Influence of caffeine ingestion on perceived mood states, concentration, and arousal levels during a 75-min university lecture

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caffeine is the world’s most widely used and often abused drug and is commonly found in a variety of commercial products such as colas, coffee, tea, and confectionaries (20). It is estimated that worldwide, caffeine consumption is in the order of 76 mg/day per person (17); however, the consumption rate exceeds 230 mg/day in the United States, Canada, and Australia (10). The widespread use of such a drug has seen caffeine become the focus of much research in the past decade. As a result, it is now commonly recognized that caffeine ingestion promotes an affect on behavioral functions such as vigilance, attention, mood, and arousal (3, 7, 9).

The aforementioned behavioral variables affected by caffeine consumption are important factors when considering an educational setting. Should the consumption of caffeine enhance these behavioral functions, a more favorable learning environment might be fostered. Previous research involving prepubertal children has shown that caffeine consumption (5 mg/kg), compared with a placebo, was responsible for enhanced performance on a test of attention and manual dexterity. Furthermore, these authors (3) also reported that participants felt significantly “less sluggish” and significantly more anxious when caffeine was consumed. In support of such findings, Frewer and Lader (11) showed that a moderate (250 mg) dose of caffeine was effective in enhancing performance of a continuous attention task. It was proposed by these authors that the caffeine supplement potentially attenuated the performance decline seen during the same task when supplemented with a placebo. However, it was also shown that if the caffeine dose was too high (500 mg), the arousal levels of the subjects were overstimulated, and the continuous attention task performance began to decline. The culmination of these two investigations suggests that caffeine consumption at moderate concentration levels can enhance a number of fundamental behavioral processes important to learning.

In addition to superior levels of attention, alertness, and arousal, it was also suggested that caffeine consumption might enhance the cognitive function of memory. Riedel et al. (19) showed that a 250 mg supplement of caffeine was responsible for enhanced test performance on a word-learning task. As such, Riedel and colleagues concluded that the effect of caffeine on the central nervous system induces enhanced cholinergic stimulation, ultimately attenuating the scopolamine-induced impairment of free recall from short- and long-term memory. As a result, it is plausible to suggest that a caffeine-induced improvement in the utilization of both long- and short-term memory during a classroom situation might enhance a student’s ability to recall and associate lecture material over the duration of the class.

Despite the above-mentioned positive findings, one must consider the dose of caffeine provided (250–500 mg) during each of these studies. Previous research has suggested that that the majority of caffeine research that currently exists employs supplementation doses larger than those generally consumed from a single serving of beverage or food (16, 21). As such, Liberman and colleagues (16) supplemented 20 healthy males with a range of caffeine doses (ranging from 32 to 256 mg) to assess the effect on a number of performance tasks (sustained complex motor performance, visual reaction time, and auditory vigilance) and moods measured by self-reported questionnaires. From their results, these authors were able to conclude that low doses of caffeine (32 mg), equivalent to those found in commonly consumed beverages and foods, can significantly improve performance on auditory and visual tasks, without
having negative effects on mood profiles such as anxiety. In support of these outcomes, Smith et al. (21) showed that a number of common drink choices (water, tea, coffee, or cola) supplemented with an additional low dose (40 mg) of caffeine could significantly enhance performance of a choice reaction time test, a semantic memory task, and a delayed recognition memory task compared with a decaffeinated placebo drink. However, in contrast to Lieberman and colleagues (16), the participants of the Smith et al. study (21) reported greater feelings of alertness and anxiety when the low-dose caffeinated beverage was consumed. Smith and colleagues concluded that there was no evidence to suggest that the type of drink consumed (i.e., cola or coffee) modified the effect of the caffeine and that a low-dose supplement may be important in maintaining performance efficiency.

