The study of Caffeine on Reaction time and Error rate among College Students.

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Submitted in partial fulfilment of the requirements of the Bachelor of Arts degree (honours Psychology) at DBS School of Arts.

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March 2014

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Acknowledgements

A special thank you to my supervisor Dr. Rosie Reid for the support, advice and guidance she has shown me.

I would like to thank my mam and dad for supporting me through college and providing inspiration and encouragement every step of the way.

I would like to thank Michael Nolan for his support and help during my thesis preparation

I would also like to express my gratitude to my fellow students for their time in participating in my experiment and the courtesy shown to me by Dr. Rosie Reid for allowing me to ask her students to participate.

Finally, to the lecturing staff of the psychology department, in the school of arts, Dublin business School: thank you.

Abstract

The present study used an experimental design to examine the effects of caffeine on the measured variables of reaction time and error rate among college students. Caffeine was also measured against the descriptive variable gender, along with error rate and reaction time. A clinical sample of people (N=26) was used, twelve males (n=12) and fourteen females (n=14) participated voluntarily. The results indicated that there was no significance between caffeine, reaction time and error rate due to some limitations outlined in the discussion section of this paper. The result also indicated a significant relationship between caffeine and gender differences in error rate (U= 4.500, p= .424), and the findings suggest for future studies, the area of gender differences across different dose of caffeine is an area that could be further researched. Overall the findings of this study remain positive, although no significance was found with two out of three hypothesis, it is hoped that this research might enhance future research and perspective in the area of psychopharmacology and awareness about the benefits for caffeine and its psychostimulant effects on the human body.

Introduction

For thousands of years, humans have used psychoactive substances to modify their perceptions and mood. Throughout most of this period, plants were the sole source of these substances but around the nineteenth century things started to change dramatically with the birth of modern chemistry. The identification and extraction of active ingredients in plant spices and the growing sophistication of chemical synthesis techniques, allowed the development of new drugs that could be used to treat various diseases and mental disorders. Without the advancement in the powerful biochemistry and molecular biology techniques, the insight into the mechanisms of drug action would have been impossible just a few decades ago.

In the history of drugs, opium held an important role in ancient medicine. Opium poppies, which contain morphine and codeine were used by ancient societies almost 7,000 years ago. Opium was extremely popular during the eighteenth century and was prescribed in numerous cases as a narcotic and a remedy against diarrhoea, vomiting and coughing. Pharmacological research on opium started around 1742 by a man called Charles Alston and paved the way for novel insights into the mode and site of drug action in the human body, contributing to the development and understanding of pharmacological and physiological processes. During the 1800's a number of psychoactive drugs were isolated from plants such as morphine from the opium plant in 1805 and was viewed as an effective treatment for insanity, while cocaine was extracted from the coca leaf in 1857 and used a an treatment for depression .

Formal relationships between drugs and psychological processes, particularly mental illness began to develop during the 1800's. The book Hashish and Mental Illness published in mid-1800's by Joseph Moreau de Tours, compared drug induced symptoms with mental

symptoms that occurred in psychoses, while more famously Sigmund Freud spent three years investigating the effects of cocaine on fatigue, depression and strength.

Despite the early history of drug use and investigations carried out by Freud and a few others, little collaborated interest existed in studying drugs and their influence on emotions, cognition and behaviour until the middle of the twenty century, when the discovery of the effects of chlorpromazine on schizophrenia patients was made. The drug chlorpromazine was found to dramatically reduce the main symptoms of schizophrenia without simply sedating patients as was the practice at the time, but also to increase their interactions with others and improve their thought processes. This discovery also highlighted the fact that certain forms of mental illness could be linked to abnormalities in the brain and dismissed environmental conditions such as bad parenting, which were the view at the time. It is regarded that this discovery led to the formation of the formal and distinct discipline known as psychopharmacology.

Psychopharmacology

Psychopharmacology is concerned with the study of the variables affecting drug-induced changes in mood, thinking and behaviour. The word psychopharmacology can be broken down by explaining the 'pharmaco' part which is the drug component. The term drug is used to explain a chemical that effects one or more biological process in living organisms, and important factors in determining a drugs effect are the concentration of a drug at its site action and the rate of accumulation there. Myer and Quenzer (2005) highlight the science behind the term drug action and the effects it has on functions of the brain, "by referring to the specific molecular changes produced by a drug when it binds to a particular target site or receptor, these molecular changes lead to more widespread alterations in physiological or psychological functions, which we consider drug effects" (Myer and Quenzer, 2005, p.4).

Drugs are used in a wide variety of social and recreational settings and therapeutically to diagnose, treat and prevent illness, and can have many different cognitive and behavioural affects.

How drugs are handled by the body

The branch of pharmacokinetics examines the movement of drugs throughout the human body, using processes like absorption, distribution, metabolism and elimination. It allows the determination of the concentration of a drug at its sites of action and the intensity of the drug effect on the receptors. The process of drug absorption refers to the mechanisms by which drugs pass from into the blood stream. Drugs are most commonly administered in one of six ways, with oral, parenteral (injection) and topical routes the most common methods. Once absorbed into the bloodstream, the drug is distributed throughout the body by the circulating blood until it reaches its site of action. Julien (2003) describes the action of the bloodstream in the average-size adult by explaining the heart pumps a volume of blood that is roughly equal to the total amount of blood around the circulatory system every minute, "The entire blood volume circulates in the body about once every minute, and once absorbed into the blood stream, a drug is rapidly distributed throughout the circulatory system" (Julien, 2003 p.13).

