Associations among Chronotype, Social Jetlag and Academic Performance

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Abstract

Individual circadian rhythms are integral to performance in daily life; particularly in societies dominated by imposed social clocks. Evening types, despite delayed circadian phase are forced to wake early for social obligations, putting them at risk for chronic sleep restriction, and asynchrony in phase of learning. The present study recruited 1800+ university students to complete the Morningness-Eveningness Questionnaire, Munich Chronotype Questionnaire and/or sleep diaries. Evening types showed the highest levels of social jetlag and greatest percentage of sleep lost on work days. Assessments of chronotype by MEQ and MCTQ remained consistent over multiple measurements regardless of keeping a sleep diary; however chronotype assessment did change based on season, with the latest midsleep times occurring in the summer semester. Later midsleep time on free days ($MCTQ_{MSF}$) was predictive of lower GPA in females; this relationship was not mediated by social jetlag. Considerations regarding measures of chronotype are discussed.

Keywords: Chronotype; Midsleep; Social Jetlag; Academic Performance; Sleep Duration; Circadian Rhythms

Dedication

This document is dedicated to Crocodile Ball who valiantly gave his left side to support the creative process, and who acted as my brown paper bag for use during hyperventilation.

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List of Acronyms

MCTQ	Munich Chronotype Questionnaire
MEQ	Morningness Eveningness Questionnaire
MSF	Midsleep Time on Free Days
MSW	Midsleep Time on Work Days
SJMS	Social Jetlag Midsleep
SJSD	Social Jetlag Sleep Duration
%SLW	Percentage of Sleep Lost on Work Days

Chapter 1.

Circadian Rhythms and Chronotype

1.1. Basis of the Circadian Clock

Circadian rhythms influence many aspects of people's lives. The human species is diurnal, meaning that the wake state is mostly consolidated to the day and the sleep state to the night. Cell autonomous circadian clocks control daily rhythms of everything from gene expression (Akashi et al., 2010), to physiology (e.g., hormone secretions and body temperature; Bailey & Heitkemper, 2001), to rest-activity states and higher cognitive processes (e.g. Carrier & Monk, 2000; Schmidt et al., 2007; Czeisler & Gooley, 2007). These clocks are self-sustaining, and, in the absence of external time cues, run at their own rate approximating the 24 hour day. To ensure that rest-activity states occur at the 'correct' time of day, circadian clocks are actively synchronized ('entrained') by local environmental time cues, of which daily light-dark cycles are the most potent. The 'master' circadian clock in mammals has been localized to the suprachiasmatic nucleus (SCN) of the hypothalamus. The SCN is entrained to the solar day through exposure to light which is transduced by the retina and transmitted to the SCN via the optic nerve. Light entrains the circadian clock by regulating expression of circadian clock genes in SCN circadian clock cells. The timing of light is critical; light stimuli in the evening and early night phase delay the circadian clock, while light stimuli in the late night and morning advance the circadian clock, with the transition from delay to advance occurring at the minimum of the circadian body temperature, approximately 2-3 h before habitual wakeup time (e.g. Minors, Waterhouse & Wirz-Justice, 1991; Czeisler & Gooley, 2007).

The commercialization of the light bulb in the 19th century has resulted in light exposure at times of day in which our species has evolved under conditions of darkness. Be it natural, or artificial, light exposure during these critical times can cause alterations in phase in some individuals.

Individual differences exist in periodicity of circadian cycling. The period ('τ', the duration of a complete cycle) of the clock is determined by the rate of a genetic feedback loop cycling within cells of the SCN. In the absence of synchronizing cues, one cycle is completed every 23.85 to 24.55 hours, depending on the individual (Czeisler et al., 1999). Individual differences in τ lead to differences in phase angle of entrainment (i.e. the relationship between the endogenous circadian clock and external synchronizing stimuli), and result in varied preferences for timing of sleep and other behaviours, a phenomena termed chronotype. Individual differences are exaggerated in modern society, due to reduced exposure to outside light during the day, and increased exposure to artificial light late in the evening, which can phase delay the circadian clock and reinforce a genetically based tendency to delay bedtime and express a 'night owl' or 'evening' chronotype (Wright et al., 2013).

