Effects that caffeine consumption

Caffeine is the most commonly used psychoactive substance in the United States (Roehrs & Roth, 2008). Regular coffee drinkers consume an average of 200-500mg of caffeine per day (Julien, 2005). Caffeine is found in a broad variety of sources including coffee, tea, energy drinks, chocolate and some over the counter medications (Roehrs & Roth, 2008). Upon consumption, caffeine reaches peak plasma levels in 30-75 minutes and has a half life of 3-7 hours when consumed in a single dose (Roehrs & Roth, 2008). When consumed in greater quantities, the half life is extended (Roehrs & Roth, 2008). Caffeine's high rate of consumption may be due to the desirable effects it produces, such as increase mental alertness, improved flow of thought and of course, feelings of wakefulness (Julien, 2005). Caffeine is not without it's undesirable effects; caffeine consumption may have a negative effect on tasks which require fine motor skills, complex arithmetic skills, or precise timing (Julien, 2005).

Structurally, caffeine is similar to adenosine. In the brain, adenosine decreases neural firings and inhibits neurotransmitter release (Roehrs & Roth, 2008). Caffeine works as an adenosine antagonist; blocking adenosine receptors in the brain. As a consequence, caffeine prevents adenosine from decreasing neural firings, leading to an increase in firings, and the stimulant effects caffeine is well known for (Roehrs & Roth, 2008). Caffeine's blocking of adenosine receptors leads to dopamine release in the prefrontal cortex, causing caffeine's alerting effects (Julien, 2005). While discontinuation of caffeine consumption may produce withdrawal symptoms, caffeine does not influence the dopaminergic structures associated with rewards and addiction

(Julien, 2005). Typical withdrawal symptoms include headache, drowsiness, fatigue, and negative mood (Julien, 2005).

It is often difficult to estimate the amount of caffeine a person consumes due to great variability in the amount of caffeine per beverage (particularly coffee), exclusion of new caffeinated products on questionnaires, and variation in consumption from day to day. It is also difficult to compare results between studies due to a great amount of variation in methods of measuring caffeine consumption levels (Shohet & Landrum, 2001). A study by Shohet & Landrum (2001) of undergraduate university students implemented the use of an updated version of the caffeine consumption questionnaire as well as looking at chronotype and age. The caffeine Consumption questionnaire decreases a great deal of inaccuracy of caffeine consumption measurement. Shohet & Landrum (2001) found that the average participant in the study consumed 1597. 6mg/week. They also found that level of caffeine consumption is positively correlated with age. It was speculated that this increase may be an effort to compensate for decreased metabolism and subsequent decrease in energy (Shohet & Landrum, 2001). In the same study, there was no significant difference in caffeine consumption between males and females (Shohet & Landrum, 2001). Caffeine consumption in the evening was higher among older people, who tended to be morning-types (Shohet & Landrum, 2001).

The effects that caffeine consumption has on sleep are vast. Orbeta, Overpeck, Ramcharrin, Kogan & Ledski (2006) found in a study of American high school students that those who reported a high rate of caffeine consumption also reported more difficulty falling asleep and felt more tired in the morning. In a number of studies, caffeine administration in varying amounts significantly reduced total sleep time and increased sleep onset latency (Roehrs & Roth, 2008). Some studies also found a reduction in percentage of slow wave sleep after caffeine administration (Roehrs & Roth, 2008). In a study where caffeine was administered prior to sleep, EEG spectral power density was reduced in the . 75 – 4. 5 Hz band. In a parallel study, men were administered 200 mg of caffeine upon waking (07: 00 h) still experienced a reduction in EEG spectral power density in the . 75 – 4. 5 Hz range in the subsequent night sleep (Landolt, Werth, Borbely, & Dijk, 1995). In this same study, total sleep time and sleep efficiency were reduced following caffeine administration in the morning. Power density was reduced in the . 25 – . 5 Hz range, and enhanced in the 11. 25 – 12. 00 Hz and 13. 25-14. 00 Hz ranges for NREM sleep (Landolt et al., 1995). Though a single 200 mg dose of caffeine in the morning clearly influences sleep propensity and power density of the EEG in the subsequent sleep episode, there was no deterioration in subjective sleep quality, and there is not a severe disruption of sleep continuity (Landolt et al., 1995). In contrast, a study by Sanchez-Ortuno, Moore, Taillard, Valtat, Leger, Damien, Bioulac, and Philip (2005)

found that up to eight cups of coffee consumed by ‘ regular coffee drinkers’ was not associated with reduced TST. There was also no relationship found between caffeine consumption and day time sleepiness in participants consuming up to eight cups daily (Sanchez-Ortuno et al., 2005).

