

The Effects of Energy Drinks, Caffeine, and a Placebo
on Cognitive Functioning after Physical Exercise

Eoin Smyth

Student Number 1720000

Supervisor: Dr Patricia Frazer

March 2016

Department of Psychology

Dublin Business School

School of Arts

Acknowledgments

I would like to thank first Dr Patricia Frazer for the role as my supervisor helping me along with any problems I encountered throughout this year and more importantly a great lecturer for the last 4years. I received excellent support and great depth of information from her classes and appreciated all the help greatly.

I would also like to thank Michael Nolan who works in Dublin Business School. Who without him there would have been no tests. He created the tests after I gave him my designs, and I highly appreciate the support.

Next, I would like to thank my girlfriend Grainne for her great understanding and for the overall drive she instilled in me to continue to thrive to better myself.

Finally, I would like to thank all members of the DBS soccer team who took part in the study. Thank you - you're a great bunch of lads.

Table Of Contents

Abstract.....	5
Introduction.....	6
Methods.....	13
Participants.....	13
Design.....	13
Materials.....	14
Procedure.....	16
Results	18
Discussion.....	23
References.....	28
Appendices.....	31

Abstract

The aim of this study was to provide support to the basis of knowledge that Red Bull and energy drinks provide prolonged cognitive abilities such as inhibition control, executive function, memory and reaction time over a Placebo group and a Diet Coke (caffeine) group. Also that caffeine is not the main ingredient and glucose and taurine have a vital part in cognition. The design of the study was a true experiment, placebo controlled and double blind design. There were 50 participants, all of whom were male, who were tested on three different cognitive tests: a Stroop test, 2back test and Visual light speed test. The results of the scores after being tested on a non parametric Mann Whitney U test found significant difference in scores between the Red Bull group and the Placebo on correct scores of Stroop test and visual light speed test. However, there was no significant difference in the Red Bull group over the Diet Coke group in any tests. In conclusion, this suggests that caffeine is the main component in higher levels cognition compared to glucose and taurine.

Introduction

Energy Drink effects and problems

Since the late 80's, energy drinks (ED) have demonstrated an effective increase in sales and have become the most improved segment in soft drinks (Zenith International 2001). With 5.6million cans of Red Bull sold in 2014 (Red Bull, 2015) the market is flooded with energy drinks with slogans such as “gives you wings”, Monster’s “unleash the beast” and Lucozade “goes 33% longer than water”. Energy drinks can be defined as beverages containing ingredients of caffeine, taurine, glucose and vitamins that provide a source of energy also other substances, devised for a specific purpose of demonstrating real or placebo modified physiological and cognitive performance improvements (Finnegan, 2003).

Research in the United States found on the 600 nationally advertised beverages, sales in ED's had surpassed that of other sports and fruit drinks (Yale Rudd Centre for Food Policy & Obesity, 2011). Thailand was found to have the highest consumption of ED's per capital followed by United States, Austria then Ireland in third (Seifert, Schaechter, Hershorin, & Lipshultz, 2011). Red Bull have claimed their product is the key reason for improved functionality and improved cognition. Research into the area of ED's claims the increase in the consumption of taurine, glucose and caffeinated energy drinks (Monster, Red Bull and Lucozade) has dramatically shot up in secondary schools (Howard and Marcziniski,2010). Studies in America found that 31% of 13-17 year olds regularly drink ED's (Park, Blanck, Sherry, Brener, O'Toole, 2012). In Germany, research found that 26% of teenagers consume ED's daily (Simon, and Mosher, 2007). However, ED's are emerging as public health issue, especially for youth. The safe food board was directed by the Minister of Health in Ireland to research and monitor the potential problems surrounding this issue.

The Birth of the Bull

In an ever-evolving world, humans are constantly looking for a source of energy from food/drink that will meet the ever-changing demands of their environment. The market has identified the needed for a beverage that is specifically engineered and research

backed to provide source of energy, increase physical endurance and cognitive functioning (Brown, 2013). This beverage could have multiple uses to a wide range of people - it could provide students that ability to focus an hour longer for that exam and improve memory for recall, or provide a solid extra physical endurance and mental alertness to their demanding manual day. The company that created this beverage would be far from in the Red or in trouble financially (Brown, 2013).

That company became Red Bull through their innovative owner Dietrich Mateschitz, who formulated an answer to the presented questions above after inspiration from a Thai energy drink called Krating Daeng that cured his jet lag from his travels (Solomon, 2012). Dietrich created Red Bull in Austria in 1985, the product itself named Red Bull a beverage itself that “vitalize the mind” (Red Bull, 2013). Research supporting that specific ingredients instil the products desired effects. Red Bull Gmbh processed a new market in their pioneering product of energy drinks.

Reasons for Experiment

There is an established wealth of research demonstrating that consumption of either glucose or caffeine can have increased cognitive performance (Scholey and Kennedy, 2004). Although most of the conducted research was administered in laboratory controls conceptualizing the study of cognitive functioning and energy drinks. The reason for the use of laboratory settings is to provide rigorous controls for the construct of cognitive function that is being studied. The strict governing of the laboratory stops extraneous variables effecting research and in this experiment for example a way of stopping confounding variables may be stopping the consumption of caffeine before the task (playing football match). However, with the high constraints applied in a laboratory setting the study loses ecological validity (Nestor and Schutt, 2012). There are also limitations to studying in laboratory settings as seen in such experiments like the Hawthorne effect (Landsberger, 1950) the sample performed in a way they thought the experimenter wanted no matter what constraints were administrated

This design true experiment was chosen and the intention was to apply it in a natural observable setting on a football field and try to identify all confounding variables and design a formulated approach to govern for all so that the results of the study can be applied to general social society in their natural environment (Nestor and Schutt, 2012). The design devised is a quantitative true experiment, between groups placebo controlled

double blind design with a two tailed hypothesis. This design will try to contain all confounding variables trying the validity of the research.

The Benefits of Caffeine, Glucose and Taurine on Cognition

Research is conflicting on whether Red Bull has any effects beyond placebo. The placebo effect is using a stimulus that mimics the actual independent variable without having any of the properties of independent variable (Kennedy and Scholey, 2004). The first study picked to provide support that caffeine and glucose (ingredients in Red Bull) play important role in cognition is (Kennedy and Scholey,2004). Kennedy's researched the effects of glucose and caffeine in combination vs the placebo on cognitive functioning. The method assembled a sample of 20 participants in a double blind study (stopping for experimenter bias's) placebo controlled described above. The sample was assessed on mood, cognition and psychological effects 30minutes post consumption of the 250ml drink containing 37.5g glucose, 75 mg caffeine in whole drink versus the placebo. The results found a significant increase in the memory and speed of attention in the caffeine group over the placebo. In conclusion, of the study caffeine and glucose affect improvements in cognitive modulating.

Although, like plenty of research, there is research finding that the opposite effect is identified, beginning with a study carried out in Colombia on 14 army soldiers on the effects of Red Bull on cognition and physical abilities (Kramer and Jaramillo, 2014). The design of the experiment was a double blind placebo controlled study, the soldiers were tested on Grid test and memory test for cognition and isometric strength and vertical jump test for physical abilities. The results from the study after consumption of 80ml caffeine and 100ml of triune, also a can of Red Bull there was no significant difference between red bull group and placebo group recorded in this research (Kramer and Jaramillo, 2014).