1.2. Circadian Rhythms of Performance

Performance and alertness levels across the day are influenced by two opposing processes that regulate the sleep-wake cycle. Sleep is very important to performance, and increase in sleep pressure leads to decline in performance and alertness. A homeostatic process increases the pressure to sleep as a function of the duration of prior waking. A circadian process superimposes a 24 hour rhythm on the drive to sleep, promoting arousal during the day and sleep at night (Daan et al., 1984). Despite the buildup of sleep pressure with time awake, alertness and cognitive performance are typically highest late in the day, due to an active role of the circadian clock opposing the sleep homeostat. A similar opposition occurs late in the sleep period, when the circadian clock promotes sleep, delaying wake-up despite the dissipation of homeostatic sleep drive. The interaction between the opposing homeostatic and circadian processes results in consolidation of sleep to the subjective night with the strongest circadian pressure to sleep occurring at the body temperature minimum (Dijk & Czeisler, 1994). Studies have repeatedly shown that performance is best late in the waking day near the peak of the body temperature rhythm and worst late at night, near the minimum of core body temperature, approximately 2 - 3 hours prior to spontaneous wake-up. These predictable fluctuations with time of day have been demonstrated using a wide range of tasks measuring levels of attention, memory, and executive functioning (see Schmidt et al. 2007 for review).

During extended sleep deprivation, impairments of cognitive performance are magnified at the minimum of the core body temperature and may be entirely reversed at the maximum of the temperature rhythm, demonstrating the importance of circadian timing for physical and cognitive performance. Forced desynchrony studies further show that cognitive performance is best when the length of prior time awake is shorter, core body temperature is at its highest, and rapid-eye-movement (REM) sleep quantities during the last sleep episode are greatest (Darwent et al., 2010). Despite these regular and predictable rhythms of performance, individual differences are apparent. Although not the first to recognize them, Öquist was the first to begin characterizing individual differences in circadian rhythms. In a quote from his 1970 thesis at the University of Göeteborgs, Sweden, he discusses observations that have led to modern research into chronotypes:

> "Twente (1964) believes that there are two types of *awakeners:* one type finds waking pleasant, quickly regains contact with reality, and prefers to get up as soon as he awakes; the other finds it hard to awake, resumes contact with reality very slowly, and has great difficulty getting going in the morning."

1.3. What is chronotype?

Individuals feel and operate best at different times of day. This is most evident in daily sleep and activity patterns. These patterns vary on a continuum from those who prefer to sleep and wake very early, to those who prefer to sleep and wake very late in the day. Although commonly reduced to a description of sleep and wake patterns, chronotype is additionally representative of the daily rhythms of multiple physiological and biological functions that lead to cognitive, mental and physical alertness levels. Chronotype is most often conceptualized as a trait lying on a continuum, with the majority of the population falling between morning and evening extremes. *Morning types* prefer to sleep and rise early, and reach their physiological and biological peaks earlier in the day compared to *evening types*. In the general population, chronotype is normally distributed with a slight overrepresentation of evening types (Roenneberg et al., 2004; 2007).

To a large extent, individual circadian parameters underlie chronotype, and a relationship exists between τ of the internal clock and chronotype (Duffy, Rimmer & Czeisler, 2001). Sleep-wake transitions occur earlier in individuals with shorter τ and later in those with longer τ (Duffy et al., 2001). Endogenous τ is determined by the interaction between genetic and environmental factors. Differences in τ, in addition to genetic composition (Toh et al., 2001), age, and the intensity, timing, and duration of light exposure (Roenneberg et al., 2013; Wright et al., 2013), lead to different phases of entrainment. Social variables are emerging as a vital consideration, as they strongly interact with individual circadian timing by controlling when light exposure occurs.