The major route of termination of drug action in the body is through the process of excretion. Drugs in the body's system are biodegraded into liquid-soluble drugs usually transformed by enzymes located in the liver and excreted rapidly. These biodegradable process are essential part of determining drug action.

Psychoactive drugs and the central nervous system

Psychoactive drugs can have many different effects, primarily acting on the central nervous system (CNS) where it affects brain function resulting in alterations in perception, mood, cognition and behaviour. Most psychoactive drugs acting on the nervous system do so by influencing synaptic transmission, affecting the synthesis, release, degradation or reuptake of transmitter's processes. Brodal (1992) describes psychoactive drugs and the effects on the central nervous system, and highlights how most transmitters are present is several parts of the nervous system. "It should not be surprising that even drugs that apparently influence the actions of only one transmitter nevertheless have multifarious effects. Development of more specific drugs -for example, drugs acting on only one receptor subtype –may reduce the side effects but will hardly eliminate them. Thus each receptor type is expressed in several functionally different parts of the central nervous system" (Brodal, 1992, p.62).

Psychoactive substances often bring about subjective changes in mood and consciousness and sustained use of some substances may develop a psychological and physical dependence.

Psychological and behavioural effects of psychoactive drugs

In addition to having many positive psychological and behavioural effects, especially in the medical area, psychoactive drugs can also have some profound negative effects on human psychology and behaviour. Drug abuse, drug dependence and drug addiction are all psychological and behavioural aspects resulting from psychoactive drugs. Grilly (2002) highlights human behaviour and attitudes towards psychoactive substances, "many individuals who exhibit the normal range of moods, emotions, cognitive activity, and behaviour willingly administer drugs to themselves to alter their emotional experiences,

consciousness, or behaviour in recreational, social, or religious settings" (Grilly, 2002, p.8). Human beings self-administer psychoactive drugs for a variety of purposes, usually to enhance mood or performance, to cope with adverse situations, to socialise or to conform, and a psychological dependence can often occur.

Psychological dependence refers to a strong compulsion to experience the effects of a drug because it produces pleasure or reduces an emotional distress or discomfort. This psychological dependence can lead to regular administration of the drug, therefore becoming a habitual occurrence and carries with it the behavioural effects such as drug addiction.

Mechanisms of psychoactive drugs

All human thoughts, actions and behaviours result from biochemical interactions that take place between neurons located in our central nervous system. Psychoactive drugs affect these process and act to alter neuronal function or communication between neurons in the CNS. The human brain consists of around ninety billion individual neurons located in the skull and spinal canal. The neuron is the basic component of the CNS and each neuron shares common structural and functional characteristics. Kolb and Whishaw (2011) describe the function of neurons in the CNS as, "the information-processing units of the nervous system, neurons acquire information from sensory receptors, pass that information on to other neurons, and make muscles move to produce behaviours" (p.72). A typical neuron has a cell body that surrounds the neuron filled with fluid, which acts as protection and helps to carry out the cells particular function.

In addition there is also another protected layer of fluid surrounding the neuron which is called extracellular fluid, from which the cells take up oxygen, various nutrients and if presents drugs. It is in this fluid that different concentrations of negatively and positively charged ions exist. The four main ions essential for electrical transmission within a neuron

are sodium (Na+), potassium (k+), chloride (Cl-) and calcium (Ca++), and are allowed to move across the cell membrane.

All neurons have a resting membrane potential which is the difference in electrical charge inside the cell compared to outside the cell, and the difference is -70millivolts (mV) making the neuron polarised. The rapid changes in the membrane potential provide the means for neurons to conduct information which in turn influences lots of other cells in the nervous system. The rapid change in the membrane potential, which is the reversal in the polarity of an axons membrane, is called the action potential. An action potential normally consists of the summed current changes caused by the inflow of Na+ ions and then by the outflow of K+ ions which are sensitive to the membranes voltage. These voltage sensitive channels are closed when an axons membrane is at resting potential and so ions cannot pass through them. When the membrane reaches threshold voltage, the voltage sensitive channels alter and open allowing ions to pass through, thus gated channels can controlled to open and close to permit flow or restrict flow of ions.

How do neurons communicate?

A typical neuron has a cell body called the soma which is the core region of the cell containing the nucleus, short fibres called dendrites, which receive input from other neurons through receptors located on the dendritic membrane and the axon which in essence transmits electrical activity from the soma to other neurons or to muscles, organs or glands of the body. The junction between one and another neuron where this process takes place is called the synapse.

