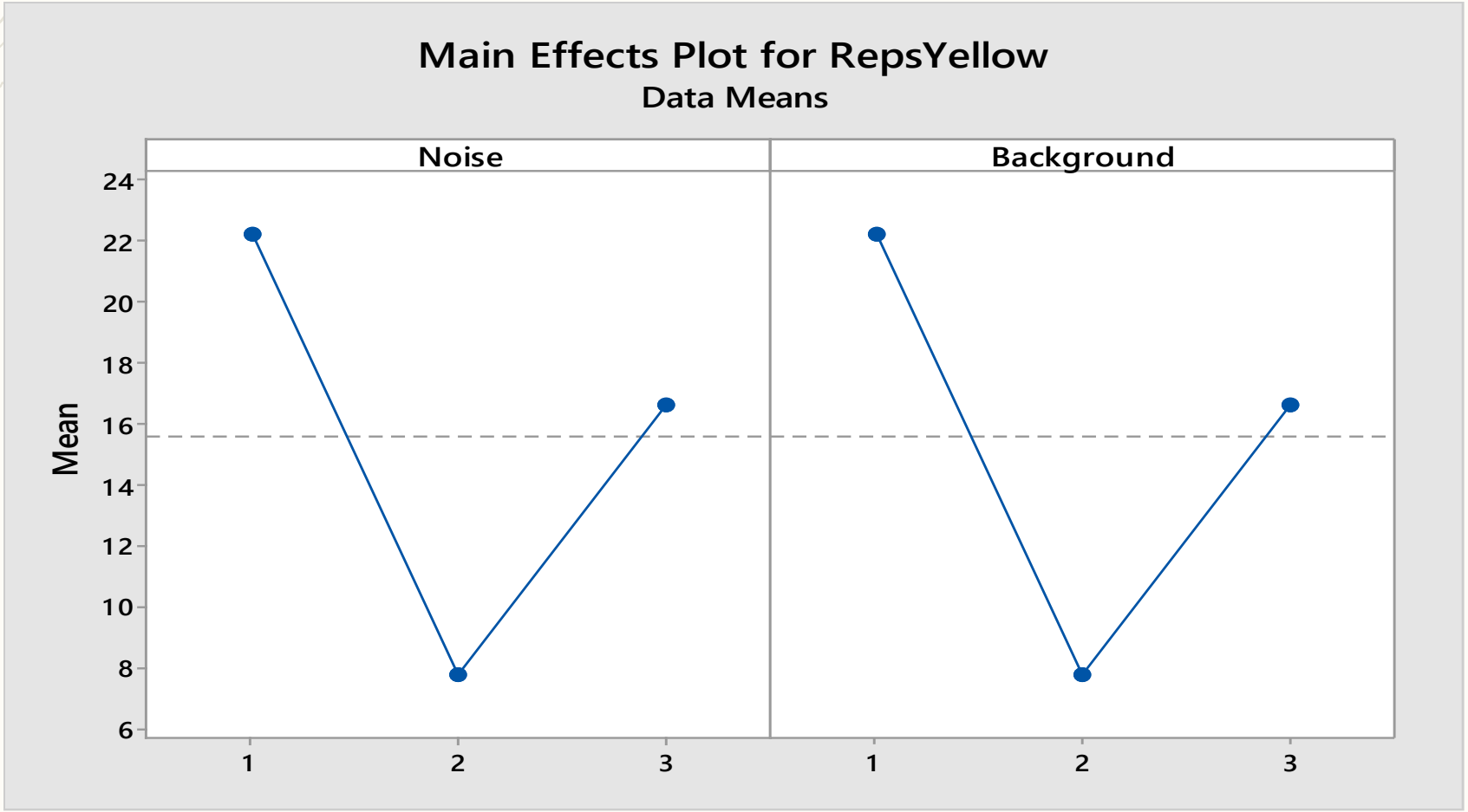
- Noise- Insignificant
- Background- Insignificant
- Interaction- Insignificant

Yellow Response: Tukey's Plot





Yellow Response:
Main Effect Plot



Recognition versus Science

Expected Results

- Fluorescent yellow- Insignificant
  - despite hearing an auditory response, subjects would choose the color that the eye is generally drawn to and irritated by the most

OR

- Red- Significant
  - subjects would link the fire truck siren to a particular color and the eye would seek that color