So research has been divided on the effects of Red Bull on cognition, does Red Bull live up to their slogan and marketing efforts? Research proposed that caffeine is the main

ingredient in Red Bull that is responsible for creating any of the effects proposed by the company for their product and not the combination of the ingredients as whole (Howard & Marczyński, 2010). Supporting this claim, Woojae (2003) catalogued a meta analysis of all the previous research into the ingredients and found that even though glucose and taurine are vital in neurotransmission no research in meta analysis found that alone they could have any effects on cognition alone Woojae (2003).

But as the ever expanding amount of research and most relevant studies keep being published researchers will find different results. Giles, Mahoney, Brunyé, Gardony, Taylor, & Kanarek, (2012) broke the ingredients of Red Bull down to the individual level (Caffeine, Glucose and Taurine). The design was a randomized, double blind, mixed design and the sample was 48 caffeine consumers. The participants were told to not drink caffeinated drinks for 24hours before. When the study began the sample was randomly assigned to four groups receiving different ingredients (200 mg caffeine/0 mg taurine, 0 mg caffeine/2000 mg taurine, 200 mg caffeine/2000 mg taurine, 0 mg caffeine/0 mg taurine) then tested 30minutes post consumption and an hour post consumption. The test post 30mins assessed attentional tasks. Then the test posted an hour tested working memory and reaction time. The results of the study demonstrated that caffeine plays a part in effecting executive control and working memory, taurine improved choice reaction time but slowed down reaction time in working memory. Glucose alone slowed down reaction time.

The conclusion of the study suggests the caffeine is the main factor in improvement of cognition but at the same time proved that other ingredients have a role to play. Also a limitation to study is that taurine takes an hour to break down post consumption, so this may be a reason for the low score in attentional tasks (Giles, et al 2012). The divide in research between caffeine being the main ingredient in effects one cognition interested one research, for that reason the main variable will be Red Bull (with multiple ingredients) vs Diet Coke (caffeine only) vs placebo.

Reaction time and Memory

The most research into cognitive abilities relating to Red Bull is reaction time and memory, the construct area is the most researched in reaction to energy drinks and beverage. The studies use a placebo control vs Red Bull design in the research of reaction time beginning with evidence for the effects of Red Bull on reaction time. Mets, Ketzer,

Blom, Van Gerven, Van Willigenburg, Olivier, & Verster, (2011) studied the effects of Red Bull on counteracting sleepiness and driving impairments in prolonged sleepiness.

The research design was a sample of 24 subjects in a double blind, placebo, cross over study. The driving was done in a driving simulator for obvious ethical issues. After a two-hour period, the sample took a 15minute break and either consumed Red Bull 250ml or a placebo drink (Red Bull Energy Drink without the functional ingredients: caffeine, taurine, glucuronolactone, B vitamins (niacin, pantothenic acid, B6, B12), and inositol) before driving for two additional hours. The next condition was 4hours of continuous driving. The abilities tested were first road position, mental effort, speed and subject driving quality. Results of the study devised no significant difference in red bull over placebo on any tests after two hours, but after 4hours examined Red Bull significantly improved control of weaving of driving, Red Bull also showed significant results in improved driving, less mental effort to the task, and control of speed over placebo. The conclusion Red Bull has a significant difference over placebo in reaction time in driving (Mets, et al 2011).

However as mentioned research has been split on reaction time and the effects of Red Bull on cognition in more recent research (Astorino, Matera, Basinger, Evans, Schurman, & Marquez, 2012). The study investigated Red Bull Vs Placebo on repeated sprint performance in women athletes. The sample was 15 college students at mean age of 19.5 participated in the randomized, placebo controlled cross over design. The tasks after performing a familiarized trial, the sample conducted 3 sets 8 bouts of a modifies t-test post consumption of 225ml placebo or a can Red Bull. The results of the research demonstrated calculated findings 255ml of Red Bull containing 1.3 mg/kg of caffeine and 1 g of taurine does not modify repeated sprint performance, RPE, or HR in women athletes versus placebo (Astorino, 2012). The established results from the studies above are important to oneself, because it allows this experiment to research the area of reaction time in memory and support the theories that Red Bull has a significate difference of improved abilities over placebo.

Increase in Executive Functioning

Executive functioning is one of the constructs mentioned early on in the introduction that must be given an operational definition because a lot of different experimenters have given their own perspective what executive function may include. Barkley (2012) defined executive functioning as a generated range of skills such as problem solving to achieve

certain goals, also the control or inhibition of behaviour or self regulation, finally, a hierarchical calculations of actions and a schema representations of the task (Barkley, 2012). Therefore, executive functioning is the organization and integration of higher level cognition, which embodied lower subordinate skills such as inhibition, abstract thinking, concept formation and creativity (McCloskey & Perkins, 2013).

As the experiment undertaken was to study inhibition control in a Stroop test to understand the effects of Red Bull on executive functioning, it is relevant to mention previous research in the area. Frazer developed a repeated measures design, placebo controlled to discover the effects of Red Bull Vs Placebo in a first person shooter game where the sample was (n) 21, 18 males and 3 females (Frazer, 2006). The shoot him game would assess the participant on a number of executive functioning and levels of difficulty such as inhibition and abstract thinking - for example abstract thought would be implemented to think what happens if one shoots a friendly, secondly inhibition/ impulse control to differentiate between friendlies and enemies in firing in quick succession and not to fire of and a loss of control. The results recorded a significant increase in performance on gaming after Red Bull consumption but no significance in difficulty levels. Conclusion to research was that Red Bull's increase of gaming still remains unclear due to the fact no significance was observed between reaction times and specific attentional performance.

Taking the above research into consideration, this study will try to build on to base of research of the effects of Red Bull on cognitive functioning.

Rationale

Beginning with the aim of the proposed experiment, one will try to add to the research supporting the significance of energy drinks in increased abilities in cognitive functioning. Through testing the college football team and working professionals with the use of a computerized program to test cognitive abilities after a half hour of physical exercise which will comprise of a soccer match. The cognitive test involved in the experiment are as follows: Executive function- inhibition colour word test, Memory-2 back test and visual information processing test- light speed visual perception. The sample of the study (N) 52 was achieved through a Cohen's D power analysis will have to meet an inclusion criterion before taking part in the study. The rationale for the use of the soccer match is to demonstrate the counteraction of Red Bull on fatigue and to increase

performance over placebo as supported by (Mets, et al 2011) and their research on fatigue in driving and the positive effects of Red Bull on prolonged driving.

The main question that is provided by research on fatigue in prolonged driving and the positive effects of Red Bull on cognition (keeping in between lines in the road, maintain safe speed and least amount of mental effort) Vs placebo (Mets,2011). This research gives a baseline of the significant effects of Red Bull, however a more recent study by (Kramer and Jaramillo, 2014) found no significant results when testing 14 soldiers on repeated measures of strength and mental abilities when fatigue is setting in with Red Bull and Placebo.

