Cognitive Effects of Sugar & Caffeine on Human Alertness

Group 6

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Introduction

Research Question

“How does caffeine and sugar affect a person’s mental alertness?”

Sampling Process

- Randomly selected city in Bonne Santé
- Randomly selected people of different age groups using birth records and schools

**Note: This is not completely randomized since our sample is limited to specific towns on a single island.

Factor Identification

Treatment Variables

i. Sugar

(sugar free / with sugar)

ii. Caffeine

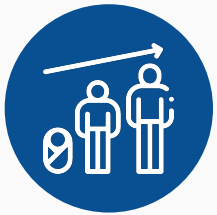
(caffeine free / with caffeine)

Response Variable

Improvement in Vigilance Test Score

(minutes)

Measured in minutes taken to circle all Z's on a page of 2000 random letters before and after drinking an energy drink.



Nuisance Factor

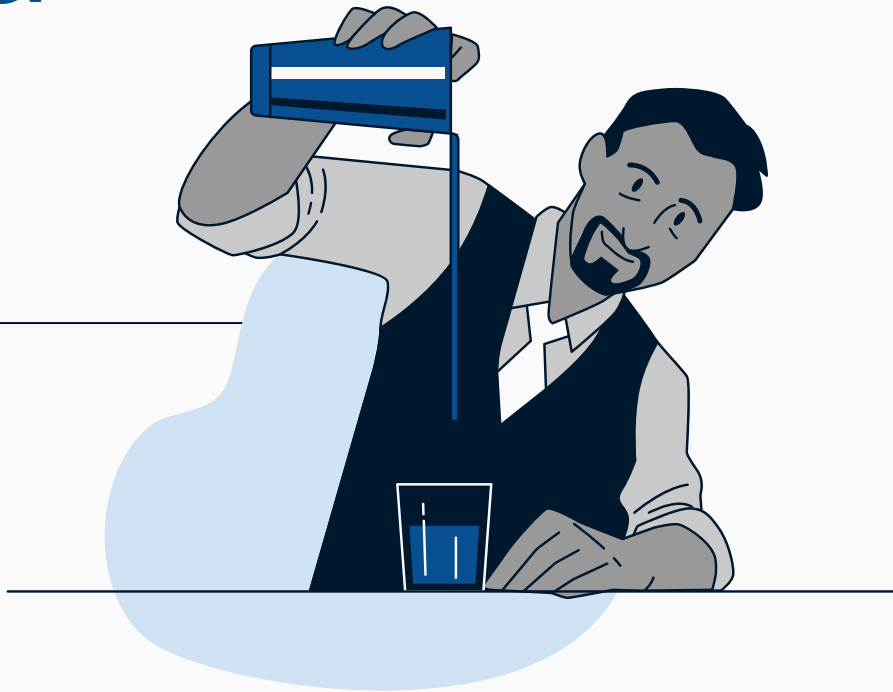
Age

(children, youth, adult, senior)

Groupings were based on Statistics Canada.

