Tea Data Analysis

Group 3

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Introduction

Tea and coffee are two kinds of popular caffeinated beverages. Ingestion of both beverages have effects on the cognitive performance and mood situation of human.

The best-known ones are alerting effects after consumption of tea of coffee mainly caused by caffeine in them. The day-long consumption of caffeine can maintain performance of cognition and psychomotor throughout the whole day (Hindmarch et al. 2000). The study of Hindmarch and his teammates also tells differences between tea and coffee for tea is less likely to disrupt sleep because of lower caffeine levels.

However, the experiment of us focus more on the effect on mood which can be measured by some certain physiological index. The level of caffeine has been studied by a randomise full crossover designed experiment with SBP, DBP, heart rate, skin temperature, skin conductance, and mood monitored over each 3-h study session (Quinlan et al. 2000). The study of Quinlan showed that tea and coffee can cause an elevation in mood with SBP, DBP, and skin conductance increasing but heart rate and skin temperature lower. What's interesting in Quinlan's study is that the caffeine level is not am important factor affecting these index. As for the difference of tea and coffee, it has been studied by the comparing the effect of theanine and caffeine in a randomised, double-blind, placebo-controlled study(Rogers et al. 2008). It has been found that caffeine can cause a increase in self-rated alertness and jitteriness and blood pressure while theanine reduces the effect on blood pressure remaining other index the same.

However, caffeine is not all that caffeinated beverages contains and different kinds of beverages has varied effects on people's mood. Previous study has showed that hot caffeinated beverages can stimulate a more quick alertness process and caffeine and milk reduce the anxiety(Quinlan et al. 1997).

With the help of previous study, the experiment we study mainly want to investigate the alertness effects of different kinds of tea or coffee. The subjective feelings, some physiological signal and brain electrical activities will be monitored.

Experiment Procedures

I. Participant (Subject) Requirements:

- Equal number of man and woman
- Right handed

- Normal olfactory nerve olfactory and palate nerve system

II. Experiment Materials

Product Name	Amount	Purpose
East-leaf Black Tea, Wulong Tea, Nestle Latte, Nestle Mocha	*20mL/(person-by-minute)	Experiment purpose drinks (East-leaf Black Tea 480ml, Nestle Coffee)
30ml opaque vial	6 个	For subjects to drink equal amount
Thin Straw	*6/each-people	Object for subjects to drink by the opaque bottle
500ml large bottle	2	For subjects to drink water and gargle
Thick Straw	*1/each-people	Object for subjects to drink by the large bottle
Paper Cup	1	For subjects to spit out the drinks
Napkin	1	Wiping subject's lips and for cleaning environment purpose
Medical Bandage	1 Roll	To fasten the experimental equipment
Contact Lens Care Solution	1 Bottle	Electrode conduction for experimental equipment
No.5 Battery	4	For experimental equipment's electricity

III. Measuring equipment: (from laboratory)

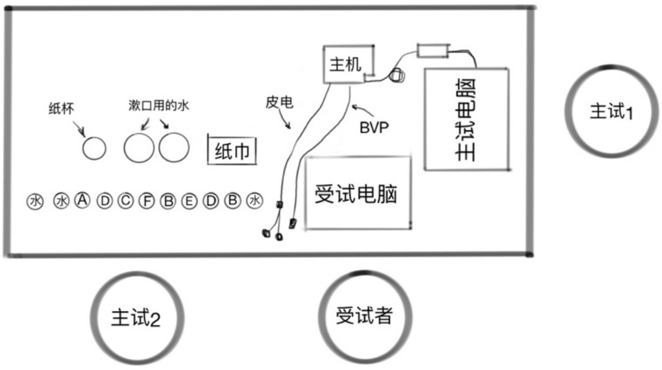
Equipment item	Content	Picture
Biofeedback equipment (manufactured by Thought Technology Ltd.)	The host, optical fiber, converter, electric skin gloves, BVP infrared sensor	
Computer for participants	Computer for participants , shows the subjects the SAM scale	
Computer for experimenter	Computer for experimenter, equipped Emotiv TestBench, Biofeedback software	

IV. Experiment Preparation:

- Take 4 vials and label A to D, pour black tea, green tea, latte, Mocha in order of 20 ml A to D in 4 vials, and fill other 2 vials with drinking water without labeling. Also fill 2 large bottles (500ml) with drinking water.
- Set the 4 filled opaque bottles in following order, from left to right of the table:

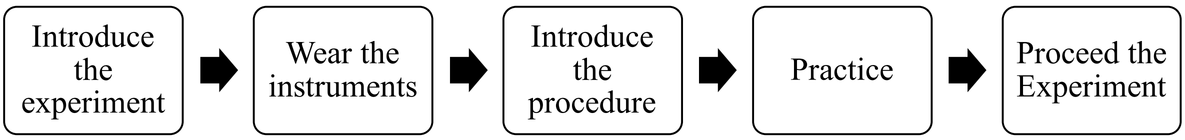
[Water-(A B C D)-Water]

- Set 2 large water bottle, napkin and the paper cup at the left side of the participant’s table.
- Insert the 6 straws into the vial and a thick straw into the large water bottle.



