A Project entitled

Examining the effects of instant one-time caffeinated coffee consumption on cognitive performance of partially sleep-deprived university students with evening chronotype

Submitted by

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Declaration

I, LUI An, declare that this research reports represents my own work under the supervision of Dr. WAN Lai Yin, Sarah, and that it has not been submitted previously for examination to any tertiary institution for a degree, diploma or other qualifications.

*Signed*____________________________

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Abstract

Evening-chronotyped university students are commonly found in Hong Kong university campuses during late night. Despite previous literature studying the impacts of evening chronotype on college and university students, very few studies have examined the effects of instant one-time caffeinated coffee consumption on cognitive performance of partially sleep-deprived university students with evening chronotype. The main objective of this study is to compare the cognitive performance among partially sleep-deprived university students who have instantly one-time consumed caffeinated coffee and those who have not, in the areas of short-term memory capacity, information processing speed and arithmetic accuracy. Data for this research will come from experiment and questionnaire. Of the 36 university students, they will be arranged into three subject groups: (i) instantly one-time consuming caffeinated coffee, (ii) instantly one-time consuming decaffeinated coffee, and (iii) no instant coffee consumption, for conducting this study. For comparison of three cognitive variables of the aforementioned three subject groups, a three-way between-groups MANOVA will be run. It was found that there were statistically significance between two cognitive variables and subject groups, i.e. short-term memory capacity (p = .000) and information processing speed (p = .001), instead of arithmetic accuracy (p = .646). Cognitive performance, especially in short-term memory capacity and information processing speed, of partially sleep-deprived university students with evening chronotype is likely enhanced if they instantly one-time consume caffeinated coffee just 30 minutes before attending cognition-demanding tasks and learning activities, yielding a more favourable learning outcome.

Keywords: Evening Chronotype, Instant One-time Coffee Consumption, Partial Sleep Deprivation, Cognitive Performance, Short-term Memory Capacity, Information Processing Speed, Arithmetic Accuracy

Introduction

Evening chronotype is endemic among university students in Hong Kong, whose events organized by university and campus residence are usually scheduled in nighttime (Lau et al., 2013). A vast majority of university students engage in part-time jobs and complete assignments at the expense of sleep. In fact, from biological perspective, there is a propensity for late adolescence to delay their circadian rhythm, shifting their circadian typology to be more evening-typed (Short et al., 2013). Thus, evening-chronotyped university students with late night bedtimes usually report insufficient sleep or sleep deprivation (Wernette & Emory, 2017). In the meantime, it is commonly to observe that a lot of Hong Kong university students drink caffeinated coffee to counteract drowsiness resulted from sleep deprivation. Compared to other caffeinated beverages or energy drinks, canned coffee is more easily accessible in vending machines and convenient stores, thus becoming one of the most welcome choices of "night owl" university students. Instant coffee consumption shows a recuperative effect in improving various types of cognitive performance (Mahachandra, Munzayanah & Yassierli, 2017), and the chemical mechanism is found to be related to pharmacological activity of caffeine (Zhou et al., 2018).

Not surprisingly, not many evening-chronotyped university students would take actions to adjust their late sleep schedules. Short et al. (2013) pointed out that evening-chronotyped adolescents are predicted to show poorer academic results due to markedly lower cognitive abilities. This is an important finding which is consistent with previous research. Although a lot of literature studied the adverse impacts of sleep deprivation on academic performance, very few of them addressed the effects of instant one-time caffeinated coffee consumption on cognitive performance of partially sleep-deprived students with evening chronotype. In view of this, this research aims to compare the cognitive performance between partially sleep-deprived university students who have instantly one-time consumed caffeinated coffee and those who have not, with particular focus in three main cognitive areas, namely short-term memory capacity, information processing speed and arithmetic accuracy. Short-term memory and arithmetic accuracy are two specific cognitive abilities which predict academic performance of students

(Bangirana et al., 2013), and information processing speed is of essential importance to sleep-deprived students who are often required to process academic input (Cohen-Zion et al., 2016). Therefore, it is theoretically important to examine the effects of one-time caffeinated coffee consumption on cognitive performance of partially sleep-deprived students in hope of suggesting another drinking routines for these evening-chronotyped students as a way of boosting their academic performance.

Literature Review

Evening Chronotype

Chronotype is an individual preference for sleep timing and timing of other activities as stable traits (Lucassen et al., 2013). Morningness and eveningness are two main extents to measure an individual preference for one's sleep timing and behaviors (Lucassen et al., 2013). Considering an individual with eveningness, Hasler et al. (2013) explained that individuals with evening chronotype present with an altered sleep pattern and circadian rhythm which are characterized by delayed bedtime, shorter total sleep duration on weekdays, marked fatigue when awake and observable swings between sleep-wake timing on work and free days. Some scholars in the field of sleeping developed a standardized test to distinguish one's circadian typology. To determine morningness or eveningness of an individual, Horne and Ostberg developed a quantitative Self-assessment Morningness-eveningness questionnaire to classify one's chronotype of based on a total score reported by the individual (Horne & Ostberg, 1976).

In this research, evening chronotype is defined as one's chronotype characterized by having delayed sleep onset, shorter total sleep duration on weekdays, presenting with marked fatigue when awake, and observable swings between sleep-wake timing on work and free days. Eveningness leads to delayed sleep onset and shorter total sleep duration on weekday (Hasler et al., 2013), and eventually evolves into partial sleep deprivation (Gilbert & Weaver, 2010). Adolescents with evening chronotype, who experience marked fatigue and sleepiness due to partial sleep deprivation during school times, predicts poor academic performance resulted from decreased cognitive functions that are essential to academic performance (Short et al., 2013). Even though a number of literatures pointed out the adverse impacts of evening chronotype on academic performance, the effects of instant one-time caffeinated coffee consumption on average cognitive performance of these partially sleep-deprived populations with evening chronotype is still unknown.

Partial Sleep Deprivation

According to Pilcher and Huffcutt (1996), there are three main types of sleep deprivation. Individuals may have different kinds of sleep deprivation based on the total consecutive length of sleep deprivation, which can be classified into long-term sleep deprivation (> 45 hours), short-term sleep deprivation (≤ 45 hours), and partial sleep deprivation (< 5 hours within 24 hours) (Pilcher & Huffcutt, 1996). In addition, some literature reveals the definition of partial sleep deprivation, defining it as sleep restriction less than 7 hours within 24 hours (< 7 hours within 24 hours) (Durmer & Dinges, 2005). To come up with a more appropriate definition, partial sleep deprivation is thus defined as total sleep duration restricted to less than 5-7 hours within 24 hours in this study.

Partial sleep deprivation is more common in normal population. Despite partial sleep deprivation giving a more accurate depiction of real-life situations, only a handful of literature evaluated the effects of partial sleep deprivation on cognitive performance (Alhola & Polo-Kantola, 2014). Mahachandra, Munzayanah and Yassierli (2017) pointed out that elevated levels of fatigue and sleepiness owing to sleep deprivation poses negative effects on cognitive performance. Decline in neurocognitive performance is mediated through decreased alertness and attention, slowing of cognitive processing, and wake-state instability (Alhola & Polo-Kantola, 2014), resulting in cognitive lapses characterized by very short periods of sleep-like electroencephalography activity (Priest et al., 2001). It is expected that an evening-chronotyped university student shows a significant decline in cognition after partial sleep-deprivation in a certain weekday. The effects of partial sleep deprivation on cognitive domains that are important to academic performance become a research focus in this study.

One-time Caffeinated Coffee Consumption

Chaudhary et al. (2016) stated that use of caffeine has been associated with improving cognitive performance resulted from sleep deprivation. Current caffeine consumption literature pointed out three main caffeine intake method including one-time intake, intermittent intake and habitual intake (Mahachandra, Munzayanah & Yassierli, 2017). Mahachandra, Munzayanah and Yassierli (2017) studied the efficacy of coffee intake as a countermeasure to sleepiness on partially sleep-deprived drivers. They found that coffee intake gives a marked improvement in cognitive function of partially sleep-deprived drivers, regardless of one-time or intermittent intake (Mahachandra, Munzayanah & Yassierli, 2017). The reaction time and attention spans of partially sleep-deprived drivers having caffeinated coffee consumption are found to be shortened and prolonged respectively when compared to partially sleep-deprived drivers without coffee consumption. and attention spans Even though coffee is proven to increase cognitive abilities, different intake methods will result in mild different cognitive outcomes (Mahachandra, Munzayanah & Yassierli, 2017). Even though Mahachandra, Munzayanah and Yassierli discovered a marked improvement in reaction time and attention spans of partially sleep-deprived individuals, they have not found and explained the effects of one-time caffeinated coffee consumption in cognitive domains essential to academic performance. To enable optimal experimental accuracy, one-time intake is selected in this study to eliminate other possible inferences and functional variables.

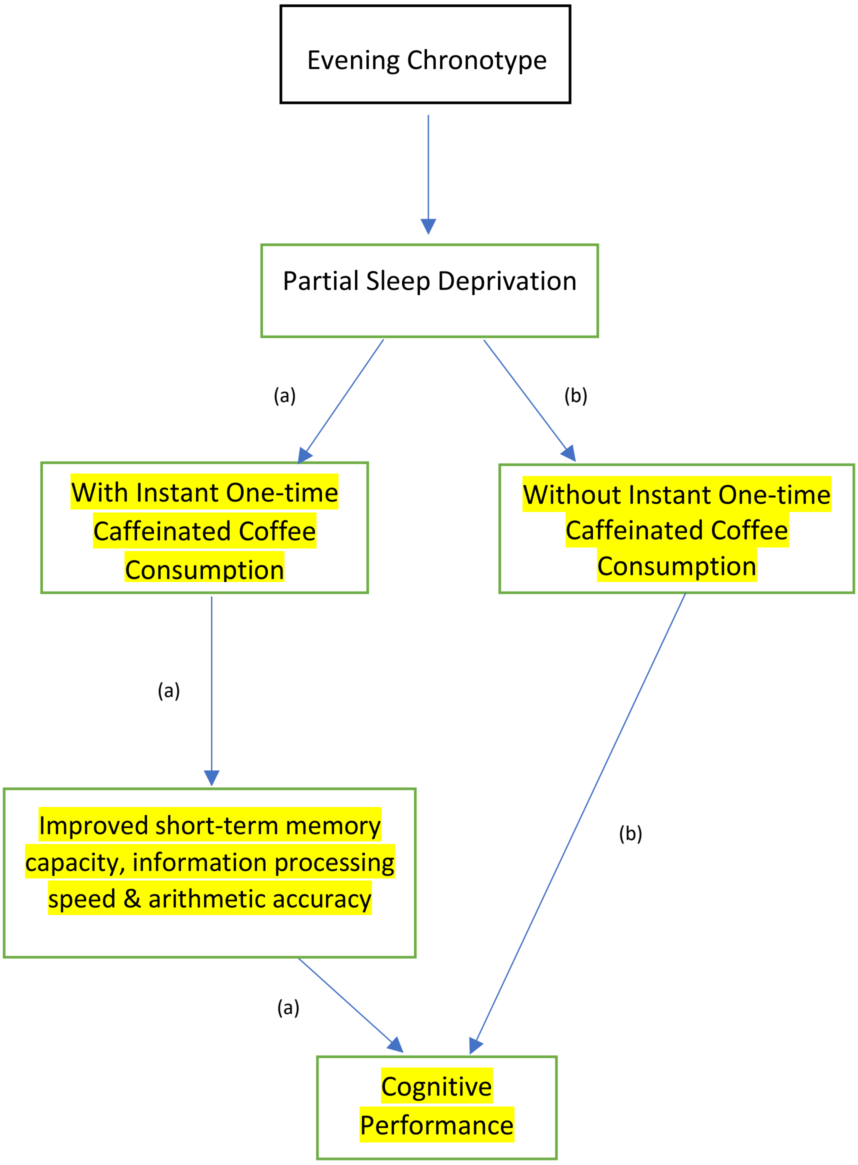
On the other hand, the volume of coffee and dose of caffeine intake are also concerned in this study. In fact, the concept of “one cup of coffee” remains debatable across literature. The definition of “one cup of coffee” is arguable as the caffeine content and its pharmacokinetics are variable due to different preparation methods (Bangalore, Parkar & Messerli, 2007; Nikic et al., 2014). Some literature revealed "one cup of coffee" as one cup of 8-oz, i.e. 250 mL, of coffee with caffeine content ranging from 30 to 100 mg (Bangalore, Parkar & Messerli, 2007). To easily control the amount of caffeine consumed by subject groups, standardized can of 250 mL Nescafe containing 60 to 80 mg of caffeine (Nestle, n.d.) is used in this experimental design as the liquid volume and dose of caffeine are more consistent with the definition in current literature.