Experimental Design

2^2 **Factorial Design** with **1 Block**



Sampling Process & Sample Size

Data from Eden

House	Name	Sugar	Caffeine	Age Block	Age	B4	After	Vigilance Test Improvement	Age
148	Jeremy Bager	0	0	1	0-14	6.4	6.2	0.2	12
262	Laurie Zaman	0	1	1	0-14	6.2	6.1	0.1	10
228	Adam Watanabe	1	0	1	0-14	6.6	6.2	0.4	8
491	Karlene Morris	1	1	1	0-14	7.7	7.1	0.6	7
376	Armand Bhatt	0	0	2	15-24	5.2	5.3	-0.1	19
412	Ella Jensen	0	1	2	15-24	3.9	3.9	0	22
417	Claire Erickson	1	0	2	15-24	5.8	5.6	0.2	18
384	Harvey Edwards	1	1	2	15-24	4.6	4.4	0.2	15
Arcadia 443	Lamont Page	0	0	3	25-64	5.3	5.2	0.1	53
271	Aahna Ramanuj	0	1	3	25-64	5.4	5.3	0.1	45
721	Ishana Shah	1	0	3	25-64	4.9	4.5	0.4	32
478	Pranay Asan	1	1	3	25-64	5.5	5.1	0.4	32
352	Jermaine Bager	0	0	4	65+	5.2	4.9	0.3	76
227	Asmee Bhatt	0	1	4	65+	7.3	7.4	-0.1	73
230	Zania Banerjee	1	0	4	65+	5	4.6	0.4	66
20	Mallory Abel	1	1	4	65+	4	4.1	-0.1	73

```
> sugar <- rep(c(0, 0, 1, 1), 4)
> caffeine <- rep(c(0, 1), 8)
> block <- c(rep(1, 4), rep(2, 4), rep(3, 4), rep(4, 4))
>
> response <- c(-0.2, -0.1, -0.4, -0.6,
+               0.1, 0, -0.2, -0.2,
+               -0.1, -0.1, -0.4, -0.4,
+               -0.3, -0.1, -0.4, 0.1)
>
> response <- response * -1
> model_no_block <- aov(response ~ factor(sugar)*factor(caffeine))
> model_block <- aov(response ~ factor(sugar)*factor(caffeine) + factor(block))
> summary(model_no_block)
                          Df Sum Sq Mean Sq F value Pr(>F)
factor(sugar)              1 0.1806 0.18063   5.522 0.0367 *
factor(caffeine)           1 0.0156 0.01563   0.478 0.5026
factor(sugar):factor(caffeine)  1 0.0006 0.00063   0.019 0.8923
Residuals                 12 0.3925 0.03271
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
> summary(model_block)
                          Df  Sum Sq Mean Sq F value Pr(>F)
factor(sugar)              1 0.18063 0.18063   6.359 0.0327 *
factor(caffeine)           1 0.01563 0.01563   0.550 0.4772
factor(block)              3 0.13688 0.04563   1.606 0.2554
factor(sugar):factor(caffeine)  1 0.00062 0.00062   0.022 0.8853
Residuals                  9 0.25563 0.02840
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
> #no block
> d <- 0.2
> MSE <- 0.03271
> #install.packages("pwr")
> library(pwr)
> pwr.anova.test(k = 4, f = d/sqrt(MSE), power = 0.9)

     Balanced one-way analysis of variance power calculation

              k = 4
              n = 4.035544
              f = 1.105833
      sig.level = 0.05
          power = 0.9

NOTE: n is number in each group
```

Compared to the MSE, we can note that MS block is not that large. So, blocking is not necessary.

Since **n = 4.035544**, we should use at least **n = 5** replicates per treatment combo.

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Interpreting Our Results

A Breakdown of Our Data

Factors | **Age Block** | **Response Variable**

Sugar <int>	Caffeine <int>	Age.Block <int>	Age <chr>	B4 <dbl>	After <dbl>	Vigilance.Test.Improvement <dbl>	Age.1 <chr>
0	0	1	0–14	6.4	6.2	0.2	12
0	1	1	0–14	6.2	6.1	0.1	10
1	0	1	0–14	6.6	6.2	0.4	8
1	1	1	0–14	7.7	7.1	0.6	7
0	0	2	15–24	5.2	5.3	−0.1	19
0	1	2	15–24	3.9	3.9	0.0	22

This process was repeated 6 times for **6 random cities** on the island of Bonne Santé. With **16 observations per city**, we collected data on a total of **96 subjects**.