- The computer should be placed on the table in front of the subjects' seat, adjust the questionnaire paper, and confirm whether the participant is comfortable of being immobile.
- Set the experimenter’s computer on the table on the right side of the subject’s seat. Insert the Emotiv USB into the computer, adjust the Emotiv TestBench, and put the marker aside. Open the Biofeedback setting software, set 6 trials, 2 modes, each 20 sec, than start the measurement software and set it aside
- Install the BVP and SC, connect the equipment to the experimenter’s computer and place it behind the SAM scale computer. Shut down the machine at any time since it's easy to lose electricity (prepare medical bandage, battery No. 5).

V. Experiment Process

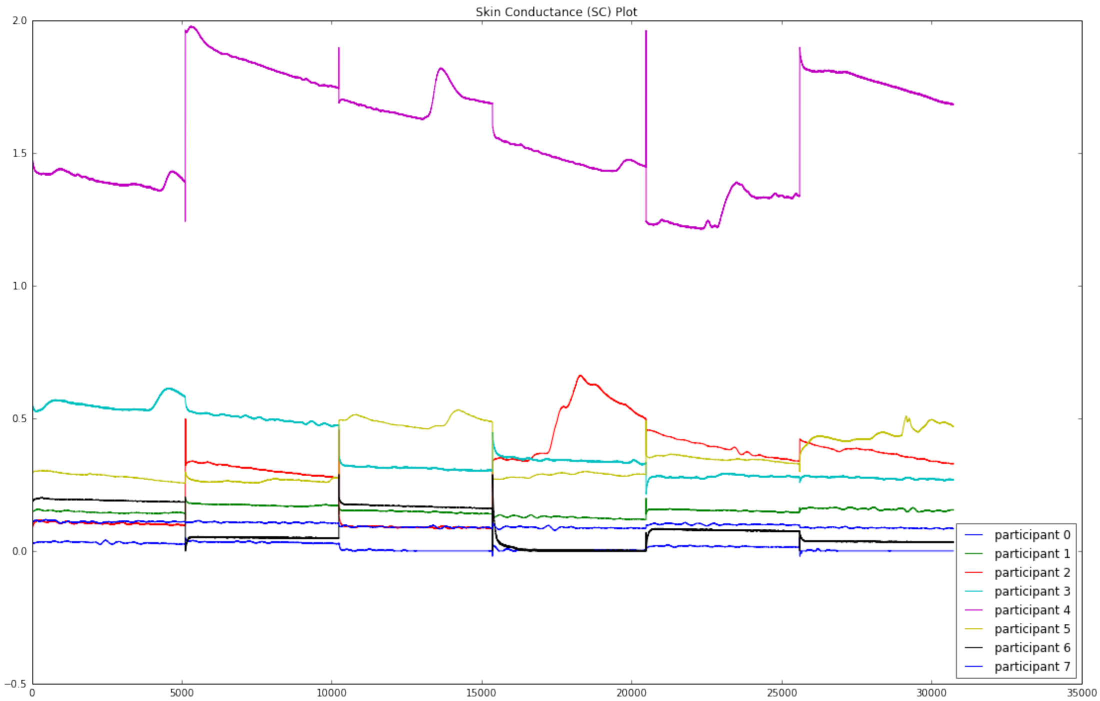


Result Analysis

1. Skin Conductance Response (SCR)

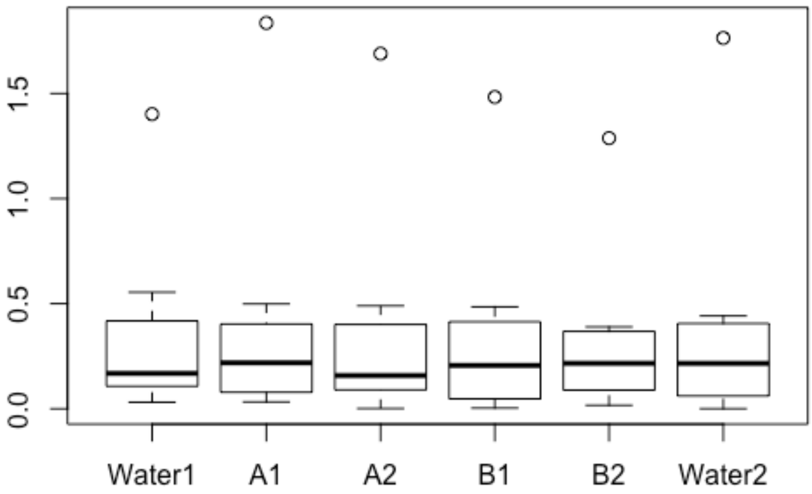
Odors and tastes are known elicitors of emotion, and they may induce autonomous nervous system responses. One typical measure of this neural pathway is the skin conductance response (SCR). The objective of this part is to present some basic features of the participants’ SCRs and to verify whether emotional reactions to odors and tastes elicit such autonomic motivational responses.

First we plotted the Skin Conductance Rate elicited by the tasting experiences of each participant as below. We can see the average SC level differs individually. Some parts of the plot do show a similar tendency among all the participants, which means potential influences of the tastes on participants' emotions. For example, several participants tend to have experienced a jump in the second half of the session when tasting A2, and then the SCR restored to normal value. Generally, all the participants experienced descending SCR in each session. However, abnormal values also exist such as when participant 2 (the red line) tasted B1. Further analysis is needed.



Then we derived this kind of psychophysiological results by averaging SCR amplitudes of each participant in each session. The average SCR magnitudes for 4 sessions of each participant are presented in the figure below.

V1	V2	V3	V4	V5	V6
Min. :0.03115	Min. :0.03256	Min. :0.001296	Min. :0.003288	Min. :0.01658	Min. :0.0003974
1st Qu.:0.10877	1st Qu.:0.09296	1st Qu.:0.090026	1st Qu.:0.067521	1st Qu.:0.09437	1st Qu.:0.0739750