The synapse which is the point of contact between an axon terminal and another cell, and consists of the synaptic cleft, which is a minute space between the presynaptic membrane of one neuron and the postsynaptic membrane of another. The presynaptic terminal contains

numerous structural elements, the most important of which are the small synaptic vesicles each containing thousands of molecules of neurotransmitters. Julien (2003 p.64) highlights the essential process of the release of a neurotransmitter into the synaptic cleft, by describing how vesicles store the transmitter through a process called exocytosis and under the influence of calcium ions, vesicles fuse with the presynaptic membrane and molecules of the transmitter are released into the synaptic cleft. The transmitter substance diffuse across the synaptic cleft and attaches to protein receptors on the postsynaptic membrane thereby transmitting information chemically from one neurons to another.

The effects of the neurotransmitter are kept relatively brief by their reuptake by transporter modules or their destruction by enzymes in the presynaptic membrane. Drugs that affect synaptic transmission are classified as either antagonists or agonists. Antagonists block or inhibit the postsynaptic effects while agonists facilitate them.

The CNS contains three types of neurons which are all structured differently to perform their specialised tasks .The function of the sensory neurons is to carry incoming information from sensory receptors into the visual centres of the brain. Motor neurons collect information from many different sources and carry that outgoing information to the body's muscles. Motor neurons are located in lower brainstem and spinal cord. While the final type of neuron found in the CNS is called interneurons or association cells because they link sensory and motor neurons to better collect information from many different sources.

Psychological and behavioural effects of caffeine

Caffeine is the best known member of a family of drugs known as methylxanthines and is the most widely used psychoactive drug in use today. It is sourced from coffee beans which are seeds of the coffea arabica plant, and is normally consumed orally through drinks like coffee and tea while also occurring in a number of non-prescription and prescription

drugs in which it is present and produces acute behavioural and physiological effects. Caffeine has mostly stimulating and fatigue reducing effects but low to intermediate does roughly 200-300mg, can increase feelings of well-being, enhanced energy and increased concentration, while higher does 400mg and above, can lead to feelings of tension and anxiety. Julien (2003, p.223) describes the psychological and behavioural effects of caffeine by describing caffeine as an effective psychostimulant, ingested to obtain a rewarding effect and leaves the individual usually de felling more alert and competent. Behavioural effect seen at the lower doses of caffeine include increased mental alertness, a faster and clearer flow of thought, and wakefulness.

Other physiological effects of caffeine include increased blood pressure, respiration rate, diuresis which is the process of enhanced water excretion and stimulation of catecholamine, the release of adrenaline. Although caffeine is not regarded as medical agent, therapeutically it does have several benefits and has been used to treat a variety of disorders including asthma, narcolepsy, migraines and other pain syndromes.

How does caffeine work?

Caffeine exerts a variety of effects on the CNS at different dose levels. But for does routinely consumed by humans the major action of the drug is the blocking of adenosine receptors, while four different types of adenosine receptors exist in humans (A1, A2a, A2b and A3). The blocking of adenosine by caffeine results in an increase in the "firing of cortical neurons and the locus coeruleus and an increase in behavioural activity" (Grilly, 2002, p. 36). Since caffeine also has the same properties as more potent psychostimulants like cocaine, caffeine's actions also seem to be determined by the release of epinephrine and other catecholamines. This indirect effects may contribute to the stimulating effects of caffeine.

The release of epinephrine caused by caffeine results in stimulation of the sympathetic nervous system. However caffeine can also cause effects outside of the CNS, smooth muscles tend to relax and striated muscles are strengthened. Caffeine also has different effects on blood flow in different parts of the body. Mckim (2003) highlights the effects of caffeine on blood flow and the explanation of why caffeine is found in many drugs for headaches:

> It causes a constriction of blood vessels in the brain but dilation in the rest of the body.by constricting the blood flow to the brain, caffeine is able to reduce headaches caused by high blood pressure. For this reason caffeine is found in many over the counter headache remedies. (p.203)

Caffeine crosses the blood brain and placental barriers without difficulty and reaches all body organs. About 10 to 30 percent of caffeine in the blood becomes bound to protein and trapped in the blood circulatory system.

Caffeine is completely absorbed from the gastrointestinal tract within thirty to sixty minutes. Caffeine absorption begins in the stomach but takes place mainly within the small intestine. The plasma half-life of caffeine varies substantially from one person to another, but the average value is about four hours. Most of the caffeine will be cleared out of the circulatory blood system during sleep. Meyer et al (2005) highlights how caffeine is cleared from the body after consumption and is converted to a variety of metabolites by the liver. "These metabolites account for almost all caffeine excretion, as only 1 to 2% of an administered dose is excreted unchanged. In humans, approximately 95% of caffeine metabolites are eliminated through the urine, 2 to 5% through the feces, and the remainder through other bodily fluids such as saliva" (Meyer et al, 2005, p.320).

Adenosine receptors are present in almost all brain areas, with the highest concentrations in the hippocampus, cerebral cortex, cerebellum and thalamus. It is the

increase in neural activity resulting from the inhibiting adenosine effects which cause the behavioural responses such as arousal, cogitative performance and motor activity. Because caffeine is primarily an antagonist of the central nervous systems receptors for the neurotransmitter adenosine, the bodies of individuals that regular consume caffeine adapt to the continuous presence of the drug by increasing the number of adenosine receptors in the central nervous system.