The second question is whether caffeine the only ingredient in Red Bull that makes a difference to cognition. A lot of previous research states this as fact, such as Woojae (2003). However, (Giles, Mahoney, Brunyé, Gardony, Taylor, & Kanarek, 2012) broke the 3 ingredients (Caffeine, Taurine and Glucose) down to the individual parts and assessed them and found that taurine plays a part also. Taurine improved choice reaction time but slowed down reaction time in working memory and glucose alone slowed down reaction time (Giles ,2012). So like the previous question, research is divided. Therefore, the rationale for the use of Red Bull contains all 3 ingredients, Diet Coke has only Caffeine and placebo just mimics the features of an energy drink.

To find a true effect of the independent variable, Red Bull, it must be measured against a beverage that mirrors the Red Bull structure but does not match the function of the ingredients of Red Bull. All the research above used a placebo in their research to attain their results. The ingredients for the placebo was retrieved from (Alford 2001) which consisted of 12 parts soda water,3-parts lime concentrated, 3-parts apple juice, 1-part blackcurrant (13mls) per 250ml serving for placebo (Alford 2001).

Another key point that previous research above implemented is a double blind design. The researcher brings in an associate to delegate the 3 beverages (Red Bull, Diet Coca Cola and placebo) to certain cups that will not opaque. The cups will have a coffee cup lid so the beverage is not visible Frazer (2006). The reason for this is to keep a rigorous design and stop confounding variables like experimenter bias. Also like Frazer (2006) participants will be given a mint before consumption to disguise taste.

Hypothesis

(H1) It is hypothesized that there will be a significant difference in scores on cognitive testing after a half hour of physical exercise in the Red Bull group over the caffeine group and the placebo group.

(H2) It is hypothesized that there will be significantly higher score results in the Red Bull group when tested on inhibition - colour word test (Stoop test), over the other three groups.

(H3) It is also hypothesized that the Red Bull group will score significantly higher scores on memory-2 back test scores go/no go, over the other groups again.

(H4) It is also hypothesized that the Red Bull group will have scores significantly higher when being tested by a visual information processing test- light speed visual perception test, again over the caffeine group, placebo group.

(H5) It is hypothesized that there will be significantly higher scores in reaction times on each cognitive test in the Red Bull group over the Placebo group and Diet Coke group.

Method

Participants

The sample was a convenience haphazard sample of males, made up of ages between 19-40. The males have a good mix of nationalities German, French American and Irish. So the sample will give a good psychological demographic.

The sample of convenience was a none probability sample, a Prori Cohen's D power analysis was conducted using a one way between groups Anova. The significance level is

0.5 with a medium effect size of .25. Using Cohen's D formula is implied and $df=3g-1, g(n-1)$. Therefore, the n the number is 52 after looking up Cohen's D table at sig .5 and medium effect size for two tailed hypotheses therefore the Df (2,153) (Cohen,1969) however the sample size achieved was only 50.

The inclusion and exclusion criteria, participants involved in the study age range must be not under 18years old to be able to take part and to drink Red Bull, also because all participants were male there will be no issue of pregnancy. Also, the participants were questioned about health issues and if they had any underlying medical problems. If any of those stipulations were met the the participant will be excluded (Moore 2014).

Design

A quantitative true experiment, between groups placebo controlled double blind design with a two tailed hypothesis. Students will be randomly allocated to assigned groups. The hypotheses were all two tailed. The independent variables are the cognitive tests taking and the group to which the person is allocated to and the dependent variables are scores in each tests.

Beginning with its hypothesized that there will be a significant difference in scores on cognitive testing after a half hour of physical exercise in the Red Bull group over the caffeine group and the placebo group. Followed by that, it was hypothesized that there will be significantly higher score results in in the red bull group when tested on inhibition - colour word test (Stoop test), over the other three groups. The third would be hypothesizing that the Red Bull group will score significantly higher scores on memory-2 back test, over the other groups again. Finally, it was also hypothesized that the Red Bull group will have scored significantly higher when being tested by a visual information processing test- light speed visual perception test, again over the caffeine group, placebo group.

The independent variables were the group the participants find themselves in (A, B, C) the Red Bull group, Placebo group, Diet Coke group. The cognitive tests, Executive function- colour word (Stroop test) test, Memory-2 back test, Visual information processing test-light speed visual.

The dependent variables were the scores from the cognitive tests from E prime program. Executive function- colour word (Stroop) test, Memory-2 back (N) test scores, Visual information processing test- light speed visual perception scores.

The random assignment to the groups was achieved by taking a letter (A, B, C) from a hat. The placebo will be used to find a baseline and to measure the true effect of Red Bull and Diet coke on cognition. The ingredients for the Placebo were retrieved from (Alford 2001) which consisted of 12 parts soda water, 3-parts lime concentrated, 3-parts apple juice, 1-part blackcurrant (13mls) per 250ml serving for placebo (Alford 2001). The double blind aspect of the design was to protect from the experimenter bias.

Materials/Apparatus

The materials that will be applied in the test beginning with the paper to randomize the groups. An E prime programme system that will use constructs of cognitive stimuli tests, such stimuli are Color-Word (Stroop) test, 2Back test and Visual lightspeed test.

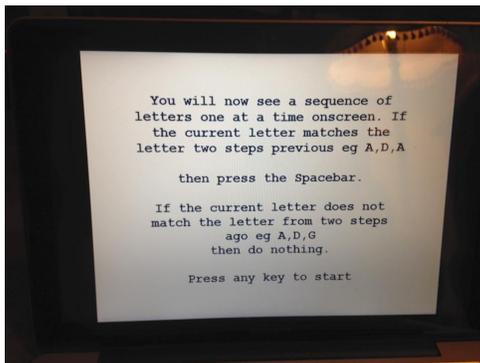
You're going to type the first letter of either the word presented, or the color of that word. Example: for green, you will type r if the task is Color, but g if the task is Word. It gets tricky; pay attention to tasks switching! Use your dominant hand, and have your fingers ready on top of the r, g, b keys.



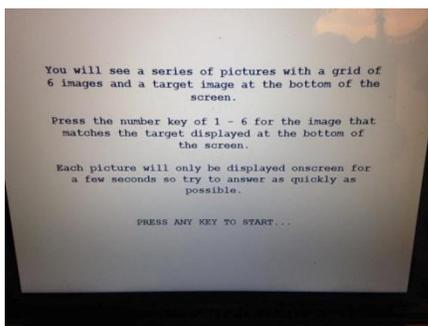
The reliability and validity of Stroop test in inhibition testing of cognition, is demonstrated in a vast amount of research starting as far back as the birth of introspection and Wilhelm Wundt in 1883. Wundt recommended to James Cattell that his doctoral

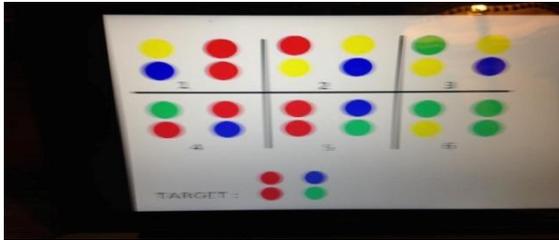
studies should focus on the time it takes to differentiate between colours and words (1886). It has been frequently used in the last 30 years (since the writing of this paper) showing high levels of reliability it also provides validity in individual difference, although the individual difference the ranking of scores maintain the magnitude of all participants (Jensen & Rohwer 1966).

