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# Effect of Exposure to Different Colors on Tiredness and Anxiety

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# Introduction (1)



We got interested in how effective these color treatments are on one's tiredness or anxiety level.

We wanted to conduct an experiment to study the relationship between samples' exposure to different colors and level of tiredness or anxiety.

# Introduction (2)

## IE 400 Project Survey

Thank you for responding to our survey. This survey was constructed for the final project of IE 400 course from the University of Illinois at Urbana Champaign. This survey is designed to research the effect of the worldwide pandemic on the psychological wellness and task accomplishing ability of community personnel. The survey will be conducted anonymously, and it will take approximately 5 minutes to complete.

설문에 응해주셔서 정말 감사드립니다.

본 설문은 University of Illinois at Urbana Champaign, Industrial Engineering 400 교과과정의 프로젝트를 위하여 설계되었습니다. 이 설문조사는 COVID-19 에 따른 사회구성원들의 심리건강과 생활습관, 그리고 주어진 과제에 대한 수행능력의 변화에 대하여 연구하기 위하여 설계되었습니다. 이 설문조사는 철저히 익명으로 진행될 예정이며 약 5분 정도 소요될 예정입니다.

\* Required

Confirm your age please.당신의 나이를 기재해주세요 \*

- ☐ 10s  
☐ 20s  
☐ 30s  
☐ 40s+

What is your average amount of sleep per day in hours? 당신의 하루 평균 수면시간은 몇시간입니까? \*

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# Factors & Model Design

- Response Variable : Tiredness and Anxiety Index
- Treatment Factor: Different theme color of the survey
- Blocking Factors
  - Age of experimental units
  - Time of the day when survey was taken
- Three non-binary blocking/treatment factors
  - Latin Square Design
  - Conducted experiment for 4 colors
    - Divided each block in 4 levels
  - Replicate in order to increase accuracy of design.

# Model Design

Age	Time that the survey was taken			
	1	2	3	4
1	A	B	C	D
2	B	C	D	A
3	C	D	A	B
4	D	A	B	C

Treatment Factor 1: Theme Color of Survey (A=Red, B=Yellow, C=Blue, D=Green)

Blocking Factor 1: Age ( $1=10s$ ,  $2=20s$ ,  $3=30s$ ,  $4=40s$ )

Blocking Factor 2: Time of the day (1 = Morning (8am-12pm), 2 = Afternoon (12pm-4pm), 3 = Evening (4pm-8pm), 4 = Night (8pm-12am))

# Experimental Design

- Survey was given to 48 samples.
  - Chose samples selectively by age for blocking.
  - Send surveys to samples in different time of the day.
    - Checked completion time
  - People were told that survey was designed to study the effect of COVID-19 on task-accomplishing ability.
- Survey has 10 questions
  - 2 questions relevant to tiredness and anxiety
  - Questions were answered on a linear scale (1-10)
  - Added the values and defined "Tiredness and Anxiety Index."
    - Min: 2 Max: 20

# Statistical Analysis (1)

Latin Square Model with replication

$$Y_{ijklm} = \mu + \rho_i + \kappa_j + \tau_k + \epsilon_{ijklm}$$

$\mu$  is a constant

$\rho_i$  row blocking effect (age group) subject to  $\sum \rho_i = 0$

$\kappa_j$  column blocking effect (time the survey was taken) subject to  $\sum \kappa_j = 0$

$\tau_k$  Latin Letter treatment effect (Color of the survey) subject to  $\sum \tau_k = 0$

$\epsilon_{ijklm}$  are independent  $N(0, \sigma^2)$

$i, k, j = 1, \dots, 4$  ,  $m = 1 \dots 3$

# Statistical Analysis (2)

## The GLM Procedure

Dependent Variable: resp

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	960.687500	106.743056	17.81	<.0001
Error	38	227.791667	5.994518		
Corrected Total	47	1188.479167			

