The Effects of Energy Drinks on Cognitive Ability

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By

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Dedication

I dedicate this research to my family who has been my source of inspiration throughout my academic career.

Abstract

Fatigue problems have been widespread in the air traffic control industry; in past years a common practice among air traffic controllers has been to consume highly caffeinated beverages to maintain awareness and thwart sleep deprivation. This study sought to examine what impact the consumption of an energy drink had on Air Traffic Control Collegiate Training Initiative students at Middle Tennessee State University to solve Air Traffic Selection and Training Battery Applied Math type test problems. Participants consumed a Red Bull energy drink or a placebo and then were asked to complete speed, time, distance, and rate of climb and descent rates questions in addition to answering questions regarding their perception of energy drinks. An appropriate statistical analysis was applied to compare scores of participants. The experimental group which received the energy drink averaged slightly lower (M=77.27, SD=19.79) than the control group, which consumed the placebo beverage (M=81.5, SD=19.01), but this difference was not statistically significant.

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List of Abbreviations

ATCS	Air Traffic Control Specialist
ATM	Air Traffic Management
AT-SAT	Air Traffic Selection and Training
CPT	Continuous Performance Test
DAWN	Drug Abuse Warning Network
FAA	Federal Aviation Administration
FDA	U.S. Food and Drug Administration
ICAO	International Civil Aviation Organization
MG	Milligrams
NTSB	National Transportation Safety Board
SAMHSA	Substance Abuse Mental Health Services

CHAPTER I – INTRODUCTION

Energy drinks are beverages that have a stimulant effect on the central nervous system specifically designed to give the user increased energy. The use of energy drinks among college students has become widespread and prevalent on college campuses. Due to the surge in marketing of products such as Red Bull that advertise increases in performance, reaction time, and cognitive ability, the sale of energy drinks has risen dramatically. Red Bull's worldwide sales were estimated at $1.32 billion in 2002 with more than a billion cans sold each year in over one hundred countries (Red Bull GmbH, 2012). Red Bull energy drink, through a direct marketing approach, advertises its product as a functional beverage providing various benefits, especially in times when increased performance is needed; it is stated that the beverage helps to improve concentration, helps to increase alertness, contributes to mental performance, and contributes to the reduction of tiredness and fatigue (Red Bull GmBH, 2012). The straightforward marketing strategy of providing users with immediate fulfillment by means of a beverage has created a multibillion-dollar industry. Due to Red Bull being categorized as a food supplement it is not regulated like other beverages sold throughout the United States, nor have the claims or potential risks of Red Bull been fully evaluated by the Food and Drug Administration (FDA).

Health Concerns

Bernstein, Carroll, Thuras, Cosgrove, and Roth (2002) found that caffeine use over time could cause dependence and withdrawal symptoms. Health officials argue the high level of caffeine (the key ingredient in energy drinks) combined with other additive ingredients (Taurine, Glucuronolactone, Niacin, B-Group Vitamins, Sucrose, and Glucose) found in energy drinks such as Red Bull creates health risks along with an addictive potential. These additive

ingredients have been found to increase the stimulant effects of caffeine. There is no experimentally determined safe level for caffeine dosage; researchers suggest the daily dosage for adults to be around 100 to 200 milligrams (mg) daily, which is equivalent to a cup of coffee. The amount of caffeine in an energy drink may vary depending on the brand. Researcher's estimate that the caffeine dosage of many favored drinks range anywhere from 80 mg to over 500 mg in a single serving. Through the use of the Drug Abuse Warning Network (DAWN) public health surveillance systems were able to monitor trend data among emergency room hospital related visits to identify the negative consequences associated with drug use. This was used as a source of information to identify drug related visits associated with the use of alcohol, caffeine, illegal drugs (marijuana, cocaine, heroin), and; pharmaceuticals (over-the-counter medicines, prescription medications, vitamins, and nutritional supplements) in the United States.

The Substance Abuse and Mental Health Services Administration (SAMHSA) through the use of DAWN reported that the excessive caffeine intake from energy drinks could cause arrhythmias, hypertension, dehydration, insomnia, nervousness, and contingent on the individual's health status cardiac conditions, eating disorders, diabetes, anxiety disorders, and other medical complications (SAMHSA, 2011). With the use of DAWN reports SAMSHA found a substantial increase in the number of emergency room visits involving energy drinks between 2005 (1,128 visits) and 2009 (13,114 visits) that represented a ten-fold increase during the four-year period (SAMHSA, 2011). Upon further examination 67% of the reported emergency room visits were caused by adverse reactions to energy drinks, with approximately half of the visits involving a combination of energy drinks and alcohol or other drugs (SAMHSA, 2011).

Usage Patterns among College Students

The addictive potential, immediate rewards and aggressive advertising has made energy drinks a success among college students. While the perceived health risk of energy drinks remains on the rise, the main population of its consumption continue to be ages 18-25 (SAMHSA, 2011). There are limited studies for the support of the consumption of energy drinks before the conduct of high-level cognitive tasks. The majority of studies on college students focus on the effects/usage rates of the combined use of alcohol and energy drinks or the effects of energy drinks on physical performance. This information may suggest that energy drink consumption has become widespread among college students and evidence advised that usage rates could be higher in student populations.

Oteri, Salvo, Caputi, & Calapai, (2007) conducted a study to increase the knowledge of energy drink use alone or in the association with alcoholic beverages. The study consisted of an anonymous questionnaire administered to 500 students at the School of Medicine of the University of Messina in Italy. The questionnaire focused on the method of using energy drinks, reason of utilization, and the monthly number of cocktails consumed containing energy drinks. Analysis of the data suggested that 56.9% of students surveyed used energy drinks. Students reported ingesting more than three energy drinks within the last month, with 53.2 % reporting using both energy drinks alone and energy drinks with alcohol. More than half the students reported ingesting more than three cocktails composed of energy drinks and alcohol. More than two thirds of users reported the primary motivator for the consumption of energy drinks was “I like it” and linked the usage to a sensation of pleasure (Oteri, Salvo, Caputi, & Calapai, 2007, p.1679).

The Malinauskaus, Aeby, Overton, Carpenter-Abey, and Barber-Heidal (2007) conducted research to identify energy drink consumption patterns and side effects linked to energy drink consumption among college students in the United States. Based on a focus group of 32-college students who were asked open-ended questions regarding their frequency patterns, situations involving energy drink usage, and side effects from energy drink usage a 19-item questionnaire were developed. The questionnaire was administered to 496 undergraduate and graduate students recruited from a state university located in the Central Atlantic region of the United States. Research of energy drink consumption patterns among United States college students found that 51% reported drinking greater than one energy drink each month. Further assessment of the college students found they reported using energy drinks due to insufficient sleep (67%), to increase their energy (65%), to drink with alcohol while partying (54%), while studying or completing a major course project (50%), while driving (17%), and to treat hangovers (17%) (Malinauskaus et al., 2007). Side effects were reported as jolts (feelings of increased alertness and energy followed by sudden drop in energy) and crash episodes, heart palpitations, and headaches (Malinauskaus et al., 2007).

Positive Effect Studies

There have been contradicting research studies concerning the effects of energy drinks on cognitive and physiological performance. Kennedy & Scholey (2004) studied the effects of a combination of caffeine and glucose during extended performance of cognitively demanding tasks. In two double- blind, placebo controlled, cross over studies, 30 participants received counter balanced caffeine and carbohydrate drinks and a placebo drinks on separate days. During a second study 26 participants received a drink containing a lower level of caffeine and carbohydrates. Both groups completed a ten minute battery task consisting of a two minute Serial

Subtraction Task and a five minute Rapid Visual Information Processing Task, as well as a mental fatigue rating, before the drink and six times in sequence ten minutes after consumption. When compared to the placebo group, the experimental group in the first study who had received a higher level of caffeine indicated lower levels of mental fatigue. Furthermore, it was found that the main ingredients of energy drinks (caffeine & glucose) could improve deficits in cognitive performance and subjective fatigue during periods of cognitive demand (Kennedy & Scholey, 2004).

A double blind, placebo controlled study conducted by Seidl, Peyrl, Nicham, & Hauser, (2000) measuring motor reaction time on taurine and caffeine containing drink stimulants in 10 graduate students was conducted. Researchers used a P300 event-related potential (component described by a large wave 300 milliseconds following stimulus presentation, it is used to analyze a person's reaction in the decision making process.) while measuring motor reaction time and testing for assessment attention. Results indicated that the mixture of three key ingredients of Red Bull energy drink (caffeine, taurine, glucuronolactone) in the experimental group indicated positive effects upon human mental performance and mood compared to the placebo group (Seidl, Peyrl, Nicham, & Hauser, 2000).

Negative Effect Studies

Carvajal-Sancho & Moncada- Jiménez (2005) conducted a double blind placebo controlled study on 20 male soccer athletes from the University of Costa Rica to determine the effectiveness of acute energy drink consumption on physical and cognitive variables. Participants were instructed to fast overnight then given breakfast the morning of the test. On different instances participants consumed an energy drink and placebo beverage under each condition administered short-term physical and cognitive test in the exact same order. The participants

were informed they received two beverages intended to enhance their physical and cognitive performance. Thirty minutes following consumption of the beverage the participants performed post-test physical and cognitive tests. A factorial 3x2 repeated measures analysis of variance was conducted to analyze the variables. The results indicated no significant changes in physical and cognitive variables when comparing the energy drink and the placebo. The energy drink did not enhance mental performance.