Cognitive Performance

Markedly lower cognitive abilities due to partial sleep deprivation often result in human errors, leading to poorer academic performance (Short et al., 2013). Literature pointed out that several cognitive domains are essential to academic performance. Working memory, visual and spatial abilities, attention, arithmetic and reasoning are examples of cognitive measures of students in academic performance (Bangirana et al., 2013). More importantly, short-term memory and arithmetic accuracy are two specific cognitive abilities that are susceptible to sleep loss effects and predict academic performance of students (Bangirana et al., 2013), and information processing speed is particularly vulnerable to sleep-deprived students who are often required to process academic input (Cohen-Zion et al., 2016). As a result, short-term memory capacity, information processing speed and arithmetic accuracy are three key cognitive domains to academic performance to be studied.

Theoretical Framework

Below is a theoretical framework illustrating the general relationship among different operational variables in this study.



Note: 1. (a) refers to partially sleep-deprived students with evening chronotype having instant one-time caffeinated coffee consumption.

2. (b) refers to partially sleep-deprived students with evening chronotype NOT having instant one-time caffeinated coffee consumption.

3. Highlights in yellow colour indicate operational variables.

Figure 1. A theoretical framework illustrating the relationships among evening chronotype, partial sleep deprivation, instant one-time caffeinated coffee consumption and cognitive performance.

Research Questions

Previous literature has examined gender differences in chronobiology thoroughly. Male university students are significantly different from female university students in morningness-eveningness preference, presenting male having a more pronounced preference to evening-chronotype due to time of greatest efficiency, sleep phase and sleep inertia (Adan & Natale, 2002). However, the gender differences in improvement of cognitive performance associated with partial sleep deprivation by one-time caffeinated coffee consumption remains unknown. The present research examining the effects of instant one-time caffeinated coffee consumption on average cognitive performance of partially sleep-deprived students with evening chronotype would probe into three questions of interest:

Q1) Is short-term memory capacity of partially sleep-deprived students with evening chronotype better after instant one-time caffeinated coffee consumption?

Q2) Does information processing speed of partially sleep-deprived students with evening chronotype become faster after instant one-time caffeinated coffee consumption?

Q3) Does calculation of partially sleep-deprived students with evening chronotype become more accurate after instant one-time caffeinated coffee consumption?

Hypotheses

Based on the above three research questions, three hypotheses are derived as belows:

Hypothesis 1: Instant one-time caffeinated coffee consumption enables greater short-term memory capacity of partially sleep-deprived students with evening chronotype.

Hypothesis 2: Instant one-time caffeinated coffee consumption enables faster information processing speed of partially sleep-deprived students with evening chronotype.

Hypothesis 3: Instant one-time caffeinated coffee consumption enables more accurate calculation of partially sleep-deprived students with evening chronotype.

Research Methodology

Nature of Participants

In this research study, convenience sampling was employed. A relevant research conducted by Mahachandra, Munzayanah, and Yassierli (2017) determined 8 participants in their within-subject experimental design. Therefore, 12 participants recruited for each subject group can ensure robustness of data. A total of 36 participants (18 males and 18 females) were involved in this research. Participants were divided into three subgroups (refer to the Table 1 below): (1) instantly one-time caffeinated coffee consumption (6 males & 6 females), (2) instantly one-time decaffeinated coffee consumption (6 males & 6 females), and (3) no instant one-time coffee consumption (6 males & 6 females). All the participants met the following criteria: (1) having an evening chronotype and (2) were partially sleep-deprived (sleep duration restricted to less than 5-7 hours within 24 hours). To check their eligibility, they were asked to complete 19 standardized questions in Horne and Ostberg's Self-assessment Morningness-eveningness Questionnaire in the beginning (Horne & Ostberg, 1976). The remaining information were collected only if they met all the requirements after quick calculation. For evening-chronotyped met the above criteria, the sleep duration is self-reported by them and is recorded by student investigator.

Group Types	Nature of Participants
Group 1 Instant one-time caffeinated coffee consumption	8 Males and 8 Females
Group 2 (Control Group) Instant one-time decaffeinated coffee consumption	8 Males and 8 Females
Group 3 No instant one-time coffee consumption	8 Males and 8 Females

Table 1. Three subject groups in experiment.

Instruments

Horne & Ostberg Self-assessment Morningness-eveningness Questionnaire

Horne & Ostberg Self-assessment Morningness-eveningness Questionnaire (MEQ) was developed by Horne and Ostberg as a standardized scale to determine circadian chronotype of an individual (Horne & Ostberg, 1976). MEQ involves a section of 19 standardized questions related to individual sleep preferences and habits. Based on individual sleep preferences and habits reported by the individual in the questionnaire, he/she was classified into one of the five main chronotypes (See Table 2 below). In Adan & Natale (2002)'s research regarding the gender differences in morningness-eveningness preference, they employed Horne and Ostberg Self-assessment MEQ to investigate the gender differences in morningness-eveningness preference among largest university student population (N = 2135). According to Adan & Natale (2002), men are found to present a more pronounced evening chronotype, showing a significant difference in mean scores ($p < 0.0001$) and distribution per circadian typology ($p < 0.00001$) using Horne and Ostberg Self-assessment MEQ. In the meantime, Adan & Natale mentioned in their research that the full scale alpha Cronbach coefficient of the MEQ for their present sample is 0.83 (Adan & Natale, 2002). In general, reliability of the questionnaire is usually measured by Cronbach's alpha correlation coefficient, with its values ranging from 0.7 to 0.9 being considered to be very reliable (Bravo & Potvin, 1991). Therefore, Horne & Ostberg Self-assessment MEQ is a reliable instrument which gives out a valid research output. Table 2 shows suggested five main chronotypes in chronobiology by Horne and Ostberg.

16-30	31-41	42-58	59-69	70-86
Definite Evening	Moderate Evening	Intermediate	Moderate Morning	Definite Morning

Table 2. Five main chronotypes in chronobiology.

To check reliability of Horne & Ostberg Self-assessment Morningness-eveningness Questionnaire (MEQ), the reliability analysis was conducted as belows:

Reliability Analysis (Horne & Ostberg Self-assessment Morningness-eveningness Questionnaire)

Case Processing Summary

		N	%
Cases	Valid	36	100.0
	Excluded[a]	0	.0
	Total	36	100.0

Table 3. Case Processing Summary

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.808	.812	19

Table 4. Reliability Statistics

Item Statistics

	Mean	Std. Deviation	N
MEQ Q1	1.06	.984	36
MEQ Q2	.83	1.082	36
MEQ Q3	1.19	.401	36
MEQ Q4	1.86	.990	36
MEQ Q5	1.67	.632	36
MEQ Q6	1.61	.728	36
MEQ Q7	1.56	.652	36
MEQ Q8	1.22	.422	36
MEQ Q9	1.58	.500	36
MEQ Q10	1.50	.697	36
MEQ Q11	1.72	.566	36
MEQ Q12	1.31	.467	36
MEQ Q13	1.36	.683	36
MEQ Q14	1.08	.280	36
MEQ Q15	1.67	.632	36
MEQ Q16	1.72	.741	36
MEQ Q17	1.47	.560	36
MEQ Q18	1.06	.333	36
MEQ Q19	1.00	1.014	36

