Reaction Time of Athletes vs Non-Athletes At Varying Levels of Sobriety

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Background

As college students, we have been exposed to alcohol and its effects numerous times. It is a proven fact that alcohol hinders a person's ability to function normally. So, we wanted to find some interesting way to quantify and actually examine how significant the effects of alcohol can be.

The purpose of our study was to investigate how an individual's athletic background is related to their reaction time at varying levels of sobriety. Accordingly, subjects in the experiment were identified as athletes or non-athletes. If they consented to being a test subject, they were given a test at a certain point when they reached a specific level of drinks. Upon reaching that level, a ruler was dropped into their hand from eye level and a measurement was taken from where the ruler was caught. This process was repeated for 3 trials to get an average measurement for reaction time.

We considered running the experiment two ways. The first way would have been a repeated measures design where we would test the same 15 athletes and 15 non-athletes. The second way was to set it up as a standard 2-way ANOVA where we randomly tested different people at different levels of drinks. Due to the difficulty of collecting the data using the repeated measures design, we decided to proceed with the experiment using the second method. Subjects were administered drinks so that they would be accurately tested in terms of alcohol consumption.

In order to control for obvious differences in effects of alcohol for different people, we decided to test only male subjects at the ages of 21 and 22. We felt this was important because at higher amounts of drinks, the effects of alcohol on females are definitely greater than that on males. Also, we felt age was important for reasons such as tolerance, alcohol experience, etc. Another constraint we placed involved the type of athlete. We only used athletes from sports that require a high level of physical fitness (soccer, basketball, track and lacrosse). This was necessary because we are interested in the effects of alcohol on reaction time for different body types; if an athlete plays a sport that does not require high physical fitness then he or she is more or less no different than a non-athlete. In addition, we asked subjects if they had eaten anything within 2 hours of starting drinking. If so, we did not include them in the experiment. We also gave subjects specific instructions concerning the testing. They were told not to eat anything during the experiment and also to get tested within 2-3 minutes of reaching the specific level that they volunteered to be tested at. Finally, we made sure that the subjects had not already started drinking prior to the start of the experiment.

So, the experiment can be summarized as follows:
Experimental Unit: 21 and 22 year old males
Dependent Variable: Reaction time (measured in inches)
Independent Variables: Athletic Background and Number of Drinks

The two main treatment factors in the experiment are Athletic Background and Number of Drinks. As previously explained, Athletic Background was determined by simply asking the subject if he or she played a sport, and if so, what sport it was. If the sport required a high level of physical fitness, then the subject was asked to be a part of the experiment. For our second factor, Number of Drinks, we decided to test subjects at 3 different levels: 0 drinks (sober), 2 drinks, and 6 drinks. We felt that these 3 levels would adequately account for the effects of alcohol.

Overall, we thought that the setup and conditions were well controlled. Other factors that could help explain reaction time may have been included, however. For instance, some type of body size measurement could have been very useful. A person's weight and height are definitely important factors to consider with the effects of alcohol. It would have been interesting, although very difficult, to try to block for physical stature among the subjects.

Objectives

The objectives of the experiment were as follows:

1) Examine the relationship between reaction time and athletic background.
2) Determine if athletic background has a main effect on reaction time.
3) Determine if sobriety level has a main effect on reaction time.
4) Determine if there exists and interaction effect between athletic background and number of drinks. In other words, does the reaction time for athletes and non-athletes change in a different way for different levels of sobriety?

Data Collection/Preliminary Analysis

The data we collected can be seen below:

Observation	athlete (1)	**(0 drinks) Average**	**(2 drinks) Average**	**(6 drinks) Average**
1	1	**8.00**	**7.50**	**10.08**
2	1	**3.67**	**4.08**	**6.54**
3	1	**0.92**	**1.50**	**2.00**
4	1	**4.00**	**3.67**	**3.21**
5	1	**4.71**	**5.75**	**6.17**
6	1	**6.38**	**5.59**	**6.25**
7	1	**1.17**	**2.21**	**6.25**
8	1	**2.13**	**1.50**	**3.67**
9	1	**5.63**	**4.04**	**4.83**
10	1	**5.25**	**6.54**	**9.29**
11	1	**3.67**	**4.33**	**6.25**
12	1	**4.83**	**5.58**	**5.83**
13	1	**5.08**	**6.17**	**7.08**
14	1	**4.58**	**4.08**	**6.25**
15	1	**4.29**	**5.58**	**6.33**
16	2	**7.00**	**6.92**	**9.38**
17	2	**6.92**	**5.21**	**8.04**
18	2	**2.25**	**2.83**	**4.08**
19	2	**3.83**	**8.38**	**9.00**
20	2	**4.71**	**6.38**	**4.83**
21	2	**6.38**	**6.13**	**7.04**

