

# Attention and Reaction Time in University Students Following the Consumption of Red Bull®

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**Abstract:** In this double-blind study, the effects of consuming a single can (250 ml) of Red Bull®, Sugar Free Red Bull®, or a flavor/appearance-matched placebo on attention and reaction time were measured using a computerized continuous performance task, administered 30 minutes after drink ingestion. No significant differences in continuous performance task performance were related to ingestion of any of the drinks. Effects of Red Bull® or Sugar Free Red Bull® on continuous performance task performance are, therefore, negligible, and are no greater than potential psychomotor enhancements resulting from placebo expectancies.

**Keywords:** Energy drink, continuous performance task, attention, reaction time.

## INTRODUCTION

In the past ten years, energy drink consumption has steadily increased amongst university students, who ingest beverages like Red Bull® (RB) in an attempt to enhance mental performance [1]. Energy drinks like RB (which are usually carbonated and contain significant quantities of sugar and caffeine as well as blends of herbal extracts, B vitamins, and amino acids) are popular with university students because their consumption is typically assumed to provide increased energy and noticeable improvements in cognition [1]. RB contains several potentially psychoactive ingredients including taurine, glucuronolactone, and caffeine; and cans of RB state that the beverage “increases concentration and reaction speed”. Due to the popularity of RB, several investigations have assessed the claims of cognitive performance enhancement resulting from its use. Oral ingestion of RB or some or all of its principle ingredients has been shown to shorten reaction time, facilitate attention, and enhance some forms of memory [2-11]. However, these studies have often been conducted in clinical settings following an overnight fast and/or period of caffeine abstinence. Few investigations have examined the effects of RB in contexts that are relevant to “real world” consumption, using appropriate control drinks, in settings that are free of overnight fasting and caffeine withdrawal. This may be of particular importance, as some researchers have suggested that caffeine’s positive effects on cognition may be attributed to the reversal of withdrawal [10, 12; but see 11, 13]. Students in the United States typically consume one can/serving (250 ml) of RB per sitting, in order to counteract drowsiness and increase energy [1]. Consumption of energy drinks on university campuses is likely to occur at the end of a busy weekday while the individual is in a partially fasted state. In the study described herein, the effects of RB on sustained attention and reaction

time in university students were examined in a “real world” context that mimicked the conditions described above.

## MATERIALS AND METHODOLOGY

All participants gave their informed consent prior to their inclusion in this study. All experimental procedures were approved by the Elon University Institutional Review Board and were performed in accordance with the 1964 Declaration of Helsinki. Thirty-six university student volunteers participated in the study (18 males/18 females, median age 20 years, age range 18-22 years). The participants primarily self-identified as White/Caucasian (86.1%), all were familiar with computers and considered English their primary language, and six were current users of tobacco products. The majority of participants (72.2%) stated that they consumed 1-2 caffeinated beverages per day, and only two indicated that they were not familiar with commercially available energy drinks.

Participants were not told the investigation’s precise objectives, only that the study would be examining the effects of some of the ingredients of “common carbonated beverages” on psychological function. Once enrolled, two testing sessions (each taking place on a weekday between 16:00 and 18:00) were scheduled for each participant, with the second session taking place 24 - 240 h after the first. As undergraduate university students, our participants typically had hectic daily schedules. The wide range of time elapsing between the two testing sessions was required in order to schedule a second testing session that was convenient for each participant. Because it is unlikely that either individual biological responses to RB or performance on the cognitive measures we utilized would change significantly over a period of 10 days or less, this variability in time between the two testing sessions should not have impacted the data in any meaningful way. Prior to each session, participants were instructed to eat, drink, and consume caffeinated products as normal through mid-day, but ingest nothing but plain water for 4 hours prior to the session. Participants were also instructed to abstain from alcohol (for 24 hours) and recrea-

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tional drug use (for 48 hours) prior to testing. Two female participants were excluded from the study for failing to follow study instructions.

At each of the testing sessions, participants were weighed using a digital scale (Taylor Precision Products, Las Cruces NM, USA), and randomly received either 250 ml of Red Bull® (RB; Red Bull N.A., Santa Monica CA, USA), Sugar Free Red Bull® (SFRB; Red Bull N.A., Santa Monica CA, USA), or a caffeine and calorie-free placebo beverage (PBO), with the stipulation that all participants consumed the PBO beverage at least once. Individual participants were assigned an ID number based on the temporal order of their enrollment in the study. Assignment of participants to individual experimental and control groups was completed using a randomized matrix of participant ID and group numbers that was constructed before data collection was initiated. Each 250 ml can of RB contains 110 calories, and includes 1000 mg of taurine, 600 mg of glucuronolactone, 80 mg of caffeine, 18 mg of niacin, 6 mg of pantothenic acid, 2 mg of vitamin B6, 1.65 mg of riboflavin, and nearly 27 g of a glucose/sucrose blend. A 250 ml can of SFRB contains 10 calories, and differs from RB in that aspartame is substituted for the glucose/sucrose blend. The PBO consisted of 242.5 ml of Diet Vernors Ginger Ale® (Dr. Pepper/Seven Up, Inc., Plano TX, USA) and 7.5 ml of Monin O'Free Raspberry Syrup® (Monin Inc., Clearwater FL, USA). The products used to create the PBO were sweetened with aspartame and Splenda®, and the PBO beverage did not contain any calories, protein, or caffeine. The PBO beverage was similar in color and taste to RB/SFRB, and all beverages were served (double-blind) in plain opaque cups at room temperature to further mask their identity. After beverage consumption, each participant was escorted to a room where they could watch TV, relax, or work on a computer for 30 minutes. The Red Bull North America corporate website states that "It is recommended to drink one can of Red Bull® Energy Drink about 30 min before the start of a concentration task or the start of a race or game in sports. This is about the time for the ingredients of Red Bull® Energy Drink to become effective in the body [14]." Caffeine and taurine are indeed rapidly absorbed following oral administration and elevated plasma levels can be observed approximately 30 minutes following intake [15-17].