The chronotype of an individual may be related to caffeine consumption. Chronotypes are a preference for being active during a particular time of day (Giannotti, Cortesi, Sebastiani, & Ottaviano, 2002). Some individuals may be categorized as Morning-Types. Morning Types prefer to wake early in the morning, retire earlier in the evening, and are most active in the early hours of the day, where as Evening-Types prefer to rise later, and engage in activities later in the day. Others may fall somewhere between the morning-type and evening-type extreme. Daily physiological rhythms such as core body temperature, blood pressure and hormone secretions vary from one chronotype to another. Morningness and Eveningness also tend to vary with age, with older adults generally demonstrating a preference for morning activity, and younger adults a preference for evening activity (Giannotti et al., 2002). A study by Giannotti et al. (2002) of adolescents found that as they approached young adulthood, their circadian preference shifted more towards Eveningness. Giannotti et al. (2002) also found that Evening types tended to consume more caffeine, particularly in the morning. This may be due to forced pressure to adhere to a schedule more appropriate for those with a preference for morning activity (Giannotti et al., 2002). In a study of both men and women with different, but fixed work schedules by Ana Aden (1994) it was found that caffeine consumption increased with preference for evening. Evening types consumed more caffeine than neutral types, and neutral types consumed more caffeine than morning types. Interestingly, a large percentage of evening types were found to be caffeine abusers. 500 mg or more of caffeine per day was considered abuse (Aden, 1994).

Adolescent evening types showed a more irregular sleep schedule and poorer subjective sleep quality in a study by Giannotti et al. (2002). Evening types also had higher sleep/wake behaviour scores than morning types, an indication of more sleep problems in evening types (Giannotti et al., 2002).

Evening type adolescents reported consuming more sleeping pills than morning types as well as more day time sleepiness (Gianotti et al., 2002). Evening types had a greater tendency to fall asleep at school, and attention problems as well (Giannotti et al., 2002).

An increase in the accessability of technology like computers, internet, television, and MP3 players may also impact caffeine consumption as well as sleep. A study by Calamaro, Mason, & Radcliffe (2009) found that adolescents with higher scores on the multi-tasking index also reported higher caffeine intake, increase daytime sleepiness, increased incidents of falling asleep at school, and decreased total sleep time. Only 20% of the teenagers in this study received the recommended 8-10 hours of sleep for their age (Calamaro et al., 2009). 33% reported falling asleep at school on a regular basis, and 37% and 42% take naps on school days and weekends respectively (Calamaro et al., 2009).

Clearly there is a great deal of interaction between caffeine consumption and chronotype. There is also apparent interaction between caffeine consumption and sleep quality. Chronotype had an influence on sleep quality in adolescents, There is also a relationship between caffeine consumption and sleep quality and multi-tasking/technology use. The present study aimed to examine the interrelationship between these variables in a group of university students. It was hypothesized that students who reported higher caffeine consumption would report lower subjective sleep quality. This relationship would be demonstrated by a significant positive correlation between level of caffeine consumption determined by Caffeine Consumption Questionairre (mg/week) (Modified from Landrum, 1992) and score on the

Pittsburgh Sleep Quality Index (a higher score indicates poorer sleep quality) (Buysse et al., 1989). It was also predicted that students who were evening-types would consume a greater amount of caffeine than morning-type students. This would be demonstrated by a significant negative correlation between Morningness-Eveningness Questionairre (a lower score indicates a preference for eveningness) (Horne & ‘ stberg, 1976) and daily caffeine consumption (mg/week) . Next, it was predicted that evening types would experience more subjective sleep problems than morning types. More specifically, there would be a significant negative relationship between scores on the Morningness-Eveningness Questionnaire and Pittsburgh Sleep Quality Index score. The fourth prediction was that students who scored higher on the Nighttime Activities (Multi-tasking) Index would also consume a greater amount of caffeine. Specifically, there would be a positive relationship between Caffeine Consumption Questionnaire score and Nighttime Activities (Multi-Tasking) Index score. Finally, we predicted that students who were evening-types would use more technology between 21: 00 and 06: 00. This would be indicated by a significant negative relationship between Morningness-Eveningness score and Nighttime Activities (Multi-Tasking) Index score.