With this in mind, it is apparent that there exists a plethora of research concerning the effects of caffeine and its dosage on human physiology, cognitive, and behavioral processes and performance task outcomes, all of which could potentially impact on education and learning. However, to date, no previous investigations have examined the effect of caffeine consumption on perceived mood states at a tertiary institution level and how this may impact on a student’s ability to learn. Furthermore, some discrepancy exists as to the impact of a low-dose caffeine supplement on perceived mood states such as anxiety. As such, the purpose of this investigation was to assess the effect of a caffeine supplement on perceived mood state, concentration, and arousal during a 75-min university lecture.

METHODS

Subjects. Ten third-year Human Movement and Exercise Science students from the University of Western Australia were recruited for participation in this study. All subjects were briefed on the purpose, requirements, and risks involved with participation in this investigation. Written informed consent was signed in accordance with the Human Ethics Committee of The University of Western Australia.

Experimental overview. This investigation was a randomized, blind, cross-over design that ran over a course of 2 consecutive weeks. During week 1, 10 third-year Human Movement and Exercise Science students, all considered to be regular caffeine consumers (consumption of 1 or 2 caffeinated products daily) were assigned to either a caffeine- or placebo-supplemented group and were subsequently required to attend a 75-min exercise rehabilitation lecture. Seven days later, students were assigned to the opposite supplementation group before attending a second follow-on lecture, equal in duration to that of week 1. In the 24 h prior to the commencement of each lecture, all students were asked to abstain from the consumption of any caffeinated products.

On the morning of each lecture, all participants were required to attend the venue 60 min prior to its commencement. At this point, the caffeine-supplemented group was supplemented with 100 mg caffeine, an amount approximately equivalent to 1 cup of peculated coffee or two 350-ml cans of soft drink (5). Additionally, the placebo-supplemented group was supplemented with 100 mg NaCl. Supplements were given to the participants in the form of identically sized

Fig. 1. Mean (±SE) 7-point Likert scale ratings for the following 7 mood adjectives: awake (A), clear minded (B), energetic (C), creative (D), alert (E), anxious (F), and efficient (G). *Significant difference between the caffeine-supplemented group (CAF group) and the placebo-supplemented group (PLA group).
white pills covered by a gelatin capsule to disguise any taste that may result from the content of the pills. Participants were supplemented 60 min prior to the lecture, since it has been suggested that peak blood concentrations of caffeine occur ~1 h postsupplementation (1, 6). Sixty minutes later, all subjects attended a 75-min exercise rehabilitation lecture. At the conclusion of the 75-min period, participants were given a mood perception questionnaire to assess the perceived level of mood state, concentration, and arousal during the lecture.

Questionnaire. The student perception questionnaire used in this investigation was divided into two sections. Section 1 was based on the mood questionnaire employed previously by Leatherwood and Pollet (15) to assess the effects of caffeine on subjective sensations. To complete this questionnaire, each participant was asked to give an indication of how they felt during the 75-min lecture by rating seven adjectives (awake, clear minded, energetic, creative, alert, anxious, and efficient) on a 7-point Likert Scale. Additionally, section 2 asked each participant to rate their perceived level of arousal and concentration during the lecture period on a 10-point Likert Scale.

Statistical analysis. All data was analyzed with paired-samples t-tests using the Excel for Windows computer software package. Statistical significance was accepted at an α-level of P ≤ 0.05. Data are expressed as means ± SE.

RESULTS

Figure 1 shows mean (±SE) ratings given for the seven adjectives listed in section 1 of the student perception questionnaire. The results showed that after caffeine consumption, students perceived themselves to be significantly more awake (P = 0.01), clear minded (P = 0.03), energetic (P = 0.02), alert (P = 0.05), and anxious (P = 0.03) than after consuming the placebo. Conversely, after the consumption of caffeine, students did not feel more efficient (P = 0.29) or creative (P = 0.12) during the 75-min lecture period.

Figure 2 shows mean (±SE) ratings given for perceived levels of concentration and arousal during the lecture. The statistical analysis revealed that after caffeine consumption, students felt they were better able to concentrate (P = 0.01) and had a greater level of arousal (P = 0.02) than when the placebo was consumed.