A double blind study on the effects of consuming a single can of Red Bull/Sugar Free Red Bull on attention and reaction time measured using a computerized Conner's Continuous Performance Test II (CPT) in a university setting was conducted. Participants were instructed to maintain their normal diet while refraining from alcohol and recreational drugs use for 24 -48 hours prior to testing. They were allowed to consume only water four hours prior to testing. Participants then consumed Red Bull/Sugar free Red Bull or a caffeine and calorie free placebo beverage, with the requirement that every participant receive the placebo beverage once. Following a 30-minute absorption period for the drink to become effective a CPT was conducted to evaluate visual attention and reaction time. The participants were given random letters on a screen at inconstant speeds and intervals while being required to press the space key for every letter except the letter X. The CPT software measured the rate of omission errors (failing to press the space key when appropriate), commission errors (pressing the space key when inappropriate) on this task, and reaction time, and calculated a measure of the participant's overall ability to discriminate targets from non-target stimuli (Gendle, Smucker, Stafstrom, Helterbran, & Glazer, 2009). The results indicated that although Red Bull/Sugar Free Red Bull may improve cognition in certain clinical settings, when taken by university students it does not

improve reaction time or visual attention as measured by the CPT (Gendle, Smucker, Stafstrom, Helterbran, & Glazer, 2009).

A limited amount of research has been done on the effects of energy drinks on collegiate students conducting high cognitive and performance tasks. Few studies have been conducted to examine the effects of energy drink consumption on collegiate flight students. One study by Depperschmidt, Bliss, & Wooley (2010) sought to understand the effects of energy drink consumption on collegiate flight student's pilot skills in simulated flight. Depperschmidt et al. (2010) identified the general effects of energy drink consumption on pilot skills in collegiate flight students in three different in-flight areas; straight and level flight, complex turns, and in-flight emergencies in simulated flight. The participants for this study were 30 undergraduate aviation students majoring in Professional Pilot at Oklahoma State University. The participants were tested in two separate sessions using electronic flight simulation software.

A two-group reverse treatment pretest – posttest design was used to analyze the possible side effects associated with consuming the energy drink. Each participant conducted two separate flight sessions to exclude the effect of the energy drink. Both groups received the 16-ounce energy drink and 16-ounce placebo beverage in alternating flight sessions (Group A received energy in flight session one and Group B received the energy drink in flight session two) then waited 30 minutes for the energy drink to take effect. The consumption of energy drinks was found to have a significant effect on collegiate flight students' pilot skills. College flight students became less able to perform routine flight maneuvers or apply what they had learned to unpredicted flight situations (Depperschmidt, Bliss, & Wooley, 2010).

Participants were less accurate and required more time to follow (in order) the five steps in –flight emergency checklist. The energy drink participants required 52 seconds and completed

an average of 4.5 steps of five-step checklist versus the placebo participants which required 47 seconds and completed an average of 4.8 steps of five-step checklist). In addition, 87% of the pilots had a larger number of point deductions while maintaining straight and level flight segments with majority of point deductions following consumption of the energy drink. On average 53% of student pilots completed the complex turn more quickly after consuming the energy drink, but it took ten additional seconds to recover from the complex turn and achieve straight and level flight (Depperschmidt, Bliss, & Wooley, 2010).

Depperschmidt and Bliss (2010) surveyed collegiate flights student's energy drink consumption patterns and perception of the side effects after consuming an energy drink. The participants in the study consisted of same undergraduate Professional Pilot aviation students enrolled in flight courses at Oklahoma State University as previously discussed in Depperschmidt et al. research study. The research apparatus was designed to gain knowledge of the perception and effects of energy drinks on student pilots. Demographic information, Likert-scale statements, and a comment section were developed to provide an accurate research instrument. Research indicated that 60% of students reported they consumed energy drinks and have seen other student pilots consume energy drinks the same day they piloted an aircraft; 67% of the participating flight students agreed that energy drinks have an effect on collegiate flight students' ability to pilot an aircraft. Still, 90% of student pilots considered it okay to consume an energy drink the same day they piloted an aircraft. The student pilots reported the three most common reasons for consuming energy drinks were: needing more energy (23%), driving an automobile for a long period of time (20%), and studying for an exam/completing homework (17%).

Deixelberger-Fritz, Tischler, & Kallus, (2003) conducted a study to examine the effects of a single standard dose energy drink (250ml Red Bull) on the performance of pilots in a fatigue-inducing paradigm. A randomized repeated measure double-blind cross over study was utilized on 24 pilots and 8 non-pilots in a fatigue-stimulating environment for six hours on two separate days. Each participant received both treatment conditions during a six-hour work block on two separate days. A sustained match to sample test, arithmetic continuous performance task CPT, and letter cancellation test (continuous attention performance) test were conducted. Analysis of the data found clear-cut positive effects of the energy drink at the .05 level that could be demonstrated on reaction time and on performance in a concentration test (Deixelberger-Fritz, Tischler, & Kallus, 2003). Participants also performed significantly better on the continuous performance task when given Red Bull compared to the placebo drink. In the decision time of correct decisions in the continuous match to sample test, highly selective subjects like pilots showed an improvement of about 0.1 seconds with Red Bull energy drink (Deixelberger-Fritz, Tischler, & Kallus, 2003).

Although Pilots and Air Traffic Control Specialists (ATCS) have different jobs in the field of aviation both remain responsible for the safe flight of aircraft in the sky. The required level of safety is extremely dependent on maintaining high levels of concentration while performing numerous responsibilities on a daily basis. ATCS coordinate the movement of air traffic to ensure that aircraft stay safe distances apart (Occupational Outlook Handbook, 2012). The work environment of an ATCS varies depending on the type of facilities, which include control towers, approach control facilities, or enroute centers. Many ATCS work in dark environments and must maintain absolute concentration with an appropriate balance of separation between airplanes to ensure the separation of air traffic. Air traffic control is a

dynamic occupation that requires an ATCS to execute swift decision making to rapidly shifting situations (Banyard, n.d.)

One of the most utilized functions ATCS perform is mathematical estimating. ATCS must perform multiple calculations more quickly than the average person with the possibility of any error resulting in loss of life and property. ATCS must calculate climb or descent rates and rates of closure through desired altitudes for aircraft conducting high-speed flight. Due to the high consequences associated with poor job performance of ATCS, the Federal Aviation Administration (FAA) has developed an Air Traffic Selection and Training (AT-SAT) exam to measure the skills and abilities of individuals seeking to become ATCS. The AT-SAT test was developed to minimize the cost to the FAA associated with attrition during ATCS training, to ensure that hired applicants had the required skills to become ATCS (King, Manning, & Drechsler, 2007).The AT-SAT exam provides a vehicle that will screen all candidates through a Multi-Path Training Model designed to assess if a candidate has the basic skills needed to perform the work of ATCS (Ramos, Heil, & Manning, 2001). The AT-SAT test consists of eight subtests (Dials, Applied Math, Scan, Angles, Letter Factory, Air Traffic Scenarios, Analogies, and Experience Questionnaire). The Applied Math subtest tests the ability of the applicant to solve basic math problems such as applied distance, rate, and time (Ramos, Heil, & Manning, 2001).

Fatigue in ATC

The National Airspace System operates twenty-four hours a day and three hundred sixty five days a year, so controllers must work alternating schedules to accommodate the influx of air traffic. It is reported that at least twenty five percent of controllers work a "2-2-1″ schedule, working afternoon to night the first two days, followed by a mandatory minimum of eight hours

for rest before starting two morning-to-afternoon shifts, another eight or more hours for sleep, then a final shift starting between 10 p.m. to midnight (Garner, 2011). This type of unfavorable scheduling has been reported to contribute to high levels of mental fatigue in the workplace.

Fatigue is the physiological state of reduced mental or physical performance capability resulting from sleep loss or extended wakefulness, circadian phase, or workload (mental and/or physical activity) that can impair and individuals alertness and ability to perform safety-related duties (FAA, 2012). Fatigue can have serious safety implications and has been identified by the National Transportation Safety Board (NTSB) as a potential contributing factor in several operational errors where controllers failed to maintain required distances between aircraft (FAA, 2009). Roske-Hofstrand (1995) reported that 21% of the incidents reported in the Aviation Safety Reporting System mentions factors related to fatigue for pilots and air traffic controllers.

Due to continuous Air Traffic Management (ATM) operations conducted within the U.S. controllers have been forced to accommodate high traffic levels for longer periods of time. ATCS facility personnel identified inadequate staffing levels, increased work load (traffic volume and complexity), and extended time on position or lack of position rotation as several factors that could cause fatigue (FAA, 2009). The pressure of personal factors and unfavorable shift patterns during times of increase concentration has led to fatigue becoming a safety issue in ATM. The NTSB has listed fatigue on its most wanted improvements list for 2012 (Moore, 2013) In addition, Professor Philippe Cabon (2011) member of the International Civil Aviation Organization (ICAO) Fatigue Risk Management Systems task force states that the Air Traffic Control Organization working hours led to various cognitive performance degradations associated with sleep deprivation and working at times for which humans are not biologically

programmed. Health, age, and gender have been found to be factors influencing fatigue in ATC (European Organization for Safety Navigation, 2011).

Caffeine in ATC

Caffeine is the most highly consumed stimulant and its popularity has been linked to activating the central nervous system and temporarily overcoming tiredness while improving alertness and performance (Holmes, 2011). Caffeine comes in many forms including coffee, tea, soda, chocolate, over the counter supplements, and energy drinks. Dr. Alexandra Holmes (2011) with over a decade of experience in fatigue management for aviation professionals (air traffic controllers, pilots, cabin crews, mechanics, etc.), reported that in industries such as aviation, that operate 24 hours 7 days a week and require people to work in shifts, caffeine a widely used strategy to cope with work-related tiredness.