The next test is a two back (N) test of memory a stimulus that had been previously showing two previous will be either showing or not showing and the participant must click yes or no if they remembered the correct stimulus. An example below of the test, the reliability and validity of the 2 back test was back up by a neuroscientific met analysis from (Owen, McMillan, Laird, & Bullmore 2005). The research results were the use of memory back tests validity was showing on the FMRI with locations in of frontal and parietal cortical regions and for process- and content-specific frontoparietal activation by working memory.



The third and final test was a test of reaction time and visual perception as like the Stroop test before the stimulus at the bottom must be matched one of the stimulus above and is timed.





As well as the test there were 15 cans of Red Bull, 15 cans Diet Coke and a mix from the ingredients formulated by (Alford 2001) for the placebo. The E Prime computer program and the IBM program SPSS will be run on Mac Book Pro with the data base split for windows to run such programs.

Procedure

The procedure began with first splitting the Mac computer data base to allow windows to be run and the downloading of E Prime and SPSS. After this a text message was sent asking all the participants to take part in the study and not to intake caffeine 24hours before. From this, 50 people agreed to take part in study.

First, 30 students met at a football field. The participants were asked whether they had any allergies to the ingredients in Red Bull or Diet Coke and if they were over 18 years old - the two main exclusion rules, then asked to sign a formal consent form (Appendix A) to take part in the study. At the sports ground, the drinks were split between 9 Lucozade sports bottles.

The research helper poured the drink into the bottles to protect the double blind study. The participants were asked to drink a measurement of 250ml and stop. Drinks were allocated by letters where A=Red Bull, B=Diet Coke and C=Placebo. The groups were picked out randomly from a hat.

After one hour of the game the participants would each come in and sit the three tests on the E Run Program the Stroop test, 2 Back memory and visual light speed test - see (Appendix B). After the research was done the participants were handed a debriefing sheet.

The other 20 participants were working professional males(soldiers). They also received the same text asking to take part and not to take in caffeine 24hours before. Once again, at the football field, research the helper poured the beverages into 3 different bottles and the participants drank 250mls out of the three groups A, B and C then again were tested after part taking in a football match.

After both tests all groups were giving a debriefing sheet see (Appendix C) and thanked for taking part. The results were then all calculated and saved to the Mac Pro Computer. Then the research was stored and calculated by SPSS with the use of data analysis.

Results

Descriptive Statistics

The acquired in this experiment was first class nominal data drinks (independent) consumed by participants and the scale data with the dependent variables of scores on the cognitive tests. The first thing to check was that all assumptions met the parametric standard set in SPSS data bases. First parametric assumption the dependent variables are scale.

The next assumption is normal distribution both Red Bull scores on the Stroop test and reaction time were not normally distributed. The histogram showed a negative skew which was caused by the ceiling effect, the way to recondition this problem was to use transform in SPSS use the 3 different functions inverse, squared and squared root. However, none of these functions worked so the parametric test being used is Manova which provides the justification to continue to use the parametric testing because there is no counter part non parametric test.

Descriptive Statistics Table

<u>Drinks</u>	<u>Tests</u>	<u>Mean</u>	<u>Median</u>	<u>Standard</u>	<u>Variance</u>	<u>CI 95%</u>
---------------	--------------	-------------	---------------	-----------------	-----------------	---------------

				<u>Deviation</u>		<u>Upper</u> <u>Lower</u>
Red Bull	Stroop test correct scores	17.94	20.00	18.20	18.9	20.13/15.75
Diet coke		17.88	20.00	3.60	13.00	19.80/16.00
Placebo		17.06	18.00	3.50	12.05	19.00/15.27
Red Bull	Two back Test	20.00	20.00	3.00	7.00	21.00/18.26
Diet Coke		21.00	21.00	1.20	1.40	21.43/20.20
Placebo		19.00	21.00	5.30	27.4	21.34/16.00
Red Bull	Visual lightspeed	17.00	17.00	3.0	6.26	18.00/15.24
Diet Coke		16.00	16.00	2.4	6.00	17.00/14.42
Placebo		13.00	14.00	5.0	23.00	15.45/11.00

Inferential Statistics

As mentioned above the test chosen to conduct the data analysis is a Manova to avoid the risk of type 1 error. To run a Manova there must be more than one groups, 1 independent variable and 3 or more dependent variables that are scale. The difference between the Manova and one way between groups Anova is the continues of the dependent variable justifying one's choice of test. However due to not meeting such assumptions of a one way Manova such as Box's test of equality of covariance matrices being lower than .001 and a few of the dependent variables having significate scores on Levene's test. The parametric tests were not going as mention that there was no counter part to the Manova in non parametric test one would have to break down the tests to find a compatible non parametric counter part. The conclusion was the use of 4 different Mann Whitney U tests. Applying the Mann Whitney U with the sample size of below 61 will give exact p value on the median.

To begin with, the The first hypothesis is overall result and will be discussed in discussion when the results are generated, and in the second hypothesis (H2) it is hypothesized that there will be significate higher score results in in the Red Bull group when tested on inhibition - colour word test (Stroop test), over the other three groups.

The results found when using the non parametric test Mann Whitney U was that there was no significant difference between Red Bull and Diet Coke when tested on Stroop test correct scores. The (Mdn=20.00) of scores for Red Bull however was higher than Diet Coke (Mdn=19.50) scores on the Stroop test $U=122.00$, $p=.60$, $r=0.4$. Suggesting the null hypothesis could be accepted there are no significant differences between higher Red Bull scores on Stroop test than Diet Coke scores.

As the Mann Whitney U can only test two groups at once, the Red Bull and placebo were now tested on Stroop test scores, the results indicated a significate difference between the group that drank Red Bull over the placebo. The Mann Whitney U suggested that there's was higher (Mdn=20.00) of scores for Red Bull drinkers over the Placebo group (Mdn=18.00) scores, $U=87.000$, $p=0.40$, $r=0.4$. Demonstrating that the null hypothesis can be rejected there are significantly higher scores on the Stroop test when drinking Red Bull when fatigued than drinking placebo.

The third hypothesis (H3) is that the Red Bull group will score significantly higher scores on memory-2 back test scores go/no go, over the other groups again. The results gathered from conducting the Mann Whitney U suggested no significant difference between higher scores on the two back test after fatigue when tested with the Red Bull group and the Diet Coke group. The Diet Coke group had a higher (Mdn= 21.00) scores on the two 2 back test when compared to the Red Bull group (Mdn=20.00) after consumption, $U=96.000$, $p=.073$, $r=0.3$. The results suggested that the null hypothesis can be accepted and there is no significant difference between Red Bull scores on the 2 back test after fatigue and Diet Coke scores.

Still testing the (H3) the Red Bull scores versus the Placebo also showed no significant difference when tested using the non parametric Mann Whitney U. The results also demonstrated a higher (Mdn=21.00) scores for the group that drank the placebo over the (Mdn=20.00) Red Bull consumption group, $U=130.000$, $p=.619$, $r=.10$. Results proving also that the null hypothesis can not be rejected.

(H4) It is also hypothesized that the Red Bull group will have score significantly higher when being tested by a visual information processing test- light speed visual perception test, again over the caffeine group, placebo group.

After testing the hypothesis with the Mann Whitney U the results also demonstrated no significant difference between the Red Bull group and the Diet Coke group. The Red Bull group however did have a higher (Mdn=17.00) score for the visual light speed test than the Diet Coke (Mdn=16.00) score after consumption, $U=108.500$, $p=.323$, $r=.20$. The data also suggests that there is no significant difference between Red Bull scores and Diet Coke scores on the visual light speed test after fatigue and concluding the null hypothesis can not be rejected.