22	2	**5.88**	**5.58**	**7.25**
23	2	**6.34**	**2.75**	**7.71**
24	2	**3.63**	**6.21**	**7.71**
25	2	**6.17**	**5.21**	**8.96**
26	2	**5.42**	**3.00**	**2.00**
27	2	**6.00**	**6.75**	**6.50**
28	2	**6.83**	**7.00**	**8.58**
29	2	**5.00**	**5.58**	**7.58**
30	2	**6.83**	**7.08**	**8.92**

*A printout of the whole data set is attached at the end of the project.

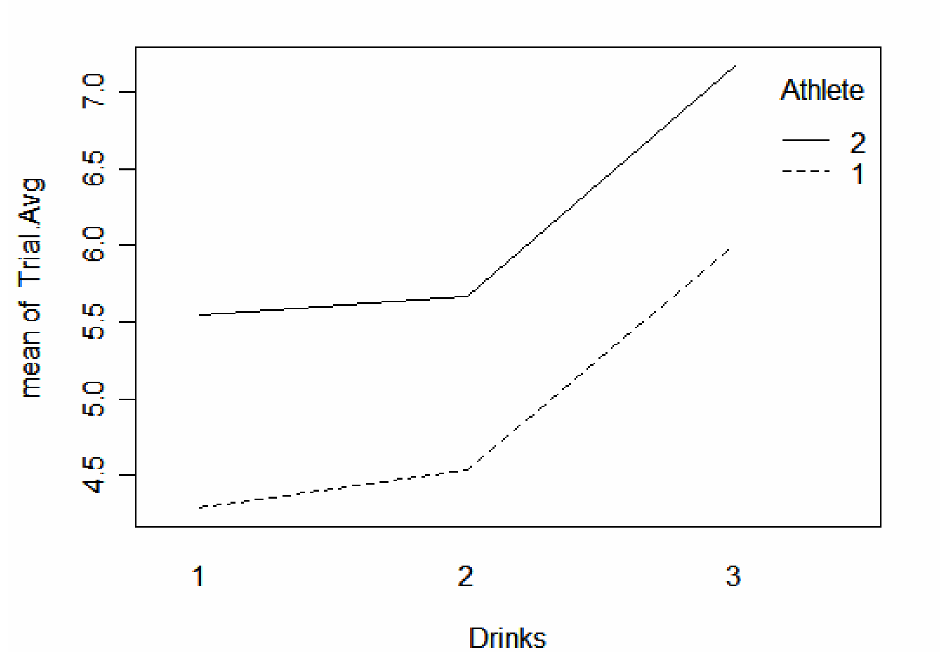
To understand the data we collected better, we will first obtain fitted values and check for any interaction effect. This will give us a better idea of what our data shows and if there are any relationships between factors.

Fitted Values:

	0 Drinks	**2 Drinks**	**6 Drinks**
Athletes	4.086	4.943	5.801
Non-Athletes	5.315	6.128	6.941

The fitted values turned out as expected. As the number of drinks increased, the average reaction time fell. Subjects reacted slower to catching the ruler as they drank more alcohol. Interestingly, we also see that at each level of sobriety, non-athletes had a higher average reaction time. We will leave further investigation and discussion of this data for later on when we test for actual statistical significance of our data.

Interaction Plot:



It appears that over the 3 different levels of drinks, reaction time changes similarly for athletes and non-athletes. From level 2 to 3 (higher number of drinks), reaction time decreases at almost the exact same rate for both groups. However, we see that at lower levels of drinks, there is a different effect on reaction time between the two groups. At lower amounts of drinks, the reaction time for athletes increases faster than for non-athletes. This slight difference warrants inclusion of an interaction term in our model, although we hypothesize that the term will not be statistically significant.