Table 5. Item Statistics

Inter-Item Covariance Matrix

	MEQ Q1	MEQ Q2	MEQ Q3	MEQ Q4	MEQ Q5	MEQ Q6	MEQ Q7	MEQ Q8	MEQ Q9	MEQ Q10	MEQ Q11	MEQ Q12	MEQ Q13	MEQ Q14	MEQ Q15	MEQ Q16	MEQ Q17	MEQ Q18	MEQ Q19
MEQ Q1	.968	.181	.046	.179	.219	.194	.083	.073	.052	.171	-.013	.040	.179	.081	.190	.016	.116	.054	.171
MEQ Q2	.181	1.171	.205	.405	.171	.362	.210	.038	.100	.286	-.076	.224	.233	-.071	.171	.067	.081	.010	.286
MEQ Q3	.046	.205	.161	.228	.038	.135	.060	.041	.055	.100	-.030	.139	.071	.012	.010	-.002	.048	-.011	.086
MEQ Q4	.179	.405	.228	.980	.181	.259	.165	.146	.169	.243	.046	.215	.166	.040	.152	.103	.296	.008	.371
MEQ Q5	.219	.171	.038	.181	.400	.067	.076	.048	.029	.143	.076	.133	.067	.029	.200	.162	.048	.019	.114
MEQ Q6	.194	.362	.135	.259	.067	.530	.137	.117	.062	.086	.089	.122	.087	.033	.095	.060	.132	.079	.343
MEQ Q7	.083	.210	.060	.165	.076	.137	.425	-.013	.095	.171	.044	.111	.194	-.019	.076	.216	.073	.025	.000
MEQ Q8	.073	.038	.041	.146	.048	.117	-.013	.178	.038	.029	.006	.044	.032	.038	-.038	-.022	.006	-.013	.114
MEQ Q9	.052	.100	.055	.169	.029	.062	.095	.038	.250	.071	.052	.017	.040	.007	.000	.110	.060	-.033	.143
MEQ Q10	.171	.286	.100	.243	.143	.086	.171	.029	.071	.486	-.057	.129	.100	-.014	.171	.086	.129	.029	.114
MEQ Q11	-.013	-.076	-.030	.046	.076	.089	.044	.006	.052	-.057	.321	.002	-.068	.024	.076	.035	.106	.073	.057
MEQ Q12	.040	.224	.139	.215	.133	.122	.111	.044	.017	.129	.002	.218	.087	.002	.048	.002	.023	-.017	.029
MEQ Q13	.179	.233	.071	.166	.067	.087	.194	.032	.040	.100	-.068	.087	.466	-.031	.067	-.040	.053	.037	-.029
MEQ Q14	.081	-.071	.012	.040	.029	.033	-.019	.038	.007	-.014	.024	.002	-.031	.079	.029	-.033	.017	-.005	.029
MEQ Q15	.190	.171	.010	.152	.200	.095	.076	-.038	.000	.171	.076	.048	.067	.029	.400	.019	.133	.076	.114
MEQ Q16	.016	.067	-.002	.103	.162	.060	.216	-.022	.110	.086	.035	.002	-.040	-.033	.019	.549	.049	.016	.171
MEQ Q17	.116	.081	.048	.296	.048	.132	.073	.006	.060	.129	.106	.023	.053	.017	.133	.049	.313	.087	.200
MEQ Q18	.054	.010	-.011	.008	.019	.079	.025	-.013	-.033	.029	.073	-.017	.037	-.005	.076	.016	.087	.111	.057
MEQ Q19	.171	.286	.086	.371	.114	.343	.000	.114	.143	.114	.057	.029	-.029	.029	.114	.171	.200	.057	1.029

Table 6. Inter-Item Covariance Matrix

Inter-Item Correlation Matrix

	MEQ Q1	MEQ Q2	MEQ Q3	MEQ Q4	MEQ Q5	MEQ Q6	MEQ Q7	MEQ Q8	MEQ Q9	MEQ Q10	MEQ Q11	MEQ Q12	MEQ Q13	MEQ Q14	MEQ Q15	MEQ Q16	MEQ Q17	MEQ Q18	MEQ Q19
MEQ Q1	1.000	.170	.117	.184	.352	.270	.129	.176	.106	.250	-.023	.086	.267	.293	.306	.022	.210	.165	.172
MEQ Q2	.170	1.000	.471	.378	.250	.459	.297	.083	.185	.379	-.124	.443	.316	-.235	.250	.083	.134	.026	.260
MEQ Q3	.117	.471	1.000	.573	.150	.462	.230	.244	.273	.357	-.133	.741	.258	.106	.038	-.005	.215	-.083	.211
MEQ Q4	.184	.378	.573	1.000	.289	.359	.256	.350	.342	.352	.082	.465	.245	.146	.243	.141	.534	.024	.370
MEQ Q5	.352	.250	.150	.289	1.000	.145	.185	.179	.090	.324	.213	.451	.154	.161	.500	.345	.134	.090	.178
MEQ Q6	.270	.459	.462	.359	.145	1.000	.287	.383	.170	.169	.216	.359	.176	.163	.207	.112	.323	.327	.464
MEQ Q7	.129	.297	.230	.256	.185	.287	1.000	-.046	.292	.377	.120	.365	.435	-.104	.185	.447	.200	.117	.000
MEQ Q8	.176	.083	.244	.350	.179	.383	-.046	1.000	.181	.097	.027	.226	.110	.322	-.143	-.071	.027	-.090	.267
MEQ Q9	.106	.185	.273	.342	.090	.170	.292	.181	1.000	.205	.185	.071	.119	.051	.000	.296	.213	-.200	.282
MEQ Q10	.250	.379	.357	.352	.324	.169	.377	.097	.205	1.000	-.145	.395	.210	-.073	.389	.166	.329	.123	.162
MEQ Q11	-.023	-.124	-.133	.082	.213	.216	.120	.027	.185	-.145	1.000	.006	-.177	.150	.213	.083	.335	.387	.100
MEQ Q12	.086	.443	.741	.465	.451	.359	.365	.226	.071	.395	.006	1.000	.271	.018	.161	.005	.088	-.112	.060
MEQ Q13	.267	.316	.258	.245	.154	.176	.435	.110	.119	.210	-.177	.271	1.000	-.162	.154	-.078	.139	.160	-.041
MEQ Q14	.293	-.235	.106	.146	.161	.163	-.104	.322	.051	-.073	.150	.018	-.162	1.000	.161	-.160	.106	-.051	.101
MEQ Q15	.306	.250	.038	.243	.500	.207	.185	-.143	.000	.389	.213	.161	.154	.161	1.000	.041	.377	.361	.178
MEQ Q16	.022	.083	-.005	.141	.345	.112	.447	-.071	.296	.166	.083	.005	-.078	-.160	.041	1.000	.119	.064	.228
MEQ Q17	.210	.134	.215	.534	.134	.323	.200	.027	.213	.329	.335	.088	.139	.106	.377	.119	1.000	.468	.352
MEQ Q18	.165	.026	-.083	.024	.090	.327	.117	-.090	-.200	.123	.387	-.112	.160	-.051	.361	.064	.468	1.000	.169
MEQ Q19	.172	.260	.211	.370	.178	.464	.000	.267	.282	.162	.100	.060	-.041	.101	.178	.228	.352	.169	1.000

Table 7. Inter-Item Correlation Matrix

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	1.393	.833	1.861	1.028	2.233	.088	19

Table 8. Summary Item Statistics

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
MEQ Q1	25.42	33.564	.357	.	.804
MEQ Q2	25.64	31.666	.473	.	.796
MEQ Q3	25.28	35.978	.511	.	.798
MEQ Q4	24.61	30.873	.613	.	.783
MEQ Q5	24.81	34.561	.489	.	.794
MEQ Q6	24.86	33.152	.586	.	.787
MEQ Q7	24.92	34.764	.443	.	.797
MEQ Q8	25.25	37.050	.267	.	.806
MEQ Q9	24.89	36.216	.354	.	.802
MEQ Q10	24.97	34.142	.488	.	.794
MEQ Q11	24.75	37.393	.128	.	.812
MEQ Q12	25.17	35.686	.483	.	.797
MEQ Q13	25.11	35.644	.305	.	.804
MEQ Q14	25.39	38.187	.096	.	.810
MEQ Q15	24.81	35.018	.425	.	.798
MEQ Q16	24.75	36.021	.228	.	.809
MEQ Q17	25.00	34.971	.500	.	.795
MEQ Q18	25.42	37.507	.240	.	.807
MEQ Q19	25.47	32.828	.408	.	.801

Table 9. Item-Total Statistics

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
26.47	38.599	6.213	19

Table 10. Scale Statistics

As previously mentioned, the full scale alpha Cronbach coefficient of the MEQ for their present sample is 0.83 (Adan & Natale, 2002). In our research, the Cronbach alpha coefficient was .81. In brief, Horne & Ostberg Self-assessment Morningness-eveningness Questionnaire is a reliable scale to determine the chronobiology of the participants. In the next section, the assumption checking for MANOVA analysis will be conducted.

Assumption Checking

Before proceeding to the MANOVA analysis, assumption testing has to be completed, including sample size, normality, univariate and multivariate outliers, multivariate normality, linearity, multicollinearity and singularity, and homogeneity of variance-covariance matrices.

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation
Result (Digit Span Test)	36	6	7	13	9.36	1.533
Result (Polygon Test)	36	91	6	97	44.36	19.236
Result (No. of Errors in Mental Arithmetic Subtraction Test)	36	6	0	6	2.00	1.957
Valid N (listwise)	36					

Table 11. Descriptive Statistics (Assumption Checking of Sample Size)

In this present research, there are a total of twelve cells involved (sex of participants and three subject groups as four independent variables, and three dependent variables for each). There were 36 participants in total, i.e. sample size N = 36, which can ensure “robustness” of data set (Julie, 2003). Thus, there are no serious violation of assumption checking in sample size and normality. Then, univariate and multivariate outliers, and multivariate normality are checked below:

Descriptive Statistics

	N	Minimum	Maximum
Zscore: Result (Digit Span Test)	36	-1.53970	2.37295
Zscore: Result (Polygon Test)	36	-1.99428	2.73653
Zscore: Result (No. of Errors in Mental Arithmetic Subtraction Test)	36	-1.02214	2.04429
Valid N (listwise)	36		

Table 12. Descriptive Statistics (Assumption Checking of Multivariate Outliers)

Regression

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Result (No. of Errors in Mental Arithmetic Subtraction Test), Result (Digit Span Test), Result (Polygon Test)[b]	.	Enter

a. Dependent Variable: Caffeinated Coffee Consumption = 1,
Decaffeinated Coffee Consumption = 2,
No Coffee Consumption = 3

b. All requested variables entered.

Table 13. Regression Table (Assumption Checking of Multivariate Outliers)

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.721[a]	.520	.475	.600

a. Predictors: (Constant), Result (No. of Errors in Mental Arithmetic Subtraction Test), Result (Digit Span Test), Result (Polygon Test)

b. Dependent Variable:
Caffeinated Coffee Consumption = 1, Decaffeinated Coffee Consumption = 2,
No Coffee Consumption = 3

Table 14. Model Summary of Regression Table (Assumption Checking of Multivariate Outliers)

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12.480	3	4.160	11.556	.000[b]
	Residual	11.520	32	.360		
	Total	24.000	35			

a. Dependent Variable: Caffeinated Coffee Consumption = 1, Decaffeinated Coffee Consumption = 2, No Coffee Consumption = 3

b. Predictors: (Constant), Result (No. of Errors in Mental Arithmetic Subtraction Test), Result (Digit Span Test), Result (Polygon Test)

Table 15. ANOVA Table (Assumption Checking of Multivariate Outliers)

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.545	.654		8.478	.000
	Result (Digit Span Test)	-.341	.081	-.632	-4.200	.000
	Result (Polygon Test)	-.005	.006	-.112	-.745	.462
	Result (No. of Errors in Mental Arithmetic Subtraction Test)	-.067	.052	-.159	-1.301	.203

a. Dependent Variable: Caffeinated Coffee Consumption = 1, Decaffeinated Coffee Consumption = 2,
No Coffee Consumption = 3

Table 16. Coefficients Table (Assumption Checking of Multivariate Outliers)

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	.58	3.02	2.00	.597	36
Std. Predicted Value	-2.384	1.708	.000	1.000	36
Standard Error of Predicted Value	.126	.319	.193	.055	36
Adjusted Predicted Value	.43	3.02	1.99	.606	36
Residual	-.798	1.496	.000	.574	36
Std. Residual	-1.330	2.493	.000	.956	36
Stud. Residual	-1.360	2.682	.007	1.018	36
Deleted Residual	-.835	1.731	.010	.652	36
Stud. Deleted Residual	-1.379	2.999	.024	1.057	36
Mahal. Distance	.578	8.911	2.917	2.351	36
Cook's Distance	.000	.302	.035	.067	36
Centered Leverage Value	.017	.255	.083	.067	36

a. Dependent Variable: Caffeinated Coffee Consumption = 1, Decaffeinated Coffee Consumption = 2, No Coffee Consumption = 3

Table 17. Residuals Statistics (Assumption Checking of Multivariate Outliers)

Number of dependent variables	Critical Value
2	13.82
3	16.27
4	18.47
5	20.52
6	22.46
7	24.32

Cited in Pearson, E.S. and Hartley, HO. (Eds) (1958). Biometrika tables for statisticians (vol. 1, 2nd edn). New York: Cambridge University Press.