Statement of Problem

While fatigue problems have been widespread in the air traffic control industry, in past years a common practice among air traffic controllers has been to consume highly caffeinated beverages (coffee and energy drinks) to maintain awareness and thwart sleep deprivation. This tradition of utilizing highly caffeinated beverages to maintain awareness and increase performance is also practiced among collegiate air traffic control students. Research has suggested 57% of student pilots report consuming energy drinks 1-3 times a week. Further research implied that 67% of participating flight students agreed that energy drinks have an effect on collegiate flight student's ability to pilot an aircraft (Depperschmidt & Bliss, 2010). The effect of use and the perception of energy drink usage among air traffic control students has not been researched to date. This study will examine what impact the consumption of an energy drink has on Air Traffic Control Collegiate Training Initiative (AT-CTI) students' ability to

solve AT-SAT Applied Math type test problems. This study will also examine the perception of energy drink usage among air traffic control students. The specific research questions to be addressed include:

1. Will AT-CTI students who have consumed energy drink score higher on ATC applied math aptitude test problems than those that do not?
2. What are AT-CTI student's current usage patterns of energy drinks?
3. What are AT-CTI student's perceptions regarding how energy drinks effect their performance?

CHAPTER II-METHODOLOGY

The FAA employs the majority of ATCS in the United States. The bulk of the ATCS are reaching the mandatory retirement age of 56 at an alarming rate due to mass firings conducted by the President Ronald Regan in 1981. The FAA has begun hiring initiatives to replace the dwindling workforce with AT-CTI students. A high number of AT-CTI students will begin to fill the vacancies and become certified ATCS in the near future. Fatigue and the maintenance of high levels of cognitive ability experienced by ATCS in an operational environment may be similar to the mental fatigue that is experienced by collegiate air traffic control students, due to their unorthodox hours of studying and the need to maintain high levels of cognitive functioning in the collegiate setting. This similarity makes AT-CTI students ideal candidates to evaluate whether energy drinks effect cognitive ability in answering applied math type problems much like controllers use on a daily basis.

The AT-SAT test was developed to minimize the cost to the FAA associated with attrition during ATCS training and to ensure that hired applicants had the required skills to become ATCS. The King, Manning, and Drechsler, (2007) study, The Operational Use of Air Traffic Selection and Training Battery, reported that the goal of the AT-SAT is to predict the likelihood of success in air traffic control training, and more importantly, subsequently on the job. Seven of the eight subtests assess aspects of cognitive ability, while one, the Experience Questionnaire, assesses personal history and the personality realm (King, Manning, & Drechsler, 2007). Thus, AT-SAT applied math type problems were determined to be an appropriate way to assess the effects of energy drinks on cognitive ability. Applied math is a key component of the FAA administered AT-SAT test. Due to its capability of assessing cognitive ability by having

participants solve distance, rate, and time problems section of the AT-SAT, problems similar to those found in applied math will be used in this study.

Study Design

The study experimental design was appropriate because experimental research was the most practical means of gathering the data required for this research. By using an experimental research design, the researcher was able to manipulate the experimental group receiving the energy drink, control the group receiving the placebo drink (Non Caffeinated Ginger Ale), and observe the effect of the energy drink on the control group. Experimental research design presented the most structured environment for participants, while establishing a cause-effect relationship. Experimental research design was chosen over a survey only methodology due to the close-ended nature of the research questions. However, in addition to the experimental design a survey was used to establish ATC-CTI student's perception of energy drink usage. Testing participants under other research conditions such as correlational research study would have extended the time required to gather the data and would only predict an individual score for a particular participant. Experimental research design was preferred over causal-comparative due to the ability to randomly assign participants to treatments.

Participants

Permission to perform this research study was granted by the MTSU Institutional Review Board, IRB# 13-134. The IRB approval letter may be seen in Appendix A. The participants of this study consisted of 21 undergraduate and graduate Middle Tennessee State University (MTSU) students enrolled in the Air Traffic Collegiate Training Initiative Program classes (AT-CTI) AERO 3630 Intro to Air Traffic Control or AERO 4650 Air Traffic Control: TRACON Operations, during the fall 2012 semester. Participants enrolled in these classes have been

exposed to the air traffic control radar atmosphere, phraseology, and procedures associated with preparing students for subsequent training at the FAA Air Traffic Training Academy in Oklahoma City, Oklahoma. Participants were, randomly split into two groups, experimental and control. All participants gave their informed consent prior to their participation in the study (See Appendix B). In order to be eligible to participate in the study subjects had to meet the following criteria, which was obtained by questionnaire: a) Be under the age of thirty one and currently enrolled in the MTSU AT-CTI program; b) Have not taken the FAA AT-SAT exam; c) Have a current FAA 2nd class medical certificate; e) Not be on medication or nutritional supplements; and f) Not consume energy drinks regularly (More than three times a week). Participants were excluded from the study if they: a) Were allergic or sensitive to any ingredients contained in energy drinks; b) Under the care of a physician and/or have taken any nutritional supplement containing the ingredients found in Red Bull energy drink (Caffeine, Taurine, Glucuronolactone, Niacin, B-Group Vitamins, Sucrose, and Glucose) (Red Bull, 2012); c) Presented any psychiatric or neurological disease; d) Presented any cardiac problems; e) Were currently participating in a pharmacological research study. Prior to the study participants were instructed to maintain their normal diet, but refrain from alcohol and recreational drug use for twenty-four hours prior to testing.

Instruments

This study utilized a multiple-choice test in the data collection process (See Appendix C). The impact of consumption of an energy drink on solving applied math problems was determined by comparing the achievement of the two groups as measured by an applied math test. The testing instrument was developed from an air traffic control practice test available online. At the time of this research study the Federal Aviation Administration did not publish

AT-SAT applied math test questions for the general public. The mathematical concepts and problem solving skills are universal among air traffic controller (Banyard, n.d.); as a result this test was generated from practice tests from other countries. The test measured participants' ability to answer time, distance, and speed problems based off basic addition, subtraction, multiplication, and division knowledge utilized by ATCS. This particular sub-test was chosen due to its static nature (showing no change) and ability to test distance, rate, and time under a fixed stationary condition (See Appendix E). Three graduate faculty members from Middle Tennessee State University and two ATCS subject matter experts reviewed the math test to establish validity and reliability.

A questionnaire survey was also developed to determine AT-CTI student's current usage patterns of energy drinks and perceptions regarding how energy drinks effected their performance as well as cognitive ability. The survey asked how often did AT-CTI students consume energy drinks on a monthly basis and what side effects were experienced after consumption. In addition to surveying have AT-CTI students consumed an energy drink on the same day as they were controlling air traffic in a simulated environment and did they believe consuming the energy drink effect their cognitive and performance abilities. These questions were surveyed to better understand how often energy drinks were consumed among AT-CTI students and the overall perception of how AT-CTI students perceived energy drinks to effect their performance during high cognitive task.

Procedures

At the start of the testing process participants received either 250 ml of Red Bull energy drink (Caffeine, Taurine, Glucuronolactone, B-Group Vitamins, Niacin, Sucrose, and Glucose) (Red Bull, 2012) or a placebo containing 250 ml of non-caffeinated Ginger Ale beverage

(Carbonated Water, High Fructose Corn Syrup, Citric Acid, Natural Flavors, Sodium Benzoate (Preservative), Caramel Color) (Canada Dry, 2013). The participants were assigned a random identification number and placed in the experimental group or control group. Subjects were unaware if they were in the experimental group or control group. After consuming the beverage the participants were placed in quiet room where they had thirty minutes to review a brief study guide of an AT-SAT conversion chart, applied math example formulas, and problems. Both groups covered the same subject matter and used the same test. After thirty minutes all participants were given a test consisting of twenty-seven questions. The test consisted of twenty multiple choice AT-SAT applied math problems, where participants were asked to solve for speed and time in addition to responding to seven questions regarding their perception of energy drinks. The maximum allocated time for the test was thirty minutes. Participants were not allowed to use any type of calculator, scratch paper or writing utensils. Participants were instructed to use only mental mathematical calculations during the test.

The participants were instructed to use the learned formulas given to them during the study session: TIME = DISTANCE/SPEED and SPEED=DISTANCE/TIME to solve the math problems. Participants were not allowed to use any type of study guide material during the test. Following participants' completion of the study, the tests were graded for data analysis.

Data Analysis

This study utilized primarily a quantitative method of data analysis, due to the collection and analysis of numerical data. Data was analyzed and stored using Microsoft Excel. A *t* test was used to determine if the difference between the tests scores (experimental group vs. control group) were statistically different; with the hypothesis being that there would be no difference in performance between the two groups. Additionally, AT-CTI student's perception of energy

drinks usage among air traffic control students was collected in this study. This survey data is reported using charts and graphs to analyze AT-CTI student's current usage patterns, along with the perception of how energy drinks effect performance.

CHAPTER III - RESULTS

To examine the effect that energy drink consumption had on AT-CTI student's ability to solve AT-SAT applied math type test problems, a t-test was used to compare scores of participants who consumed the Red Bull energy drinks (experimental group) and the Ginger Ale placebo (control group). Both groups covered the same subject matter and completed the same test. Charts and graphs were utilized to show the results of the experimental and control groups. Participants were also surveyed to establish the prevalence of energy drink usage among AT-CTI students.

The data generated from the entire math test was analyzed using t-tests for two samples assuming equal variances (N=21). This type of t-test was used to determine if the difference between the tests scores of the experimental group versus the control group were statistically different; with the difference expected to be by chance only. As shown in Table 1, the scores of the experimental group, which received the energy drink, averaged slightly lower (M=77.27, SD=19.79) than the control group, which consumed the placebo beverage (M=81.5, SD=19.01), but this was not statistically significant. Thus, there was not a significant effect on AT-CTI student ability to solve AT-SAT applied math type test problems when consuming the energy drink, $t(19) = .498$, $p < .05$. The AT-CTI students raw scores and means are shown in Table 2.

Table 1

Mean, Standard Deviations, and t-Test: Two-Sample Assuming Equal Variances for the Experimental and Control Groups.

Score	n	Experimental Group	Control Group	t
M	11	77.27	81.5	.498
SD	10	19.79	19.01	

Note. Maximum score for Applied Math Test = 100. p<. 05. Generated using Microsoft Excel.