R-Square	Coeff Var	Root MSE	resp Mean
0.808333	25.05795	2.448370	9.770833

Source	DF	Type I SS	Mean Square	F Value	Pr > F
age	3	272.3958333	90.7986111	15.15	<.0001
time	3	45.5625000	15.1875000	2.53	0.0713
trt	3	642.7291667	214.2430556	35.74	<.0001

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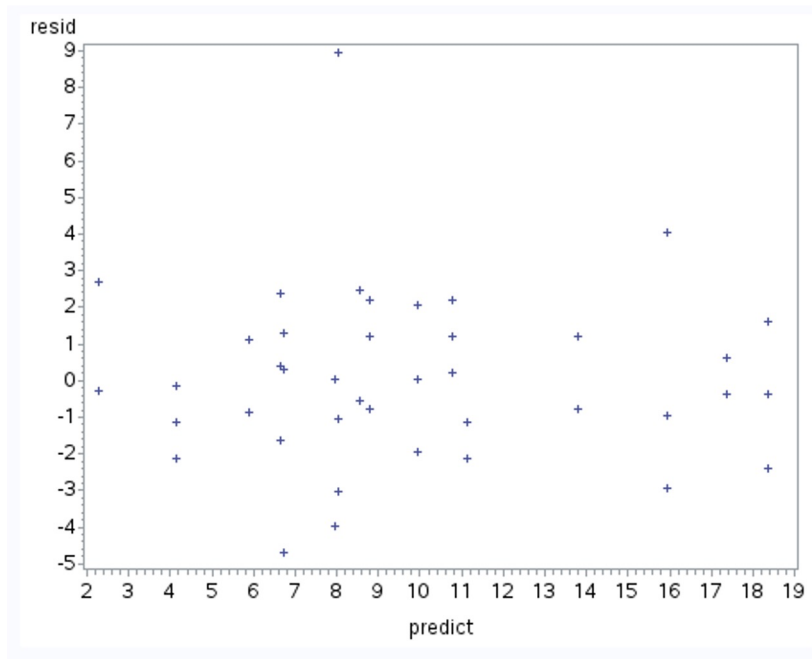
Original Latin square model  
degrees of freedom of  $(r-1)(r-2) = 6$   
if there were not any replication.

But for the one with replication it  
follows the term of  $n \cdot r^2 - 3 \cdot r + 2$ , which  
is shown correctly in the table.