Age and sex play important roles in determining chronotype. Circadian clock τ and sleep-wake timing change predictably over the lifespan (e.g. Duffy & Czeisler, 2002). Circadian rhythms delay during adolescence with evening type preference commencing during puberty and *eveningness* peaking in young adulthood (Tonetti et al., 2008). In the late teens or early 20's, chronotype begins to advance gradually towards a morning preference (Roenneberg et al., 2004). This has been proposed as a new biomarker of the end of adolescence. Males reach their peak eveningness 1 to 2 years later than females (Roenneberg et al., 2004). Circadian τ is generally longer in males (Wever, 1984; Duffy et al., 2011) leading to higher prevalence of evening preference in males.

Chronotype is instrumental in daily rhythms of performance. Morning types wake on the rising phase of their core body temperature rhythm when the drive for sleep from their circadian system is decreasing. Evening types on the other hand are waking shortly after their body temperature minimum at a time when the circadian pressure to sleep is high and levels of alertness and performance are low (Duffy et al., 2001). Thus, paradoxically, morning types tend to wake up later in their circadian alertness and performance cycle than do evening types, which explains why morning types are alert on waking, while evening types may seem to take hours to become fully alert.

1.3.1. Measures of Chronotype

Various questionnaires have been developed to measure chronotype (e.g. The Composite Scale of Morningness: [CSM; Smith, Reilly & Midkiff, 1989]; Sleep-wake pattern assessment questionnaire: [SWPAQ; Putilov 1990]; Diurnal Type Scale [DTS; Torsvall & Akerstedt, 1980]; Circadian Composite Scale [CCS; Smith et al., 1989]), but the most widely used has been the *Morningness-Eveningness Questionnaire* (MEQ; Horne & Östberg, 1976). The MEQ asks 19 questions regarding daily timing preferences and yields a score that when higher indicates greater morning preference. The original questionnaires reflect preferences in timing of daily behaviours such as preferred sleep, wake and times of "feeling best." Nevertheless, in societies dominated by social clocks, most individuals cannot live by their preferences, or what would otherwise be dictated by their underlying biological clock, and thus, questions have arisen as to the best definition and form of measurement for chronotype. Chronotype is a continuous biological trait and not a psychological one, and psychological questionnaires such as the MEQ are subjective and can be influenced by extraneous variables (e.g. comparison relative to peers, societal values).

To account for this, Roenneberg, Wirz-Justice and Merrow (2003) developed the *Munich Chronotype Questionnaire* (MCTQ) to assess chronotype using self-reporting of individual sleep phase and accurate timing of daily behaviours separately for "work" and "free" days. Midsleep time on free days (MSF; the mid-point in time between sleep onset and wake time on free days) is used as the phase reference point to determine chronotype. MSF is assumed to be less influenced by the social clock than sleep timing on work days. A later midsleep time reflects a later chronotype. MSF correlates highly with MEQ score (Zavada et al., 2005). Findings from Önder et al., (2014) indicate that 19% of the variance in MEQ score was explained by midsleep on free days. Both of these measures have been additionally validated through correlations with biological measures (e.g. Kitamura et al., 2014).

Chapter 2.

Chronotype and Academic Performance

Chronotype has been associated with academic achievement in students (e.g. Borisenkov, Perminova & Kosova, 2010). In particular, evening types have been found to perform worse academically (e.g. Randler & Frech, 2009; Taylor et al., 2011). Those with proclivity towards eveningness have been found to have lower levels of performance motivation, show higher levels of work avoidance, are less conscientious and consume more nicotine and alcohol than morning oriented students (Preckel et al., 2013). Not surprisingly, cognitive performance is correlated with academic achievement. Despite eveningness having been shown to be positively correlated with cognitive test performance, it is negatively related to academic achievement (e.g. Cavalleraa & Giudici, 2008; Roenneberg, Wirz-Justice & Merrow, 2003; Sadeh, Gruber & Raviv, 2003).

A meta-analysis conducted by Preckel et al., (2011) using a 2 dimensional construct of chronotype (Composite Scale of Morningness: CSM), analyzed 10 studies looking at chronotype and academics. Morningness was found to be significantly positively correlated with academic achievement, and eveningness negatively correlated with academic achievement. Additionally, students high in eveningness showed poor work ethic and behavioural problems.