Following this absorption period, visual attention and reaction time were assessed using the computerized Connors Continuous Performance Test II (CPT; Multi-Health Systems, North Tonawanda NY, USA). In this task, which takes 14 minutes to administer, the participant is presented random single English letters on a screen at variable speeds and durations, and he/she must press the space key for all presented letters except X. The CPT software measures the rate of omission errors (failing to press the space key when appropriate) and commission errors (pressing the space key when inappropriate) on this task, reaction time, and calculates  $d'$ --a measure of the participant's overall ability to discriminate targets from non-target stimuli.

Statistical analysis was completed using a two-part approach. First, difference scores for each participant were calculated, which described individual changes in task performance resulting from ingestion of the PBO and either RB or SFRB. Second, data was collapsed into three groups cor-

responding to the beverage conditions, which allowed for the comparison of overall differences between the three drinks. Analysis of each CPT outcome was completed using ANCOVA/mixed models constructed with SAS 9.1 (SAS Institute, Cary NC, USA); these models included participant sex, median split of body weights (upper/lower half of distribution), and the interaction of drink condition and median split of body weight. For all models, diagnostics were carried out by examining plots of model residuals. An alpha level of .05 was used for all tests.

## RESULTS

Of the six participants who indicated use of tobacco products, three were in the PBO group, two were in the RB group, and one was in the SFRB group. The consumption of RB or SFRB had no effect on CPT performance beyond that associated with the placebo. None of the mean difference scores between the PBO, RB or SFRB were significant (all  $p$ 's > .15) for any CPT metric or covariates in any of the models. Similar null-findings were uncovered by the overall comparison of performance across the three beverage conditions, with one exception. Here,  $d'$  approached significance [ $F(2,60) = 2.98, p = .058$ ], and an examination of the differences between the beverage group means demonstrated that  $d'$  was significantly greater for the SFRB group when compared to the PBO ( $p = .02$ ). The SFRB did not differ from the RB group ( $p = .25$ ), nor did the RB group differ from the PBO ( $p = .37$ ).

## DISCUSSION AND CONCLUSION

In the present study, no significant effects of RB or SFRB on CPT performance were uncovered. Although participants who consumed SFRB demonstrated an increase in  $d'$  (which suggests an increased ability to discriminate targets from non-targets), this effect was not classically significant, and is probably of little importance. Although prior studies have found that RB improves cognitive function, to our knowledge, this study is the first to examine the effects of RB on CPT performance within the context of a "real world" university setting. Our results indicate that although RB or SFRB may improve cognition in certain clinical settings, a single 250 ml dose (one can), when taken by university students at the end of a busy weekday, does not significantly improve reaction time or visual attention as measured by the CPT. Although the sample size of this study was somewhat restricted ( $n = 34$ ), it is larger than several published studies that have found effects of RB or its ingredients on cognition in clinical settings. Given the absence of any functionally important numerical difference across the three groups in measures of attention and reaction time, we doubt that the inclusion of additional participants would have produced statistically significant findings.

We formulated the PBO to make it similar in look and taste to RB, because we knew that the majority of our participants would be familiar with energy drinks. This was an important consideration, given the body of research indicating that familiarity and expectancies play a critical role in the psychological effects of familiar caffeine-containing drinks [18]. Our null findings may be explained by placebo expectancy effects occurring in our participants (most of whom were indeed familiar with energy drinks). For each testing session, the verbal reactions of the participants following

drink consumption were noted by the blind experimenter. Several of the participants reported subjective psychological alterations (ex. "What did you give me to drink? It is really messing me up!") during the absorption period following consumption of the PBO. These participants may have assumed the placebo to be some "new" energy drink, and these expectations may have manifested performance gains on the CPT that washed out any effects obtained by consuming RB or SFRB. Overall, the results of this study indicate that the effects of RB or SFRB on CPT performance in a relevant "real world" university setting are negligible, and are no greater than potential enhancements resulting from placebo expectancy effects.

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