Direct Comparison

Response	Error	Fire Truck Siren Mean
Yellow	70.79%	7.77
Red	47.37%	32.22

Blue Response: Analysis of Variance

Analysis of Variance

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
Noise	2	496.30	7.44%	496.30	248.15	0.85	0.445
Background	2	96.30	1.44%	96.30	48.15	0.16	0.850
Noise*Background	4	814.81	12.21%	814.81	203.70	0.70	0.604
Error	18	5266.67	78.91%	5266.67	292.59		
Total	26	6674.07	100.00%				

- Background- Insignificant

$$\begin{cases} H'_0: \alpha_1 = \alpha_2 = \alpha_3 = 0 \\ H'_1: At\ least\ one\ \alpha_i \neq 0 \end{cases} \quad (1)$$

$$\begin{cases} H''_0: \beta_1 = \beta_2 = \beta_3 = 0 \\ H''_1: At\ least\ one\ \beta_i \neq 0 \end{cases} \quad (2)$$

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Conclusion & Recommendation

- Subjects were more likely to choose the red object in response to a recording of a fire truck engine on a cityscape background
- Recognition plays an important part in the color of emergency vehicles and being able to link a fire truck siren with a red fire engine is better for emergency vehicle design
- Recommendation: Red should be chosen as the predominate color of the body of the fire truck, particularly when designing fire trucks in area with a high level of distractions such as large cities

Questions?

Thank you!

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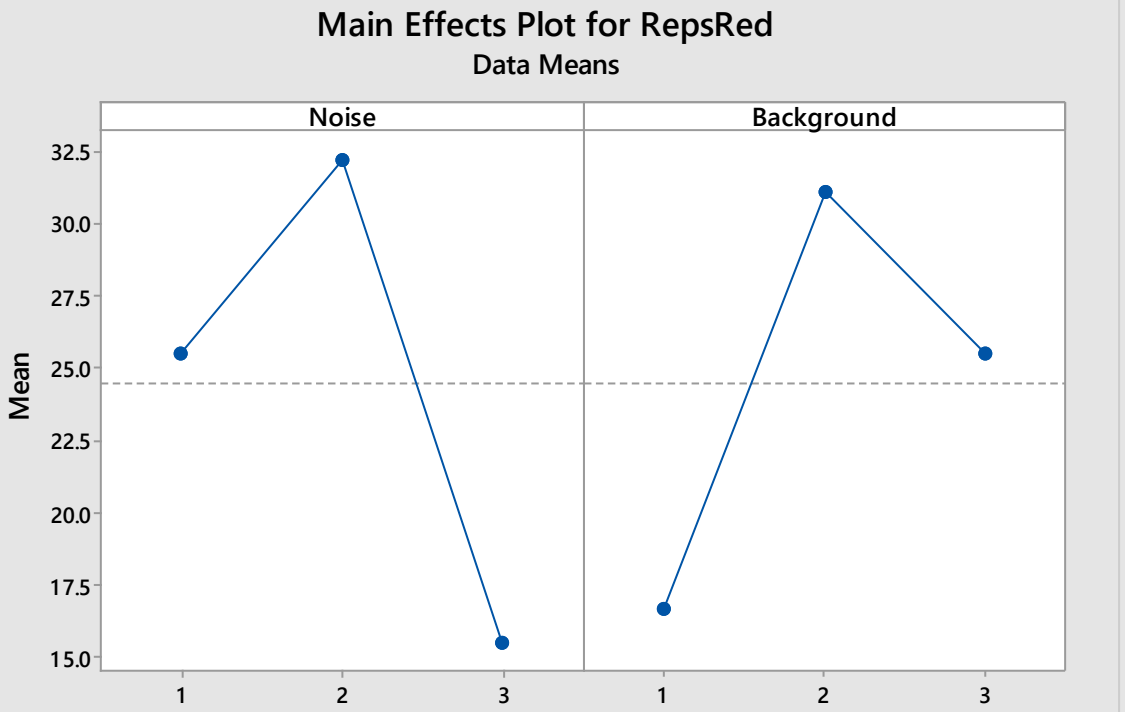
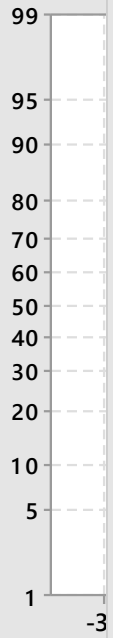
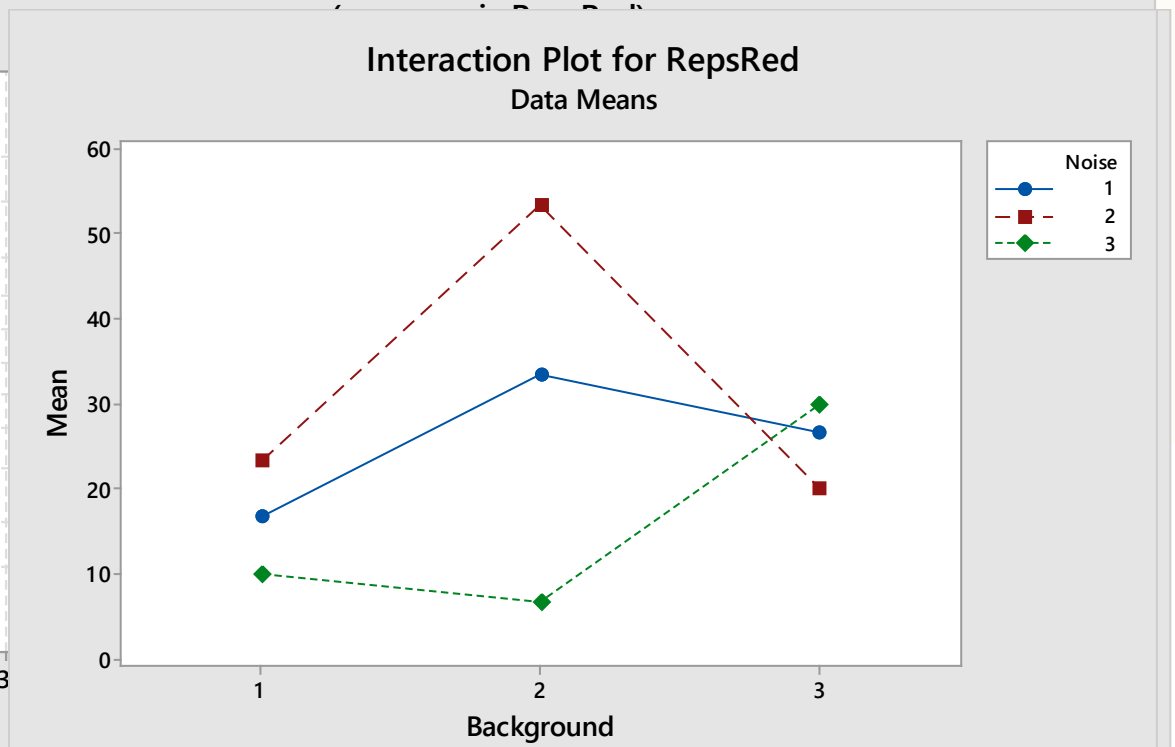
Red Response:

Analysis of Variance



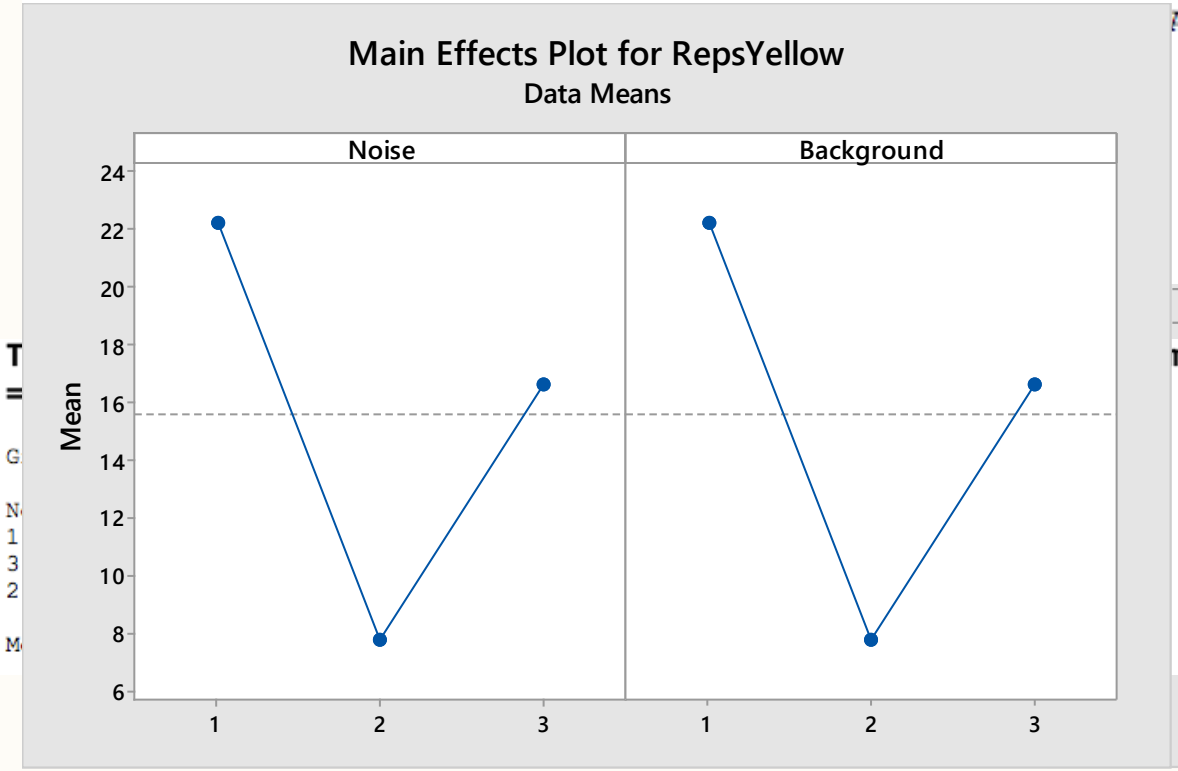


Normal Probability Plot



Yellow Response:

Analysis of Variance



Adj
477
477
388
466

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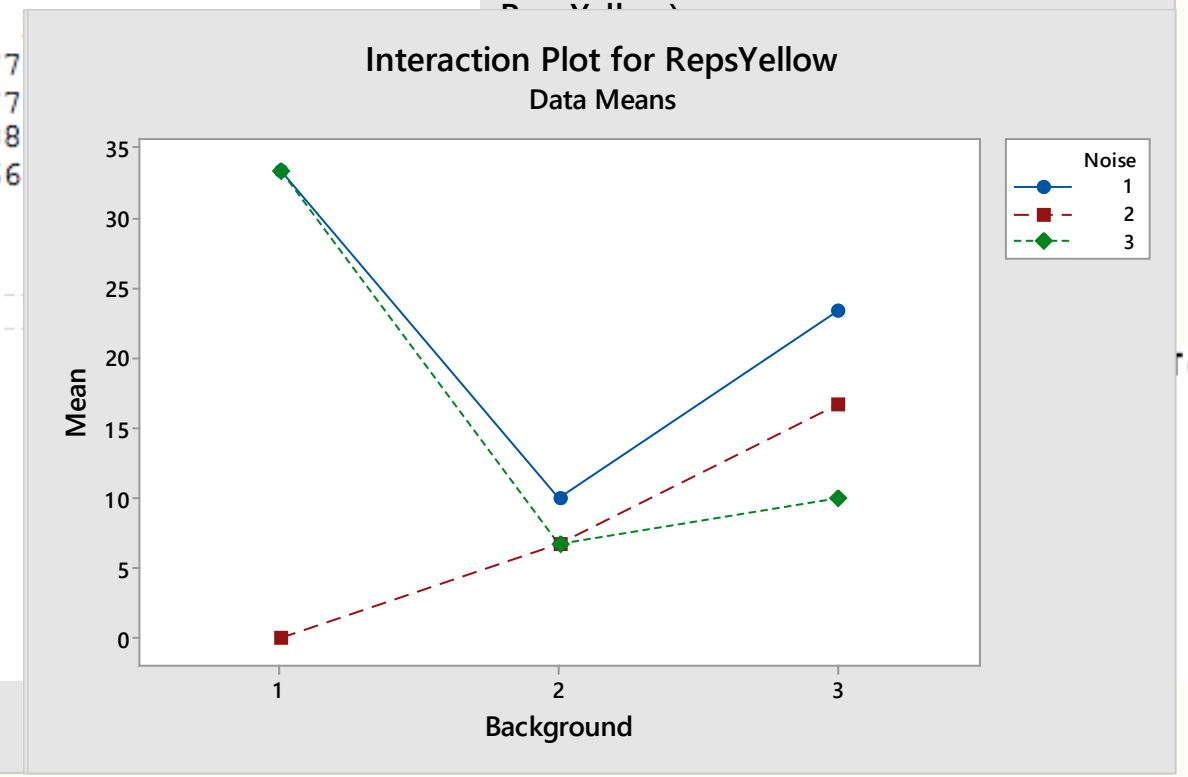

Blue Response:

Analysis of Variance