Median :0.16828	Median :0.21861	Median :0.158034	Median :0.206055	Median :0.21608	Median :0.2158146
Mean :0.35246	Mean :0.40855	Mean :0.373590	Mean :0.352664	Mean :0.33126	Mean :0.3912210
3rd Qu.:0.34969	3rd Qu.:0.35502	3rd Qu.:0.356551	3rd Qu.:0.378491	3rd Qu.:0.35747	3rd Qu.:0.3878259
Max. :1.40174	Max. :1.83553	Max. :1.689458	Max. :1.482996	Max. :1.28755	Max. :1.7638539



From the summary and Box Plot, we can see generally all the beverages have similar effect on the mean value of SCR, but A2 seems to produce a lower value among the four. Besides, the distribution of group Water1 and A2 are a little skewed to the right, which may be because of the small sample size.

First we use Bartlett test to see the homogeneity of the residuals.

Bartlett test of homogeneity of variances

data: bd by a
Bartlett's K-squared = 1.417, df = 5, p-value = 0.9224

Since the p-value is larger than 0.05, the residuals are homogenious.

```
Call:
   aov(formula = bd ~ a, data = data)

Terms:
                          a Residuals
Sum of Squares     0.032322 11.232522
Deg. of Freedom           5        42

Residual standard error: 0.517147
Estimated effects may be unbalanced

            Df Sum Sq Mean Sq F value Pr(>F)
a            5  0.032 0.00646   0.024      1
Residuals   42 11.233 0.26744
```

Therefore, from the summary table we can see that the difference is not so significant. That is, the beverages may not have effects on the SCR of participants.

We do pairwise comparison using Tukey multiple comparisons of means as follows.

	diff	lwr	upr	p adj
2-1	0.0560847245	-0.7158215	0.8279909	0.9999288
3-1	0.0211287905	-0.7507774	0.7930350	0.9999994
4-1	0.0002024995	-0.7717037	0.7721087	1.0000000
5-1	-0.0211996193	-0.7931058	0.7507066	0.9999994
6-1	0.0387593837	-0.7331468	0.8106656	0.9999886
3-2	-0.0349559340	-0.8068621	0.7369503	0.9999932
4-2	-0.0558822250	-0.8277884	0.7160240	0.9999301
5-2	-0.0772843438	-0.8491906	0.6946219	0.9996554
6-2	-0.0173253408	-0.7892316	0.7545809	0.9999998
4-3	-0.0209262910	-0.7928325	0.7509799	0.9999995
5-3	-0.0423284097	-0.8142346	0.7295778	0.9999823
6-3	0.0176305932	-0.7542756	0.7895368	0.9999998
5-4	-0.0214021187	-0.7933083	0.7505041	0.9999994
6-4	0.0385568842	-0.7333493	0.8104631	0.9999889
6-5	0.0599590030	-0.7119472	0.8318652	0.9999010