Method

Participants

Participants in this study were 49 undergraduate students enrolled in a Sleep and Arousal course and Trent University. Student age ranged from 20-31 years. Mean age of participants was 22. 12 years (SD 2. 26). 9 males and 39 females participated in this study.

Materials

Materials used were 4 established questionairres. The Morningness-Eveningness Questionairre (Horne & ‘ stberg, 1976) was used to determine an individuals chronotype (preferred or peak time of day (morning, evening or neutral)). Scores range from 16-86. Questionnaires were scored as follows: (16-30) Definitely Evening, (31-41) Moderately Evening, (42-58) Neutral, (59-69) Moderately Morning, (70-86) Definitely Morning.

The Pittsburgh Sleep Quality Index was used to measure students overall sleep quality (Buysse et al. 1989). Scores range from 0-21, with lower scores indicating better sleep quality.

A modified version of the Caffeine Consumption Questionairre (Landrum, 1992) was used to estimate weekly caffeine consumption in students. Participants indicate how much caffeine they consume in the morning, afternoon, evening, and night time. Students also indicate the source of caffeine (small coffee, medium tea, soft drink, large coffee). The caffeine content of each type and size of drink was determined by Calamaro et al. (2009) and Roehrs and Roth (2008).

Finally, the Night-Time Activities Questionnaire, modified from Calamaro et al. (2009) was used to measure the amount of time students spent doing various technology based activities in the evening (9: 00pm – 6: 00am). Activities such as watching television, and using the computer were included). A multi-tasking index was then created by adding the total hours of time spent on all tasks and dividing this number by 9 (the total hours between 9: 00 pm and 6: 00 am). A student who engages in 9 hours of activity in that 9 hour period would receive a score of 1. 0 (A score greater than 1 is possible, for example, if a student was listening to music and using the computer at the same time).

Procedure

Participants filled out all four questionnaires during a scheduled lecture period. The Morningness-Eveningness Questionnaire and the Pittsburg Sleep Quality Index were scored by students after completion, while the other two questionnaires were scored by the instructor.

Results

Caffeine Consumption Questionairre

The mean level of caffeine consumption in milligrams per week for the morning (06: 00 – 12: 00) period was 685. 63 (SD = 1032. 21). Mean afternoon (12: 00 – 18: 00) period caffeine consumption was 394. 90 (SD = 554. 39). The mean level of evening (18: 00 – 02: 00) period caffeine consumption in these university students was 320. 49 (SD = 355. 48) and mean night time (02: 00 – 06: 00) caffeine consumption was 24. 84 (SD = 64. 49) milligrams per week. Mean caffeine consumption total in milligrams per week was 1425. 86 (SD = 1737. 82). These results were similar to results found by Shohet et al. in that the greatest amount of caffeine was being consumed in the morning time. There was a slightly lower level of total caffeine consumption in our study compared to the results found by Shohet et al., with a difference of 171. 74 mg/week between the two studies. This amount is equivalent to about 1 cup of coffee. (MORE COMPARISON BETWEEN OURS AND SHOHET'.. SEE TABLE 2 IN PAPER AT BATA)

The mean source of the caffeine consumed weekly in milligrams was 974. 69 (SD = 1713. 09) for coffee, 270. 12 (SD = 338. 18) for tea, 99. 24 (SD = 163. 39) for soft drinks, 45. 06 (SD = 127. 23) for energy drinks, and 36. 73 (SD = 74. 44) for hot chocolate. The vast majority of caffeine consumed weekly by these university students was via coffee while very little caffeine was consumed in hot chocolate.

Morningness-Eveningness Questionnaire (MEQ)

The mean MEQ score was 43. 59 (SD = 12. 25). Scores ranged from 24 to 69. 16. 33% of participants were Definitely-Evening (n= 8), 34. 69% were Moderately-Evening (n= 17), 36. 73% were Neutral (n= 18) and 12. 24% were Moderately-Morning. None of the participants were Definitely-Morning types.