Caffeine tolerance and dependence

Regular caffeine use also leads to tolerance and dependence. Drug tolerance occurs when there is a diminished response to the effects of a given amount of drug as a result of previous repeated exposure. In addition increasingly larger amounts of the drug are needed to reproduce the same behavioural effect. Grilly (2002) describes the effect drug dependence has on individuals "drug dependence indicates that a person's drug use has led to the user's experiencing uncontrollable and unpleasant mood states that in turn lead the user to use the drug compulsively despite obvious adverse consequences" (p.114). Tolerance to caffeine's cardiovascular, respiratory and motor- stimulating effects occurs quickly and can be observed after one to two weeks of moderate caffeine consumption (Ettinger, 2012).

Caffeine Withdrawal

Chronic use of caffeine is often associated tolerance and dependence, and the abstinence from use of regular caffeine consumption may produce a withdrawal syndrome. A review conducted by Juliano and Griffiths (2004) found that there was sufficient evidence that discontinuation of caffeine in regular caffeine users results in a withdrawal syndrome. "Withdrawal symptoms typically begin slowly, maximise after one or two days and cease within a few days" (Julien, 2003, p.227), while Ettinger (2012) also states that caffeine effects begin within a few hours after last consumption "these effects can begin within a few

hours of abstinence but typically peak in severity between 24 and 48 hours"(p. 272). Withdrawal symptoms include headaches, drowsiness, fatigue and depressed mood and concentration, and can be rapidly relieved by readministering caffeine.

Gender differences with caffeine

Ross, Abbott, Petrovitch, Morens, Grandinetti, Tung, and white (2000) suggest that there are gender differences in neurobiological responses to caffeine. Similar gender differences have also been reported for subjective effects of caffeine. Adan, Prat, Fabbri and Sanchez (2008) reported in their research that despite all participants receiving the same dose of 100mg of caffeine, results showed that that acute caffeine administration had a greater effect in men than women. It is feasible that these different responses are a result of differences in circulating steroid hormones between men and woman. This hypothesis is supported by other studies showing caffeine consumption and subjective responses to caffeine (Terner & de Wit, 2006). These gender differences in the effects of caffeine may intervene with the different digestive patterns and motivation for caffeine usage.

Previous research

Previous research examining the effects of caffeine, has been reported in several studies to date. Although there is a large body of literature available on caffeine, few studies have detailed the impact of caffeine, reaction time and error rate together and this study aims to add to the literature on the topic. Nehlig (2010) looked at caffeine as a cognitive enhancer and found that caffeine absorption rates from the gastrointestinal tract is rapid and reaches 99% in humans in about forty-five minutes after ingestion, while Dewey Temple, and Briatico (2010) examined the effects of acute and moderate dose of caffeine on adults and found acute caffeine has a broad range of effects and that the magnitude of these effects is

moderated by gender and chronic caffeine consumption. This was carried out by Dewey et al. by measuring cardiovascular responses after administering caffeine does of 0mg, 50mg, 100mg and 200mg.

Childs (2005) looked at subjective, behavioural and physiological effects of acute caffeine in light, nondependent users found caffeine increased blood pressure, produced feelings of arousal, positive mood, and decreased reaction times in a vigilance task. A key objective of this study is to examine the effect caffeine has on reaction time and whether the research findings will advance previous research about caffeine and the on reaction time and error rate. Caffeine amounts can vary in the standard cup of coffee depending on the company and how the coffee is brewed, but the latest caffeine scorecard from the U.S food and drug administration puts a five ounce cup (mg per 5oz) of coffee at 115mg of caffeine.

Rationale for the current study

The purpose of this study is to examine relationship caffeine has with reaction time and error rate on third level college students, and to produce findings that can add to the previous literature on the topic already currently available. Specifically the aim of this study is to record the effects of caffeine will have on reaction time and examine the psychopharmacology processes caffeine has on the human body. Potential findings from this study will prove a greater understanding of how caffeine affects the body and how reaction time is effected by different amount of caffeine.

Hypothesis

H1: There will be a significant relationship between caffeine groups on reaction time

H2: there will be a significant difference between caffeine groups on error rate

H3: there will be significant gender differences across caffeine groups on reaction time and error rate.

Overall the results from this experiment should contribute to the literature within the psychopharmacology field and may yield useful information with the view to furthering the research in this area.

Methodology

Materials

Equipment

One laptop computer was used for the experiment. The laptop ran the E-Prime 2.0 program which is a suite of applications that help build computerised stimulus experiments. E-Studio is one part of that suite – it is a drag & drop interface that can construct a stimulus experiment which can present a number of trials of onscreen stimuli (text, image, video/audio) and where specified, record key press/mouse click responses to those stimuli (in terms of both reaction time & also coding the responses as correct/incorrect). The 'E-run' program presents the finished experiment to the participant and creates an 'output' file detailing the trials presented & user responses. Other materials used were one large jar of Kenco rich premium blend coffee, one jar of Kenco original decaf coffee, one measurement container and a stopwatch.