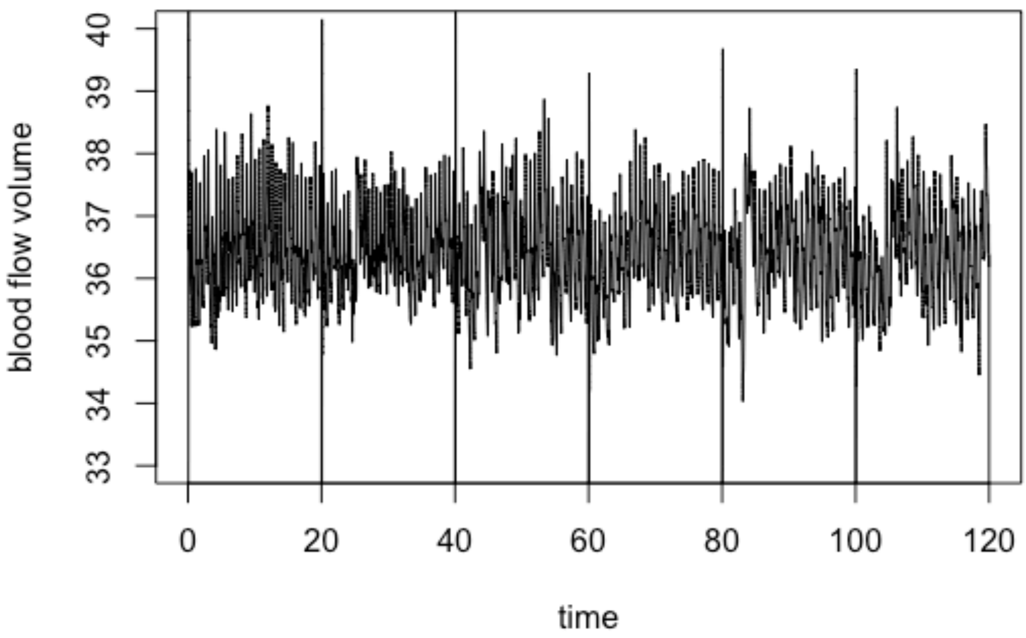
All of the pairs' difference are not significant enough to mention. Further measurements or larger sample sizes may be needed here.

2. Heart Rate (HR)

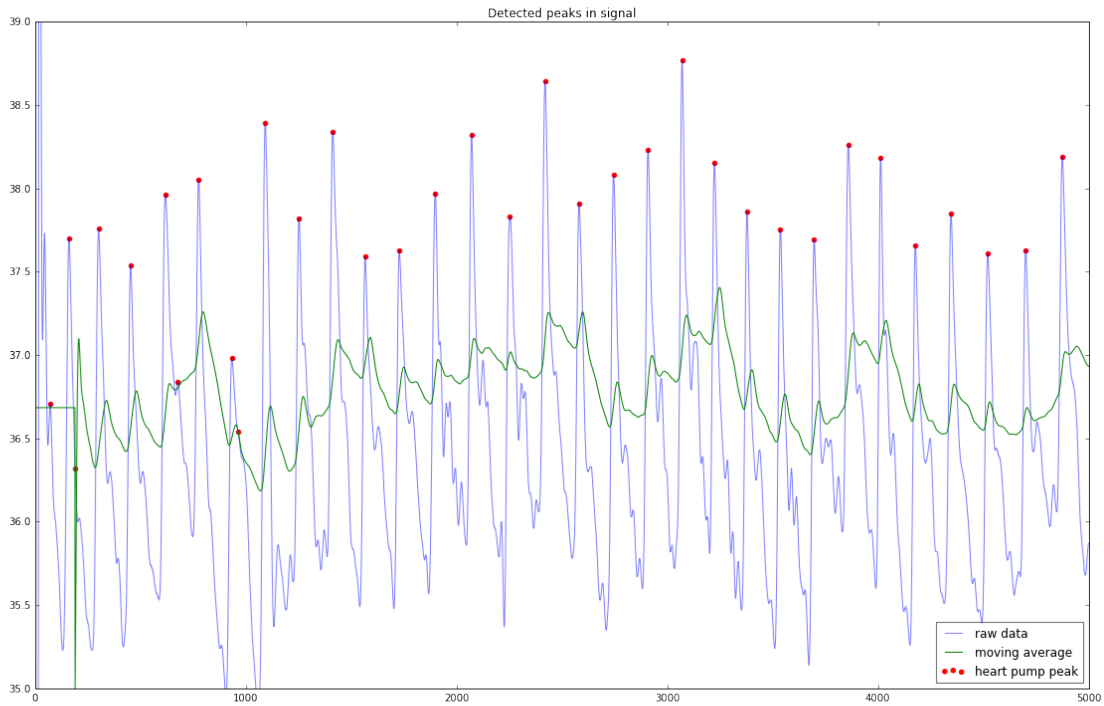
Cardiac output (Q) is the total volume of blood pumped by the heart per minute. It is the product of blood pumped by each heart beat (stroke volume or SV) and the number of beats (heart rate). The relationship between stroke volume and heart rate is constantly changing.