A positive relationship between morningness and GPA has emerged in a variety of populations (e.g. Vollmer, Schall, Hummel & Randler, 2011; Wolfson & Carskadon, 1998). Earlier chronotype is predictive of better grades and increased attention even when controlling for age and sex (Vollmer, Pötsch & Randler, 2013). Students who wake more easily in the morning perform better in school and yield higher scores on exams in pre-high school, high school and university (Beşoluk, Önder & Deveci, 2011; Curcio, Ferrara & De Gennaro, 2006; Önder, Horzum & Beşoluk, 2012; Preckel, Lipnevich, Schneider & Roberts, 2011).

Beginning in early adolescence, chronotype has been found to explain a significant proportion of variance in academic performance. 14.2% of variance in self-reported academic achievement was due to: age, degree of morning preference, thinking style and the interaction between thinking style and morning preference in students aged 10 to 14 years (Diaz-Moralez and Escribano, 2013). Controlling for total sleep time, evening types (especially males) performed worse academically measured by both self-report grade and subjective achievement, in a sample of 12 to 16 year old Spanish students (Escribano, Diaz-Moralez, Delgado & Collado 2012).

In high school populations, negative correlations emerged between degree of eveningness with overall GPA, GPA in math/science as well as GPA in languages (Preckel et al., 2013). Eveningness accounted for 4% of the variability in GPA (above the influence of age, sex, conscientiousness, cognitive ability, need for cognition, and achievement motivation; Preckel et al., 2013). A study in the U.S. of recent high school graduates found that evening types were less likely to report having received 'A' grades and were less likely to study more than 16 hours per week (Cole, 2014). The highest grades were reported by morning types who did not consume caffeinated beverages (Cole, 2014).

Researchers have found that even in university students, chronotype is maintained as a significant predictor of GPA when controlling for age, academic motivation (Önder, Beşoluk, Iskender, Masal & Demirhan, 2014), class start time and sex (Beşoluk, Önder & Deveci 2011). Chronotype and social jetlag, in addition to several personality variables (conscientiousness, intrinsic motivation to experience stimulation, intrinsic motivation to accomplishment and neuroticism) predicted 15.1% of the variance in cumulative GPA. Morning types and those with less social jetlag demonstrated higher GPA. When controlling for age and academic motivation, morning types had significantly higher GPA in both male and female samples. Evening types had worse sleep quality than morning types (Önder et al., 2014).

2.1. Social Jetlag

The relationship between chronotype and academics may be moderated by *social jetlag*. Social jetlag is defined as a mismatch between the internal clock and the social clock (Wittmann, Dinich, Merrow & Roenneberg, 2006). Evening types are biologically unable to fall asleep until late, yet are forced to awake by their alarm clock for social obligations such as school. Social jetlag could negatively impact academic performance in two ways: 1. Chronic sleep restriction: mismatch between biological and social time can be large enough across the week to cause significant sleep restriction, especially in evening types, and; 2. The Synchrony effect: evening types are being forced to learn early in the day, out of synchrony with their biological peaks of alertness. There is evidence of relationships between these parameters and academic performance. The delay in circadian rhythms during adolescence, combined with early school start times, increases social jetlag, which is more pronounced in evening type students. Haraszti et al., (2014) hypothesized that social jetlag is a better predictor of performance than chronotype and found that social jetlag negatively predicted weekly test scores (Haraszti et al., 2014).

2.1.1. Sleep and Academic Performance

Due to early school start times, evening type adolescents experience a greater misalignment between biological and social time. As stated earlier, the delayed circadian phase in evening types makes those individuals unable to fall asleep until late, and their sleep episode is subsequently truncated on school days due to the morning alarm clock. Evening types sleep less on school days, show higher levels of daytime sleepiness (Randler & Frech, 2006), and report more school related problems (Vollmer et al., 2011). Many reports have shown that on school days, evening types go to bed as much as 2 hours later than morning types, but wake up at the same time (Randler & Frech, 2006). In addition, evening types have reported worse sleep quality than other chronotypes (e.g. Lima, Varela, Silveira, Parente, Araujo, 2010). Conversely, morning types report better sleep quality and higher levels of daytime alertness (Escribano et al, 2012). Adolescents showing delayed circadian phase and subjected to early school start times show greater sleep propensity (shorter sleep latency and REM sleep onset; Carskadon, Wolfson, Acebo, Tzischinsky & Seifer, 1998) suggesting that they have an accumulated sleep debt.