Table 18. Number of Dependent Variables & Critical Value (Assumption Checking of Multivariate Outliers)

By assumption checking, Residuals Statistics is obtained, with Mahalanobis Distance shown on third last row on the above table, i.e. 8.911. As the Mahalanobis Distance (8.911) is smaller than the critical value

(16.27), there are no substantial multivariate outliers in the present research. In the next step, linearity will be checked.

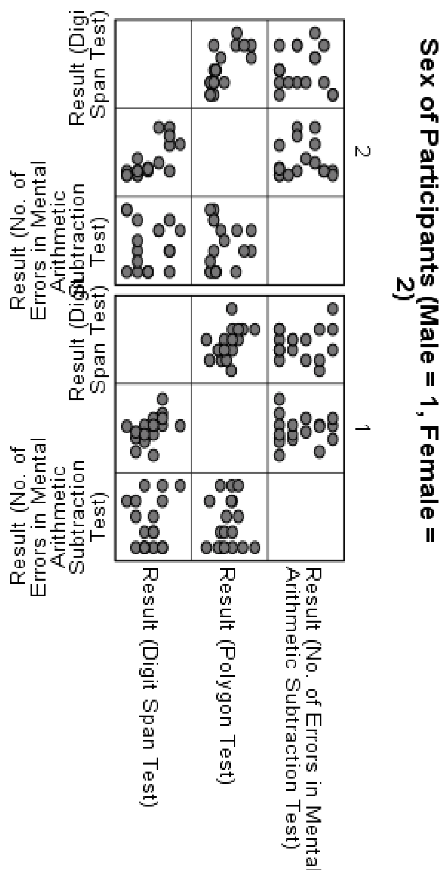


Figure 2. Linearity Plot (Assumption Checking of Linearity)

These plot output above does not show any obvious evidence of non-linearity, with the assumption of linearity satisfied in our research.

Correlations

Correlations

		Result (Digit Span Test)	Result (Polygon Test)	Result (No. of Errors in Mental Arithmetic Subtraction Test)
Result (Digit Span Test)	Pearson Correlation	1	.581**	.000
	Sig. (2-tailed)		.000	1.000
	N	36	36	36
Result (Polygon Test)	Pearson Correlation	.581**	1	-.005
	Sig. (2-tailed)	.000		.975
	N	36	36	36
Result (No. of Errors in Mental Arithmetic Subtraction Test)	Pearson Correlation	.000	-.005	1
	Sig. (2-tailed)	1.000	.975	
	N	36	36	36

**. Correlation is significant at the 0.01 level (2-tailed).

Table 19. Correlation Table (Assumption Checking of Multicollinearity and Singularity)

Julie (2003) pointed out that MANOVA analysis works best when the dependent variables are moderately correlated. The pearson correlation coefficient is .581 between digit span test result and polygon test results, these two variables are suitable for MANOVA analysis. However, the number of errors in mental arithmetic subtraction test is correlated to digit span test result (pearson coefficient = .000) and is negatively correlated to polygon test result (pearson coefficient = -.005). Therefore, this variable is not quite suitable for MANOVA analysis (this variable also does not reach statistical significance in MANOVA analysis, which will be presented in the "Results" section.)

Coffee

Canned caffeinated Nescafe, with a total volume of 250 mL and containing 60 to 80 mg of caffeine, will be used in this study. 250 mL Canned Nescafe is the easiest to purchase from vending machines and convenient stores compared to other brands of coffee. For the preparation of decaffeinated coffee, Nestle coffee beans (97% Decaffeinated) will be prepared for subject group 2. To avoid possible placebo effect, a glassed cup with 250 mL volume will be used to serve participants so as to conceal the actual kind of coffee to be consumed.

Rationale of Experimental Design & Possible Placebo Effect

Interindividual variability of caffeine absorption and its effect to human body is often shown in experiment (Nehlig, 2018). Blanchard and Sawers (1983) discovered that there is a large variation in caffeine half-life in humans, ranging from 2.3 to 9.9 hours (cited in Nehlig, 2018). Blanchard and Sawers (1983) also pointed out that 99% of caffeine ingested in gastrointestinal tract is absorbed within 45 minutes, with peak plasma caffeine concentration reached at 30th minute (Nehlig, 2018). Therefore, participants who took part in the experiment had been reminded not to drink any caffeine-containing beverages 10 hours before the experiment so as to avoid remaining caffeine effects by previous consumption. For participants in subject group 1 and 2 (16 males and 16 females in total), they were asked to start cognitive tests 30 minutes after instant one-time coffee consumption in order to ensure maximum caffeine amount was in effect.

To further note here, participants with instant one-time coffee consumption in the experiment were not told the actual type of coffee they had consumed. This experimental design is to minimize possible placebo effect that may interfere the actual cognitive performance of the participants in the experiment. In addition, urgeness to urinate is another possible masking factor that has a considerable influence on participants' willingness to continue cognitive tasks. According to Mahachandra, Munzayanah & Yassierli (2017), caffeine in liquid state can catalyze its function as a diuretic which could cause the participants to need to urinate during the data collection process. Participants who had instant coffee consumption in the experiment were therefore advised to go to toilet before attending cognitive tasks.

Cognitive Tasks

To compare the cognitive performance among three subject groups, three cognitive tasks will be introduced. Cambridge Brain Science online cognitive tasks are employed to assess partcipants in the areas of short-term memory capacity and information processing speed (Cambridge Brain Sciences, 2020). The details of these two cognitive tasks are as below:

Cognitive Task 1: Digit Span Test (for short-term memory capacity assessment)

Step 1: A sequence of numbers appears on the screen one at a time.

Step 2: At the sound of the beep, participant need to click the numbers in the same order.

Step 3: The number of digits increases with correct answers. His/Her performance is indicated by the average number of digits correctly remembered.

Cognitive Task 2: Polygon Test (for information processing speed assessment)

Step 1: Two panels appear on screen. One contains two overlapping shapes and another contains just one shape.

Step 2: Participant must determine if the single shape is identical to one of the overlapping shapes, or if it is subtly different than both shapes. The difficulty level increases with every correct answer.

On the other hand, a mental arithmetic subtraction test is used to test arithmetic accuracy of the participants. This cognitive task aims to assess the maximum level of mental subtraction and to record the number of inaccuracy reported by the participants. This task will last for 5 minutes.

Cognitive Task 3: Mental Arithmetic Subtraction Test (for arithmetic accuracy assessment)

Step 1: Participant will be asked to subtract 1000 by 7 and obtain a result.

Step 2: Participant will subtract the first result by 7, and so on. If the participant fails to get the correct remainder during the test, he/she will be asked to re-attempt the subtraction from 1000 again.

Data Collecting Procedure

In the beginning, participants were asked to complete section one and two of the questionnaires. If the participant was identified as evening-chronotyped, he/she was invited to complete the remaining sections. The sensitivity and confidentiality of academic results may create ethical consideration. Therefore, an ethical research approval was shown and consent of participants were obtained in advance. Participants then completed the survey individually and were notified their sensitive data will be kept strictly confidential before and after the survey. Before the day of experiment, participants had received *instructions to participants* (both Chinese and English version) via email or WhatsApp (refer to Appendix F & Appendix G).

Results

Statistical Package for Social Sciences (SPSS) was used for statistical analysis in this research. Descriptive statistics were reported to show the main information, including (1) nature of participants, i.e. sex of participants and age, (2) total score obtained by participants in Morningness-eveningness Questionnaire (MEQ), (3) data group, i.e. caffeinated coffee consumption (Group 1), decaffeinated coffee consumption (Group 2) and no coffee consumption (Group 3), (4) sleep duration of participants before the day of experiment, (5) result in digit span test, (6) result in polygon test, and (7) result in number of errors recorded in mental arithmetic subtraction test. To compare the average performance in three cognitive tasks among partially sleep-deprived university students who have instantly one-time consumed caffeinated coffee, those who have instantly one-time consumed decaffeinated coffee, and those who have not instantly one-time consumed caffeinated coffee, a three-way between-groups multivariate analysis of variance (MANOVA) was run.

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation
Sex of Participants (Male = 1, Female = 2)	36	1	1	2	1.50	.507
Age	36	7	18	25	21.92	2.407
Total Score obtained in MEQ#	36	21.00	17.00	38.00	26.5556	6.13395
Caffeinated Coffee Consumption = 1, Decaffeinated Coffee Consumption = 2, No Coffee Consumption = 3	36	2	1	3	2.00	.828
Sleep Duration (Hours)	36	3.75	3.00	6.75	5.3056	1.06923
Result (Digit Span Test)	36	6	7	13	9.36	1.533
Result (Polygon Test)	36	91	6	97	44.36	19.236
Result (No. of Errors in Mental Arithmetic Subtraction Test)	36	6	0	6	2.00	1.957
Valid N (listwise)	36					

Note: # Since only participants with evening chronotype were invited for experiments, i.e. Definite Evening (16-30) and Moderate Evening (31-41), the range of total score in Morningness-eveningness Questionnaire of participants is between 16 and 41.

Table 20. Descriptive Statistics

Descriptive Statistics

A total of 36 participants were involved in this research (*N* = 36; Male = 18, Female = 18). The youngest participant is aged 18, while the oldest participant is aged 25 (*Range* = 7, *M* = 21.92, *SD* = 2.407). Among 36 participants, the minimum score of MEQ obtained by the subject was 17, while the maximum score of MEQ obtained was 38 (*Range* = 21, *M* = 26.56, *SD* = 6.13). The total sleep duration was reported by the participants, with the minimum of 3 hours and maximum of 6.75 hours (*Range* = 3.75, *M* = 5.31, *SD* = 1.07). With regard to the performance of 36 participants in cognitive tests, the minimum score and maximum score in digit span test were 7 and 13 respectively (*Range* = 6, *M* = 9.36, *SD* = 1.53). Also, in polygon test, the minimum score and maximum score reported by the participants were 6 and 97 (*Range* = 91, *M* = 44.36, *SD* = 19.24). The minimum number of errors recorded in mental arithmetic subtraction test was 0, while the maximum number of errors was 6 (*Range* = 6, *M* = 2.00, *SD* = 1.96).