Cardiac output (Q) = stroke volume (SV) x heart rate (HR)

Here we have data for the blood flow volume (BFV).When BFV reaches the peak, it means a bump of the heart. To calculate the heart rate, we need to pre-process the data and calculate its frequency in the 6 experimental sessions for each participant. Below is a typical plot of blood flow volume versus time for participant 1. Note that the time session is broken into 6 parts by extremely high and low values of BFV. This is caused by attaching and removing the sensors, which is coherent with our experiment procedures.

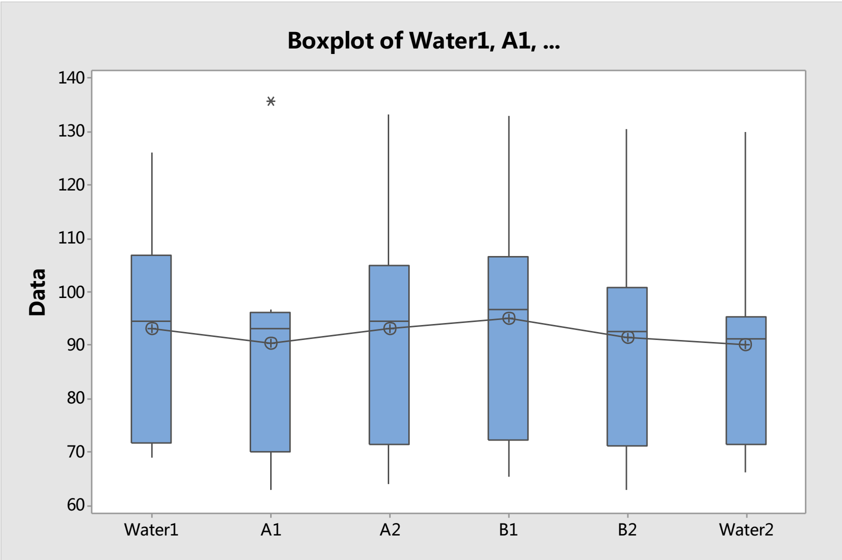


We analyzed the discrete BFV signal using Python. After filtering the signal we are able to identify the peak values of the BFV, and therefore we are able to extract the participants' relevant heart rate in each session.In the detection plot below, the red dots are the peak values that are detected. Hence we can see that our detection technique is valid.



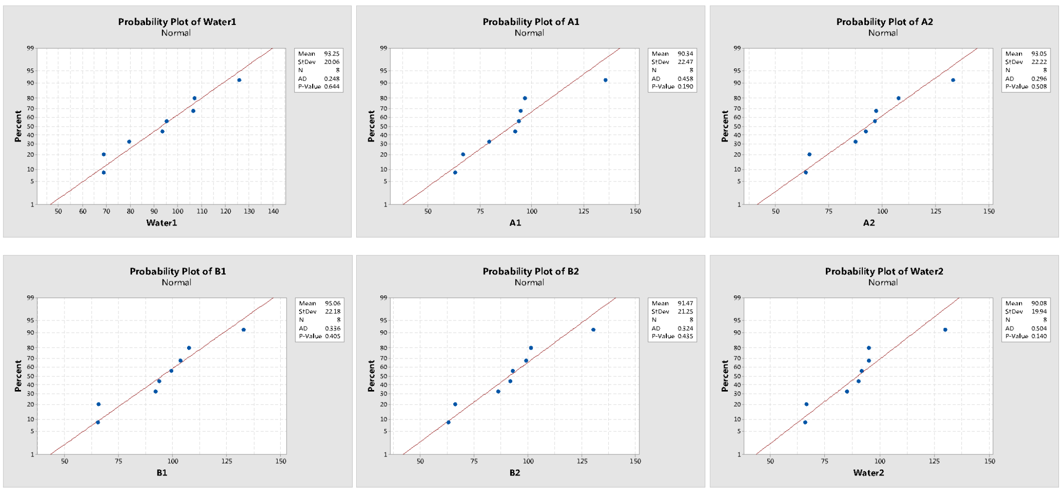
After we know the position of each peak in time, calculating the average 'beats per minute' (BPM) measure over this signal is straightforward. We calculate the distance between the peaks, take the average and convert to a per minute value. In this way we are able to derive heart rate for all the participants in the 6 experiment sessions.

