The effects of caffeine on mental alertness psychology essay

Caffeine has been identified as an effective psycho-stimulant. The stimulant effects of caffeine, achieved through the consumption of beverages such as coffee, may be altered by the addition of various substances such as sugar. Sugar has a general excitatory effect on mental alertness but an excessive amount reduces this effect due to the suppression of orexin. In the experiment, we investigated how varying amounts of sugar added in coffee might have affected caffeine's ability in inducing alertness. Participants were given coffee with different amounts of sugar and the Psychomotor Vigilance Test was used to gauge their reaction times. From the data interpretation, we were able to address our primary research aim in two parts: (i) The addition of two teaspoons of sugar results in maximal stimulation of mental alertness. (ii) One to four teaspoons of sugar facilitates caffeine in promoting mental alertness, while an addition of five teaspoons of sugar blocks this stimulatory effect of caffeine. For our secondary objective, we found that there is no significant difference in the mean reaction times between the male and female participants, as shown from the paired t-test. Future studies could be conducted to investigate the effect on mental alertness when more than 5 teaspoons of sugar are added to coffee. Furthermore, possible ways to alleviate the suppression of orexin could also be investigated.

Section 1: Introduction

Psycho-stimulants are substances used to temporarily improve mental functions of an individual and are commonly used to relieve symptoms of tiredness such as reduced mental alertness. Identified as an effective psycho-stimulant, caffeine can antagonize sleep-inducing effects by preventing adenosine from binding to the adenosine receptors in the

hypothalamus. This will then inhibit the release of gamma-aminobutyric acid (GABA). As a result, this prevents GABA’s inhibitory effect on neurons involved in wakefulness, which helps one to stay more mentally alert1.

The stimulant effects of caffeine, achieved through the consumption of beverages such as coffee, may be altered by the addition of various substances such as sugar. As past research has shown, sugar has excitatory effects on our mental alertness and so too little or no sugar in the bloodstream decreases the energy available for the brain to utilize and hence this causes one to be tired, sleepy, and unable to concentrate2. Conversely, too much sugar will suppress orexin, a biochemical substance that stimulates mental vigilance3 which may reduce the wake-promoting efficacy of caffeine. Previous studies only focused on the effects of a single amount of sugar4. However, there are no studies on how the different levels of sugar may affect caffeine’s ability in stimulating mental alertness and consumers frequently overlook that an excessive amount may actually reduce its ability to stimulate wakefulness. We conducted an experiment to find out both the ideal amount of sugar required in consumption with caffeine for maximum mental alertness and the amount of sugar that could bring about slower reaction time. In addition, we want to determine if there is a difference in the results obtained between male and female.

This paper is organized as follows. Section 2 describes the participants, materials and experimental procedures. The result of the tests is presented and analyzed in Section 3 while the conclusions are covered in Section 4.

Section 2: Method

The experiment examined the sugar concentration in coffee that would bring about the maximum improvement of mental alertness as well as the amount that could block the stimulatory effect of caffeine. In addition, the experiment compared the improvement in mean reaction times of both genders.

2. 1 Participants

Ten undergraduates (five males and five females from the Nanyang Technological University) with Body Mass Index (BMI) of 18 to 23 kg/m2 and aged 18 to 25 were selected for the test. Participants were asked to fill out a pre-screening questionnaire to verify that they have fulfilled the following conditions:

(1) A low daily caffeine intake of less than 100 mg

(2) No significant health problems such as diabetes

(3) They are non-smokers

(4) They lead sedentary lifestyles

2. 2 Materials

Sixty packets of 15 g ‘ Kopi-Kosong’ black coffee powder, ten 200-ml cups and 100% cane sugar were used in the experiment. To record the participants’ reaction times, we used the Psychomotor Vigilance Test (PVT) which is a common standard used in assessing alertness levels and attention

after prolonged sleep loss5. It is a 10-minute visual test which continually displays a visual prompt at pseudo-random gaps ranging from 2 seconds to 10 seconds. The subject presses a button as fast as possible and the time reading is recorded. As research has found that the caffeine salivary level peaks between 35 to 120 minutes6, the test was conducted every 30 minutes for 3 hours.

2. 3 Experimental Procedure

Ten 200-ml cups of black coffee were prepared, using 15 g of coffee powder for each cup. Sugar-free black coffee was used as the control variable.

Prior to the test, a minimal uninterrupted sleep duration of 4 hours on a Saturday from 0200 hrs to 0600 hrs was allocated to simulate sleep deprivation and the participants were expected to abstain from food and beverage for 8 hours. Participants were given 2 hours to travel to Nanyang Technological University, School of Physical and Mathematical Sciences Building, MAS Computer Laboratory 1. The participants were strongly encouraged to reach the stipulated venue at least 15 minutes before the actual commencement of the test.