Table 2.

AT-CTI Students Raw Score and Means on Applied Math Test.

Experimental Group	**Control Group**
40%	100%
65%	40%
95%	80%
100%	90%
85%	95%
75%	90%
45%	60%
85%	100%
85%	85%
80%	75%
95%	
Mean	**Mean**
77.27%	81.5%

Note: Maximum score for applied math test = 100. Generated using Microsoft Excel.

Further analysis was conducted to determine whether there was any significant difference between the experimental group and the control group on particular types of

applied math test questions. Distance, speed, time, rate of climb and descent, and a combination of speed, distance, and rate of descent questions were categorized among the experimental group and control group to analyze the performance in each area and establish if there was any significant difference on a particular kind of question. The questions in this subgroup were 2, 3, 4, 11, 12, 15, and 16. A t-test for two sample assuming equal variances was used to determine whether there was any statistical significance between the experimental group and the control group. There was not a significant effect on AT-CTI student's ability to answer applied math distance problems when consuming an energy drink $t(17) = .811$, $p < .05$. AT-CTI students that received the energy drink averaged slightly lower ($M = 80.18$, $SD = 22.51$) than the control group, which consumed the placebo beverage ($M = 86.8$, $SD = 14.327$), but this was not statistically significant. The AT-CTI students raw scores and means are shown in Table 3.

Table 3.

AT-CTI Students Raw Score and Means on Applied Math Test Distance Problems.

Experimental Group	**Control Group**
25%	100%
57%	57%
85%	85%
100%	85%
100%	100%
71%	100%
71%	85%
85%	100%
100%	85%
85%	71%
100%	
Mean	**Mean**
80.18%	86.8%

Note: Maximum score for applied math test distance problems = 100. Generated using Microsoft Excel

The same type of t-test was used to determine what effect the energy drink had on AT-CTI student's ability to answer applied math speed problems. The questions in this subgroup were 1, 6, 7, 9, and 18. These questions did not have a significant effect on AT-CTI students ability to answer applied math speed problems when consuming an energy drink $t(19) = .557$, $p < .05$. The scores of the experimental group, which received the energy drink, averaged lower ($M = 61.81$, $SD = 32.807$) than the control group, which consumed the placebo beverage ($M = 70$, $SD = 34.31$), but this was not statistically significant. The AT-CTI students raw scores and means are shown in Table 4.

Table 4

AT-CTI Students Raw Score and Means on Applied Math Test Speed Problems.

Experimental Group	**Control Group**
20%	100%
40%	20%
100%	80%
100%	80%
60%	100%
60%	80%
0%	0%
80%	100%
60%	60%
60%	80%
100%	
Mean	**Mean**
61.81%	70%

Note: Maximum score for applied math test speed problems = 100. Generated using Microsoft Excel.

For the applied math time problems, a t-test was used to determine the effect the energy drink had AT-CTI students ability to answer applied math time problems. The questions in this subgroup were 4 and 13. There was not a significant effect on AT-CTI students ability to answer applied math time problems when consuming an energy drink $t(18) = .605$, $p < .05$. The scores of the experimental group, which received the energy drink, averaged higher ($M = 90.9$, $SD = 20.225$) than the control group, which consumed the placebo beverage ($M = 85$, $SD = 24.152$), but this was not statistically significant. The AT-CTI student's raw scores and means are shown in Table 5.

Table 5

AT-CTI Students Raw Score and Means on Applied Math Test Time Problems.

Experimental Group	**Control Group**
50%	100%
100%	50%
100%	100%
100%	100%
100%	100%
100%	100%
100%	50%
100%	100%
50%	100%
100%	50%
100%	
Mean	**Mean**
90.9%	85%

Note: Maximum score for applied math test time problems = 100. Generated using Microsoft Excel

For the applied math rate of climb and descent problems, a t-test was used to determine the effect the energy drink had AT-CTI student's ability to answer the problems. The questions in this subgroup were 8, 10, 14, and 19. There was not a significant effect on AT-CTI student's ability to answer applied math rate of climb and descent problems when consuming an energy drink $t(19) = .131$, $p < .05$. The scores of the experimental group, which received the energy drink, averaged slightly higher ($M = 86.36$, $SD = 23.354$) than the control group, which consumed the placebo beverage ($M = 85$, $SD = 24.152$), but this was not statistically significant. The AT-CTI students raw scores and means are shown in Table 6.

Table 6

AT-CTI Students Raw Score and Means on Applied Math Test Rate of Climb and Descent problems.

Experimental Group	**Control Group**
75%	100%
100%	25%
100%	75%
100%	100%
100%	100%
75%	75%
25%	75%
100%	100%
100%	100%
100%	100%
75%	
Mean	**Mean**
86.36%	85%

Note: Maximum score on applied math test rate of climb and descent problems = 100. Generated using Microsoft Excel.

In the final measurement of the effects of energy drink on AT-CTI students ability, more complex questions that required a combination of speed, distance, time, and rate of climb and descent calculations. The questions in this group were 17 and 20. There was not a significant effect on AT-CTI students ability to answer the combination of problems when consuming an energy drink $t(19) = .906$, $p < .05$. The scores of the experimental group, which received the energy drink, averaged lower ($M = 68.18$, $SD = 33.709$) than the control group, which consumed the placebo beverage ($M = 80$, $SD = 25.819$), but this was not statistically significant. The AT-CTI students raw scores and means are shown in Table 7.

Table 7

AT-CTI Students Raw Score and Means on Applied Math Test Speed, Distance, and Rate of Descent Problems.

Experimental Group	**Control Group**
0%	100%
50%	50%
100%	50%
100%	100%
50%	50%
100%	100%
50%	100%
50%	100%
100%	100%
50%	50%
100%	
Mean	**Mean**
68.18%	80%

Note: Maximum score on the applied math test combination of speed, distance, time, and rate of climb and descent problems. Generated using Microsoft Excel.

The applied math problems gave participants two variables that required them to solve for the third variable of speed, distance, or time in addition to being asked to incorporate climb and descent rates. The answers could be determined by estimating and rearranging the equations: TIME = DISTANCE/SPEED, SPEED = DISTANCE/TIME, and DISTANCE = SPEED x TIME. These particular questions were selected in detail since they were the most frequently missed questions between the experimental group and control group. Question 6 asked participants to solve for speed expressed in miles. The question stated that the distance between New Orleans and Gulfport is 85 miles. If an aircraft took 17 minutes to fly this leg of the trip, students were asked to express this speed in miles per hour. As seen in Figure 1, more

participants who received the energy drink answered the question 6 estimation of speed problem incorrectly.

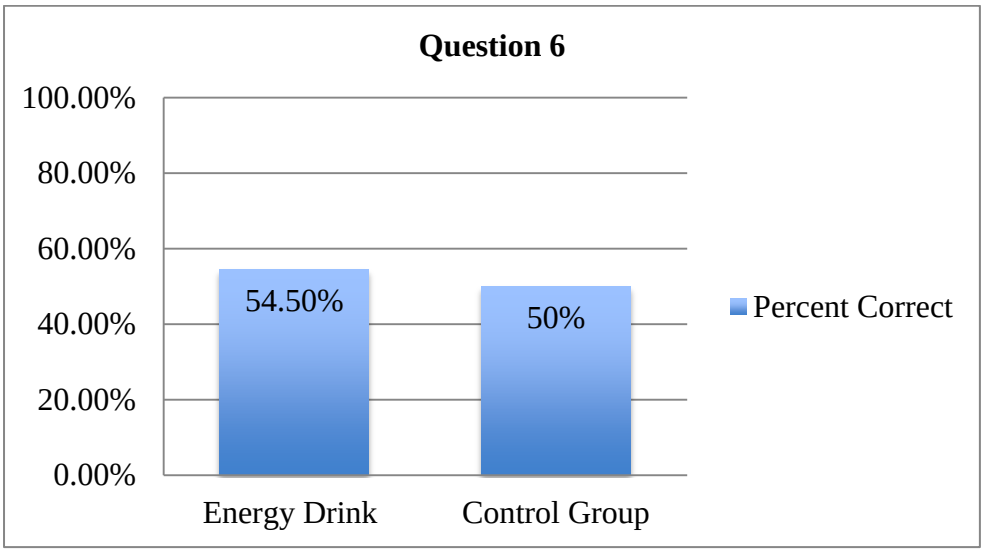

Figure 1: Percentage of AT-CTI Students Who Answered Question 6 Incorrectly. Generated using Microsoft Excel.

Question 13 asked participants to solve for time expressed in minutes. The question stated that an aircraft averaged 300 miles per hour. If the distance between Knoxville and Chattanooga were 90 miles the students were asked how long would it take to fly this leg of the trip? As seen in Figure 2, all the participants in the energy drink group answered correctly, while the entire control group missed this question.

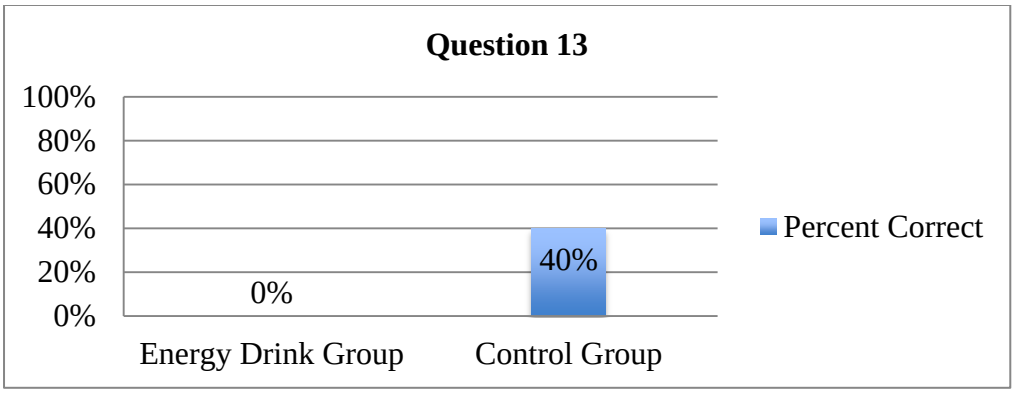

Figure 2: Percentage of AT-CTI Students Who Answered Question 13 Incorrectly. Generated using Microsoft Excel.