Participants	1	2	3	4	5	6	7	8
Session 1	107.11	68.88	95.31	125.95	68.91	106.65	79.70	93.51
Session 2	107.65	64.05	103.56	135.62	66.27	99.15	85.61	92.13
Session 3	101.40	63.06	94.73	133.15	65.99	97.16	79.59	95.15
Session 4	99.47	63.08	92.25	132.92	65.61	93.92	86.22	92.05
Session 5	96.73	65.34	93.01	130.59	66.91	93.82	87.46	96.71
Session 6	95.27	66.15	90.43	129.87	66.66	91.84	85.29	95.10



From the above plot, we can safely come to the conclusion that there are some differences among each type of beverage. However, the differences are not significant, further examinations are needed.

Then we did normality test regarding the data in each experiment session. We chose Anderson-Darling method and got the following Normality Plots.



The above normality plots indicate that the data can be fitted to normal distribution. We did One-Way ANOVA to test if the mean values of the heart rates are different from each other, and got the following results.

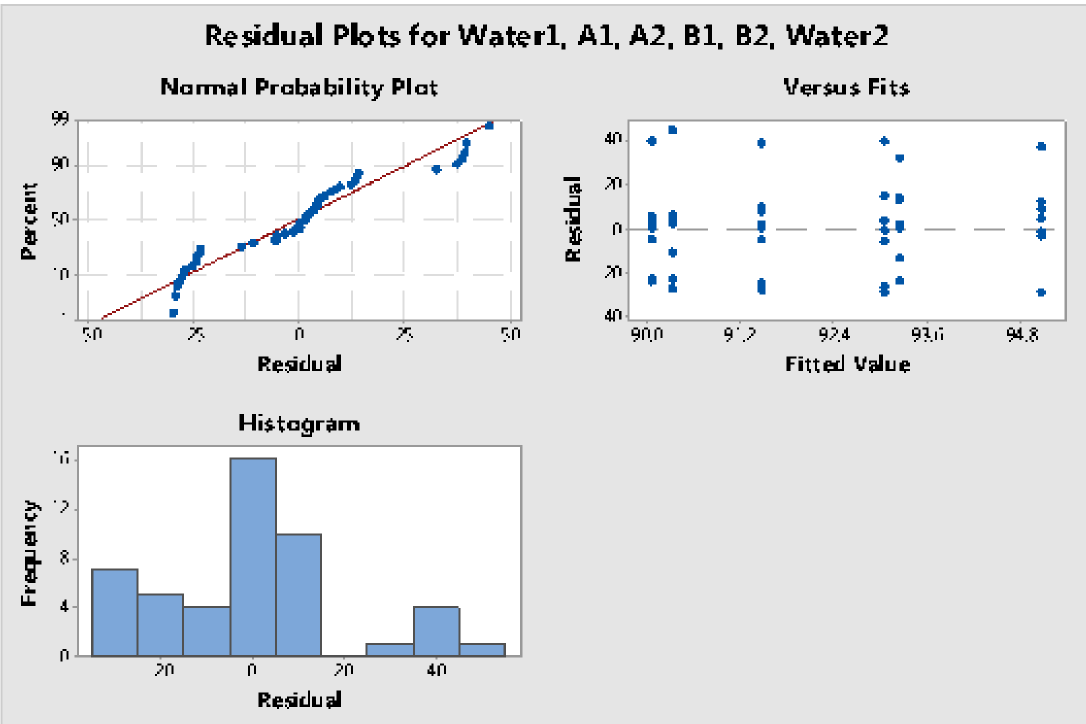
Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Factor	5	148.3	29.66	0.06	0.997
Error	42	19194.8	457.02		
Total	47	19343.1			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
21.3780	0.77%	0.00%	0.00%

We can see that the P-Value exceeds 0.05, which means we cannot reject the original hypothesis. We cannot conclude that the participants' heart rates are different in the 6 experiment sessions.