Experimental Model

The initial model that we will analyze is as follows:

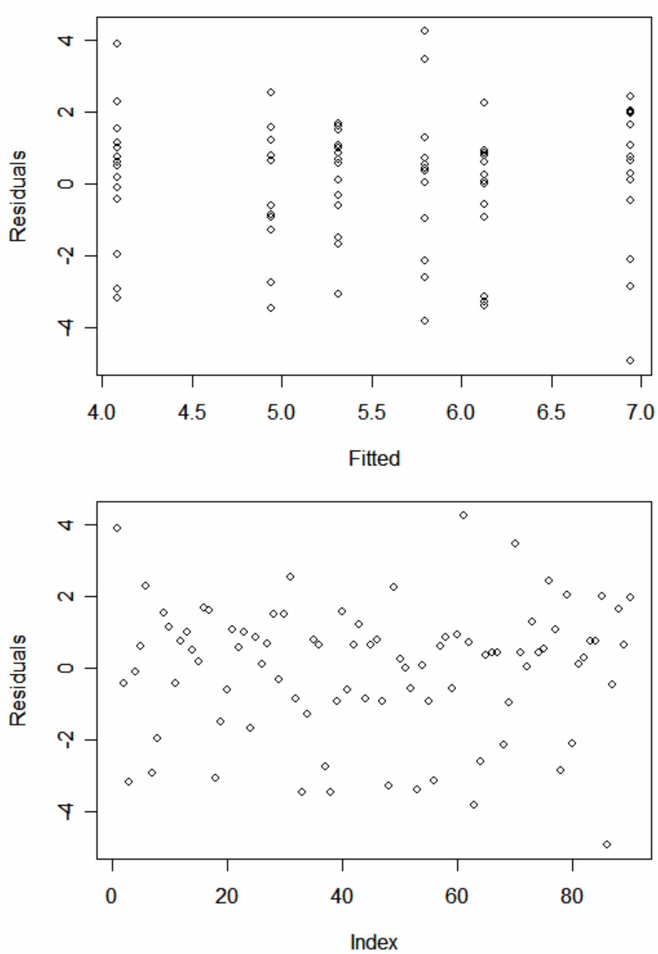
$Yij = \mu + \alpha_i + \beta_j + \alpha\beta_{ij} + \epsilon_{ij}$ where i = 1,2 ; j = 1, 2, 3

The α's represent the main effects for factor A, Whether the subject is an Athlete or Non-Athlete.
The β's represent the main effects for factor B, The number of alcoholic drinks consumed.
The αβ term represents the potential interaction between athletic and sobriety factor.

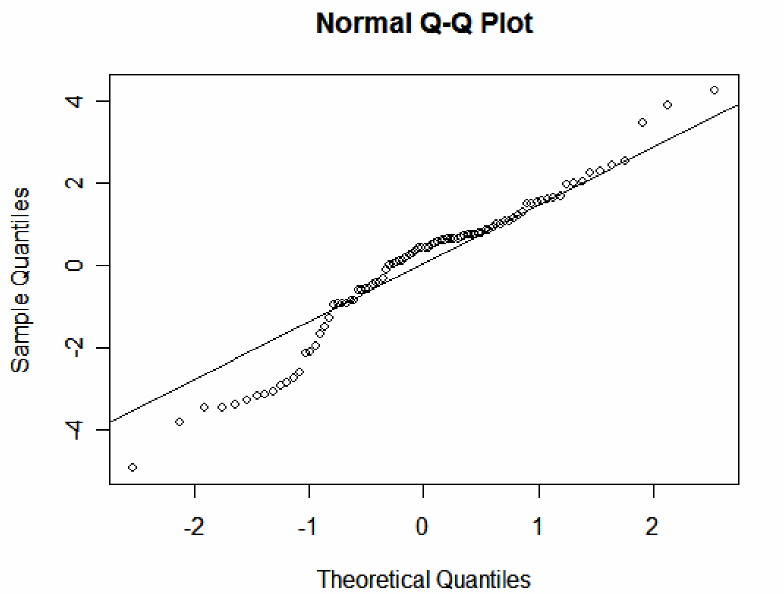
	Df	Sum of Sq	Mean Sq	F Value
A	a-1	SSA	SS(A)/df	MS(A)/MSE
B	b-1	SSB	SS(B)/df	MS(B)/MSE
A:B	(a-1)*(b-1)	SSAB	SS(AB)/df	MS(AB)/MSE
Error	diff.	SSE	SSE/df	
Total	N-1	SST		

Assumption Analysis

Before running the model, we wanted to do an assumption analysis to check for the normality of our data. This is important to see if we are violating any assumptions in our analysis of variance. First we created a plot of the residuals and a residual vs. fitted plot, as shown below:



The plot of the residuals shows a random scatter of points with no signs of any unusual patterns. The residual vs. fitted plot also looks good. Points seem to be equally scattered around zero and there are no strong signs of non-horizontal bands. We can now take a look at the normal probability plot:



The normal probability plot looks fairly good except for the left tail. Beyond that, it is straight and the points are tightly fit. Our assumption analysis shows that the standard ANOVA assumptions are fairly accurate. Therefore, we can continue with our ANOVA procedure and run the model.