Question 17 asked participants to solve the distance expressed in miles by solving the descent rate of an aircraft. This was an example of a complex question where participants had to use multiple calculations to solve the descent rate of the aircraft in order to calculate the distance the aircraft had traveled. This question asked, if a plane was descending at 500 feet per minute from an altitude of 18,000 feet while traveling at 165 mph, how many miles would the plane have traveled as it descended to 14,500 feet? As can be seen in Figure 3, more participants in the energy drink group-missed question 17 as compared to the control group.

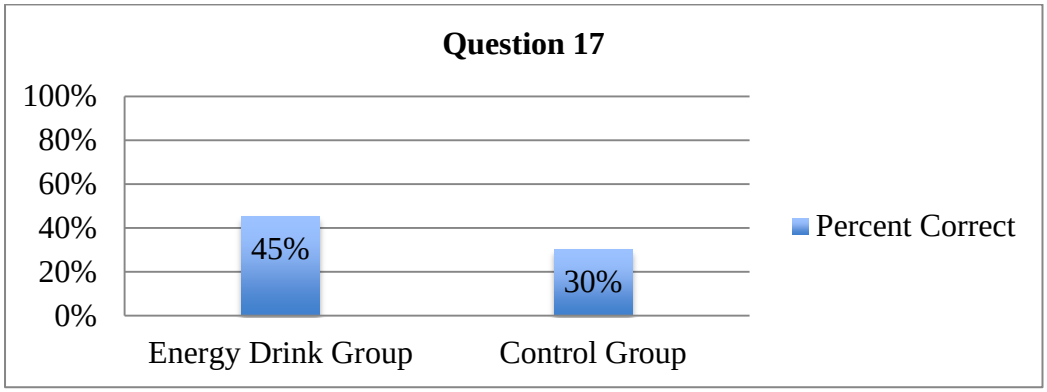

Figure 3: Percentage of AT-CTI Students Who Answered Question 17 Incorrectly. Generated using Microsoft Excel.

Question 18 asked participants to solve for speed expressed in miles per hour. The question stated, assume that an aircraft averaged 117 miles every 9 minutes. Given this, what was the speed expressed in miles per hour? As seen in Figure 4, more participants in the energy drink group answered incorrectly as compared to the control group.

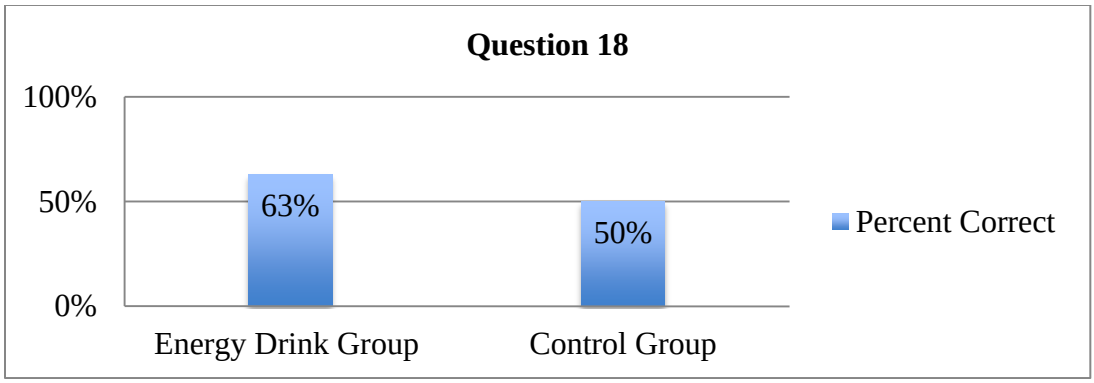

Figure 4: Percentage of AT-CTI Students Who Answered Question 18 Incorrectly. Generated using Microsoft Excel.

Survey Questionnaire

Question 21 surveyed how often AT-CTI students consume energy drinks on a monthly basis. The majority of AT-CTI's students reported consuming an energy drink, with 38% reporting consuming an energy drink 1-3 times, 24% reporting 4-6 times, 7% reporting greater than 7 times, and 29% reporting consuming energy drinks 0 times a month (see Figure 5).

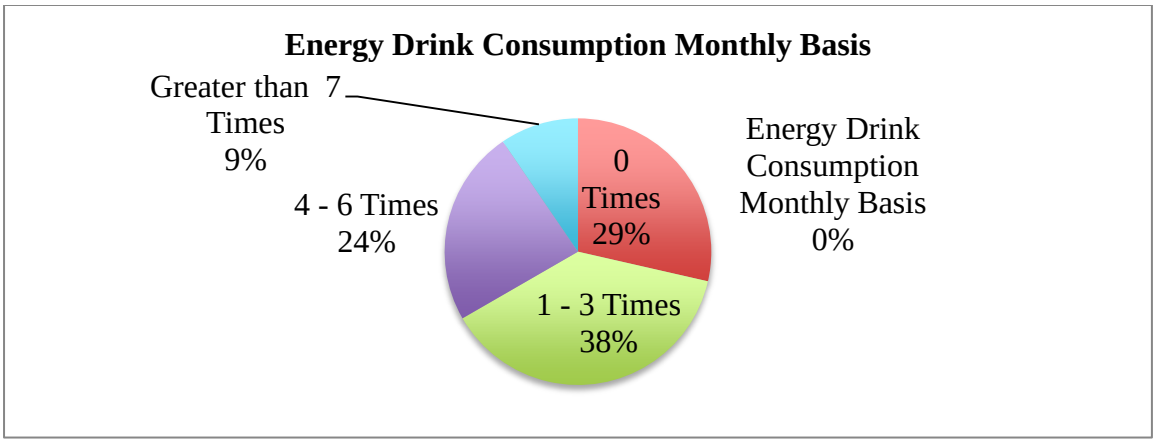

Figure 5: Percentage of AT-CTI Students Usage of Energy Drinks on a Monthly Basis. Generated using Microsoft Excel.

Question 22 and 23 asked whether AT-CTI students had any side effects after consuming an energy drink and if so, how these side effects would be classified. Interestingly, 24% of AT-CTI students reported experiencing side effects. Of those who reported side effects, four participants classified these side effects as moderate and two participants as very mild (see Figure 6).

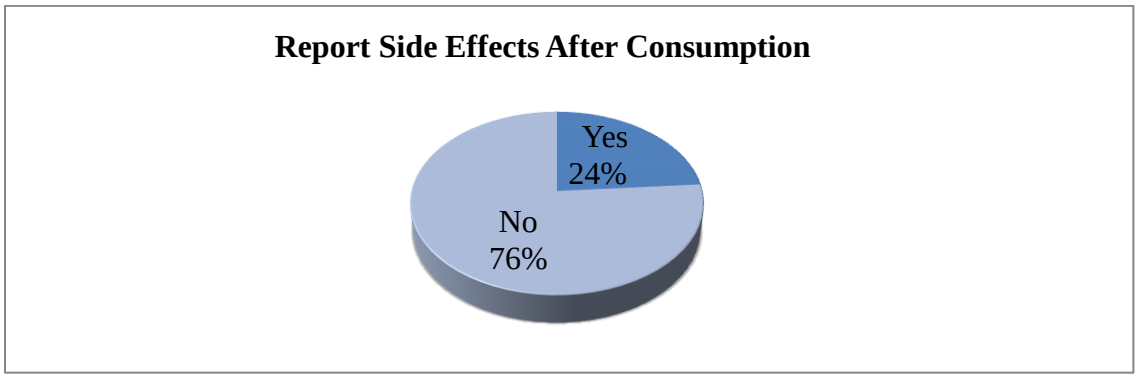

Figure 6: Percentage of AT-CTI Students Report of Side Effects after Consuming Energy Drinks. Generated using Microsoft Excel.

Question 24 and 25 surveyed whether AT-CTI students have ever consumed an energy drink on the same day as controlling air traffic in a simulated environment. If they had, they were asked what effect consuming the energy drink had on their performance. Of the participants, 24% of the students reported consuming an energy drink the same day as they were controlling air traffic in a simulated environment. Of the AT-CTI students who answered yes to consuming energy drinks the same day as they controlled air traffic in a simulated environment, 75% reported they felt that to some degree the energy drink affected their performance (see Figure 7).