A demographic A4 paper questionnaire was used and questions such as gender, age, education, which caffeinated products are most consumed and how often are caffeinated products consumed on a daily basis, were asked. (See *appendix* 4). The questionnaire featured larger, clearer type fonts, to make it easier for participants to understand. A private, quite, well- lit room was used to experiment with the participants.

Participants

The target population for this experiment, were men and woman in full time or part time education, over the age of eighteen. The accessible population was the students at Dublin Business School and initial contact was made with the student population by asking permission from lecturers to gather college email addresses and from there contact was made directly with participants. A notice was also posted on the psychology board advertising for participants and then a follow on email was sent once interest was registered by a student. All students that were contacted were informed that participation was voluntary and all information gathered was for research purposes only and would be secured safely. Using the snowball technique others of eligible suitability were also recruited from students who agreed to partake. None of the participants were paid for their participation in the experiment and would be excluded if they did not give informed consent, or have any allergies to caffeine. All access to sampling was strictly adhered to by the code of professional ethics PSI 2003.

A sample of 26 participants(n=26) agreed to take part in this study, twelve males(m=12) and fourteen females(f=14) and they were aged between 20-54 years of age, both part-time /full time students.

Design

A true experimental design will be used for this experiment. There will be three groups were participants have been randomly assigned in advance. The groups consist of one control group, one low caffeine group and one moderate caffeine group and participants will be given a 150ml cup containing a dose amount of coffee depending on which group they are allocated too. The control group contains one tea-spoon of decaf coffee, the low caffeine group contains one tea-spoon of coffee, equalling 60-80mg of caffeine while the moderate group will contain three tea-spoons of coffee, equalling roughly 200mg of caffeine. After the participants have consumed the cup of coffee, a stopwatch is started and forty-five minutes is counted down before participants complete a reaction time test using a laptop running the E-prime software. The IV will be caffeine, while reaction time and error rate were considered the DV.

Procedure

All students that were contacted and agreed to the experimental conditions were given appointments and asked to stay off all caffeinated products for 24 hours prior to their appointment. At the beginning of each appointment a short introduction describing the purpose of the experiment and reassurances that they did not have to participate if they did not want to were given. This was preceded by the experimental dialog being distributed and after reading the description of the study in the cover sheet, information sheet and consent form, participants were asked to fill in the demographic questionnaire (see appendix 4) and their responses were collected without incident. Depending on which group the participant is assigned to, they received a cup of coffee with the assigned dose and the stopwatch started.

While participants are waiting 45minutes for the Caffeine to reach peak blood level in the body, reading material will be provided. Forty minutes after consuming the cup of coffee, participants will be given an instructional brief about the test and explained that an example run through of the experiment is provided before the real experiment begins. This is done to customise the participant to the laptop screen, experimental settings and what is been required of them, before results are recorded and took five minutes to complete. After trial run, the computer will ask for confirmation by the push of the ‘s’ button to begin the experiment and at this point participants are left by themselves to conduct the experiment. Once the experiment is complete on the laptop, the participants were verbally debriefed, questions answered and participants thanked for taking part. The length of time for each participant took fifty minutes.

Ethical considerations such as anonymity, right to withdraw and informed consent were addressed during the briefing stage at the start of the experiment.

Results

Table 1

Descriptive statistics of participants across demographic variables

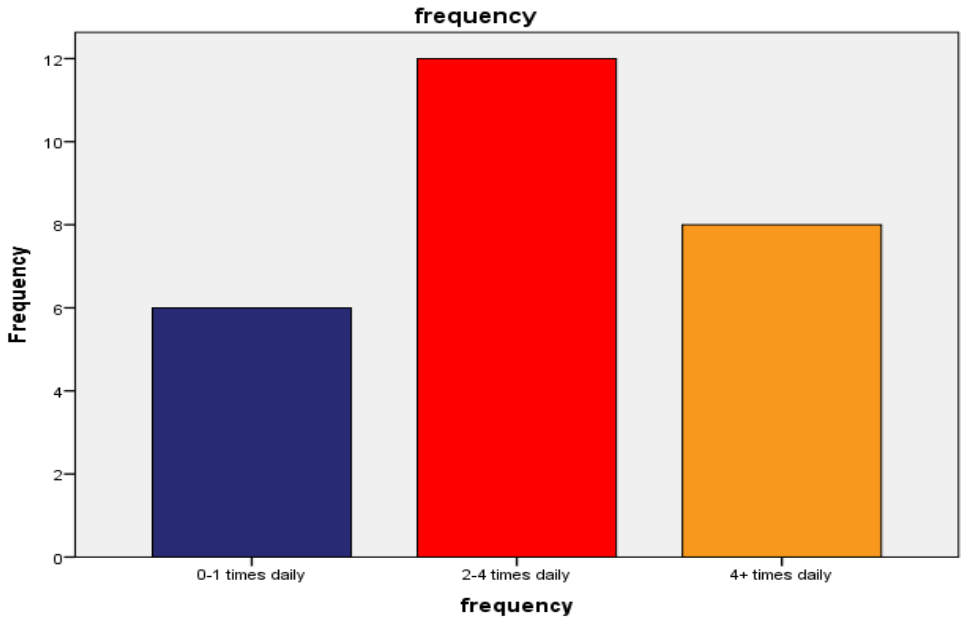
		gender	age	education	error	Rt	frequency
N	Valid	26	26	26	26	26	26
	Missing	0	0	0	0	0	0
Mean		1.5385	26.8462	1.6538	98.35	1063.0600	2.0769
Std. Deviation		.50839	6.80407	.48516	2.208	162.05599	.74421
Range		1.00	34.00	1.00	9	520.83	2.00
Minimum		1.00	20.00	1.00	91	815.22	1.00
Maximum		2.00	54.00	2.00	100	1336.05	3.00

