

# **The Effects of Emotion and Alcohol Consumption on Short-Term Memory**

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- **Introduction**

Memory has been a mysterious field that arouses many interests as it influences one's success in school, society, and personal life (Grayson, 2017). Short-term memory is a special sector of it that refers to the capacity for holding information in a short period of time. There are many factors that may affect one's short-term memory ability. This study explores two most common factors: emotional status and alcohol consumption, and investigates their relationships with short-term memory.

We expect to see an increase of short-term memory ability with a joyful mood and a decrease with a depressed mood. We also expect a decrease of short-term memory ability with more alcohol consumption. The method of approach is to randomly select samples, assign blocking and treatments, conduct the experiment and analyze the data.

- **Design of the experiment**

A Randomized Complete Block Design (RCBD) is chosen for the purpose of our research. Time spent in playing memory game serves as the variable of interest. Shorter time to finish a memory game indicates a better memory ability of the participant.

Our null hypothesis for the test is that alcohol consumptions, emotional status and their interaction have no significant effect on one's short-term memory performance. The alternative hypothesis is that at least one of the main factors or interaction have significant effect on people's short-term memory performance.

## Main factors:

### i) Alcohol Consumption

We select three levels to study the effect of alcohol consumption on short-term memory, specifically, 0, 2, and 4 intakes, with each intake containing 30ml of vodka. Previous study has compared similar consumption of vodka with other types of alcohol on memory ability (Khazan, 2017). We further the experiment to test out the effect of different levels of vodka consumption on short-term memory. To compensate the possible quick declination of effect of alcohol consumption, participants consume multiple intakes of alcohol without any midway stops.

### ii) Emotion

Previous study suggests that being exposed to emotionally arousing stimuli may result in varying ability when memorizing neutral items afterwards (Mather & Sutherland, 2012). To further study the effect of emotions, this study employs three emotional treatments where each participant is asked to experience one minute of sad memories, happy memories, or no experience of memories, respectively.

### Block:

The brain's volume summits in the 20s and declines afterwards, in which memory is the first to decline. Therefore, age is the nuisance factor in this experimental design and two age groups are used as blocking: Age Group 20-30 (representing young adults) and Age Group 60-70 (representing seniors).

### Sample:

The sampling population consists of Islanders born in the city of Colmar, Mahuti, and Riroua aging from 20-30 (2304 in total) and 60-70 (1422 in total). We first obtain a list of all participants from the three cities and randomize the list using R. Then, we obtain research consent from participants alive according to generated order until the sample size is met. Then within each age group, participants are randomly assigned to treatment number 1 to 9 (See the Table below).

The order of run for replicates in each treatment combination and the order of two treatments for each participants are both randomly determined. Participants are asked to memorize 30 pairs of cards immediately after the treatments combination is performed, and their usage of time are recorded.

| Age Group: A: 20-30/ B: 60-70 |          |           |           |
|-------------------------------|----------|-----------|-----------|
|                               | 0 Intake | 2 Intakes | 4 Intakes |
| Sad                           | 1        | 2         | 3         |
| Neutral                       | 4        | 5         | 6         |
| Happy                         | 7        | 8         | 9         |

Table: Design Layout, 12 replicates for each combination

There are  $3*3=9$  different combinations for each age groups (block). Since both main effects - emotion and alcohol consumption - have three levels, the size of each combination should be at least 12 for a sample with power 0.8 and effect size 0.4, resulting in a total of  $2*3*3*12=216$  samples.

```
> pwr.anova.test(k=9, f=0.4, sig.level=0.05, power=0.8)
```

Balanced one-way analysis of variance power calculation

```
      k = 9
      n = 11.32166
      f = 0.4
sig.level = 0.05
power = 0.8
```