Our Models

Main Effects

```{r}
effect1 <- na.omit(2*coef(model1)[-1])
effect1
```

```
factor(Sugar)1 factor(Caffeine)1 factor(Sugar)1:factor(Caffeine)1
    0.50000000     -0.03333333                     -0.02500000
```

positive

negative

```{r}
effect2 <- na.omit(2*coef(model2)[-1])
effect2
```

```
            factor(Sugar)1             factor(Caffeine)1             factor(Age.Block)2
                0.50000000                   -0.03333333                   -0.06666667
            factor(Age.Block)3             factor(Age.Block)4 factor(Sugar)1:factor(Caffeine)1
                -0.02500000                   -0.13333333                   -0.02500000
```

Age block is NOT significant

Without blocking

```{r}
model1 <- aov(Vigilance.Test.Improvement ~ factor(Sugar)*factor(Caffeine), data = data)

summary(model1)
```

```
                            Df Sum Sq Mean Sq F value  Pr(>F)
factor(Sugar)                1 1.4259  1.4259  43.650 2.5e-09 ***
factor(Caffeine)             1 0.0126  0.0126   0.386   0.536
factor(Sugar):factor(Caffeine)  1 0.0009  0.0009   0.029   0.866
Residuals                   92 3.0054  0.0327
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Sugar is significant

With age block

```{r}
model2 <- aov(Vigilance.Test.Improvement ~ factor(Sugar)*factor(Caffeine)
                                           + factor(Age.Block), data = data)
summary(model2)
```

```
                            Df Sum Sq Mean Sq F value   Pr(>F)
factor(Sugar)                1 1.4259  1.4259  43.104 3.37e-09 ***
factor(Caffeine)             1 0.0126  0.0126   0.381    0.539
factor(Age.Block)            3 0.0611  0.0204   0.616    0.606
factor(Sugar):factor(Caffeine)  1 0.0009  0.0009   0.028    0.867
Residuals                   89 2.9443  0.0331
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Investigating Our Interaction Term

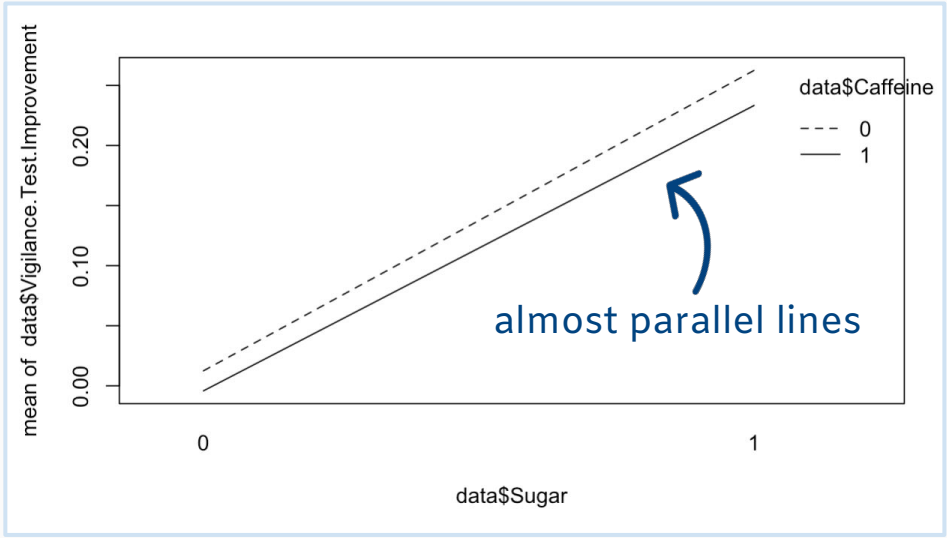
```r
model1 <- aov(Vigilance.Test.Improvement ~ factor(Sugar)*factor(Caffeine), data = data)

summary(model1)
```