The results of the descriptive statistics will be given and discussed first, followed by the results of the experiment. The results of the experiment were obtained by carrying out Mann Whitney U, Kruskal Wallis and one-way analysis of variance.

Descriptive statistics were carried out initially. The total number of participants in the current study was 26 (n=26), were 46.2% (N=12) male and 53.8 %(N=14) female. There was 9 full time students (34.6%) and 17part-time students (65.4%) participating in the experiment. The mean score for gender was 1.53 (SD= .508). The mean age of the participant was 26.84, ranging from 20-54 years. The mean score of the frequency showed that participants in this study drank between 2-4 cups of coffee a day, the mean was 2.0769 (SD= .9615). The mean score for error rate was 98.35 (SD= 2.208). The mean score for reaction time was 1063.06 (SD= 162.05).

Table 2

Bar chart showing participant's frequency of caffeine per day



The sample as a whole showed that the participants who participated in the study drank coffee most frequency two to four times daily, and that the average age of the participants in this study was 26 years of age. It also showed that the average reaction time between the decaf, low and moderate caffeine groups was 1063.06. Out of the 26 participants that took part, (23.1%) drank caffeinated products 0-1 times a day, while almost half (46.2%) of the participants drink caffeinated products between 2-4 times a day. Eight participants out of the twenty-six total drank coffee 4+ times a day (30.8%).

Table 3

Table showing the results of a Kruskal Wallis one-way Anova

	group	N	Mean Rank
Error	decaf	9	16.94
	low	9	10.72
	moderate	8	12.75
	Total	26	
Rt	decaf	9	11.11
	low	9	14.89
	moderate	8	14.63
	Total	26	

	error	rt
Chi-Square	3.341	1.348
df	2	2
Asymp. Sig.	.188	.510

a. Kruskal Wallis Test

b. Grouping Variable: group

(H1)

A Kruskal-Wallis one way ANOVA was conducted to test for significance among three or more unrelated groups. The results showed that there was no significance difference between error and reaction time for decaf, low and moderate group's scores. Error rate did not differ significantly (X^2 (2) = 3.341, p= .188). Reaction time did not differ significantly (X^2 (2) = 1.348, p = .510).

Table 4

Table showing a Pearson's correlation between error rate and reaction time variables

	Mean	Std. Deviation	N
error	98.35	2.208	26
Rt	1063.0600	162.05599	26

		error	rt
Error	Pearson Correlation	1	-.014
	Sig. (2-tailed)		.945
	N	26	26
Rt	Pearson Correlation	-.014	1
	Sig. (2-tailed)	.945	
	N	26	26

(H2)

A Pearson's correlation test was then conducted to see if there is a relationship between the error rate and reaction time variables. The mean score for error rate was 98.35 (SD= 2.208) and for reaction time was 1063.06 (SD= 162). A Pearson correlation coefficient found that there was no significant relationship between error rate and reaction times. ($r(26)= 0.94, p<.01$).

Table 5

A Mann Whitney U test group scores between genders

Group		error	Rt
Decaf	Mann-Whitney U	4.500	2.000
	Wilcoxon W	25.500	23.000
	Z	-1.381	-1.807
	Asymp. Sig. (2-tailed)	.167	.071
	Exact Sig. [2*(1-tailed Sig.)]	.262[b]	.095[b]
Low	Mann-Whitney U	8.500	7.000
	Wilcoxon W	18.500	17.000
	Z	-.386	-.735
	Asymp. Sig. (2-tailed)	.700	.462
	Exact Sig. [2*(1-tailed Sig.)]	.730[b]	.556[b]
moderate	Mann-Whitney U	5.000	.000
	Wilcoxon W	11.000	6.000
	Z	-.800	-2.236
	Asymp. Sig. (2-tailed)	.424	.025
	Exact Sig. [2*(1-tailed Sig.)]	.571[b]	.036[b]

a. Grouping Variable: gender
b. Not corrected for ties.

(H3)

A Mann Whitney U test was used to test the hypothesis that there will be significant gender differences across caffeine groups on reaction time and error rate. The decaf group had a mean rank of 6:50 for error rate and a mean rank of 7:33 for reaction time, compared to the moderate group mean rank 5 for error rate and 6 for reaction time. The Mann Whitney U revealed that gender differences differed significantly across the caffeine groups on error rate (U= 4.500, p= .424) but not reaction time.