NOTE: n is number in each group

- **Results and Interpretation**

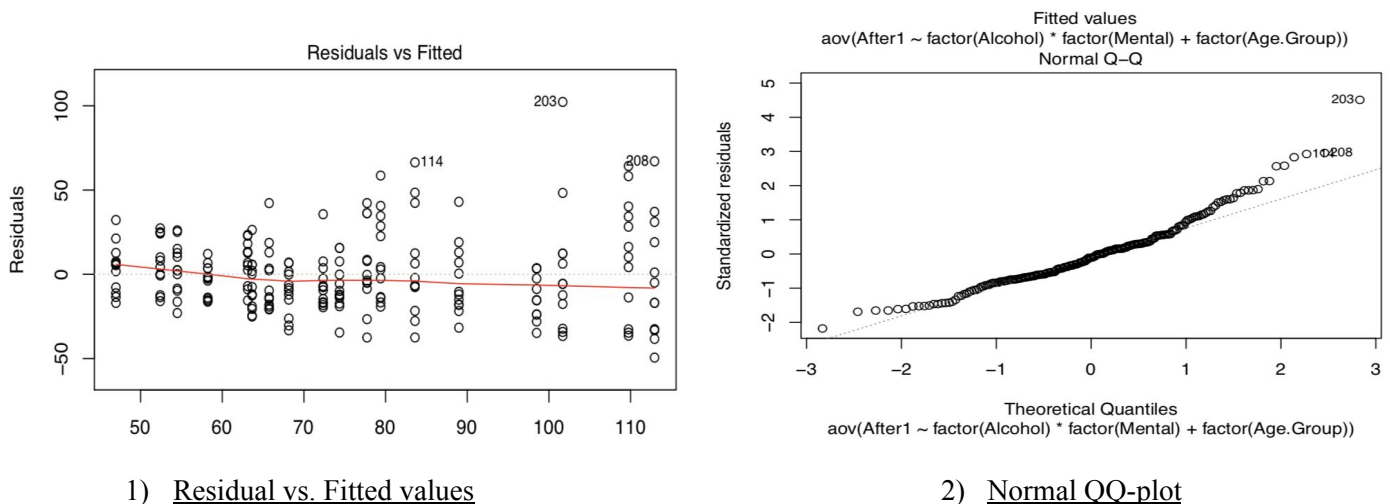
### Overall F-Test

```
try <- aov(After1~factor(Alcohol)*factor(Mental)+factor(Age.Group))
summary(try)
```

|  | Df  | Sum Sq | Mean Sq | F value | Pr(>F)       |
|--|-----|--------|---------|---------|--------------|
| ## factor(Alcohol)   | 2   | 1684   | 842     | 1.559   | 0.212718     |
| ## factor(Mental)  | 2   | 54463  | 27231   | 50.421  | < 2e-16 ***  |
| ## factor(Age.Group)   | 1   | 6830   | 6830    | 12.646  | 0.000467 *** |
| ## factor(Alcohol):factor(Mental)                                | 4   | 16074  | 4019    | 7.441   | 1.29e-05 *** |
| ## Residuals   | 206 | 111255 | 540     |         |              |
| ## ---   |     |        |         |         |              |
| ## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 |     |        |         |         |              |

Age, emotions and the interaction between alcohol and emotions do affect young adults' and seniors' short-term memories under the significance level of 0.05, while drinking alcohol alone has little effect on memory given that the p-value for "Alcohol" is insignificant.

### Model assumption

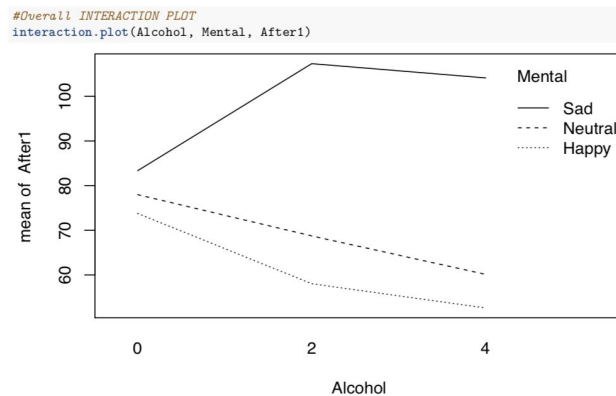


The residual plot indicates that residual points scatter randomly around the fitted line, except for outliers such as point 203 and 208. Overall, the residuals vs. fitted plot shows that the model assumption of constant variance is satisfied.