DISCUSSION

The results of this investigation suggest that a low dose of caffeine (100 mg), consumed 60 min prior to the commencement of a 75-min university lecture, can enhance a student’s perception of specific behavioral functions and mood states that are vital to learning. Specifically, these results show that students feel significantly more awake, clear minded, energetic, alert, anxious, concentrated, and aroused as a result of caffeine supplementation.

With enhanced subjective feelings toward such behavioral mood states, it is apparent that caffeine supplementation improved the mood state of the students throughout the 75-min lecture period. Research has shown that central nervous system release of the catecholamine norepinephrine (NE) can significantly alter mood state (18). These authors suggested that an appropriate level of NE firing is necessary to optimize attention, learning, and arousal. Additionally, Berkowitz et al. (2) showed that caffeine is responsible for a stimulatory increase in the central nervous system release of NE. As such, it is possible that the enhanced mood state of the caffeine-supplemented students within this investigation was a result of a caffeine-augmented release of NE. Such a hypothesis is supported by the student’s significantly greater perception of anxiety when supplemented with caffeine. Dazzi et al. (8) have shown increased tone of the noradrenergic system when levels of anxiety are increased and decreased levels during periods of depression. Since caffeine is a stimulant, the increased levels of anxiety reported from our students should be expected. However, rather than having a negative impact on mood state during a lecture, it is possible that the greater anxiety levels were actually beneficial as a result of an increased NE drive. Furthermore, the increased levels of anxiety seen from our sample population support the findings of Smith et al. (21), who also showed greater feelings of anxiety with consumption of a low-dose caffeinated beverage.

Despite the positive effects of caffeine supplementation on mood state seen during this investigation, it should be highlighted that the caffeine dosage we provided to students (100 mg) is considered a low dose. Previous work has shown that the same positive effects on mood states (21) as well as visual and auditory performance (16) from a low dose of caffeine consumption can occur compared with that of a high-dose supplement. Additionally, previous research has shown that high doses of caffeine (500 mg) are associated with dysphoric somatic effects, unfavorable subjective mood states, and over-stimulated arousal levels (11, 14). Kaplan et al. (14) suggested a dose-dependent relationship of caffeine, with slower clearance rates and longer half-lives at higher dosages. In essence, it is possible that students may become overaroused and...
anxious from excessive dosages and consumption frequencies of caffeine, and, as such, the same favorable responses to mood states during a classroom setting that we have shown from a single instance may not prevail with low-dose supplement. Furthermore, the long-term effects of excessive caffeine consumption are still unknown. Potentially, excessive caffeine consumption can result in hypertension (12) or reduced bone mineral density (13). Therefore, the practice of high-dose caffeine supplementation for an increased mood state during a lecture is not recommended.

**Practical applications.** The methods used and the positive findings that have resulted from this research can be applied to improve physiology education in two ways. First, from the aspect of a student, it is possible that the consumption of a low-dose caffeine supplement prior to entering a classroom setting may improve mood state, enhance the ability to concentrate, and allow retention of information over the duration of a lecture period. Second, as a teacher, the structure and design of this investigation is a simple and effective means for practical application in the classroom to show the outcome of caffeine supplementation on a number of physiological and psychological variables.

**Conclusions.** The results of this investigation show that university students report enhanced perceptual feelings of behavior and mood state when a low dose of caffeine is consumed 60 min prior to a 75-min academic lecture. Such positive reports of mood state are potentially beneficial to enhancing a student’s ability to learn during a lecture period. However, a limitation of this study is that no performance tests were implemented at the conclusion of the lecture to assess any improvements to information retention. Although the low dose of caffeine used in this investigation had a positive influence on mood state, it is possible that excessive caffeine consumption prior to a lecture may overarouse students and therefore be deleterious to their learning outcomes.

**REFERENCES**