The second groups to be compared on the Mann Whitney U was the Red Bull and the placebo group, the Mann Whitney this time demonstrated that the Red Bull group had a significant difference of higher scores after fatigue than the placebo in the visual light speed test. The Red Bull also had a higher (Mdn=17.00) score on the test over the Placebo (Mdn=14.00) after consumption, $U=76.500$, $p=.017$, $r=.41$. The Results gained from the Mann Whitney U suggests the the null hypothesis can be rejected and that there is a significant difference between Red Bull and placebo on visual light speed after fatigue.

The last hypothesis was (H5) It is hypothesized that there will be significantly higher scores in reaction times on each cognitive test in the Red Bull group over the placebo group and Diet Coke group.

After conducting the last two Mann Whitney U tested the results that were found were the following, no significant difference between the Red Bull group and the Diet Coke group on all the tests when reaction time was being assessed. In the reaction time of the Stroop test the Diet Coke processed a higher (Mdn=53096.00) over the Red Bull (Mdn=44000.00) after testing, $U=129.000$, $p=.817$, $r=.04$.

The results on the reaction time of the two back test the Red Bull group showed also a lower (Mdn=53096.00) over the Diet Coke group (Mdn=11511.50) for testing, $U=114.000$, $p=.444$, $r=.13$. Finally, in the first group the scores on the visual light speed reaction time the Diet Coke also had a higher (Mdn=161539.50) compared to the Red Bull (Mdn=161513) after testing, $U=134.000$, $p=.956$, $r=.01$. The results gained from the Mann Whitney U demonstrate no significant difference in the scores in reaction time when the Red Bull group is compared to the Diet Coke Group therefore the null hypothesis can not be rejected.

The last group to be compared is the Red Bull and the Placebo, after conducting the Mann Whitney U the results of this groups also suggested no significant difference on reaction time of the three cognitive tests. The Placebo group also had a higher (Mdn=55266.00) on first the reaction time of scores on the Stroop test when compared to Red Bull group (Mdn=44000.00) after test, $U=103.000$, $p=.160$, $r=.24$.

The Placebo also had a higher (Mdn=156987.00) on the reaction to the two back test when compared to the Red Bull group (Mdn=12838.00) after test, $U=125.000$, $p=.518$, $r=.12$.

The final test of the groups was reaction time on visual light speed the Placebo also had a higher (Mdn=171863.00) when compared to Red Bull group (161513.00) after test, $U=118.000$, $p=.371$, $r=.16$. The results achieved from the Mann Whitney U suggests that there is no significant difference between reaction time in the Red Bull group and the Placebo after fatigue therefore the null hypothesis can not be rejected.

The results obtained from testing all the groups (independent variables) on the Mann Whitney U against the test scores (Dependent variables) and relating back to the main hypothesis, (H1) Its hypothesized that there will be a significant difference in scores on cognitive testing after a half hour of physical exercise in the Red Bull group over the caffeine group and the placebo group. The results suggested that there is no main

significant difference between Red Bull and the Caffeine group when tested on cognitive abilities, suggesting that the null hypothesis can not be rejected.

Discussion

Reintroduction to the Aim

The aim of the study was to show the benefits of energy drinks in cognition and physical abilities after being fatigued and to support the previous research. The participants were involved in 1 hour of a football match and afterwards were tested on the four hypothesized questions, which were tests of cognition. These were comprised of a Stroop Test, Visual Light speed test and a 2back test which results obtained added support to such studies like (Kennedy and Scholey,2004) and Frazer (2006). Their studies provide significant results for Red Bull over the Placebo group. The final aim was to refute such studies like (Woojae,2003) and (Kami, Genii, Kori, & Rahnama,2009) that suggest that caffeine is the main component and ingredient of energy drinks suggesting they have no significant difference from coffee or just a caffeinated drink.

Evaluation of The Results

The first point of the discussion is the justification of the non parametric test. Although the parametric tests are robust after the results of the normal distribution were highly skewed and not normal when studying the Q/Q plots and the histogram which was caused by the ceiling effect (Teasdale & Owen, 2005), the next assumption was to check if Shapiro Wilks was not significant but this assumption was also broken. There finally was another to try and get a normal distribution by transforming the results by either inverse, squaring or square rooting however this also did not provide a normal distribution.

However, because one was using a one way Manova which does not have a non parametric counterpart there was still justification to continue with the test. But with one assumption broken before beginning to meet the assumptions of Manova's with unequal groups the research was leaning further to a non parametric a further two assumptions were broken with the Box's test of equality of covariance matrices being lower than .001 and a few of the dependent variables having significant scores on Levene's test. The final solution was a number of non parametric Mann Whitney U's.

The first and main hypothesis suggested that H1) It's hypothesized that there will be a significant difference in scores on cognitive testing after a half hour of physical exercise in the Red Bull group over the caffeine group and the placebo group. The results found however do not add support to (Kennedy and Scholey, 2004) that there is a no significant difference in Red Bull over the Placebo group however the Stroop test correct results when compared with the placebo provided support and visual light speed scores both provided significant results for Red Bull over placebo.

Although when interrupting all the results there is overall acceptance of the null hypothesis in no test was there any significant difference provided between the Red Bull group and the Diet Coke or just Caffeine ingredient group add support to Woojae (2003) research and the fact that there was significant difference of the Red Bull group over the Placebo group in the both tests above possibly adds more support to Woojae's theory that caffeine is the main ingredient in energy drinks.

The second hypothesis was the testing of the Stroop test and inhibition control the results add support to Frazer (2006) that there is a significant difference between Red Bull group and Placebo on inhibition control and in this study on Stroop test correct answers scores. The results although provide no support for (Giles, Mahoney, Brunyé, Gardony, Taylor, & Kanarek, 2012) which their study suggest that the ingredients of Taurine and Glucose play a part in improve cognition and caffeine is not the only responsible ingredient like with (Mets, et al 2011) Giles et al found positive findings in a repeated measures the

participants were tested after a have hour, the results above and in all tests show no significant difference between the Red Bull and Diet Coke group.

The third and fourth hypothesis are assessing stimulus recognition and memory the results the results achieved from the visual light speed which is just differentiating and matching stimulus which with the significant results achieved between the Red Bull and Placebo groups adds support also again to Frazer's (2006) shoot him up study of differentiating between targets.

The results achieved from the two back test however gave support (Kramer and Jaramillo, 2014) and their study of soldiers and cognition and physical ability providing no significate difference in Red Bull group and the Placebo group.

The final hypothesis was the testing of reaction times of all three tests which could provide support to all of the above studies on the benefits of caffeine on performance are important Red Bull. However, the results received from the Mann Whitney U only provided for studies like Woojae (2003) also another study (Kazemi, Gaeini, Kordi, & Rahnama,2009) that found no effects from ingredients in Red Bull in study of 12 Iranian girls on exercise abilities. Both studies claimed that there was no difference in energy drinks and coffee as caffeine is the main ingredient. It also provides negative support to studies such as (Mets, et al 2011) where their study on prolonged driving focused on reaction times with a Red Bull group versus placebo in a repeated measures design. After the second trial the results were evident - the results above accepted the null and was not significant. This may be due to testing after only an hour and not like (Mets, et al 2011) repeated measures.