MANOVA

Between-Subjects Factors

		N
Sex of Participants (Male = 1, Female = 2)	1	18
	2	18
Caffeinated Coffee Consumption = 1, Decaffeinated Coffee Consumption = 2, No Coffee Consumption = 3	1	12
	2	12
	3	12

Table 21a. Descriptive Statistics (MANOVA - Between-Subjects Factors)

	Sex of Participants (Male = 1, Female = 2)	Caffeinated Coffee Consumption = 1, Decaffeinated Coffee Consumption = 2, No Coffee Consumption = 3	Mean	Std. Deviation	N
Result (Digit Span Test)	1	1	11.17	.983	6
		2	9.00	.632	6
		3	8.67	1.211	6
		Total	9.61	1.461	18
	2	1	11.00	.632	6
		2	8.00	.632	6
		3	8.33	1.211	6
		Total	9.11	1.605	18
	Total	1	11.08	.793	12
		2	8.50	.798	12
		3	8.50	1.168	12
		Total	9.36	1.533	36
Result (Polygon Test)	1	1	66.83	16.774	6
		2	34.33	4.803	6
		3	39.33	24.590	6
		Total	46.83	21.990	18
	2	1	54.50	15.796	6
		2	33.67	5.428	6
		3	37.50	18.108	6
		Total	41.89	16.287	18
	Total	1	60.67	16.816	12

		2	34.00	4.899	12
		3	38.42	20.611	12
		Total	44.36	19.236	36
Result (No. of Errors in Mental Arithmetic Subtraction Test)	1	1	2.00	1.897	6
		2	1.00	1.549	6
		3	1.67	1.366	6
		Total	1.56	1.580	18
	2	1	2.83	1.835	6
		2	2.83	2.317	6
		3	1.67	2.658	6
		Total	2.44	2.229	18
	Total	1	2.42	1.832	12
		2	1.92	2.109	12
		3	1.67	2.015	12
		Total	2.00	1.957	36

Table 21b. Descriptive Statistics (MANOVA - Between-Subjects Factors)

Box's Test of Equality of Covariance Matrices[a]

Box's M	49.993
F	1.221
df1	30
df2	2033.938
Sig.	.191

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.

a. Design: Intercept + Sex + DataGroup + Sex * DataGroup

Table 22. Box's Test of Equality of Covariance Matrices

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Sex	Pillai's Trace	.124	1.326[b]	3.000	28.000	.286	.124
	Wilks' Lambda	.876	1.326[b]	3.000	28.000	.286	.124
	Hotelling's Trace	.142	1.326[b]	3.000	28.000	.286	.124
	Roy's Largest Root	.142	1.326[b]	3.000	28.000	.286	.124
DataGroup	Pillai's Trace	.733	5.594	6.000	58.000	.000	.367
	Wilks' Lambda	.279	8.331[b]	6.000	56.000	.000	.472
	Hotelling's Trace	2.538	11.422	6.000	54.000	.000	.559
	Roy's Largest Root	2.521	24.368[c]	3.000	29.000	.000	.716
Sex * DataGroup	Pillai's Trace	.119	.614	6.000	58.000	.718	.060
	Wilks' Lambda	.883	.598[b]	6.000	56.000	.731	.060
	Hotelling's Trace	.129	.582	6.000	54.000	.743	.061
	Roy's Largest Root	.099	.957[c]	3.000	29.000	.426	.090

a. Design: Intercept + Sex + DataGroup + Sex * DataGroup

b. Exact statistic

c. The statistic is an upper bound on F that yields a lower bound on the significance level.

Table 23a. MANOVA Test

Levene's Test of Equality of Error Variances[a]

		Levene Statistic	df1	df2	Sig.
Result (Digit Span Test)	Based on Mean	2.074	5	30	.097
	Based on Median	1.857	5	30	.132
	Based on Median and with adjusted df	1.857	5	24.962	.138
	Based on trimmed mean	2.033	5	30	.102
Result (Polygon Test)	Based on Mean	3.181	5	30	.020
	Based on Median	1.434	5	30	.241
	Based on Median and with adjusted df	1.434	5	18.544	.259
	Based on trimmed mean	2.804	5	30	.034
Result (No. of Errors in Mental Arithmetic Subtraction Test)	Based on Mean	1.504	5	30	.218
	Based on Median	.395	5	30	.848
	Based on Median and with adjusted df	.395	5	12.535	.843
	Based on trimmed mean	1.335	5	30	.277

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Sex + DataGroup + Sex * DataGroup

Table 23b. MANOVA Test (Levene's Test of Equality of Error Variances)

Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Sex	Result (Digit Span Test)	2.250	1	2.250	2.647	.114	.081
	Result (Polygon Test)	220.028	1	220.028	.871	.358	.028
	Result (No. of Errors in Mental Arithmetic Subtraction Test)	7.111	1	7.111	1.803	.189	.057
DataGroup	Result (Digit Span Test)	53.389	2	26.694	31.405	.000	.677
	Result (Polygon Test)	4902.722	2	2451.361	9.702	.001	.393
	Result (No. of Errors in Mental Arithmetic Subtraction Test)	3.500	2	1.750	.444	.646	.029
Sex * DataGroup	Result (Digit Span Test)	1.167	2	.583	.686	.511	.044
	Result (Polygon Test)	247.722	2	123.861	.490	.617	.032
	Result (No. of Errors in Mental Arithmetic Subtraction Test)	5.056	2	2.528	.641	.534	.041
Total	Result (Digit Span Test)	3237.000	36				
	Result (Polygon Test)	83795.000	36				
	Result (No. of Errors in Mental Arithmetic Subtraction Test)	278.000	36				
Corrected Total	Result (Digit Span Test)	82.306	35				
	Result (Polygon Test)	12950.306	35				
	Result (No. of Errors in Mental Arithmetic Subtraction Test)	134.000	35				

a. R Squared = .690 (Adjusted R Squared = .639)

b. R Squared = .415 (Adjusted R Squared = .317)

c. R Squared = .117 (Adjusted R Squared = -.030)

Table 23c. MANOVA Test (Tests of Between-Subject Effects)

Estimated Marginal Means

1. Sex of Participants (Male = 1, Female = 2)

Dependent Variable	Sex of Participants (Male = 1, Female = 2)	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Result (Digit Span Test)	1	9.611	.217	9.167	10.055
	2	9.111	.217	8.667	9.555
Result (Polygon Test)	1	46.833	3.747	39.182	54.485
	2	41.889	3.747	34.237	49.540
Result (No. of Errors in Mental Arithmetic Subtraction Test)	1	1.556	.468	.600	2.512
	2	2.444	.468	1.488	3.400

Table 23d. MANOVA Test (Estimated Marginal Means – Sex of Participants)

2. Caffeinated Coffee Consumption = 1, Decaffeinated Coffee Consumption = 2, No Coffee Consumption = 3

Dependent Variable	Caffeinated Coffee Consumption = 1, Decaffeinated Coffee Consumption = 2, No Coffee Consumption = 3	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Result (Digit Span Test)	1	11.083	.266	10.540	11.627
	2	8.500	.266	7.956	9.044
	3	8.500	.266	7.956	9.044
Result (Polygon Test)	1	60.667	4.589	51.296	70.038
	2	34.000	4.589	24.629	43.371
	3	38.417	4.589	29.046	47.788
Result (No. of Errors in Mental Arithmetic Subtraction Test)	1	2.417	.573	1.246	3.588
	2	1.917	.573	.746	3.088
	3	1.667	.573	.496	2.838

Table 23e. MANOVA Test (Estimated Marginal Means – Data Group)

3. Sex of Participants (Male = 1, Female = 2) * Caffeinated Coffee Consumption = 1, Decaffeinated Coffee Consumption = 2, No Coffee Consumption = 3

Dependent Variable	Sex of Participants (Male = 1, Female = 2)	Caffeinated Coffee Consumption = 1, Decaffeinated Coffee Consumption = 2, No Coffee Consumption = 3	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Result (Digit Span Test)	1	1	11.167	.376	10.398	11.935
		2	9.000	.376	8.231	9.769
		3	8.667	.376	7.898	9.435
	2	1	11.000	.376	10.231	11.769
		2	8.000	.376	7.231	8.769
		3	8.333	.376	7.565	9.102
Result (Polygon Test)	1	1	66.833	6.489	53.581	80.086
		2	34.333	6.489	21.081	47.586
		3	39.333	6.489	26.081	52.586
	2	1	54.500	6.489	41.247	67.753
		2	33.667	6.489	20.414	46.919
		3	37.500	6.489	24.247	50.753
Result (No. of Errors in Mental Arithmetic Subtraction Test)	1	1	2.000	.811	.344	3.656
		2	1.000	.811	-.656	2.656
		3	1.667	.811	.011	3.323
	2	1	2.833	.811	1.177	4.489
		2	2.833	.811	1.177	4.489
		3	1.667	.811	.011	3.323

Table 23f. MANOVA Test (Estimated Marginal Means – Sex of Participants & Data Group)

Post Hoc Tests

Caffeinated Coffee Consumption = 1, Decaffeinated Coffee Consumption = 2, No Coffee Consumption = 3

Multiple Comparisons

Bonferroni

Dependent Variable	(I) Caffeinated Coffee Consumption = 1, Decaffeinated Coffee Consumption = 2, No Coffee Consumption = 3	(J) Caffeinated Coffee Consumption = 1, Decaffeinated Coffee Consumption = 2, No Coffee Consumption = 3	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Result (Digit Span Test)	1	2	2.58*	.376	.000	1.63	3.54
		3	2.58*	.376	.000	1.63	3.54
	2	1	-2.58*	.376	.000	-3.54	-1.63
		3	.00	.376	1.000	-.95	.95
	3	1	-2.58*	.376	.000	-3.54	-1.63
		2	.00	.376	1.000	-.95	.95
Result (Polygon Test)	1	2	26.67*	6.489	.001	10.21	43.12
		3	22.25*	6.489	.005	5.79	38.71
	2	1	-26.67*	6.489	.001	-43.12	-10.21
		3	-4.42	6.489	1.000	-20.87	12.04
	3	1	-22.25*	6.489	.005	-38.71	-5.79
		2	4.42	6.489	1.000	-12.04	20.87
Result (No. of Errors in Mental Arithmetic Subtraction Test)	1	2	.50	.811	1.000	-1.56	2.56
		3	.75	.811	1.000	-1.31	2.81
	2	1	-.50	.811	1.000	-2.56	1.56
		3	.25	.811	1.000	-1.81	2.31
	3	1	-.75	.811	1.000	-2.81	1.31
		2	-.25	.811	1.000	-2.31	1.81

Based on observed means.

The error term is Mean Square (Error) = 3.944.

*. The mean difference is significant at the .05 level.