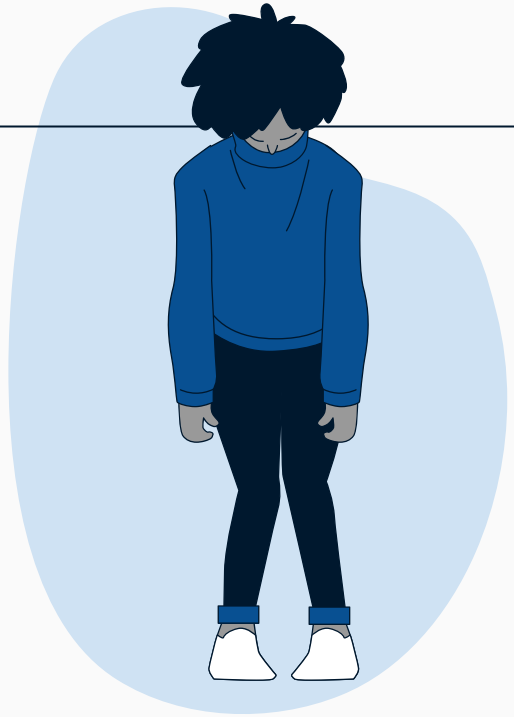
```
                          Df Sum Sq Mean Sq F value  Pr(>F)
factor(Sugar)              1 1.4259  1.4259  43.650 2.5e-09 ***
factor(Caffeine)           1 0.0126  0.0126   0.386   0.536
factor(Sugar):factor(Caffeine)  1 0.0009  0.0009   0.029   0.866
Residuals                 92 3.0054  0.0327
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Recall...
Our interaction term had a p-value > 0.05

Indicates **little to no interaction**

Interaction plot between sugar & caffeine





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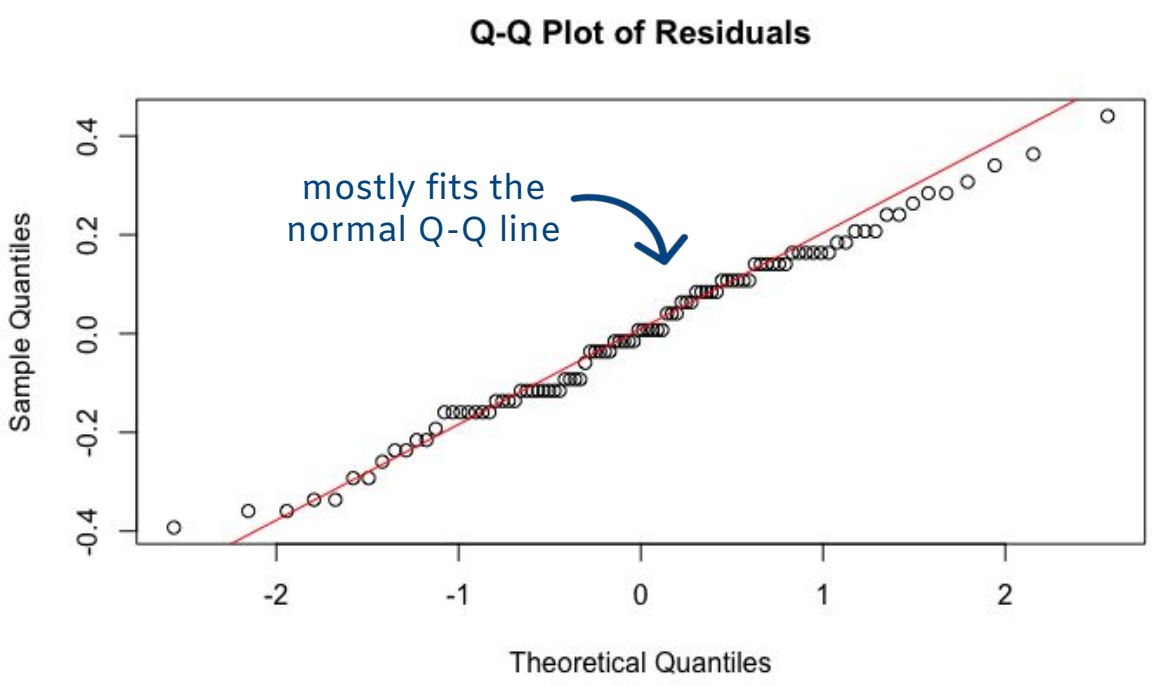
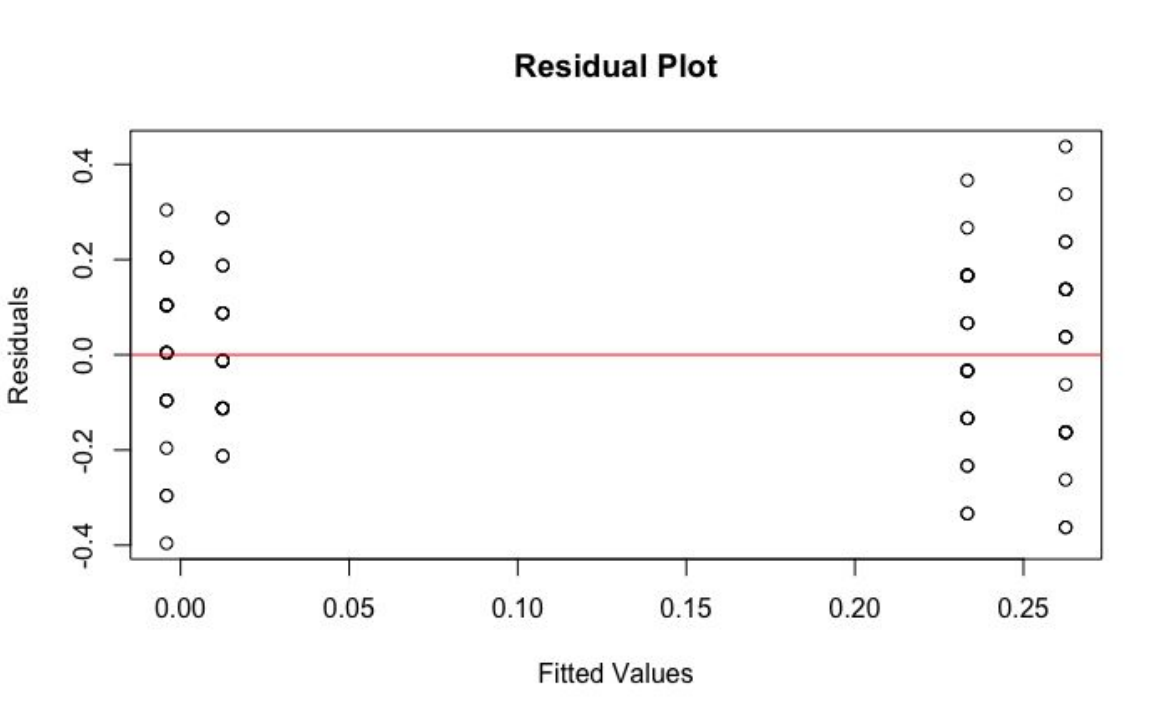
Model Assumptions

Normality



Normality is satisfied

Linearity


Residual Plot
Residuals
0.4
0.2
0.0
-0.2
-0.4
0.00
0.05
0.10
0.15
0.20
0.25
Fitted Values

Conclusions

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Limitations

Sampling

- Random selection within **6** cities on Bonne Sante

- **Not as randomized** since our sample is limited to specific towns on a single island

Age Blocking

- Blocked by age due to potential age-related cognitive and reflex differences

- Did **not** significantly contribute to the analysis

Confounding Variable

- Blocking by age might have led us to **miss another confounding variable** that was affecting the data

Ways to Improve

Larger Sample Size

Due to the limitations of a small sample size, testing could be expanded to obtain data from subjects from **more cities and islands.**

Blocking

Since we concluded Age is not a significant block, we could investigate other factors that may affect vigilance such as **Weight, Education, or Gender.**

Measure of Alertness

We could choose **more measures of mental alertness** beyond just the vigilance test in order to further validate the significance of our claim.

Measure of Sugar

We concluded sugar helps improve mental vigilance only through the form of energy drinks. We could investigate other forms of sugar such as **Lollies or Sugar Tablets** and its effects to improve our conclusion.

Thank you!

Takeaway: Sugary energy drinks improve vigilance scores!