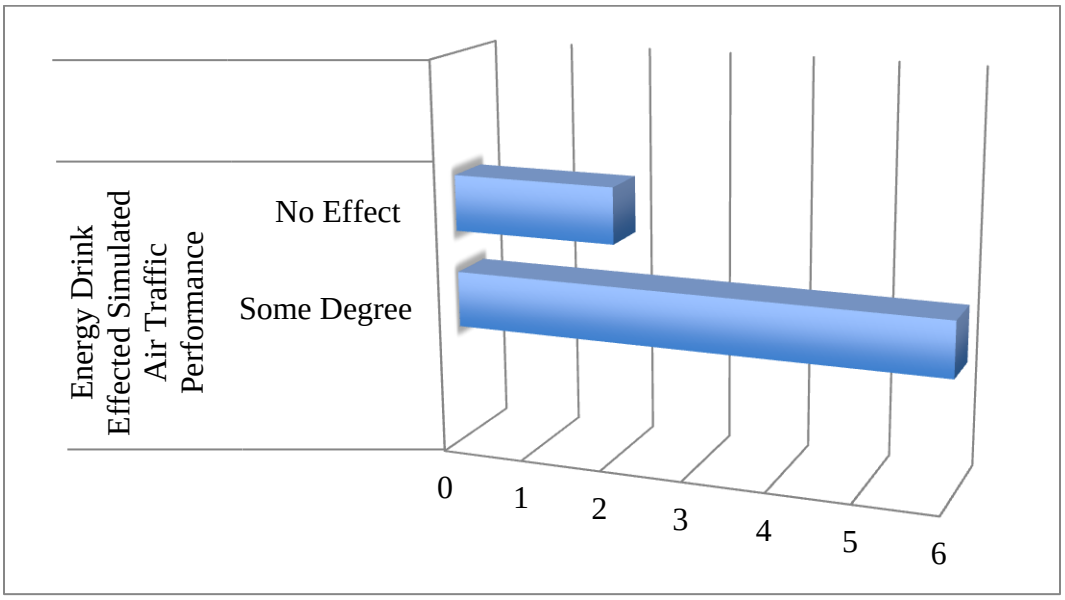

Figure 7: The Number of AT-CTI Students Who Reported That Consuming an Energy Drink the Same Day they Controlled Air Traffic in a Simulated Environment Affected Their Performance.

Question 26 surveyed whether AT-CTI students feel consuming energy drinks effects their cognitive and performance abilities. Remarkably, 67% of AT-CTI students reported that energy drinks affected their cognitive and performance abilities to some degree (see Figure 8).

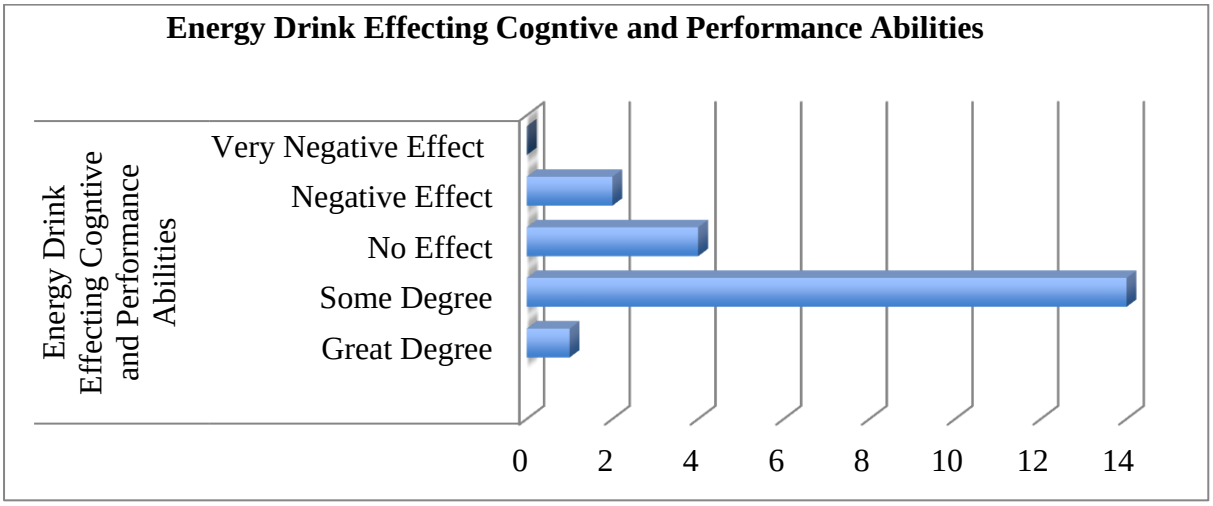

Figure 8: AT-CTI Students Who Believe Consuming an Energy Drink Would Effect Their Cognitive and Performance Abilities.

CHAPTER IV - DISCUSSION

The stress associated with a multi faceted lifestyle of managing a demanding schedule creates a high amount of stress and fatigue in college students. To combat the problems of fatigue, college students frequently rely on energy drinks to obtain the needed boost of energy. The consumption of energy drinks such as Red Bull on college campuses has most likely been a result of advertising tactics. Red Bull energy drink through a direct marketing approach, advertises its product as a functional beverage providing various benefits, especially in times of desired increased performance: It is advertised to help improve concentration, help to increase alertness, contribute to mental performance, and contribute to the reduction of tiredness and fatigue (Red Bull GmBH, 2012). Claims such as these have resulted in energy drink usage among 18-25 years olds reported as being the highest consumption population.

This study sought to give a better understanding of the effects of energy drinks on cognitive ability. Specifically, the score of Middle Tennessee State University AT-CTI students who have consumed energy drink score on AT-SAT applied math aptitude test problems is affected as compared to those that do not consume energy drinks was studied. The results indicated the mean score of the group receiving the energy drink test score was slightly lower than the mean score of those who consumed the placebo beverage, but the data was not statistically significant at the .05 significance level. Therefore, was not a significant effect on AT-CTI student ability to solve AT-SAT applied math type test problems after consuming an energy drink. As stated in Chapter III, the experimental group who received the energy drink had a mean score of 77.27, while the control group who received the placebo beverage had a mean score of 81.5.

The second question in the study sought to determine AT-CTI students' current usage patterns of energy drinks. The majority of students reported consuming an energy drink. Of those who reported energy drink consumption on a monthly basis, 38% reported consuming an energy drink 1-3 times, 24% reported 4-6 times, while 29% reported consumed no energy drinks. Subsequent survey questions asked whether AT-CTI students had any side effects after consuming an energy drink and if so, how these side effects would be classified. Of the AT-CTI students surveyed reported 24% experiencing side effects; of those who reported side effects four participants classified these side effects as moderate and two participants as very mild.

AT-CTI students were asked have they ever consumed an energy drink on the same day as controlling air traffic in a simulated environment and if so, what effect consuming the energy drink had on their performance. Of the AT-CTI students surveyed 24% reported consuming an energy drink the same day as they were controlling air traffic in a simulated environment. As an interesting fact, of the AT-CTI students who answered yes to consuming energy drinks the same day as they controlled air traffic in a simulated environment 75% reported they felt that to some degree the energy drink effected their performance.

Finally the last survey question was developed to determine the response of AT-CTI student's perceptions on how energy drinks effect their cognitive and performance abilities. Of the AT-CTI students surveyed 67% reported that energy drinks effected their cognitive and performance abilities to some degree. While the research data showed a lack of statistical significance the information will help give collegiate aviation programs a better understanding of AT-CTI's students' energy drink consumption patterns, and perception into students' ability to evaluate the risk regarding energy drink consumption. Due to the excessive usage of energy drink consumption among AT-CTI students, as well as the reported effects on performance and

cognitive abilities, future research should be done to develop a better understanding on the effects of energy drinks on cognitive ability. Future research may want to take into account the limitations of this study to develop a better understanding of how energy drinks effect AT-CTI student's cognitive ability.

The limitations to this study include: 1) the number of participants in the data collection process was small and limited to only Middle Tennessee State University AT-CTI students; if the study was conducted with a larger population at more universities with AT-CTI programs the findings may differ, (2) The test was limited to only one subset of the AT-SAT test (Applied Math); testing on different subsets of the AT-SAT such as Dials, Scan, Angles, Letter Factory, Air Traffic Scenarios, and Analogies may yield different results, 3) Participants may have had access to online AT-SAT study guide materials prior to the test, 4) The study was conducted in the afternoon following student classes, consequently results may differ if conducted in morning or nighttime conditions, 5) The FAA does not publish previous AT-SAT tests, therefore the validity and reliability of the this study is dependent on online study guide materials from other counties as well as ATCS subject matter experts, 5) The participants not being 100% trustworthy when answering test and survey question.

Future studies may also want to research the reaction time to answer each problem to determine whether energy drinks effect decision-making ability. Utilizing different types of air traffic control aptitude math problems besides basic estimating, such as rate of closure between head-on and overtaking aircraft, may prove beneficial. Furthermore, researching the effects of different types of energy drinks that contain key ingredients other than Red Bull may prove beneficial to future research. Finally, the perception of AT-CTI program directors should be

researched to asses their views on the effects of energy drinks of AT-CTI students' cognitive ability.

Regardless of the perceptions of energy drink usage among AT-CTI students, there still remains a high amount of risk associated with consuming energy drinks among the collegiate student population. While most AT-CTI students reported consuming energy drinks to increase energy and thwart sleep deprivation from excessive studying, careful consideration must give before relying on beverages to sustain high levels of performance and cognitive ability. Regardless of students' perception, it is likely that no amount of energy drink consumption will supplant a good night's rest.

As thousands of ATCS operating in the NAS begin to reach the mandatory retirement age of 56, AT-CTI students will begin to replace the aging workforce. The habits learned in the collegiate setting may be applied to ATC industry. If the perception and consumption of energy drinks among AT-CTI students are not addressed it may effect safety of the National Airspace System as well as result in the loss of lives.

References

Banyard, T. (n.d.). A.T.C. Aptitude Exams Made Simple. *Wilban Books.*

Bernstein, G. A., Carroll, M. E., Thuras, P. D., Cosgrove, K. P., & Roth, M. E. (2002). Caffeine dependence in teenagers. *Drug and Alcohol Dependency, 66*(1), 1-6.

Bureau of Labor Statistics, U.S. Department of Labor. (2012). *Occupational Outlook Handbook, 2012-13 Edition,* Air Traffic Controllers. Retrieved from http://www.bls.gov/ooh/transportation-and-material-moving/air-traffic-controllers.htm#tab-1

Cabon, P., & Holmes, A. (2011). European Organization for Safety of Air Navigation.*Hind Sight 13 Summer 2011*. Retrieved from http://www.icao.int/safety/fatiguemanagement/ArticlesPublications/Hindsight13_Summer2011.pdf

Canada Dry. (2013). Retrieved from http://www.canadadry.com/?gclid=CNyjn5zMjrUCFQq0nQodc3YAQw#/products/gingerAle

Caravajal-Sancho, A., & Moncado-Jimenez, J. (2005). The acute effect of an energy drink on the physical and cognitive performance of male athletes. *Kinesiol Slovenica,* 11:5-16

Deixelberger-Fritz, D. D., Tischler, M. A., & Kallus, K. (2003). Changes in Performance, Mood State and Workload Due to Energy Drinks in Pilots. *International Journal Of Applied Aviation Studies,* 3(2), 195-205.