According to our normal QQ-plot, the residual points in the middle generally lie along the QQ-line, except for some outliers at two tails, especially point 203 and 208 on the right tail. Hence we conclude that the normality assumption of the model is satisfied.

Interestingly, the three most significant outliers all belong to the 60-70 age group, and, what is more, most of the outliers at the right tail belong to the senior group. This observation hints that the model construction may be treated separately according to the age block since the factors may affect differently on the different age group. This guess relating to age group inferences will be discussed later.

## Interaction Plot



According to the overall interaction plot, we observe non-parallel trends of different emotional level. Thus, we conclude that there is an interaction effect between emotion and alcohol. This conclusion matches our findings in the ANOVA analysis, where the interaction variable is statistically significant.

Particularly, it seems that for low alcohol intake level, the emotion doesn't contribute to the difference of the memory time. However, when the alcohol intake is high, sad memory largely increases the memory time, while happy memory doesn't have an impact on the memory time.

## Tukey's test

```
TukeyHSD(try)
```

|  |  |  |  |  |                 |  |  |  |  |            |             |            |           |
|--|--|--|--|--|-----------------|--|--|--|--|------------|-------------|------------|-----------|
| ## Tukey multiple comparisons of means   |  |  |  |  | 2:Sad-2:Happy   |  |  |  |  | 49.283333  | 28.2510738  | 70.3155929 | 0.0000000 |
| ## 95% family-wise confidence level  |  |  |  |  | 2:Sad-2:Neutral |  |  |  |  | 38.575000  | 17.5427404  | 59.6072596 | 0.0000011 |
| ##   |  |  |  |  | 4:Sad-4:Neutral |  |  |  |  | 44.004167  | 22.9719071  | 65.0364262 | 0.0000000 |
| ## Fit: aov(formula = After1 ~ factor(Alcohol) * factor(Mental) + factor(Age.Group)) |  |  |  |  | 4:Sad-4:Happy   |  |  |  |  | 51.520833  | 30.4885738  | 72.5530929 | 0.0000000 |
| ##   |  |  |  |  | 2:Sad-0:Sad     |  |  |  |  | 23.962500  | 2.9302404   | 44.9947596 | 0.0128637 |
| ## \$factor(Alcohol)^  |  |  |  |  | 4:Happy-0:Happy |  |  |  |  | -21.170833 | -42.2030929 | -0.1385738 | 0.0471195 |
| ##   |  |  |  |  |                 |  |  |  |  |            |             |            |           |
| ## diff lwr upr p adj  |  |  |  |  |                 |  |  |  |  |            |             |            |           |
| ## 2-0 -0.3388889 -9.482782 8.805005 0.9957885                                       |  |  |  |  |                 |  |  |  |  |            |             |            |           |
| ## 4-0 -6.0861111 -15.230005 3.057782 0.2603914                                      |  |  |  |  |                 |  |  |  |  |            |             |            |           |
| ## 4-2 -5.7472222 -14.891116 3.396671 0.3007831                                      |  |  |  |  |                 |  |  |  |  |            |             |            |           |
| ##   |  |  |  |  |                 |  |  |  |  |            |             |            |           |
| ## \$factor(Mental)^   |  |  |  |  |                 |  |  |  |  |            |             |            |           |
| ##   |  |  |  |  |                 |  |  |  |  |            |             |            |           |
| ## diff lwr upr p adj  |  |  |  |  |                 |  |  |  |  |            |             |            |           |
| ## Neutral-Happy 7.476389 -1.667505 16.62028 0.1327847                               |  |  |  |  |                 |  |  |  |  |            |             |            |           |

The Tukey's test verifies our observation in the interaction plot and F-test. With a moderate or high alcohol intake (2 or 4 intakes), sadness is significant in increasing the memory time compared to neutral state (See ① in Figure above on the right). When the participants are sad, alcohol consumption will increase the memory time. (See ② in Figure above on the right) Under happiness, participants with high consumption (4 intakes) of alcohol will have a significant decrease in memory time. (See ③ in Figure above on the right)