Discussion

This study aimed to produce findings in a college population to advance existent international findings regarding the impact of caffeine on reaction time and error rate. This study firstly looked psychopharmacological processes and the effect psychoactive drugs has on the human body. Processes such as how drugs are handle by the body, mechanisms of psychoactive drugs and how psychoactive drugs effect the central nervous system, were researched.

Secondly, the study focused on the psychological and behavioural aspects of psychoactive drugs and the psychostimulant caffeine. Specifically this study focused on how caffeine works and the central nervous system processes it affects, how the human body builds a tolerance to caffeine and finally the withdrawal effects which can result from caffeine retraction. These processes where focused on to help support the hypothesis for this study.

The study firstly hypothesised that there would be a significant relationship between the decaf, low, and moderate caffeine groups on reaction time. However, no significant relationship was found between these three groups and reaction time.

Secondly, this study hypothesised that there would be a significant relationship between the decaf, low and moderate caffeine groups and error rate. However, no significant relationship was found between these groups and error rate.

Thirdly, the study sought to assess whether there would be any significant gender differences across the decaf, low and moderate caffeine groups on reaction time and error rate. This study found that there was some significance between gender differences and error rate but no significant differences between gender and reaction time.

Hypothesis one- caffeine effects on groups and reaction time.

The findings of this study do not support the hypothesis that there would be a significant relationship between the decaf, low, and moderate caffeine groups on reaction time. A Kruskal-Wallis one way ANOVA was used to test this hypothesis and although no significance was found to support previous research like Kruk et al. (2001) study on the influence of caffeine, on multiple choice reaction time, findings in this current research are more consistent with Dewey, Temple and Briatico (2010) which suggest caffeine administration has a broad range of effects and that the magnitude of these effects is moderated by gender and consumption. The current study administered the reaction time test by conducting a stroop task and a tighter control of pre-experiment requirements might have produced different results on the current research. The results in this hypothesis could have been offset by one or two participants reactions times been better than other participants, and due to the limitation of the sample size, this could have had a negative impact on the hypothesis.

Hypothesis two - caffeine effects on groups and error rate

The findings of this study do not support the hypothesis that there would be a significant relationship between the decaf, low, and moderate caffeine groups on error rate. A Kruskal-Wallis one way ANOVA was used to test this hypothesis and although no significance was found, findings in this current research are more consistent with recent research like Dixit, Goyal, Thawani and Vaney (2012) who suggest that caffeine has no effect on the performance in a stroop visual reaction time task. The current study measured the error rate alongside the reaction time task and possibly keeping both test separate might have produced different results on the current research.

Hypothesis three - gender differences across caffeine groups

A Mann Whitney U test was used to test the hypothesis that there will be significant gender differences across caffeine groups on reaction time and error rate. The findings of this study do not support the hypothesis that there would be a significant relationship between the decaf, low, and moderate caffeine groups on reaction time but do support the hypothesis that there would be a significant relationship between gender differences and error rate in the decaf and moderate groups. The research supports previous findings that suggest the effects of acute caffeine administration has gender differences (Adan, Prat, Fabbri, Sanchez-Turet, 2012). The current study had an uneven number of males and females participating in this study and possible having an equal of both males and females participating in the study might have produced different results on the current research. Relatively little research has examined this area of gender differences across different doses of caffeine and it remains an area of research that could be furthered.

Strengths and Weaknesses of Study

One of the main strengths of this research was it examined gender differences in caffeine usage and dosage, which is relatively unstudied so far. There was also a good variation in age with the age ranging from 20-54 years of age. Most of the potential weaknesses and limitations in this study could stem from the small sample size (N=26), which might have affected the overall scores of certain caffeinated groups and contributed to not finding significance in the results section. This could be down to a number of factors but most likely due to one participant who scored well in reaction time, and therefore could produce different results for that group, as the group size was limited in size to outcome that problem.

Another potential weakness might be the dosage for the moderate group of caffeine drinks, was too low. A dosage of 200mg was used for this current study but for future experiments a higher dose of around 400mg would be recommended. It was not possible to monitor all the participants for 24 hours before the experiment took place, to make sure all caffeinated products were abstained from, this could be considered a potential weakness.

A strength of this study was the use of the E-prime program to measure reaction time and error rates. The system which is a suite of applications that help build computerised stimulus experiments, and is extremely reliable.

Another potential weakness might be the length of time that participants were required to stay off all caffeinated drinks, was not long enough for heavy caffeine users who drink caffeinated products more than four times daily. In this study 8 participants were classified as heavy caffeine users and for future research a period of 48 hours would be recommended to insurance all effects of caffeine withdrawal are complete.

Other factors that might have resulted in different levels of response include Room temperature, which was not monitored in the current study. Research has shown that caffeine ingestion in a thermo- neutral environment, improved psychomotor performance, whilst at low ambient temperature was blunted (Kruk et al, 2011). Another factor not taken into account might be the time of day the part-time participants completed the reaction- time and error rate task. For some participants working in offices, starring at a computer screen for long hours could have affected their results in this current study, by simply the time of day they participated in.