ANOVA Results and Conclusions

Following is the ANOVA output from R:

```
> aov1 = aov(Trial.Avg~Athlete+Drinks+Athlete:Drinks)
> aov1
Call:
   aov(formula = Trial.Avg ~ Athlete + Drinks + Athlete:Drinks)

Terms:
                  Athlete    Drinks Athlete:Drinks Residuals
Sum of Squares   31.58914  50.23533        0.06850 281.13960
Deg. of Freedom         1         2              2        84

Residual standard error: 1.829453
Estimated effects may be unbalanced

> anova(aov1)
Analysis of Variance Table

Response: Trial.Avg
               Df  Sum Sq Mean Sq F value   Pr(>F)
Athlete         1  31.589  31.589  9.4383 0.002864 **
Drinks          2  50.235  25.118  7.5048 0.001003 **
Athlete:Drinks  2   0.068   0.034  0.0102 0.989821
Residuals      84 281.140   3.347
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

We will run our tests at a significance level of .01. First we will test for the main effects of Athlete. The appropriate F-statistic is MS(Athlete)/MSE with (1,84) degrees of freedom. We obtain an F-value of 9.4383 and a p-value of .002864. This p-value is well below .01, so we reject the null hypothesis and conclude that Athlete does have a main effect on reaction time.

Now we can test for the main effects of Drinks. The appropriate F-statistic for this test is MS(Drinks)/MSE with (2,84) degrees of freedom. We obtain an F-value of 7.5048 and a p-value of .001003. This p-value is well below .01 as well, so we reject the null hypothesis and conclude that Drinks does have a main effect on reaction time.

We can now test to see if our interaction term is significant. We obtained an F-value of .0102 with (2,84) degrees of freedom. The resulting p-value of .9898 is well above .01, so we do not reject the null hypothesis – the interaction term is not statistically significant.

Further Analysis

After analyzing the ANOVA table for our model, we turn to next analyzing the means over different factors. For this, we use a TukeyHSD comparison of the means.

```
> aov1 = aov(Trial.Avg~Athlete+Drinks+Athlete:Drinks)

> TukeyHSD(aov1, "Athlete")
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = Trial.Avg ~ Athlete + Drinks + Athlete:Drinks)

$Athlete
        diff       lwr      upr    p adj
2-1 1.184889 0.4179166 1.951861 0.002864

> TukeyHSD(aov1, "Drinks")
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = Trial.Avg ~ Athlete + Drinks + Athlete:Drinks)

$Drinks
         diff        lwr      upr     p adj
2-1 0.1876667 -0.9393712 1.314704 0.9167657
3-1 1.6703333  0.5432955 2.797371 0.0019016
3-2 1.4826667  0.3556288 2.609704 0.0065529
----- End R -----
```

For the first factor athlete, we find that with a p-value of .0029 (relatively significant) there is a difference in the mean reaction times. This indicates that the mean reaction time of an athlete is less than the mean reaction time of a non-athlete (which is indicated by a higher value measured on a rule for non-athletes).

For the sobriety factor, we notice that there does not seem to be a discernable difference in the reaction times of subjects who are sober and subjects who have had 2 drinks. However, it is important to note that this conclusion does have a very high (0.917) p-value and thus is not very significant. However, we also notice that there is needed a marked difference in the reaction times of subjects who are sober and who have had 6 drinks (expected) and between subjects who have had 2 drinks and those who have had 6 (also might be expected). These conclusions have much lower p-values (0.0019 and 0.0066, respectively) and are stronger conclusions.