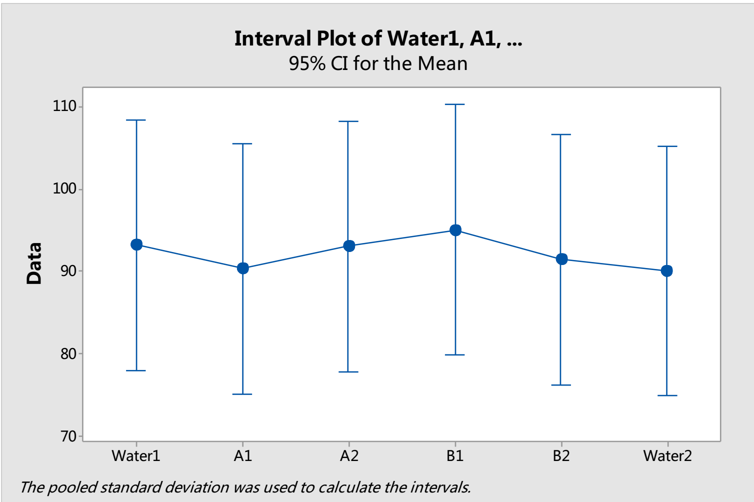
We also did some analysis for the residuals. In the probability of normal plot, all points gather along the normal line although the left tail is slightly lower than the line. In the second plot, residual of three groups are evenly distributed on the two sides of the mean. The histogram plot is not so normal-like.

And we also summed up the basic statistics and confidence intervals of the means.

Factor	N	Mean	StDev	95% CI
Water1	8	93.25	20.06	(78.00, 108.50)
A1	8	90.34	22.47	(75.08, 105.59)
A2	8	93.05	22.22	(77.80, 108.30)
B1	8	95.06	22.18	(79.81, 110.32)
B2	8	91.47	21.25	(76.21, 106.72)
Water2	8	90.08	19.94	(74.82, 105.33)

Pooled StDev = 21.3780

And we got the interval plots for each group with a 95% Confidence Interval.



3. The Self-Assessment Manikin (SAM)

The Self-Assessment Manikin (SAM) is a non-verbal pictorial assessment technique that directly measures the pleasure, arousal, and dominance associated with a person's affective reaction to a wide variety of stimuli.

Below is the statistical analysis for subjective scale.

(1) I like this taste

ANOVA result:

Source	SS	df	MS	F	Prob>F
Columns	18.75	3	6.25	5.69	0.0036

Error	30.75	28	1.09821		
Total	49.5	31			

Conclusion:
The difference in beverage types has significant influence on whether “I like this taste”.

(2) I’ll purchase drinks with this kind of taste
ANOVA result:

Source	SS	df	MS	F	Prob>F
Columns	15.0938	3	5.03125	2.97	0.0486
Error	47.375	28	1.69196		
Total	62.4688	31			

Conclusion:
The difference in beverage types has no significant influence on whether “I’ll purchase drinks with this kind of taste”.

(3) My emotion is excited or calm.
ANOVA result:

Source	SS	df	MS	F	Prob>F
Columns	39.594	3	13.1979	4.78	0.0082
Error	77.375	28	2.7634		
Total	116.969	31			

Conclusion:
The difference in beverage types has significant influence on whether “My emotion is excited or calm”.

(4) My emotion is positive or negative
ANOVA result:

Source	SS	df	MS	F	Prob>F
Columns	10.0938	3	3.36458	2.15	0.1167
Error	43.875	28	1.56696		
Total	53.9688	31			

Conclusion:
The difference in beverage types has no significant influence on whether “My emotion is positive or negative”.

(5) I play a dominant role in mood
ANOVA result:

Source	SS	df	MS	F	Prob>F
Columns	0.25	3	0.08333	0.03	0.9928
Error	77.25	28	2.75893		
Total	77.5	31			

Conclusion:
The difference in beverage types has no significant influence on whether “I play a dominant role in mood”.

(6) I’m aggressive
ANOVA result:

Source	SS	df	MS	F	Prob>F
Columns	9.0938	3	3.03125	2.05	0.1294
Error	41.375	28	1.47768		
Total	50.4688	31			

Conclusion:
The difference in beverage types has no significant influence on whether “I’m aggressive”.