Pittsburgh Sleep Quality Index (PSQI)

Each subscale of the PSQI has a possible score of 0-3. The mean Subjective Sleep Quality score was 1. 37 (SD = 0. 83). The mean Sleep Onset Latency score was 1. 84 (SD = 1. 01). The mean Sleep Duration score was 0. 78 (SD = 0. 82). The mean Habitual Sleep Efficiency score was 0. 69 (SD = 0. 98). The mean Sleep Disturbances score was 1. 55 (SD = 1. 14). The mean Use of Sleeping Medication was 0. 37 (SD = 0. 83), and the mean Daytime Dysfunction score was 1. 35 (SD = 0. 83). The mean total score on the PSQI was 7. 78 (SD = 3. 93). According to Buysse et al. (1988), a score greater than 5 indicates that someone is a poor sleeper. The mean score of our participants was within the range of abnormal. The greatest amount of sleep disturbance came from high sleep onset latency, while the least disruptive factor was reliance on the use of sleep medications.

Night-Time Activities Questionnaire (NTAQ)

The mean data for the activities included on the NTAQ are included in figure 1. The mean multi-tasking index of these night time activities is 0. 60 (SD = 0. 29). The range of multi-tasking index scores was 0. 12 – 1. 39. A score of 0. 60 means that the participant was doing some combination of the activities on the NTAQ for 5. 40 hours. (0. 60 x 9 hours = 5. 40) of the 9 hour sleep period. In the case of the score of 1. 39, the participant was engaging in an activity on the NTIQ for 12. 51 hours. Since the measured period is only 9 hours, this participant was engaging in more than one activity at a time, for example, listening to MP3 player and online computer use.

Results of Correlation Analysis

There was a significant negative correlation between MEQ and Multi-Tasking Index. Morning types tended to have lower Multi-Tasking Index scores than Evening types, $r = -. 32$, $p < . 05$. There was also a significant positive correlation between level of coffee consumption and PSQI. Participants who had high scores on the Peterson Sleep Quality Index drank greater amounts of coffee, $r = . 31$, $p < . 05$. Finally, there was a significant negative correlation between level of soft drink consumption and MEQ score. Evening types drank more soft drinks than Morning-Types, $r = -. 30$, $p < . 05$. All other correlations in the analysis failed to reach statistical significance. The complete results of the correlation analyses are presented in table 1.

Table 1

Correlations found between Morningness-Eveningness Questionnaire (MEQ), Pittsburg

Sleep Quality Index (PSQI), Multi-tasking Index, and Caffeine Consumption

Questionnaire. . _ MEQ PSQI Multi-Tasking .

MEQ score — -. 16 -. 32*

PSQI score — . 03

Caffeine Consumption

Coffee -. 06 . 31* -. 06

Tea . 20 -. 20 -. 08

Hot Chocolate . 13 -. 18 . 08

Soft Drinks -. 30* . 02 . 08

Energy Drinks -. 14 . 20 . 07

. Total Caffeine -. 06 . 25 . 01 .

* p < . 05. ** p < . 01.

Discussion

We predicted that participants who consumed a greater level of caffeine would have higher scores, indicating poorer sleep quality, on the Pittsburgh Sleep Quality Index. Although total caffeine consumption level failed to predict a higher sleep quality score, there was a significant negative correlation between level of coffee consumption and PSQI.

Morningness-Eveningness Questionnaire Score was predicted to negatively correlate with score on the Caffeine Consumption Questionnaire. Total caffeine consumption did not significantly correlate with MEQ score. Level of caffeinated soft drink consumption did significantly correlate with MEQ with evening types consuming greater amounts of caffeinated soft drinks than morning-types.

It was predicted that evening types would report more sleep problems via the PSQI. This correlation failed to reach significance in our analysis. There is no significant difference between Pittsburgh Sleep Quality Index score in evening-types from morning-types.

We predicted that students who scored higher on the Nighttime Activities (Multi-tasking) Index would also consume a greater amount of caffeine. The analysis revealed no significant relationship between these variables.

Our final prediction was that evening-types would engage in a greater level of technology use in the evening, as indicated by a significant negative relationship between MEQ score and Multi-Tasking Index. There was a significant relationship between MEQ and Multi-Tasking Index. Evening types did tend to engage in more activities involving technology between the hours of 2100 and 0600 than morning-types, as predicted.