For future studies, the area of gender differences across different dose of caffeine is an area that could be further researched. In relation to woman, caffeine and its responses could be studied across the menstrual cycle, and specific doses could be measured to see if

any subjective responses or differences occur. The findings from this study could be used in different areas of psychology including health psychology and biopsychology to give help give a better understanding of consumption and physiological process.

Conclusion

The results suggest that the findings substantially differ across subjective and behavioural domains, such as gender. The current research helps to build a foundation for examining the role of gender differences across different doses of caffeine and to add to the previous research on caffeine usage and dosage. With more specific analysis needed on the limitations of this study required to improve the experimental structure and to build a foundation for future research in this area. Overall the findings of this study remain positive, although no significance was found it is hoped that this research might enhance future research and perspective in the area of psychopharmacology and awareness about the benefits for caffeine and its psychostimulant effects on the human body.

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Appendix A

Table 6

Table showing the amount of caffeine consumed daily by participants

Frequency

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0-1 times daily	6	23.1	23.1	23.1
	2-4 times daily	12	46.2	46.2	69.2
	4+ times daily	8	30.8	30.8	100.0
	Total	26	100.0	100.0	

Appendix B

Table 7

A Mann Whitney U test group scores between genders

group		gender	N	Mean Rank	Sum of Ranks
decaf	error	male	3	6.50	19.50
		female	6	4.25	25.50
		Total	9		
	rt	male	3	7.33	22.00
		female	6	3.83	23.00
		Total	9		
Low	error	male	4	4.63	18.50
		female	5	5.30	26.50
		Total	9		
	rt	male	4	4.25	17.00
		female	5	5.60	28.00
		Total	9		
moderate	error	male	5	5.00	25.00
		female	3	3.67	11.00
		Total	8		
	rt	male	5	6.00	30.00
		female	3	2.00	6.00
		Total	8		

Appendix C

Table 8

Descriptive statistics showing the full- time/ part-time participants

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	full time	9	34.6	34.6	34.6
	part time	17	65.4	65.4	100.0
	Total	26	100.0	100.0	

Appendix 1

Cover sheet for Caffeine experiment

A Study on the Relationship between Caffeine, Reaction Time and Error Rate on Students

My name is Simon Hickey and I am conducting research in the department of psychology that explores the relationship between caffeine, reaction time and error rate on students. This research is being conducted as part of my studies and will be submitted for examination.

You are invited to take part in this study and participation involves taking part in an experiment and completing a short demographic questionnaire. The experiment which involves consuming caffeine, might change how you behave and feel but no long term risks associated with participation. If any of the questions do raise difficult feelings for you, contact information for support services are included on the final page.

Should you require any further information about the research, please contact me at,

My supervisor can be contacted at

Appendix 2

Information sheet for the study on the relationship between caffeine, reaction time and error rate on students.

You are invited to participate in a research study that will form the basis for an undergraduate thesis. Please read the following information before deciding whether or not to participate.

What are the objectives of the study? The nature of this study requires participants to partake in an experiment to exact the research question. Information about the research may influence your behaviour and responses, so for this reason we can only inform you that we are conducting research on the relationship between caffeine, reaction time and error rate. A complete debriefing will be offered after participation, where any questions will be answered.

A brief demographic questionnaire will also be conducted as part of the study and the information will be stored safely.

Why have I been asked to participate? I would like to collect information from different people. The research requires twenty-five to thirty participants to take part that meet the following criteria. Each participant should

- Be over the age of eighteen
- Be either in full-time or part-time education
- Must not be allergic to caffeine products

What does participation involve? Participation involves firstly drinking a cup of coffee and then secondly conducting a reaction time test in front of a computer screen. A time delay between consuming the cup of coffee and the reaction time test will be implemented. Once the reaction time test is finished participants will be debriefed and any questions answered.

Right to withdraw Participants will have the right to withdraw from the research at any time for whatever reason. Participants can also request at any time to have their response data and reaction times removed from record.

Are there any risks involved in participation? There are no risks associated with participation. Any inconvenience involved in taking part will be limited.

Confidentiality All individual information collected as part of the study will be used solely for experimental purposes. The information will be stored safely and will not be publicly displayed or published without prior consent.

Contact Details

If you have any further questions about the research you can contact:

Researcher: Simon Hickey email:

Supervisor: Rosie Reid email:

Appendix 3

Consent form

A Study on the Relationship between Caffeine, Reaction Time and error rate on college Students

I have read and understood the attached information leaflet regarding this study. I have had the opportunity to ask questions and discuss the study with the researcher and I have received satisfactory answers to all my questions.

I understand that I am free to withdraw from the study at any time without giving a reason and without this affecting my training.

It is important that you understand that by participating in the experiment and completing the demographic questionnaire that you are consenting to participate in the study.

Appendix 4

Questionnaire

Please circle the most relevant answer in relation to yourself.

1. Gender

Male

Female

2. AGE

Number: _____

3. Education

Full time

Part-time

4. Do you consume caffeinated products?

YES

No

If answer no, the questionnaire is now complete.

5. If so which do you consume?

Tea

Coffee

Other

6. How often do you consume caffeinated products on a daily basis?

0-1

2-4

4+