Depperschmidt, C.L., Bliss, T.J., & Woolsey, C.L. (2010). The effects of energy drink consumption on collegiate flight students' pilot skills in a simulated flight environment. *Collegiate Aviation Review*, 28(2), 1-15.

Depperschmidt, C.L., Bliss, T.J. (2010). Energy Drink Consumption and its Effects on Student Pilots: Perceptions of Collegiate Flight Students. *Collegiate Aviation Review*, 29 (2), 1-11.

Federal Aviation Administration. (2009). Air Traffic Control: Potential Fatigue Factors. Report Number AV-2009-065. Retrieved from http://www.oig.dot.gov/sites/dot/files/pdfdocs/WEB_FILE2_Controller_Fatigue_AV2009065.pdf

Federal Aviation Administration. (2012). Air Traffic Organization Fatigue Risk Management. Retrieved from http://www.faa.gov/documentLibrary/media/Order/1030.7A%20Fatique%20Risk%20Management.pdf

Garner, M. (2011). Air Traffic Control Scheduling Changes Coming. Atlanta Journal Constitution. Retrieved from http://www.ajc.com/news/news/local/air-traffic-controller-scheduling-changes-coming/nQsgT/

Gay, L., Mills, G., Airasian, P. (2009). Educational research: competencies for analysis and applications. 9th edition.

Gendle, M., Smucker, D., Stafstrom, J., Helterbran, M., Glazer, K. (2009). Attention and Reaction Time in University Students Following the Consumption of Red Bull. *The Open Nutrition Journal*, 3: 8-10.

Kennedy, D. O., & Scholey, A. B. (2004). A glucose-caffeine 'energy drink' ameliorates subjective and performance deficits during prolonged cognitive demand. *Appetite, 42*(3), 331-333. doi:10.1016/j.appet.2004.03.001

Kennedy, D., & Scholey, A. (2004). Cognitive and physiological effects of an "energy drink": an evaluation of the whole drink and of glucose, caffeine, and herbal flavoring fractions. *Psychopharmacology,* 176(3-4), 320-330.

King, R., Manning, C., & Drechsler, G. (2007). Operational Use of the Air Traffic Selection and Training Battery. *(DOT/FAA/AM-07/14). Washington, D.C.: FAA Office of Aviation Medicine.*

Malinauskas, B., Aeby, V., Overton, R., Carpenter-Aeby, T., & Barber-Heidal, K. (2007). A survey of energy drink consumption patterns among college students. *Nutrition Journal,* 6:35.

Moore, J. (2013). Aircraft Owners and Pilots Association. NTSB Release "Most Wanted" List for 2013. Retrieved http://www.aopa.org/training/articles/2012/121114ntsb-releases-most-wanted-list-for-2013.html

Oteri, A., Salvo, F., Caputi, A., & Calapai, G. (2007). Intake of energy drinks in association with alcoholic beverages in cohort of students of the school of medicine of the University of Messina. *Alcoholism: Clinical and Experimental Research,* 31 (10), 1677-1681. Retrieved from http://onlinelibrary.wiley.com/doi/10.1111/j.1530-0277.2007.00464.x/pdf

Seidl, R., Peyrl, A., Nicham, R., & Hauser, E. (2000). A taurine and caffeine-containing drink stimulates cognitive performance and well-being. *Amino Acids*, 19, 635-642

Substance Abuse and Mental Health Services Administration, Center for Behavioral Health Statistics and Quality. (2011). *The DAWN Report: Emergency Department Visits*

Involving Energy Drinks. Rockville, MD. Retrieved from http://www.samhsa.gov/data/2k11/WEB_DAWN_089/WEB_DAWN_089.htm

Ramos, R., Heil, M., Manning, C. (2001). Documentation of Validity for the AT-SAT Computerized Test Battery, Volume I. *(DOT/FAA/AM-01/05). Washington, DC: FAA Office of Aviation Medicine.* Retrieved from http://www.hf.faa.gov/docs/CAMI/0106.pdf

Red Bull, (2012). Retrieved from http://www.redbull.com/cs/Satellite/en_INT/Red-Bull-Energy-Drink/001242937921959?pcs_c=PCS_Product&pcs_cid=1242937842064&pcs_pvt=ingredient

Red Bull GmbH. (2012). Retrieved from http://energydrink.redbull.com/red-bull-energy-drink#whentodrink

Red Bull GmbH – Company History. (2012). Retrieved from http://www.fundinguniverse.com/company-histories/red-bull-gmbh-history/

Roske-Hofstrand, R. (1995). Raising awareness for fatigue among air traffic controllers. In Proceedings of the Eighth International Symposium on Aviation Psychology, 2, 985-991, Ohio State University, Columbus, OH, April 24-27, 1995.

APPENDIXES

Appendix A
Informed Consent/IRB Approval Letter

Middle Tennessee State University Institutional Review Board
Informed Consent Document for Research

MTSU
IRB Approved
Date: 11/28/2012

Principal Investigator: Marlon Lucas
Study Title: The Effects of Energy Drinks on Cognitive Ability
Institution: Middle Tennessee State University

Name of participant: _____ Age: _____

The following information is provided to inform you about the research project and your participation in it. Please read this form carefully and feel free to ask any questions you may have about this study and the information given below. You will be given an opportunity to ask questions, and your questions will be answered. Also, you will be given a copy of this consent form.

Your participation in this research study is voluntary. You are also free to withdraw from this study at any time. In the event new information becomes available that may affect the risks or benefits associated with this research study or your willingness to participate in it, you will be notified so that you can make an informed decision whether or not to continue your participation in this study.

For additional information about giving consent or your rights as a participant in this study, please feel free to contact the MTSU Office of Compliance at (615) 494-8918.

1. **Purpose of the study:**
   You are being asked to participate in a research study because you are a Middle Tennessee State University student currently enrolled in the Air Traffic - Collegiate Training Initiative courses AERO 3630 Intro to Air Traffic Control or AERO 4650 Air Traffic Control Training Ops. This study will examine what impact the consumption of an energy drink has on Air Traffic Control Collegiate Training Initiative (AT-CTI) students' ability to solve AT-SAT Applied Math type test problems. This study will also examine the perception of energy drink usage among air traffic control students.

   Description of procedures to be followed and approximate duration of the study:
   Participants will be randomly assigned to two groups. One group will receive an energy drink while the other group recieves the placebo. After consuming the beverage participants will be placed in quiet room where they will have thirty minutes to review a brief study guide of AT-SAT conversion chart, applied math example formulas, and problems. After thirty minutes participants will be given a test consisting of twenty-seven questions. The test will consist of twenty multiple choice ATC applied math problems where participants will solve for speed, distance, and time plus seven questions regarding their perception of energy drinks. The maximum allocated time for the test is thirty minutes. Participants will not be allowed to use any type of calculator, scratch paper or writing utensils. Participants must use only mental mathematical calculations during the test. The test will measure participant's ability to answer time, distance, and speed problems based off basic addition, subtraction, multiplication, and division knowledge. The entire study will last 60 minutes

2. **Expected costs:**
   None

3. **Description of the discomforts, inconveniences, and/or risks that can be reasonably expected as a result of participation in this study:**
   None are expected. However, if an individual is sensitive to the ingredients, a negative effect may be experienced.

4. **Unforeseeable risks:**
   Because energy drinks are not FDA approved, there may be unknown or unforeseeable risks associated with participation.

5. **Compensation in case of study-related injury:**
   MTSU will not provide compensation in the case of study related injury.

6. **Anticipated benefits from this study:**
   The potential benefits to science and humankind that may result from this study is determining what impact the consumption of an energy drinks has on Air Traffic Control Collegiate Training Initiative students' ability to solve AT-SAT Applied Math type test problems. This study may also benefit science and humankind by examining the perception of energy drink usage among air traffic control students.

7. **Alternative treatments available:**
   None

8. **Compensation for participation:**
   None

9. **Circumstances under which the Principal Investigator may withdraw you from study participation:**

   Participants will be withdrawn from the study if: a) they are allergic or sensitive to any ingredients contained in energy drinks; b) under the care of a physician and/or or allergic to any nutritional supplement containing the ingredients found in energy drinks (Caffeine, Taurine, Glucuronolactone, Niacin, B-Group Vitamins, Sucrose, and Glucose); c) Present any psychiatric or neurological disease; d) Present any cardiac problems; e) Are currently participating in a pharmacological research study; f) Over 31 years of age; g) Have taken the FAA AT-SAT exam; h) Do not have a FAA Class 2 Medical Certificate.

10. **What happens if you choose to withdraw from study participation:**
    Participants will not be penalized if they choose not to participate in the study.

11. **Contact Information.** If you should have any questions about this research study or possibly injury, please feel free to contact **Marlon Lucas** at **(504) 235-2703** or my Faculty Advisor**, Dr. Wendy Beckman** at **(615)494-8755**

12. **Confidentiality.** All efforts, within reason, will be made to keep the personal information in your research record private but total privacy cannot be promised. Your information may be shared with MTSU or the government, such as the Middle Tennessee State University Institutional Review Board, Federal Government Office for Human Research Protections, if you or someone else is in danger or if we are required to do so by law.