The research of (Astorino, Matera, Basinger, Evans, Schurman, & Marquez, 2012) was also given support in unlike the Stroop test and Visual Light Speed test where the Red Bull had a significant difference over the placebo. In the reaction time studies there was no significant difference adding support to their women sprinter study on performance and reaction time when the Red Bull group was compared against the placebo group.

The results achieved from the Mann Whitney U suggests that the research conducted by one adds to the support of research purposed by Frazer's (2006) and (Mets, et al 2011) on inhibition and memory that Red Bull provides a significant difference over placebo on cognitive abilities. But at time the research also supports Woojae (2003) and (Kazemi, Gaeini, Kordi, & Rahnama,2009) that there is no significant difference in the Red Bull group and the Diet Coke group suggesting that caffeine is the main component in cognitive performance in energy drinks.

Limitations and Weakness

There were issues with supporting some studies, beginning with the ceiling effect. All three tests scores were high and skewed - this possibility could have occurred for a number of reasons such as the competitiveness of all individuals that participated in the the study, as they were sports players and a key trait of playing sport is competitiveness.

Also, the level of fitness of different participants taking part in the study was another confounding variable that was not taken into account which could cause different results and scores in each of the tests. Also as the research was done in Ireland in January in a natural environment to protect ecological validity the participants were wet and cold after the match and with only using one laptop participants may have just after waiting used the Screw you effect and pressed answers as fast as possible.

The next plausible conclusion to the high scores was the use of only one computer and like repeated measures participants behind the person getting tested may be able to see how the test worked and was assessing. So when sitting the test themselves, it is possible they were familiar with what the test was asking. Also there was no use of mints so the tests were evident in drinks so with the competitive streak in sporting players and the Hawthorne effect (Landsberger, 1939). The Hawthorne effect was that researcher Henry Landsberger watched women in a factory build relays and changed all environments and conditions but no matter whatever the condition was the worker's production went up and up, whether it was in the dark or even with no tea breaks. When the workers were asked why they had such a hard work ethic they reported because the researchers were watching them.

The next limitations were the non normal distribution shown in the histograms. The sample of scores weren't normally distributed causing a problem - whether either caused from the numerous issues above or perhaps the Flynn effect (Teasdale, & Owen,2005) which is the growing in IQ and intelligence on standard testing since the 1980's. Another confounding variable may be whether or not the participant did actually abstain from caffeine for 24 hours previous or not. The main and most probable reason for the results is the small sample size and the uneven groups.

The Strengths of the Study

Every research has its weakness and as stated above this research is no different however there are also strengths and positives from this study. Its key strength is that it provides ecological validity as unlike a lot of the studies in the literature review the research was conducted on a football pitch so it was in a natural setting not a laboratory, answering the question can it be applied to everyday life/

The next strength was the use of a true experiment - the research had a causal design. The results for example from the Stroop test suggested that there is a significant difference in higher scores on the Stroop test after fatigue has set in when compared to the placebo group. So with the results one can say to certain extend after the true experiment that Red Bull prolonged cognitive abilities (inhibition control and executive functions) when tested on the Stroop test compared to the placebo group.

The next strength was the use of the researcher;s assistant to pour out the beverages to protect the double blind part of the study so that the experimenter could not confound the results of the study through experimental bias. The placebo had issues because there was no use of mints in the study like Frazer's (2006) research, however the placebo still provides a purpose of baseline for the study where no caffeine was involved.

The last strength is the use of the Mann Whitney U even though it is a thesis project and one could have been justified to use the robust Manova even though assumptions were violated. It was beneficial to learn how to apply a non parametric test and with a small sample size to use an exact significance value.

Implications of the Research

The research implications gathered from results of the Stroop test and Visual light speed with significant p value suggests that there is an effect of Red Bull on prolonged cognitive abilities such as inhibition control, executive functioning and stimulus recognition over the placebo group adding support to such researchers as (Frazer,2006) and (Mets, et al 2011).

The overall trend of the research though when the results were studied provide back up support to Woojae (2003) and (Kazemi, Gaeini, Kordi, & Rahnama,2009) because every result between Red Bull and the Diet Coke groups provide insignificant results and the null hypothesis was accepted. Add the research suggesting caffeine is the main ingredient in Red Bull and energy drinks, also in the two significant results gained from the research

it could also be concluded that it was just the caffeine in the Red Bull that provided the prolonging of the cognitive abilities.

The reasons mention above why this research found this outcome may be because with (Giles, Mahoney, Brunyé, Gardony, Taylor, & Kanarek, 2012) research it was found that taurine and glucose take longer to affect the body and may have to be assessed on repeated measures design.

Conclusions

The aims of the study were to add to the base of research suggesting that Red Bull has a positive effect to prolonging cognitive abilities. This aim was achieved when compared to the placebo group on such cognitive functions as inhibition control, executive functioning and stimulus recognition. However, in whole the results do not suggest there is any difference in reaction time or memory in Red Bull over the Placebo group and the Diet Coke group with the null hypothesis accepted.

The second aim of the study of the study was also to show that caffeine was not the only factor in energy drinks and that glucose and taurine play a valuable part of the functions of increasing and prolonging cognitive abilities. Although, the results achieved found no significant difference in the Red Bull and Diet Coke group in all tests. Which significant results achieved from the Stroop test and Visual light speed can be also be just allocated to caffeine content.

In conclusion, to answer the firsts aim of the study, one with future research would first have to get a bigger sample size to allow for normal distribution, and use more than one computer to stop preparation for the test of the next person so that results are more accurate. To answer the second aim, a repeated measures study would have to be applied to test the different ingredients of Red Bull versus just caffeine. Therefore, as cliché as it may be, future research is the answer to aims of this study and debate of the effects of energy drinks on cognition.

References

- Alford, C., Cox, H., & Wescott, R. (2001). *The effects of red bull energy drink on human performance and mood*. *Amino acids*, 21(2), 139-150.
DOI 10.1007/s007260170021.
- Astorino, T. A., Matera, A. J., Basinger, J., Evans, M., Schurman, T., & Marquez, R. (2012). *Effects of red bull energy drink on repeated sprint performance in women athletes*. *Amino acids*, 42(5), 1803-1808. DOI 10.1007/s00726-011-0900-8
- Cohen, J. (1992). *Statistical power analysis*. *Current directions in psychological science*, 98-101.
- Frazer, P. (2006). *The effects of Red Bull on computer gaming ability and other cognitive tasks* (Doctoral dissertation, Keele University).
<http://hdl.handle.net/10788/414#sthash.0BouxfnB.dpuf>
- Giles, G. E., Mahoney, C. R., Brunye, T. T., Gardony, A. L., Taylor, H. A., & Kanarek, R. B. (2012). *Pharmacology, Biochemistry and Behavior*, 102, 569-577.
DOI: 10.1016/j.pbb.2012.07.004
- Howard, M. A., & Marczinski, C. A. (2010). *Acute effects of a glucose energy drink on behavioral control*. *Experimental and clinical psychopharmacology*, 18(6), 553. <http://dx.doi.org/10.1037/a0021740>
- IBM. (2012). *SPSS Version 21* [computer software]. Chicago: SPSS Inc.
- Jensen, A. R., & Rohwer, W. D. (1966). *The Stroop color-word test: A review*. *Acta psychologica*, 25, 36-93. [http://dx.doi.org/10.1016/0001-6918\(66\)90004-7](http://dx.doi.org/10.1016/0001-6918(66)90004-7)
- Kammerer, M., Jaramillo, J. A., García, A., Calderón, J. C., & Valbuena, L. H. (2014). *Effects of energy drink major bioactive compounds on the performance of young adults in fitness and cognitive tests: a randomized controlled trial*. *Journal of the international society of sports nutrition*, 11(1), 44.
doi: 10.1186/s12970-014-0044-9