Table 23g. MANOVA Test (Post Hoc Tests)

A three-way between-groups multivariate analysis of variance (MANOVA) was performed to investigate the average cognitive performance in three cognitive tests among three subject groups. Three dependent variables were used: results in digit span test, results in polygon test and results in number of errors recorded in mental arithmetic subtraction test. The independent variables were sex and data group (caffeinated coffee consumption, decaffeinated coffee consumption and no coffee consumption). Preliminary assumption testing was conducted to check for normality, linearity, univariate and multivariate outliers, homogeneity of variance-covariance matrices, and multicollinearity, with no serious violations noted. There was no statistically significant difference between males and females on the combined dependent variables, F (3, 28) = 1.33, p = .286; Wilks' Lambda = .88; partial eta squared = .124. However, there were statistically significant differences among data group (caffeinated coffee consumption, decaffeinated coffee consumption and no coffee consumption) on the combined dependent variables, F (6, 56) = 8.33, p = .000; Wilks' Lambda = .28; partial eta squared = .472. When the results for the dependent variables were considered separately, the differences to reach statistical significance, using a Bonferroni adjusted alpha level of .639 and .317, were results in digit span test, F (2, 30) = 31.41, p = .000; partial eta squared = .68, and results in polygon test, F (2, 30) = 9.70, p = .001; partial eta squared = .39. However, results in the number of errors recorded in mental arithmetic subtraction test did not reach the statistical significance, using a Bonferroni adjusted alpha level of -.030, F (2, 30) = .444, p = .646; partial eta squared = .03. An inspection of the mean scores of result in digit span test indicated that group of caffeinated coffee consumption reported higher results in this test (M = 11.08, SD = .793) than group of decaffeinated coffee consumption (M = 8.50, SD = .798) and group of no coffee consumption (M = 8.50, SD = 1.168). In addition, an inspection of the mean scores of result in polygon test indicated that group of caffeinated coffee consumption reported higher result in this test (M = 60.67, SD = 16.82) than group of decaffeinated coffee consumption (M = 34.00, SD = 4.90) and group of no coffee consumption (M = 38.42, SD = 20.61).

In post hoc tests, it indicated that students with caffeinated coffee consumption reported a better cognitive performance in digit span test compared to students with decaffeinated coffee consumption and students with no coffee consumption in the same cognitive test (*Mean Difference* = 2.58, *p* = .000). Also, it was found that students with caffeinated coffee consumption reported a better cognitive performance in polygon test compared to students with decaffeinated coffee consumption (*Mean Difference* = 26.67, *p* = .001) and students with no coffee consumption in the same cognitive test (*Mean Difference* = 22.25, *p* = .005). However, post hoc tests indicated that there was no significant difference in performance in mental arithmetic subtraction test among three groups (*Mean Difference* = .50, *p* = 1.000; *Mean Difference* = .75, *p* = 1.000; *Mean Difference* = .25, *p* = 1.000).

Discussion

In this research, it was found that there was no statistically significant difference between sex and cognitive test results (*p* = .286), i.e. digit span test, polygon test and mental arithmetic subtraction test. This result implies that there is no main difference in cognitive performance between partially sleep deprived males and partially sleep deprived females, and provides further details in response to the current uncertainties in the relationship between sex and cognitive performance.

In addition, it was found that there was statistical significance between subject groups and three cognitive test results (*p* = .000). Three subject groups altogether show a main difference in cognitive performance. To consider the dependent variables separately, there were statistically significant difference between subject groups and two cognitive test results, i.e. digit span test (*p* = .000) and polygon test (*p* = .001). These results give an implication that the aforementioned three subject groups show a main difference in average performance in short-term memory capacity and information processing speed. In the post hoc tests, considering digit span test in Table 23g, Group 1 (caffeinated coffee consumption) reached a statistical significance when compared to Group 2 (decaffeinated coffee consumption) (*p* = .000) and Group 3 (no coffee consumption) (p = .000), while Group 2 did not reach a statistical significance when compared to group 3 (p = 1.000). This similarity was also found in polygon test. In Table 23g, Group 1 (caffeinated coffee consumption) reached a statistical significance when compared to Group 2 (decaffeinated coffee consumption) (p = .001) and Group 3 (no coffee consumption) (p = .005), while Group 2 (decaffeinated coffee consumption) did not reach a statistical significance when compared to Group 3 (no coffee consumption) (p = 1.000). These main statistical differences in between-groups comparison imply that caffeine is an active agent which enhances the average cognitive performance in the areas of short-term memory capacity and information processing speed of partially sleep-deprived students with evening chronotype. Such a key finding is found to be consistent with the previous findings on the efficacy of coffee intake as a countermeasure to sleepiness on partially sleep-deprived drivers (Mahachandra, Munzayanah & Yassierli, 2017) and aligns with Mahachandra, Munzayanah & Yassierli's findings that one-time caffeine intake gives a marked improvement in cognitive function of partially sleep-deprived individuals (Mahachandra, Munzayanah & Yassierli, 2017). This present research constructs a theoretical contribution that caffeine not only shorten reaction time and prolong attention spans, but also more importantly, enhance short-term memory capacity and information processing speed of partially sleep-deprived individuals.

Interestingly, three subject groups did not show a mean difference in the mental arithmetic subtraction test (p = 1.000). In post hoc tests, neither Group 1 (caffeinated coffee consumption) reached a statistical significance when compared to Group 2 (decaffeinated coffee consumption) (p = 1.000) and Group 3 (no coffee consumption) (p = 1.000) nor Group 2 (decaffeinated coffee consumption) compares to Group 3 (no coffee consumption) (p = 1.000). This experimental result altogether shows that caffeine did not enable more accurate calculation of partially sleep-deprived students with evening chronotype. There are several possible reasons accounting for this research finding. First, individual carelessness is one of the main contributing factors causing this statistical insignificance. Some participants might give a rapid response without thinking and checking carefully, resulting in higher number of errors in the subtraction test. In other words, the cognitive performance of participants in mental arithmetic subtraction test was likely affected by carelessness. Besides, caffeine might not be quite effective in boosting cognitive performance in repeated and tedious tasks. As caffeine is an effective agent to counteract drowsiness resulted from sleep deprivation (Mahachandra, Munzayanah & Yassierli, 2017), repeated and tedious tasks likely lead to drowsiness, which turns out to be making caffeine less effective. It is to predict that the cognitive performance of participants in other calculation tasks might show another picture if the calculation tasks require extra attentions and are in suitable level commensurate with participants' academic qualifications.

According to the experimental results, hypothesis 1 and 2 are valid while hypothesis 3 is rejected. In conclusion, instant one-time caffeinated coffee consumption enables greater short-term memory capacity and faster information processing speed, but does not enable a more accurate calculation, of partially sleep-deprived students with evening chronotype. Partially sleep-deprived university students with evening chronotype are advised to instantly one-time consume caffeinated coffee just 30 minutes before attending cognition-demanding tasks and learning activities, yielding a more favourable learning outcome.

Limitations & Suggestions for Future Studies

There are four limitations in this research study. One of the major limitations is that participants were not subject to a confined sleep hour before the experiment. Partial sleep deprivation is defined as sleep duration less than 5–7 hours within 24 hours (Durmer & Dinges, 2005; Pilcher & Huffcutt, 1996). With interindividual variations in sleep hours, the effects of partial sleep deprivation could be various from person to person, resulting in deviation of results due to possible difference in cognitive performance. To avoid such a variation, participants can be, for example, invited to sleep for a confined hour, say 5 hours in laboratories and wake up at 8:00 a.m. for experiment.

The second limitation of this research is that participants were subject to an increased level of nervousness during the experiment, which deviated from optimal performance of cognitive tasks. To avoid unwanted elevated nervousness level, it is to suggest that student investigator assertively inform participants there will be no adverse consequences and allows them to take a short break before cognitive tests if they report nervousness.

The third limitation of this study is that there might be heavy coffee consumers in group with caffeinated coffee consumption. According to Corti et al. (2002), habitual coffee drinkers exhibit different level of caffeine tolerance. This present research did not detect heavy coffee consumers or habitual coffee drinkers before the experiment. Therefore, there might be presence of heavy coffee consumers in Group 1 (Group of instant one-time caffeinated coffee consumption), which in turn affects the average cognitive performance in the previous three cognitive tasks. To ensure the result reliability, it is to suggest that student investigator inquires about the coffee-drinking habit of potential participants thoroughly in the recruitment stage in order to screen out the heavy coffee consumers.

The last limitation of this research is that the mental arithmetic subtraction test might not be the most suitable instrument to measure the arithmetic accuracy by counting the number of errors made by participants. The mental arithmetic subtraction test required participants to subtract "7" after obtaining a new number consecutively in 5 minutes, which might create tediousness, drowsiness, or even unwillingness to complete the test. To make the cognitive test less problematic, it is to suggest that student investigator designs a calculation test that involves different types of mathematical questions in appropriate level commensurate with participants' academic qualification, such as simple addition, multiplication and division, instead of one-typed mechanical subtraction.

To understand the importance of coffee tolerance or chronobiology as a masking factor, future research topic could either be developed to examine the effects of instant one-time caffeinated coffee consumption on cognitive performance of partially sleep-deprived non-heavy coffee drinkers with evening chronotype, or to examine the similar scenario but with morning-chronotyped individuals.

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Appendix A – Questionnaire (English Version)

Hello! I am a final year undergraduate student at The Education University of Hong Kong. We are now conducting a psychological research regarding sleep deprivation, habitual coffee consumption and academic performance among UGC-funded undergraduate students in Hong Kong. We hope you can spend around 5 minutes to complete and to fill up basic information. **All answers you provide will be used for research purpose only. The data will be kept in the strictest confidentiality and be destroyed after the research period.** Thank you for your precious time in taking part in this research!

Session 1 – Personal Sleep Routines

1. What time would you get up if you were entirely free to plan your day?

Time	Score (please circle)
5:00 – 6:29 am	5
6:30 – 7:44 am	4
7:45 – 9:44 am	3
9:45 – 10:59 am	2
11:00 – 11:59 am	1
Midday – 5:00 am	0

2. What time would you go to bed if you were entirely free to plan your evening?

Time	Score (please circle)
8:00 – 8:59 pm	5
9:00 – 10:14 pm	4
10:15 pm – 12:29 am	3
12:30 – 1:44 am	2
1:45 – 2:59 am	1
3:00 am – 8:00 pm	0

3. If there is a specific time at which you have to get up in the morning, to what extent do you depend on being woken up by an alarm clock?