```
----- Begin R -----
> cm = aov(Trial.Avg~Cell)
> TukeyHSD(cm, "Cell")
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = Trial.Avg ~ Cell)

$Cell
          diff        lwr       upr     p adj
2-1  1.2586667 -0.6896491 3.2069824 0.4190003
3-1  0.2540000 -1.6943158 2.2023158 0.9989315
4-1  1.3800000 -0.5683158 3.3283158 0.3151776
5-1  1.7146667 -0.2336491 3.6629824 0.1171340
6-1  2.8846667  0.9363509 4.8329824 0.0005956
3-2 -1.0046667 -2.9529824 0.9436491 0.6627117
4-2  0.1213333 -1.8269824 2.0696491 0.9999716
5-2  0.4560000 -1.4923158 2.4043158 0.9834244
6-2  1.6260000 -0.3223158 3.5743158 0.1565354
4-3  1.1260000 -0.8223158 3.0743158 0.5450652
5-3  1.4606667 -0.4876491 3.4089824 0.2549974
6-3  2.6306667  0.6823509 4.5789824 0.0022680
5-4  0.3346667 -1.6136491 2.2829824 0.9960103
6-4  1.5046667 -0.4436491 3.4529824 0.2254982
6-5  1.1700000 -0.7783158 3.1183158 0.5023764
----- End R -----
```

Cell 1: Athlete – Sober
Cell 2: Non-Athlete – Sober
Cell 3: Athlete - 2 Drinks
Cell 4: Non-Athlete – 2 Drinks
Cell 5: Athlete – 6 Drinks
Cell 6: Non-Athlete – 6 Drinks

Now, turning to the cell means model, we run a TukeyHSD comparison between each of the different cell means and find that with 95% confidence, there is only a difference in the cell means of cell 1 and 6 and cells 6 and 3. This means that in terms of reaction time, there is only a very discernable difference between sober athletes and non-athletes that have had 6 drinks. Additionally, there is also a discernable difference in the reaction times of non-athletes who have had 6 drinks and athletes who have had 2 drinks. Below is a line plot which shows the relationship(s).

Cell 1 Mean	4.086
Cell 3 Mean	4.943
Cell 2 Mean	5.315
Cell 5 Mean	5.801
Cell 4 Mean	6.128
Cell 6 Mean	6.941

A number of high p-values suggests that it may be a good idea to use a slightly less restrictive confidence interval when running this TukeyHSD comparison of cell means. As such, a TukeyHSD was conducted with a 75% confidence interval. The results were promising.

```
----- Begin R -----
> TukeyHSD(cm, "Cell", conf.level=.75)
  Tukey multiple comparisons of means
    75% family-wise confidence level

Fit: aov(formula = Trial.Avg ~ Cell)

$Cell
          diff          lwr       upr     p adj
2-1  1.2586667 -0.209209552 2.7265429 0.4190003
3-1  0.2540000 -1.213876219 1.7218762 0.9989315
4-1  1.3800000 -0.087876219 2.8478762 0.3151776
5-1  1.7146667  0.246790448 3.1825429 0.1171340
6-1  2.8846667  1.416790448 4.3525429 0.0005956
3-2 -1.0046667 -2.472542886 0.4632096 0.6627117
4-2  0.1213333 -1.346542886 1.5892096 0.9999716
5-2  0.4560000 -1.011876219 1.9238762 0.9834244
6-2  1.6260000  0.158123781 3.0938762 0.1565354
4-3  1.1260000 -0.341876219 2.5938762 0.5450652
5-3  1.4606667 -0.007209552 2.9285429 0.2549974
6-3  2.6306667  1.162790448 4.0985429 0.0022680
5-4  0.3346667 -1.133209552 1.8025429 0.9960103
6-4  1.5046667  0.036790448 2.9725429 0.2254982
6-5  1.1700000 -0.297876219 2.6378762 0.5023764
----- End R -----
```

Here, we find that there are many more cells that have means that are not likely the same. The cell means of cell 1 and 5, 1 and 6, 2 and 6, 3 and 6, and 4 and 6 are all different, with 75% confidence. The line plot below shows the relationship(s).

Cell 1 Mean	4.086
Cell 3 Mean	4.943
Cell 2 Mean	5.315
Cell 5 Mean	5.801
Cell 4 Mean	6.128
Cell 6 Mean	6.941

Conclusions

In conclusion, after completing our study we have found that athletic background and sobriety both have explanatory power regarding reaction time. In terms of athletic background, we found that athletes generally had quicker reflexes than non-athletes, which is what we expected. Furthermore, as the number of drinks consumed increased, reaction time increased, which was expected as well. As shown in our interaction plot, it was interesting to find that the rate of increase was about the same for both groups. The very high p-value of our interaction term provides evidence for these findings. Finally, while Tukey comparisons at a high confidence level do not indicate a difference between the mean reaction times between different groups, at a lower confidence level the differences are highly noticeable.