- Kazemi, F., Gaeini, A. A., Kordi, M. R., & Rahnama, N. (2009). *The acute effects of two energy drinks on endurance performance in female athlete students*. *Sport sciences for health*, 5(2), 55-60. DOI 10.1007/s11332-009-0077-7
- Kim, W. (2003). *Debunking the effects of taurine in Red Bull Energy Drink*. *Nutrition Bytes*, 9(1). <http://escholarship.org/uc/item/65k8r3bd>
- Landsberger, Henry A. *Hawthorne Revisited: A Plea for an Open City*. Cornell University, 1957.
- Mets, M. A., Ketzer, S., Blom, C., Van Gerven, M. H., Van Willigenburg, G. M., Olivier, B., & Verster, J. C. (2011). *Positive effects of Red Bull® Energy Drink on driving performance during prolonged driving*. *Psychopharmacology*, 214(3), 737-745. DOI 10.1007/s00213-010-2078-2.
- Moore, B. (2014). *Red Bull versus a placebo: tests of reaction time, executive functioning and basic motor skills*. <http://hdl.handle.net/10788/1944#sthash.ENz4jCRj.dpuf>
- Owen, A. M., McMillan, K. M., Laird, A. R., & Bullmore, E. (2005). *N-back working memory paradigm: A meta-analysis of normative functional neuroimaging studies*. *Human brain mapping*, 25(1), 46-59. DOI: 10.1002/hbm.20131
- Park, S., Blanck, H. M., Sherry, B., Brener, N., & O'Toole, T. (2012). *Factors associated with sugar-sweetened beverage intake among United States high school students*. *The Journal of nutrition*, 142(2), 306-312. doi: 10.3945/jn.111.148536
- Red Bull GmbH. (2012). *25 Years and Counting*. Retrieved from <http://energydrink-ie.redbull.com/company>
- Scholey, A., Savage, K., O'Neill, B. V., Owen, L., Stough, C., Priestley, C., & Wetherell, M. (2014). *Effects of two doses of glucose and a caffeine-glucose combination on cognitive performance and mood during multi-tasking*. *Human Psychopharmacology: Clinical and Experimental*, 29(5), 434-445. DOI: 10.1002/hup.2417.
- Seifert, S. M., Schaechter, J. L., Hershorin, E. R., & Lipshultz, S. E. (2011). *Health effects of energy drinks on children, adolescents, and young adults*. *Pediatrics*, peds-2009. DOI 10.1542/peds.2009-3592

Teasdale, T. W., & Owen, D. R. (2005). *A long-term rise and recent decline in intelligence test performance: The Flynn Effect in reverse*. *Personality and Individual Differences*, 39(4), 837-843. <http://dx.doi.org/10.1016/j.paid.2005.01.029>.

Woojae, K. (2003). *Debunking the Effects of Taurine in Red Bull Energy Drink*. *Nutrition Bytes*, 9(1)

Appendix A

Email to question to be a part of the research

Hey lads,

I would like to ask you to please partake in my final year research project testing the performance of athletes after consumption of 3 different beverages and testing of mental abilities when fatigue sets in after half hour of a game of soccer. The only question I would ask do any of the participants have any allergies to Red Bull or any Caffeine products, also if partaking please do not drink colour caffeine 12 hours before testing.

Thank you, Eoin

Consent form

I, _____, the undersigned, agree to participate in this research experiment.

Having read and understood the research aims and what will be asked of me, I agree to participate _____.

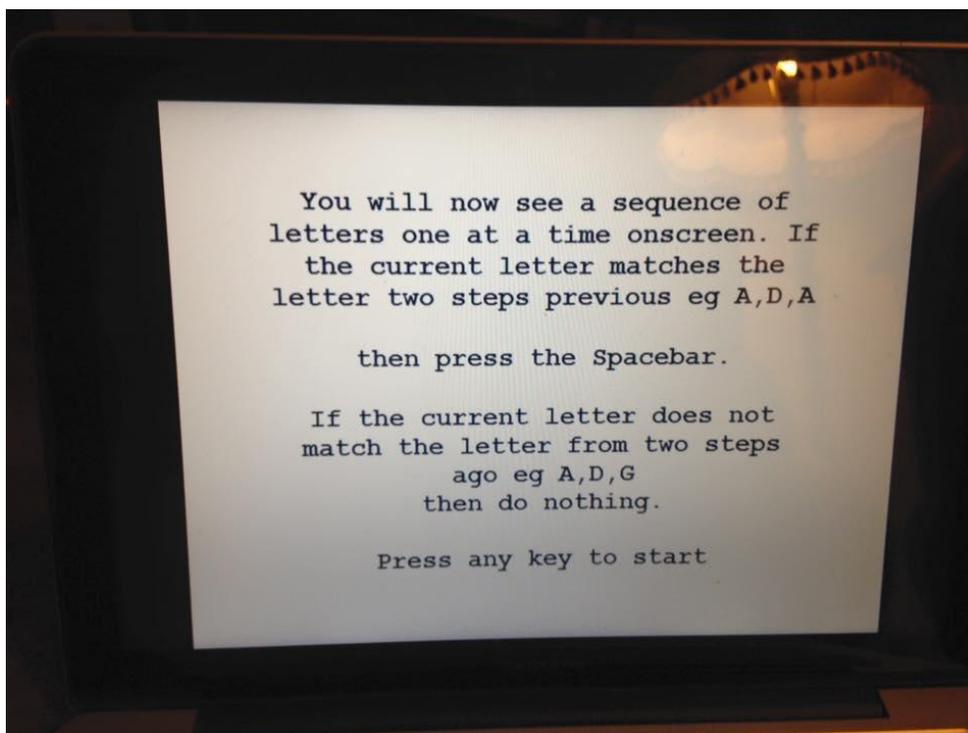
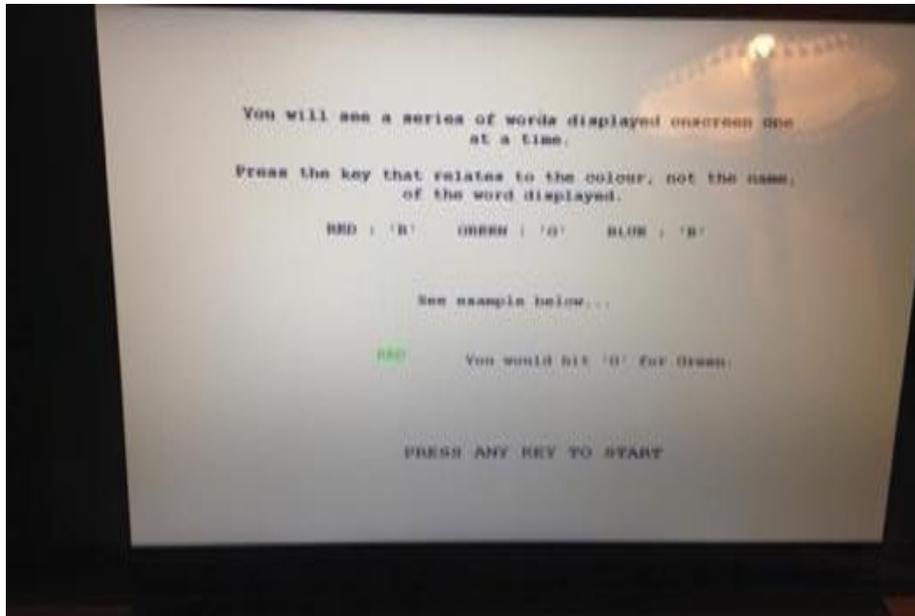
I also confirm that I have no health concerns before participation and also do not have any allergies to red bull contents _____.