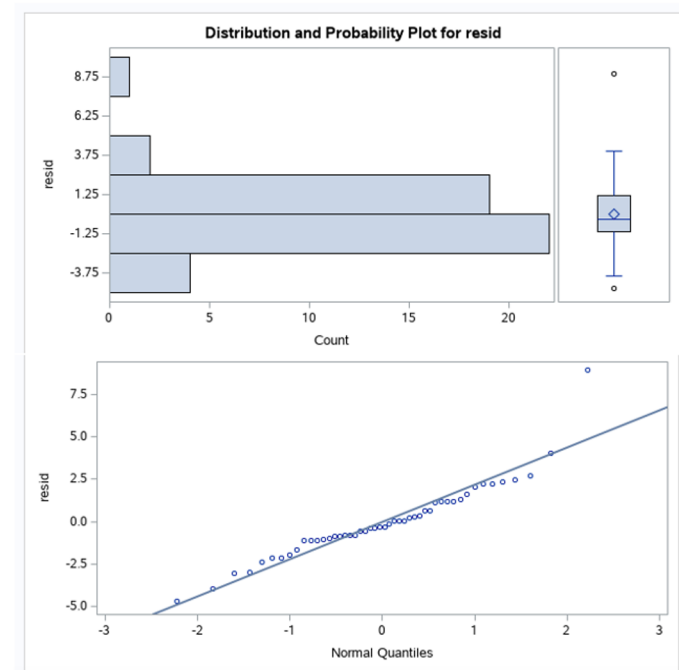


# Model Assumption

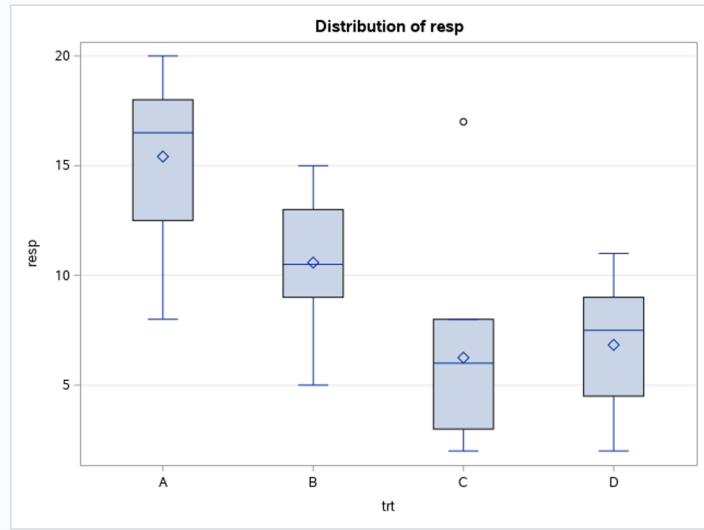
Fitted vs Residual (Constant variance)



Distribution/QQplot (Normality)



# Statistical Analysis (3)



A = Red, B = Yellow

C = Blue, D = Green

## Tukey's Studentized Range (HSD) Test for resp

Note: This test controls the Type I experimentwise error rate.

Alpha	0.05
Error Degrees of Freedom	38
Error Mean Square	5.994518
Critical Value of Studentized Range	3.79925
Minimum Significant Difference	2.6852

Comparisons significant at the 0.05 level are indicated by \*\*\*.

trt Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		
A - B	4.8333	2.1481	7.5186	***
A - D	8.5833	5.8981	11.2686	***
A - C	9.1667	6.4814	11.8519	***
B - A	-4.8333	-7.5186	-2.1481	***
B - D	3.7500	1.0648	6.4352	***
B - C	4.3333	1.6481	7.0186	***
D - A	-8.5833	-11.2686	-5.8981	***
D - B	-3.7500	-6.4352	-1.0648	***
D - C	0.5833	-2.1019	3.2686	
C - A	-9.1667	-11.8519	-6.4814	***
C - B	-4.3333	-7.0186	-1.6481	***
C - D	-0.5833	-3.2686	2.1019	

C - D contains 0 in its confidence interval

# Experimental Conclusion

Hypothesis Testing for Latin Letter Treatment (Color of the survey)

$H_0 : \tau_k = 0$

$H_a : \text{not all } \tau_k \text{ are zero}$

Test Statistic:  $F^* = (MSTR / MSRem) = (214.2430556 / 5.994518) = 35.74983$

Decision Rule:

if  $F^* < F(r-1, n-r^2-3r+2) (1-\alpha) = 2.852$ , conclude  $H_0$

if  $F^* > F(r-1, n-r^2-3r+2) (1-\alpha) = 2.852$ , conclude  $H_a$

Conclusion: The p-value of this treatment factor from ANOVA table is less than 0.0001, which is less than  $\alpha=0.05$ . Also, our test statistic is larger than the critical value 2.852. Therefore, we reject the null hypothesis and conclude that the color of the survey has statistical significance to the tired/anxiety index.

# Possible source of error

1. Latin Square model assumes that there is no interaction
2. Experimental units' different personal experience regarding COVID-19 could affect their psychological status while taking survey
  - a. E.g. If one has a close friend who has recently tested positive, such experience would have raised one's anxiety while taking survey.
3. Experimental units' psychological status may vary depending on multiple variables
  - a. Physical Condition
  - b. Work environment

# Conclusion

- Through the statistical analysis, we have shown colors do show the difference in psychological state of the people.
  - Visual effects with red raise anxiety and tiredness level.
  - Blue and green seem to lower anxiety and tiredness
- Age of experimental units also seem to be statistically significant
- This result studied and used in various fields
  - Psychiatry
  - Marketing, Branding
  - Education