	Score (please circle)
Not at all dependent	4
Slightly dependent	3
Fairly dependent	2
Very dependent	1

4. How easy do you find it to get up in the morning (when you are not woken up unexpectedly)?

	Score (please circle)
Not at all easy	1
Not very easy	2
Fairly easy	3
Very easy	4

5. How alert do you feel during the first half hour after you wake up in the morning?

	Score (please circle)
Not at all alert	1
Slightly alert	2
Fairly alert	3
Very alert	4

6. How hungry do you feel during the first half-hour after you wake up in the morning?

	Score (please circle)
Not at all hungry	1
Slightly hungry	2
Fairly hungry	3
Very hungry	4

7. During the first half-hour after you wake up in the morning, how tired do you feel?

	Score (please circle)
Very tired	1
Fairly tired	2
Fairly refreshed	3
Very refreshed	4

8. If you have no commitment the next day, what time would you go to bed compared to your usual bedtime?

	Score (please circle)
Seldom or never later	4
Less than one hour later	3
1-2 hours later	2
More than two hours later	1

9. You have decided to engage in some physical exercise. A friend suggests that you do this for one hour twice a week and the best time for him/her is between 7:00 – 8:00 am. Bearing in mind nothing but your own internal "clock", how do you think you would perform?

	Score (please circle)
Would be in good form	4
Would be in reasonable form	3
Would find it difficult	2
Would find it very difficult	1

10. At what time of day do you feel you become tired as a result of need for sleep?

Time	Score (please circle)
8:00 – 8:59 pm	5
9:00 – 10:14 pm	4
10:15 pm – 12:44 am	3
12:45 – 1:59 am	2
2:00 – 3:00 am	1

11. You want to be at your peak performance for a test that you know is going to be mentally exhausting and will last for two hours. You are entirely free to plan your day. Considering only your own internal "clock", which ONE of the four testing times would you choose?

Time	Score (please circle)
8:00 – 10:00 am	4
11:00 am – 1:00 pm	3
3:00 – 5:00 pm	2

7:00 – 9:00 pm	1

12. If you got into bed at 11:00 pm, how tired would you be?

	Score (please circle)
Not at all tired	1
A little tired	2
Fairly tired	3
Very tired	4

13. For some reason, you have gone to bed several hours later than usual, but there is no need to get up at any particular time the next morning. Which ONE of the following is you most likely to do?

	Score (please circle)
Will wake up at usual time, but will NOT fall back asleep	4
Will wake up at usual time and will doze thereafter	3
Will wake up at usual time but will fall asleep again	2
Will NOT wake up until later than usual	1

14. One night you have to remain awake between 4:00 – 6:00 am in order to carry out a night watch. You have no commitments the next day. Which ONE of the alternatives will suite you best?

	Score (please circle)
Would NOT go to bed until watch was over	1
Would take a nap before and sleep after	2
Would take a good sleep before and nap after	3

Would sleep only before watch	4

15. You have to do two hours of hard physical work. You are entirely free to plan your day and considering only your own internal "clock" which ONE of the following times would you choose?

Time	**Score (please circle)**
8:00 – 10:00 am	4
11:00 am – 1:00 pm	3
3:00 – 5:00 pm	2
7:00 – 9:00 pm	1

16. You have decided to engage in hard physical exercise. A friend suggests that you do this for one hour twice a week and the best time for him/her is between 10:00 – 11:00 pm. Bearing in mind nothing else but your own internal "clock", how well do you think you would perform?

	Score (please circle)
Would be in good form	4
Would be in reasonable form	3
Would find it difficult	2
Would find it very difficult	1

17. Suppose that you can choose your school hours. Assume that you went to school for five hours per day and that school was interesting and enjoyable. Which five consecutive hours would you select?

	Score (please circle)
5 hours starting between 4:00 – 7:59 am	5

5 hours starting between 8:00 – 8:59 am	4
5 hours starting between 9:00 am – 1:59 pm	3
5 hours starting between 2:00 – 4:59 pm	2
5 hours starting between 5:00 pm – 3:59 am	1

18. At what time of the day do you think that you reach your "feeling best" peak?

Time	**Score (please circle)**
5:00 – 7:59 am	5
8:00 – 9:59 am	4
10:00 am – 4:59 pm	3
5:00 – 9:59 pm	2
10:00 pm – 4:59 am	1

19. One hears about "morning" and "evening" types of people. Which ONE of these types do you consider yourself to be?

	Score (please circle)
Definitely a "morning" type	6
Rather more a "morning" type than an "evening" type	4
Rather more an "evening" type than a "morning" type	2
Definitely an "evening" type	0

Scoring

We will help you to calculate the overall score. Please be patient and wait for a while.

Scores can range from 16-86. Scores of 41 and below indicate "evening types". Scores of 59 and above indicate "morning types". Scores between 42 and 58 indicate "intermediate types".

You are belong to …

16-30	31-41	42-58	59-69	70-86
Definite Evening	Moderate Evening	Intermediate	Moderate Morning	Definite Morning

Session 2 – Sleep Habits

** Please circle as appropriate*

Q1. In general, consider a certain week in the semester (NOT include Saturday, Sunday & Public Holiday). On average, how many hours do you sleep each day ? (Remark : DO NOT count short nap Or afternoon nap.)

Average Hours : ____________

Q2. During the semester, at what time do you go to sleep in weekdays ?

______ : ______ a.m. / p.m. *

Session 3 – Coffee Consumption & Academic Results

** Please circle as appropriate*

Q3. Do you consume coffee habitually ? (Remark : Habitual coffee consumption is defined as consuming at least one standardized cup of Nestle coffee (250 ml) every day.)

Yes / No * (If no, please go to Q5.)

Q4. On average, how many cups of coffee do you consume each day ? (Remark : Every 250 ml of coffee is counted as one standardized cup.)

Average Number : ________ cup(s)

Q5. What is your semester grade point average (GPA) in the previous semester?

Semester Grade Point Average (GPA) : ____________

Session 4 – Personal Particulars

** Please circle as appropriate*

Gender * : Male / Female

Age : ________

Institution * : HKU / CUHK / HKUST / PolyU / CityU / HKBU / EdUHK / LingU / OUHK / HKSYU / HSUHK

Curriculum/ Programme : ____

Thank you for your participation !

Appendix B – Questionnaire (Chinese Version)

你好! 我是香港教育大學 5 年級學生，我們現正進行一項關於大學生睡眠不足、喝咖啡習慣及學業成績的研究。期望你能夠抽出大約 5 分鐘完成問卷，並且填上基本資料。請你放心，你提供的資料僅用作學術研究，所有資料將會絕對保密，並在研究完成後銷毀。感謝你百忙之中抽空參與研究!

第一部分 - 個人睡眠習慣

1. 如果前一天沒有緊湊工作，你會選擇甚麼時間起床？

時間	分數 (請圈出)
5:00 – 6:29 am	5
6:30 – 7:44 am	4
7:45 – 9:44 am	3
9:45 – 10:59 am	2
11:00 – 11:59 am	1
中午 – 5:00 am	0

2. 如果前一天沒有緊湊工作，你會選擇甚麼時間睡覺？

時間	分數 (請圈出)
8:00 – 8:59 pm	5
9:00 – 10:14 pm	4
10:15 pm – 12:29 am	3
12:30 – 1:44 am	2
1:45 – 2:59 am	1
3:00 – 8:00 pm	0

3. 如果前一天需要在特定時間起床，在多大程度上你需要鬧鐘喚醒起床？

	分數 (請圈出)
不需要	4
少許需要	3
大概需要	2
非常需要	1

4. 假設你並非被人喚醒，在多大程度上感覺容易起床？

	分數 (請圈出)
非常不容易	1
不容易	2
容易	3
非常容易	4

5. 在你起床之後的首半小時，你在多大程度上感到清醒？

	分數 (請圈出)
非常不清醒	1
不清醒	2
少許清醒	3
非常清醒	4

6. 在你起床之後的首半小時，你在多大程度上感到肚餓？

	分數 (請圈出)
完全不肚餓	1
不肚餓	2

少許肚餓	3
非常肚餓	4

7. 在你起床之後的首半小時，你在多大程度上感到疲累？

	分數 (請圈出)
非常疲累	1
少許疲累	2
不疲累	3
完全不疲累	4

8. 如果第二天並無任何特別事情，與平時睡覺時間比較，你會選擇延遲多久睡覺？

	分數 (請圈出)
不會或很少延遲	4
延遲少於 1 小時	3
延遲 1 – 2 小時	2
延遲多於 2 小時	1

9. 你已決定去做運動。你的朋友建議你在一星期內做兩次運動，每次一小時，適合你的朋友的最佳時間是早上 7 時至 8 時。聯想起你的個人生理時鐘，在多大程度上你會去做運動？

	分數 (請圈出)
適合進行運動	4
尚算適合進行運動	3
不太適合進行運動	2
非常不適合進行運動	1

10. 在一整天中，在甚麼時間你感到疲累，並且需要睡覺？

	分數 (請圈出)
8:00 – 8:59 pm	5
9:00 – 10:14 pm	4
10:15 pm – 12:44 am	3
12:45 – 1:59 am	2
2:00 – 3:00 am	1

11. 你希望在精神狀態達致高峰時進行一次長達兩小時的考試，你亦知道完成考試後將會精神耗盡。現在你可以自由分配時間，考慮你的個人生理時鐘，你會選擇下列哪一段時間？

	分數 (請圈出)
8:00 – 10:00 am	4
11:00 am – 1:00 pm	3
3:00– 5:00 pm	2
7:00 – 9:00 pm	1

12. 如果你晚上 11 時睡覺，你會感到有多疲累？

	分數 (請圈出)
完全不疲累	1
少許疲累	2
很疲累	3
非常疲累	4

13. 因為某些原因，你需要較平時延遲數小時入睡，但毋須在第二天早上某一時間起床，下列哪一項你最有可能會做？

	分數 (請圈出)
將會按平時時間起床，並不會打嗐睡	4
將會按平時時間起床，但之後會打嗐睡	3
將會按平時時間起床，但之後會重新入睡	2
將會較平時延遲起床	1

14. 為了完成夜間觀察，一晚你需要在深夜 4 時至清晨 6 時維時清醒，第二天你並無任何特別事情。下列哪一項方法對你來說最適合？

	分數 (請圈出)
直至夜間觀察完成前都不會睡覺	1
在夜間觀察進行前小睡，在夜間觀察後睡覺	2
在夜間觀察進行前睡覺，在夜間觀察後小睡	3
只會在夜間觀察進行前睡覺	4

15. 你需要進行一項長達兩小時和困難的體力勞動。你可以自由分配時間，同時考慮你的個人生理時鐘，你會選擇下列哪一段時間？

	分數 (請圈出)
8:00 – 10:00 am	4
11:00 am – 1:00 pm	3
3:00– 5:00 pm	2
7:00 – 9:00 pm	1

16. 你已決定進行一項困難的體力勞動。你的朋友建議你在一星期內進行兩次體力勞動，每次一小時，適合你的朋友的最佳時間是晚上 10 時至 11 時。聯想起你的個人生理時鐘，在多大程度上你會表現理想?