(7) I’m disgusted
ANOVA result:

Source	SS	df	MS	F	Prob>F
Columns	1.5938	3	0.53125	0.24	0.866
Error	61.375	28	2.19196		
Total	62.9688	31			

Conclusion:
The difference in beverage types has no significant influence on whether “I’m disgusted”.

(8) I’m good
ANOVA result:

Source	SS	df	MS	F	Prob>F
Columns	4.0938	3	1.36458	1.6	0.2116
Error	23.875	28	0.85268		
Total	27.9688	31			

Conclusion:
The difference in beverage types has no significant influence on whether “I’m good”.

(9) I'm loving

ANOVA result:

Source	SS	df	MS	F	Prob>F
Columns	4.0938	3	1.36458	1.49	0.2385
Error	25.625	28	0.91518		
Total	29.7188	31			

Conclusion:

The difference in beverage types has no significant influence on whether "I'm loving".

(10) I'm pleasant

ANOVA result:

Source	SS	df	MS	F	Prob>F
Columns	3.25	3	1.08333	1	0.4062
Error	30.25	28	1.08036		
Total	33.5	31			

Conclusion:

The difference in beverage types has no significant influence on whether "I'm pleasant".

(11) I'm worried

ANOVA result:

Source	SS	df	MS	F	Prob>F
Columns	2.5938	3	0.86458	0.45	0.7226
Error	54.375	28	1.94196		
Total	56.9688	31			

Conclusion:

The difference in beverage types has no significant influence on whether "I'm worried".

(12) I'm confident

ANOVA result:

Source	SS	df	MS	F	Prob>F
Columns	0.0938	3	0.03125	0.07	0.9751
Error	12.375	28	0.44196		
Total	12.4688	31			

Conclusion:

The difference in beverage types has no significant influence on whether “I’m confident”.

(13) I’m refreshing
ANOVA result:

Source	SS	df	MS	F	Prob>F
Columns	1.0938	3	0.36458	0.24	0.8671
Error	42.375	28	1.51339		
Total	43.4688	31			

Conclusion:
The difference in beverage types has no significant influence on whether “I’m refreshing”.

(14) I’m premium
ANOVA result:

Source	SS	df	MS	F	Prob>F
Columns	2.125	3	0.70833	0.61	0.6169
Error	32.75	28	1.16964		
Total	34.875	31			

Conclusion:
The difference in beverage types has no significant influence on whether “I’m premium”.

(15) I’m natural
ANOVA result:

Source	SS	df	MS	F	Prob>F
Columns	5.3438	3	1.78125	0.87	0.4705
Error	57.625	28	2.05804		
Total	62.9688	31			

Conclusion:
The difference in beverage types has no significant influence on whether “I’m natural”.

(16) I’m familiar
ANOVA result:

Source	SS	df	MS	F	Prob>F
Columns	15.3438	3	5.11458	3.19	0.0388
Error	44.875	28	1.60268		

Total 60.2188 31

Conclusion:
The difference in beverage types has no significant influence on whether “I’m familiar”.

(17) I’m functional/powerful
ANOVA result:

Source	SS	df	MS	F	Prob>F
Columns	8.125	3	2.70833	2.18	0.1124
Error	34.75	28	1.24107		
Total	42.875	31			

Conclusion:
The difference in beverage types has no significant influence on whether “I’m functional/powerful”.

(18) I’m professional
ANOVA result:

Source	SS	df	MS	F	Prob>F
Columns	1.8438	3	0.61458	0.81	0.5017
Error	21.375	28	0.76339		
Total	23.2188	31			

Conclusion:
The difference in beverage types has no significant influence on whether “I’m professional”.

(19) I’m fashion
ANOVA result:

Source	SS	df	MS	F	Prob>F
Columns	4.375	3	1.45833	1.3	0.2951
Error	31.5	28	1.125		
Total	35.875	31			

Conclusion:
The difference in beverage types has no significant influence on whether “I’m fashion”.

(20) I’m classic
ANOVA result:

Source	SS	df	MS	F	Prob>F

Columns	1.375	3	0.45833	0.31	0.8185
Error	41.5	28	1.48214		
Total	42.875	31			

Conclusion:
The difference in beverage types has no significant influence on whether “I’m classic”.

(21) I’m unique
ANOVA result:

Source	SS	df	MS	F	Prob>F
Columns	4.5	3	1.5	1.01	0.4021
Error	41.5	28	1.48214		
Total	46	31			

Conclusion:
The difference in beverage types has no significant influence on whether “I’m unique”

Final conclusion:
The difference in beverage types only has influence on whether “I like this taste”, and has little influence on specific emotion.

References

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