Using The Caffeine Consumption Questionnaire and Pittsburgh Sleep Quality Index as a measure, consumption of higher levels of caffeine did not did predict poorer sleep quality. Although several studies found that caffeine consumption increased sleep onset latency, decreased total sleep time and increased daytime sleepiness, we did not find that high levels of total caffeine consumption predicted a significantly poorer sleep quality score (Roehrs & Roth, 2008). Although total caffeine consumption and PSQI were not correlated, caffeinated coffee consumption did predict a poorer sleep quality score. This contrasts findings by Sanchez-Ortunga et al. (2005) in which up to eight cups of coffee consumed by regular coffee drinkers did not result in a significantly lower TST. Although it should be taken into consideration that TST is only one component of the PSQI.

Contrary to our findings, Gianotti et al. (2002) found that Evening-types tended to consume a greater amount of caffeine than morning types. Ana Aden (1994) also found that daily caffeine consumption increased as preference for evening activity increased. Although these results contrast our findings, we did find a slight but significant relationship between consumption of caffeinated soft drinks and preference for evening.

Gianotti et al. (2002) also found that evening-type adolescents reported poorer subjective sleep quality than morning types. These evening-type adolescents also showed a more irregular sleep schedule. Evening types showed greater daytime sleepiness, increased frequency of falling asleep during the day, and other indications of poor sleep quality (Gianotti et al., 2002). Contrary to these findings, we found no relationship between PSQI score and chronotype.

Although Calamero et al. (2009) found that those reporting an increased multi-tasking index score also consumed greater amounts of caffeine, we found no relationship between the two. We did, however, find a significant relationship between chronotype and multi-tasking index. Evening types tended to engage in more technologically based activities between 2100 and 0600. There was no previous research available examining the relationship between chronotype and Night-time Activities/Multi-tasking Index. This may be a possible area of further investigation.

One limitation of this study is the lack of diversity in the sample. The participants were a relatively small group of undergraduate psychology students between the age of 20-31. The small sample size may have made it difficult for trends in the data to reach significant levels. Also, chronotype and caffeine consumption have been shown to change over the lifetime, however, we were able to examine only a small window of young adulthood, leaving little opportunity for drastic variations. Also, being students, many of these participants may have schedules which vary drastically from day to day, as well as an increased frequency of engaging in late night activities with peers. These behaviours may have a confounding influence on many sleep variables. Thus, these findings may not be generalized to the population. Re-examining the same material with a larger and more diverse sample may yield more helpful results. This would be fairly simple to do since the questionnaires may be filled out with little guidance or instruction, and simply be distributed and returned by post or electronically administered.

Another limitation is that the entire data collection procedure relied completely on student self-reports. The accuracy of these self-evaluations of sleep quality, sleep latency, and level of caffeine consumption may not have been accurate. Some questionnaires were also self scored, leaving open the opportunity for error in calculations. Although much of our analysis of caffeine consumptions effect on sleep quality failed to reach statistical significance, the trends in the data indicate that caffeine does likely detrimentally influence sleep quality. As previous research has shown, the impact caffeine may have on daytime functioning and sleep may be greater than many people realize. Caffeine consumption may be leading to a poorer nights sleep, and this less recuperative sleep subsequently may lead to more caffeine consumption the following day to compensate for the caffeine disrupted sleep of the night before. One can see how this may result in a caffeine/poor sleep cycle.

Another interesting finding was the correlation between chronotype and Multi-tasking index score. It would be interesting to investigate whether this relationship is due to evening-types engaging in more night-time activities in order to simply occupy the time between when they believe they should be sleeping and when they are able to sleep, or if the opportunity to occupy the mind and stave off sleep, and disrupting their natural activity time preference.

Although we did not specifically make any predictions regarding Multi-tasking Index and PSQI, it is interesting to note that there was no relationship between Multi-tasking Index and PSQI. Research by Calamaro et al. (2009) found that a high Multi-tasking Index was related to sleep problems like difficulty falling asleep, decreased total sleep time and daytime sleepiness.

There was no relationship between chronotype and sleep quality in our study, despite findings of a significant relationship by Gianotti et al. (2002). Although the trend in our data leaned towards a similar relationship, it did not reach significance. The difference in our findings compared to Gianotti et al. (2008) may have to do with factors unique to adolescents.

In summary, there is a significant relationship between Multi tasking and chronotype, PSQI and coffee consumption level. All other comparisons failed to reach significance. The trend in the data indicate that caffeine does indeed detrimentally effect sleep quality, but the degree of influence it has remains unclear.

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