I confirm I have abstained from caffeine for twelve hours _____
_____. Finally, I also confirm I am over the age of 18years
old _____

Appendix B



Presentation of the green but looking for the color red Above. Below is the instructions to press either G, R, B for what ever colors is presented.



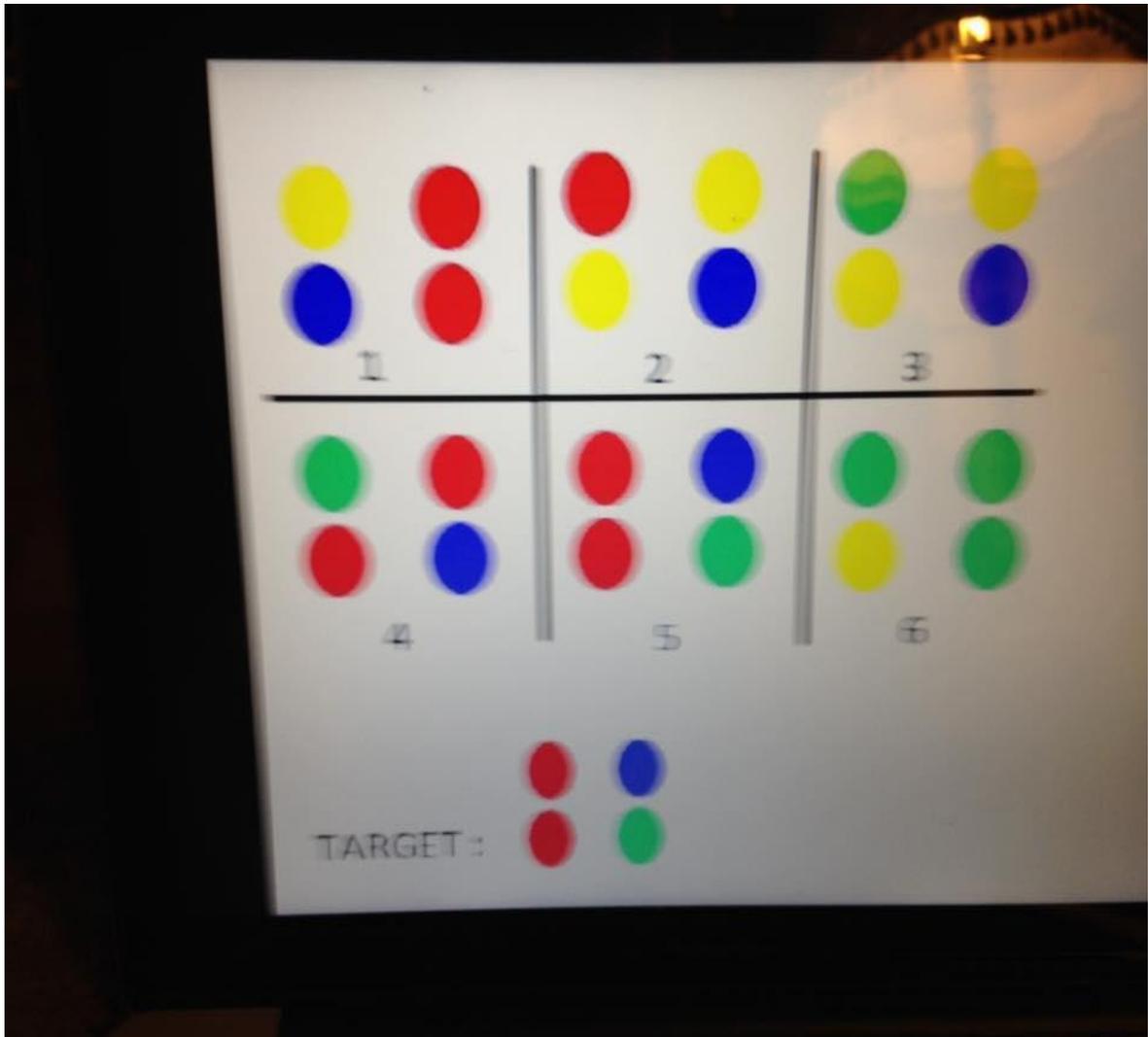
Above is instructions to the two back test. Below the instruction of the visual light speed test.

You will see a series of pictures with a grid of 6 images and a target image at the bottom of the screen.

Press the number key of 1 - 6 for the image that matches the target displayed at the bottom of the screen.

Each picture will only be displayed onscreen for a few seconds so try to answer as quickly as possible.

PRESS ANY KEY TO START...



Above an example of the stimulus presented in visual light speed test.

Appendix C

Debriefing sheet

The overall research question in this experiment is dose Red Bull demonstrate the abilities to counteract fatigue and give higher cognitive performance over Diet Coke which just has Caffeine and the placebo which mimics the proprieties of Red Bull without providing the same ingredients Mets, Ketzer, Blom, Van Gerven, Van Willigenburg, Olivier, & Verster, (2011).

The main question is provided by research on fatigue in prolonged driving and the positive effects of Red Bull on cognition (keeping in between lines in the road, maintain safe speed and least amount of mental effort) Vs placebo (Mets,2011). This research gives a baseline of the significant affects of Red Bull, however a more recent study by (Kramer and Jaramillo, 2014) found no significant results when testing 14 soldiers on repeated measures of strength and mental abilities when fatigue is setting in with Red Bull and Placebo.

The second question is caffeine the only ingredient in Red Bull that makes a difference to cognition a lot of pervious research state this as fact such as Woojae (2003). However Giles, Mahoney, Brunyé, Gardony, Taylor, & Kanarek, (2012) broke the 3 ingredients (Caffeine, Taurine and Glucose) down to the individual parts and assessed them and found that taurine paly a part Taurine improved choice reaction time but slowed down reaction time in working memory and Glucose alone slowed down reaction time (Giles ,2012). So like the pervious question research is divide therefore the rational for the use of Red Bull contains all 3 ingredients, Diet Coke has only Caffeine and placebo just mimics the features of an energy drink.

If you have any questions about the study, you can talk to your lecturer after you finish this sheet. There will now be readings on this topic available on Moodle which will help you to put the introduction section of the lab report together. Also if any distress is called this is the number of Samaritans 116 123