## Conclusion

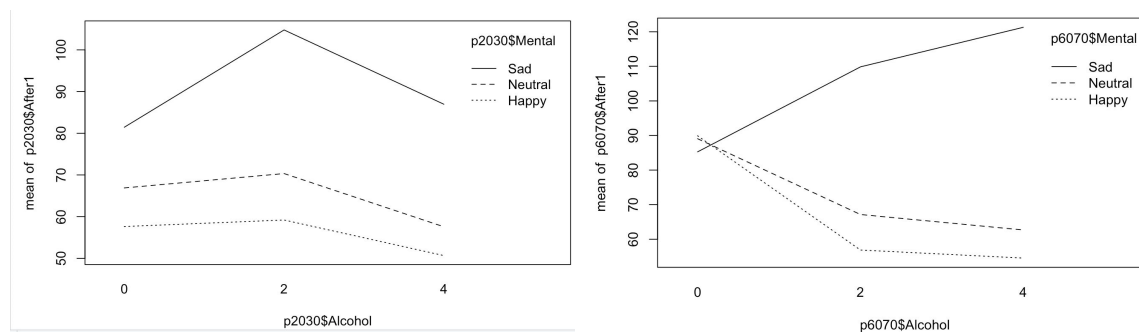
Compared with not experiencing any emotionally arousing memory, participants spend less time memorizing cards after they experienced one minute of happy memory and more time memorizing cards after they experienced one minute of sad memory.

Alcohol consumption itself doesn't affect the timing of memorizing cards; however, the interaction effect of alcohol and emotional state does significantly influence the short-term memory ability.

- **Further Investigation: Analysis within block**

Since the blocking is significant and some outliers observed, we divide our analysis into two parts which correspond to two age groups of 20 to 30 (Group A: 20-30) and 60 to 70 (Group B: 60-70).

### **Interaction plot: Group 20-30 vs. Group 60-70**



(Left: Interaction plot of 20-30 Group; Right: Interaction plot of 60-70 group)

For age group 20-30, compared to happiness, sadness have larger effect on increasing memory time, which is reflected by the larger deviation of sad emotion line from the neutral emotion line. There is little interaction effect observed in group 20-30. This finding matches the results of ANOVA analysis within the group (See R-markdown file attached), where the interaction variable is insignificant.

In age group 60-70, three lines are intersecting, which indicates that the interaction between two factors is significant. Furthermore, it seems that emotion affects memory more drastically within 60-70 group as sadness increases memory time more as the alcohol assumption increases.

For both age group, the conclusions here match the results of F-test and Tukey's test. (see R-markdown file) So despite the results concluded in the previous section, further investigation should be made to see whether the age block affects the interaction of the factors.

- **Discussion**

The results show that compared with neutral emotional state, joyful emotion increases one's short-term memory ability and depressed emotion decreases one's short-term memory ability. Surprisingly, the results indicate that alcohol consumption alone doesn't affect one's short-term memory ability, but it does enhance the effect of sad memory on short-term memory ability. An interesting finding is that the 60-70 age group seems to react more drastically towards the co-effects of the treatments than the 20-30 age group, suggesting that we may want to pay more attention towards senior's emotional changes. This experiment result recommends people to avoid negative sentiments for better memory ability.

The National Institute on Alcohol Abuse and Alcoholism has published an article suggesting that alcohol abuse affect the brain and cause memory loss (2004). Specifically, the effect of alcohol consumption is often associated with the participants' age, health status, and mental status, which resonates with our finding. Also, previous study suggests that emotionally arousing stimuli can have selective effects on short-term memory (Mather & Sutherland, 2012). It's difficult to determine the exact effect of happy and sad emotional status on memory, but there's plenty of experiments indicating different emotional status affect one's ability on short-term memory. An interesting finding of this study is that more alcohol consumptions enhances seniors' depression, in which increases the memory time. According to previous studies and literature, aging increases one's sensitivity to alcohol, as seniors often experience the effects of alcohol more rapidly ("Alcohol Abuse", n.d.). Such increased sensitivity to alcohol result in mood disorders like depression, and that depression is quite influential to the short-term memory loss (Hubbard et.al, 2015).

The limitation of this experiment is that alcohol is metabolized over a period of time rather than immediately while the experiment was conducted immediately after the subjects consume alcoholic drinks. The researchers were not able to test the effect of alcohol consumption after it was metabolized.

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