The experimental procedure was conducted once per week over a six-week period. In Week 1, the participants arrived at the school computer laboratory by 0800 hrs. At 0815 hrs, a single session of PVT was first conducted before coffee consumption. At 0830 hrs, they were then each given 200-ml of coffee with no sugar added, after which the test was carried out at 30-minute intervals over a span of 3 hours i. e. 0900 hrs, 0930 hrs, 1000 hrs, 1030 hrs, 1100 hrs and 1130 hrs. Each 30-minute interval started with a 10-minute

PVT followed by 20 minutes of relaxation time where the participants were allowed to read, study or surf the net in the computer lab. This was to help them stay awake. For the subsequent weeks, the procedure was repeated with the following changes: 1, 2, 3, 4 and 5 teaspoon(s) of sugar was added to the coffee, for weeks 2, 3, 4, 5 and 6 respectively.

2. 4 Post-experimental Calculations

We calculated Tx-T0, where Tx is the reaction time (milliseconds) at a particular number of teaspoons of sugar added, N. This was plotted against the time elapsed after the beginning of the experiment (minutes). Results of the male and female's reaction times were also considered together. The integrated area of the graph for each week, denoted as A, was then determined with Microsoft Excel using the Trapezoidal Rule (refer to Table 3 in Appendix 1). This was followed by the plotting of the integrated area against $0 \leq N \leq 5$ (refer to Figure 3 in Appendix 1). The formula of Trapezoidal Rule is as follows:

We used the paired t test to determine if there was significant difference between the results for both genders.

Section 3: Results

This section illustrates our experimental findings to (i) determine the ideal amount of sugar to add in consumption with caffeine to stimulate maximum mental alertness, (ii) determine the amount of sugar that could block caffeine's excitatory effect and (iii) determine if there is a significant difference in the effect of caffeine on both male and female.

Ideal amount of sugar in consumption with caffeine

Our first objective is to determine the ideal amount of sugar in consumption with caffeine to achieve maximum mental alertness. We found that 2 teaspoons of sugar is most likely the optimum amount. This is as shown in Figure 1, that the overall improvement in mental alertness (A) is the highest at 7000 units when 2 teaspoons of sugar are added. We also found that 1, 3 and 4 teaspoons of sugar augment an improvement in mental alertness. This is shown in Figure 1 that the additions of 1, 3 and 4 teaspoons of sugar correspond to ‘ A’ values at 6000, 6000 and 5750 units respectively, which are higher than the case when no sugar is added, with ‘ A’ value at 5100 units.

Amount of sugar that blocks the stimulatory effects of caffeine

Our next objective is to determine the amount of sugar that completely inhibits the excitatory effects of caffeine. We found this amount to be 5 teaspoons of sugar. As Figure 1 shows, 5 teaspoons of sugar resulted in a lower improvement in the mental alertness at 4100 units, as compared with the case when no sugar was added. This could be attributed to the suppression of orexin brought about by the consumption of an excessive amount of sugar3. When orexin is suppressed, the excitatory effect of caffeine is counteracted.

Figure 1: Effects of different amount of sugar on mental alertness

Comparison of the results between male and female

We compared the effects of sugar on both genders and found no significant difference between their results. As shown in Table 6 of Appendix 1, at an approximated degree of freedom of 40, the Ttable for the confidence interval of 95% is 2. 021 and that of 98% is 2. 423. Since Tcalculated = 2. 2685 is less than 2. 423, there is no significant difference in the mean reaction time for both genders at approximately 98% confidence interval.

Section 4: Conclusions

The objective of this study was to investigate how the varying amount of sugar would affect caffeine's ability in inducing mental alertness. Our findings indicated that an addition of 1 to 4 teaspoons of sugar worked in conjunction with caffeine to boost mental alertness, with the addition of 2 teaspoons of sugar being the most effective in improving alertness. However, the addition of 5 teaspoons of sugar blocked the capability of caffeine to promote alertness. This could be due to the suppression of orexin which may have been so significant that it blocked the excitatory effect of caffeine. Lastly, there is no significant difference in the improvement of mean reaction times between male and female participants.

Due to time constraints, we focused on the effects of 5 different amounts of sugar added to coffee. Therefore, the effect of more than 5 teaspoons of sugar is not known. In addition, it is uncertain whether the activities during the 20-minute breaks in between each PVT session would significantly influence the participants' mental alertness.

By knowing how the varying amount of sugar could improve or reduce caffeine’s ability in inducing mental alertness, consumers in general can then make more informed decisions to determine the ideal amount of sugar that should be added in consumption with caffeine to help them stay alert and focused.

Further studies could be conducted to find out the effect on mental alertness when more than 5 teaspoons of sugar are added to coffee. Furthermore, possible ways to alleviate the suppression of orexin could also be investigated. In addition, we recommend conducting the experiment on a larger sample size that includes people from other age groups and of different Body Mass Index.