	分數 (請圈出)
將會十分理想	4
將會尚算理想	3
將會不太理想	2
將會非常不理想	1

17. 假設你可以自由選擇上課時間。如果你每天需要上課 5 小時，而該課堂是相當有趣，你亦享受整節課堂。你會選擇下列哪一連續 5 小時？

	分數 (請圈出)
由凌晨 4:00 至 早上 7:59 開始連續 5 小時	5
由早上 8:00 至 8:59 開始連續 5 小時	4
由早上 9:00 至 下午 1:59 開始連續 5 小時	3
由下午 2:00 至 下午 4:59 開始連續 5 小時	2
由下午 5:00 至 凌晨 3:59 開始連續 5 小時	1

18. 在下列哪一段時間中，你感覺你的精神狀態達到頂峰？

時間	分數 (請圈出)
5:00 – 7:59 am	5
8:00 – 9:59 am	4
10:00 am – 4:59 am	3
5:00 – 9:59 pm	2
10:00 pm – 4:59 am	1

19. 當你一聽到「早晨型」及「夜晚型」，你覺得你屬於下列哪一類型的人?

	分數 (請圈出)
絕對是「早晨型」	6
「早晨型」多於「夜晚型」	4
「夜晚型」多於「早晨型」	2
絕對是 「夜晚型」	0

分數

我們將會協助你計算總分，請你稍等。

分數範圍介乎 16 至 86 分。41 分或以下屬於「夜晚型」，59 分或以上屬於「早晨型」，分數介乎 42 分至 58 分之間則屬於介乎「夜晚型」與「早晨型」之間。

你是屬於。。。

16-30	31-41	42-58	59-69	70-86
絕對的「夜晚型」	中度的「夜晚型」	介乎「夜晚型」與「早晨型」之間	中度的「早晨型」	絕對的「早晨型」

第二部分 - 睡眠時間及時數

Q1. 一般來說，在學期期間，考慮一星期內 (不計算星期六及日) 的睡眠時數，你平均每晚睡眠時數是多少？(註: 只計算晚上睡眠，不包括小睡或午睡。)

每晚平均睡眠時數 : ________ 小時

Q2. 在學期期間，在平日 (不包括星期六、日及公眾假期)，你習慣在甚麼時間睡覺？

_____ : _____ a.m. / p.m. *

第三部分 - 喝咖啡習慣及學業成績

**請圈出適當答案*

Q3. 你是否有喝咖啡的習慣？(註: 喝咖啡習慣是指每天喝至少一罐標準 250 毫升的雀巢咖啡。)

有 / 沒有 * (如沒有，請跳至 Q5)

Q4. 你平均每天喝多少杯咖啡？(註: 每 250 毫升作一杯咖啡計算。)

平均數目 : _______杯

Q5. 你最近學期的學業成績是？

成績平均積點 (GPA) : _______________

第四部分 - 個人資料

**請圈出適當資料*

性別 *： 男 / 女

年齡： ___________

所屬院校 * : 香港大學 / 香港中文大學 / 香港科技大學 / 香港理工大學 / 香港城市大學 / 香港浸會大學 / 香港教育大學 / 嶺南大學 / 香港公開大學 / 香港樹仁大學 / 香港恆生大學

就讀課程 : ____

謝謝你的參與！

Appendix C – Instrument (Coffee)

Figure 3. NesCafe (Caffeinated Coffee)

Figure 4. NesCafe (Decaffeinated Coffee)

Appendix D – Instrument (Cognitive Task 1 & 2 – Cambridge Brain Sciences Online Version)

Cambridge Brain Sciences. (2020). Retrieved from https://www.cambridgebrainsciences.com/science/tasks/digit-span

Appendix E – Instrument (Cognitive Task 3 - Mental Arithmetic Subtraction Test Check List)

Department of PSYCHOLOGY 心理學系

香港教育大學 The Education University of Hong Kong

Cognitive Task 3 - Mental Arithmetic Subtraction Test Check List

1000 → 993 → 986 → 979 → 972 → 965 → 958 → 951 → 944 → 937 →

930 → 923 → 916 → 909 → 902 → 895 → 888 → 881 → 874 → 867 →

860 → 853 → 846 → 839 → 832 → 825 → 818 → 811 → 804 → 797 →

790 → 783 → 776 → 769 → 762 → 755 → 748 → 741 → 734 → 727 →

720 → 713 → 706 → 699 → 692 → 685 → 678 → 671 → 664 → 657 →

650 → 643 → 636 → 629 → 622 → 615 → 608 → 601 → 594 → 587 →

580 → 573 → 566 → 559 → 552 → 545 → 538 → 531 → 524 → 517 →

510 → 503 → 496 → 489 → 482 → 475 → 468 → 461 → 454 → 447 →

440 → 433 → 426 → 419 → 412 → 405 → 398 → 391 → 384 → 377 →

370 → 363 → 356 → 349 → 342 → 335 → 328 → 321 → 314 → 307 →

300 → 293 → 286 → 279 → 272 → 265 → 258 → 251 → 244 → 237 →

230 → 223 → 216 → 209 → 202 → 195 → 188 → 181 → 174 → 167 →

160 → 153 → 146 → 139 → 132 → 125 → 118 → 111 → 104 → 97 → 90

→ 83 → 76 → 69 → 62 → 55 → 48 → 41 → 34 → 27 → 20 → 13 → 6

Appendix F – Instructions to Participants (Before Experiment) (English Version)

Before the day of experiment, each participant will be given the following instructions.

1) Attend a partial sleep deprivation schedule before the day of experiment, i.e. have a total sleep duration NOT MORE THAN 5 - 7 hours. Record the exact time before going to sleep and after awake.

2) DO NOT consume any caffeine-containing beverages 10 HOURS BEFORE the experiment, e.g. coffee, cola, tea, or other energy drinks.

3) To facilitate smoothness of experiment, participants who have instant coffee consumption are advised to go to toilet once before attending cognitive tasks.

4) Participants in Group 1 and 2 (Instant One-time Caffeinated Coffee Consumption & Instant One-time decaffeinated Coffee Consumption) will be instructed to consume 250ml Nestle coffee and 250 ml decaffeinated coffee in one-time respectively. Inform the student investigator promptly if you are feeling unwell, or have other personal reasons, if any.

Appendix G – Instructions to Participants (Before Experiment) (Chinese Version)

1) 在實驗前晚，研究參與者的睡眠時間不得多於 5 至 7 小時。睡覺前後需要記錄入睡及醒覺時間。

2) 在實驗 10 小時前，切勿飲用含有咖啡因飲品 (例如：咖啡、可樂、茶或其他能量飲品)。

3) 為了讓實驗能夠順利進行，如有需要，建議飲用咖啡的研究參與者在進行認知測試前如廁。

4) 第一組別研究參與者在實驗前需要即時一次性飲用 250 毫升含咖啡因的雀巢咖啡；第二組別研究參與者在實驗前則需要即時一次性飲用 250 毫升不含咖啡因的咖啡。研究參與者如有不適或基於個人健康理由不宜飲用咖啡，請盡早通知學生研究員。

Appendix H – QR Code for access to online questionnaire (Google Form)

麻煩你掃一掃上面嘅 QR Code，

幫我地做份問卷呀! 唔該曬~

Appendix I – Consent Form

香港教育大學

心理學系

參與研究同意書

< 一次性飲用咖啡對夜晚型部分睡眠不足大學生認知表現的影響 >

本人同意參加由溫麗妍博士負責監督學生研究員呂晏負責執行的研究計劃。她 / 他們是香港教育大學的教員和學生。

本人理解此研究所獲得的資料可用於未來的研究和學術發表。然而本人有權保護本人的隱私，本人的個人資料將不能洩漏。

研究員已將所附資料的有關步驟向本人作了充分的解釋。本人理解可能會出現的風險。本人是自願參與這項研究。

本人理解本人有權在研究過程中提出問題,並在任何時候決定退出研究，更不會因此而對研究工作產生的影響負有任何責任。

簽署 ______________________

參加者姓名： ______________________

日期： ______________________

Appendix J – Information Sheet

有關資料

< 一次性飲用咖啡對夜晚型部分睡眠不足大學生認知表現的影響 >

誠邀閣下參加溫麗妍博士負責監督負責學生研究員呂晏執行的研究計劃。她 / 他們是香港教育大學的教員和學生。

研究計劃簡介

是次研究主要目的是比較夜晚型部分睡眠不足大學生組別在一次性飲用咖啡與沒有一次性飲用咖啡的組別在短期記憶容量、腦部運作速度及計算準確度的差異。

本港大學宿舍文化傾向在夜間或深夜進行各類活動，部分大學生利用部分睡眠時間兼職、參與聯誼活動，甚至兼顧學業，經常導致睡眠不足。因此，為了消除睡眠不足引起的倦意，部分大學生會飲用咖啡。由於咖啡因能夠消除倦意，在一定時間內提升認知表現，再者認知表現直接影響學生的學習表現。因此，研究人員期望探討一次性飲用咖啡能否短時間內有效提升睡眠不足的大學生的認知表現，從而提升學習效能。

研究方法

是次研究將會邀請 48 位屬於夜晚型和部分睡眠不足的大學生參與，並分為三個研究組別：(1) 一次性飲用含咖啡因的咖啡、(2)一次性飲用不含咖啡因的咖啡及(3)沒有一次性飲用咖啡。

在實驗 30 分鐘前，研究參與者將會按所屬組別飲用特定容量及性質的咖啡，然後三項有關短期記憶容量、腦部運作速度及計算準確度的認知測試。實驗將會在參加者起床後的一至兩小時內進行，整個過程約需 45 分鐘。

是次研究並不為閣下提供任何個人利益，但所搜集之數據將對研究夜晚型部分睡眠不足的大學生提升認知表現的問題提供寶貴的資料。

任何風險

所有研究參與者在實驗前晚僅會進行不多於 5 – 7 小時的睡眠，部分睡眠不足可能引起頭痛、疲倦、煩躁或焦慮等等。此外，由於其中兩組研究參與者組別需要在實驗前飲用咖啡，部分參與者吸取咖啡因可能引致頭痛、心跳加速、心悸或嘔心等等。如閣下身體狀況不宜參與研究或因個人理由未能承受研究帶來的潛在風險，可決定退出這項研究。

閣下的參與純屬自願性質。閣下享有充分的權利在任何時候決定退出這項研究， 更不會因此引致任何不良後果。凡有關閣下的資料將會保密，一切資料的編碼只有研究人員得悉。研究所獲得的資料將會用於未來的研究和學術發表，透過撰寫學術論文發佈研究成果。

如閣下想獲得更多有關這項研究的資料,請以電郵 @s.eduhk.hk 或電話 與本人或本人的導師溫麗妍博士 @eduhk.hk 聯絡。

如閣下對這項研究的操守有任何意見,可隨時與香港教育大學人類實驗對象操守委員會聯絡(電郵: hrec@eduhk.hk; 地址：香港教育大學研究與發展事務處)。

謝謝閣下有興趣參與這項研究。

學生研究員

呂晏