13. **STATEMENT BY PERSON AGREEING TO PARTICIPATE IN THIS STUDY**
    I have read this informed consent document and the material contained in it has been explained to me verbally. I understand each part of the document, all my questions have been answered, and I freely and voluntarily choose to participate in this study.

I have read this informed consent document for this study and understand my rights as a research participant. Further, I understand that information I provide is only intended for research purposes and is not intended to establish a patient/psychologist relationship between me and the researchers/university or to be used for diagnostic purposes. A list of referral counseling services was provided to me. Should I become distressed at any time while participating in this study and feel the need that I need psychiatric/medical or other emotional assistance, I will contact one of the referral counseling services.

Date _____ Signature of patient/volunteer _____

Consent obtained by:

Date _____ Signature _____

Printed Name and Title _____

November 28, 2012

Marlon Lucas
Aerospace
Lucasmarlon1@gmail.com
Protocol Title: "The Effects of Energy Drinks on Cognitive Ability"
Protocol Number: **13-134**

Dear Investigator(s),

The MTSU Institutional Review Board, or a representative of the IRB, has reviewed the research proposal identified above. The MTSU IRB or its representative has determined that the study poses minimal risk to participants and qualifies for an expedited review under 45 CFR 46.110 Category 7.

Approval is granted for one (1) year from the date of this letter for 30 participants.

According to MTSU Policy, a researcher is defined as anyone who works with data or has contact with participants. Anyone meeting this definition needs to be listed on the protocol and needs to provide a certificate of training to the Office of Compliance. **If you add researchers to an approved project, please forward an updated list of researchers and their certificates of training to the Office of Compliance (Box 134) before they begin to work on the project.** Any change to the protocol must be submitted to the IRB before implementing this change.

Please note that any unanticipated harms to participants or adverse events must be reported to the Office of Compliance at (615) 494-8918.

You will need to submit an end-of-project form to the Office of Compliance upon completion of your research located on the IRB website. Complete research means that you have finished collecting and analyzing data. **Should you not finish your research within the one (1) year period, you must submit a Progress Report and request a continuation prior to the expiration date.** Please allow time for review and requested revisions. Your study expires **November 27, 2013**.

Also, all research materials must be retained by the PI or faculty advisor (if the PI is a student) for at least three (3) years after study completion. Should you have any questions or need additional information, please do not hesitate to contact me.

Sincerely,

Cyrille Magne
IRB representative
Middle Tennessee State University

Appendix B

Mathematical Conversion Chart

60 miles per hour	=	1 miles per minute
120 miles per hour	=	2 miles per minute
180 miles per hour	=	3 miles per minute
240 miles per hour	=	4 miles per minute
300 miles per hour	=	5 miles per minute
360 miles per hour	=	6 miles per minute
420 miles per hour	=	7 miles per minute
480 miles per hour	=	8 miles per minute
540 miles per hour	=	9 miles per minute
600 miles per hour	=	10 miles per minute
660 miles per hour	=	11 miles per minute
720 miles per hour	=	12 miles per minute
780 miles per hour	=	13 miles per minute
840 miles per hour	=	14 miles per minute
900 miles per hour	=	15 miles per minute

*Mph= miles per hour *Mpm=miles per minute

Formulas Needed

Speed = Distance/Time

Time = Distance/Speed

Appendix C

Sample Problems

1) The distance between Birmingham and Atlanta is 228 miles. If DAL 1989 maintains an average speed of 240 mph, how long will it take to fly from Birmingham to Atlanta?

   Rule #1: Convert speeds from mph to mpm before attempting a calculation!

   240 mph / 60 = 24 / 6 = 4 mpm

   Once this is completed, compute the numbers into the formula;

   TIME = Distance / Speed = 228 miles / 4 mpm = 57 minutes

2) AAL averages 180 mph and takes 39 minutes to fly from Nashville to Memphis. How far apart these two cities?

   Rule #1: Convert speeds from mph to mpm before attempting a calculation!

   180 mph / 60 = 18 / 6 = 3 mpm

   Next, rearrange the basic formula to isolate for distance;

   DISTANCE = Time x Speed = 39 minutes x 3 mpm = 117 minutes

3) The distance between Dallas and New Orleans is 840 miles. If SWA 3245 maintains an average speed of 420 mph, how long will it take to from Dallas to New Orleans?

   Rule #1: Convert speeds from mph to mpm before attempting a calculation!

   420 mph / 60 = 42 / 6 =7 mpm

   Once this has been completed, plug in numbers into basic formula.

   TIME = Distance / Speed = 840 miles / 7 mpm = 120 minutes

4) ASA 7007 covers 160 miles every 32 minutes. What is ASA 7007 speed expressed in mpm, and in mph?

   Rule # 1: To solve this problem first reduce ASA 7007 speed to mpm.

   mpm = 160 miles / 32 minutes = 5 mpm

   To answer part two we must convert mpm to mph:

   5 mpm x 60 = 300 mph

Appendix D

Applied Math Test

The Applied Math test consists of 20 multiple-choice questions and 7 survey questions. For each question you must make calculations based on distance, speed, and time to identify the correct answer. NO CALULATOR OR SCRATCH PAPER IS ALLOWED.

1. Assume that AAL 5460 average 88 miles every 11 minutes. What is his AAL 5460 speed expressed in mph?
   A) 360 mph B) 540 mph C) 480 mph D) 440 mph

2. An SWA 6922 flies for 44 minutes at an average speed of 720 mph. How many miles has SWA 6922 flown?
   A) 615 miles B) 528 miles C) 516 miles D) 540 miles

3. N654MT flies for 16 minutes at an average speed of 180mph. How many miles has N654MT flown?

   A) 48 miles B) 11 miles C) 42 miles D) 36 miles

4. ACA 881 averages 420 mph. If the distance between Memphis and Nashville is 210 miles, how long will it take to fly this leg of the trip?
   A) 28 minutes B) 42 minutes C) 30 minutes D) 50 minutes

5. N45XK flies 12 minutes at an average speed of 540 mph. How many miles has N45XK flown?
   A) 108 miles B) 172 miles C) 98 miles D) 118 miles

6. The distance between New Orleans to Gulfport is 85 miles. If DAL 1885 took 17 minutes to fly this leg of the trip, what is DAL 1885 speed expressed in miles?
   A) 333 mph B) 296 mph C) 420 mph D) 300 mph

7. UAL 2320 took 9 hours to fly from Miami to Kansas the equivalent of 1800 miles; what is the average speed in MPH?
   A) 220 mph B) 360 mph C) 480 mph D) 200 mph

8. A turboprop aircraft at 4,300 feet is climbing at 700 feet per minute after 11 minutes; what is the altitude?
   A) 11,300 feet B) 12,000 feet C) 12,400 feet D) 13,000 feet

9. ASA 5698 has flown 150 miles in 90 minutes. What is the aircraft's ground speed?
   A. 210 mph B) 175 mph C) 100 mph D) 350 mph

10. A jet at 16,000 feet is descending at 500 feet per minute after 9 minutes; what is the altitude?
A) 14,000 feet B) 20,500 feet C) 10,500 feet D) 11,500 feet

11. How many miles will AAL 777 cover if it flies for 5 hours at 230 mph?
A) 1,150 miles B) 1,160 miles C) 1,175 miles D) 1,125

12. SWA 2564 flies from Las Vegas to Las Angeles in 23 minutes averaging as speed of 480 mph. How many miles has SWA 2564 flown?
A) 156 miles B) 184 miles C) 161 miles D) 196 miles

13. N45KK averages 300 mph. If the distance between Knoxville and Chattanooga is 90 miles how long will it take to fly this leg of the trip?
A) 21 minutes B) 19 minutes C) 16 minutes D) 18 minutes

14. If DAL 349 is at 10,000 feet climbing at 900 feet per minute after 7 minutes; what is the altitude?
A) 15,400 feet B) 18,100 feet C) 16,300 feet D) 16, 600 feet

15. If N634PK flies for 50 minutes at an average speed of 480 mph. How many miles has N634PK flown?
A) 400 miles B) 360 miles C) 420 miles D) 410 miles

16. How far will a plane travel in 75 minutes if its speed is 400mph?
A) 150 miles B) 575 miles C) 450 miles D) 500 miles

17. If a plane was descending at 500 feet per minute from an altitude of 18,000 feet traveling at 165 mph, how many miles would the plane have traveled as it descended to 14,500 feet?
A) 25 miles B) 19 miles C) 11 miles D) 28 miles

18. Assume that ASH 5060 averages 117 miles every 9 minutes. What is his ASH 5060 speed expressed in mph?
A) 780 mph B) 560 mph C) 720 mph D) 810 mph

19. N863YT just left 12,000 feet descending to 8,000 feet in 5 minutes; what is the descent rate per minute?
A) 750 feet B) 500 feet C) 850 feet D) 800 feet

20. If DAL 5682 (120 mph) left Nashville airport at the same time COA 890 (180mph) going on opposite directions, how many miles apart would they be in 9 minutes?
A) 30 miles B) 22 miles C) 45 miles D) 9 miles

21. How often do you consume energy drinks on a monthly basis?
A) 0 times a month B) 1-3 times a month C) 4-6 times a month D) more than 7 times a month

22. Have you ever experienced any side effects after consuming an energy drink?
A) Yes B) No

23. If yes, how would you classify these?
A) Very Mild B) Mild C) Moderate D) Severe E) Very Severe

24. Have you ever consumed an energy drink on the same day as you were controlling air traffic in a simulated environment?
A) Yes B) No

25. If yes, do you feel consuming the energy drink affected your performance?

5	4	3	2	1
To a great degree	Some degree	No effect	Negative Effect	Very Negative effect

26. Do you believe consuming an energy drink will affect your cognitive and performance abilities?

5	4	3	2	1
To a great degree	Some degree	No effect	Negative Effect	Very Negative effect

27. If you have consumed an energy drink in the last year, please list the reason(s) for doing so?