Sleep is very important for daytime functioning. Both REM and non-REM sleep stages have been linked to memory consolidation (Stickgold, 2005), thus sleep debt and low sleep quality would be expected to negatively impact cognitive and academic performance. Poor academic performance has been attributed to insufficient sleep (Eliasson et al., 2002) which may be exacerbated in evening type students due an increase in social jetlag. Sleep parameters such as duration and quality are associated with academic performance in a manner consistent with social jetlag (Medeiros, Mendes, Lima & Araujo, 2002).

Sleep duration has been the most commonly studied sleep variable in relation to academic performance. Adolescents obtain decreasing amounts of sleep with age (Fredriksen, Rhodes, Reddy & Way, 2004). Degree of morningness, sleep length and school achievement all decreased with age in an adolescent sample (Diaz-Moralez & Escribano, 2013). Sleep length has been shown to negatively correlate with depressive symptoms, and positively correlate with self-esteem and school grades (Fredriksen, Rhodes, Reddy & Way, 2004). Evening types have shorter sleep length, higher levels of inductive reasoning but lower levels of school achievement compared to morning types (Diaz-Moralez & Escribano, 2013). Longer sleep length, increased morning preference, younger age, female sex and higher inductive reasoning were found to predict GPA (Diaz-Moralez & Escribano, 2013). In addition to sleep duration and daytime sleepiness, sex (male versus female) and alcohol consumption have also been found to be significant predictors of GPA (Singelton & Wolfson, 2009). Interestingly, Eliasson, Eliasson, King, Gould and Eliasson (2002) found no association with sleep duration and performance at school. Irrespective of sleep duration, a study by Short et al., (2013) reported that chronotype had the largest effect on performance.

Sleep quality and daytime sleepiness are also predictors of academic achievement. Gomes, Tavares, Helena and de Azevedo (2011) found that self-reported sleep quality and frequency of sufficient sleep were the main predictors of academic performance. Evening types show worse sleep quality and diminished daytime alertness, and those with worse sleep quality reported more depressed mood, which correlated negatively with grades (Short et al., 2013). In a study of 14 to 16 year old students, Roeser, Shlarb & Kubler, (2013) found that chronotype was not directly related to academic performance but was mediated by daytime sleepiness and learning motivation. In their sample, morningness negatively correlated with daytime sleepiness and positively with learning motivation whereas eveningness correlated positively with daytime sleepiness and refusal to work. In turn, refusal to work correlated negatively and learning motivation correlated positively with self-reported academic performance.

Another study found a relationship between sleep quality and academics only in students taking a full course load, suggesting that these students become more vulnerable to the effects of lower sleep quality (Howell, Jahrig & Powell, 2004).

A third important sleep variable is sleep timing, which has a direct link with chronotype. Irregular sleep schedules can lead to lower sleep quality and increased sleep restriction since changes in sleep-wake schedule further propagates the mismatch between biological and social time. Eliasson et al., (2009) found that earlier bed and rise times were related to high academic performance and high performers took more frequent naps than low performers. Gomes, et al. (2011) suggest that the relationship between chronotype and academic performance is not direct, but is mediated by sleep restriction and sleep irregularity, which are higher in evening-types (Giannotti, Cortesi, Sebastiani & Ottaviano, 2002). Gomes et al., (2011) found that individuals who failed most of their courses the preceding year exhibited greater variation in rise times on week days, in addition to later midsleep times on weeknights and weekends, and higher degree of eveningness. Grades were higher in those with more stable bedtimes, as well as earlier midsleep times, higher morningness scores, better sleep quality, higher frequency of sufficient sleep, less night outings and higher class attendance (Gomes et al., 2011).

2.1.2. Synchrony Effect

Despite predictable variation in performance across the day, studies of individual differences in circadian rhythms have shown a synchrony effect between times of peak of performance and chronotype. Morning types tend to do better earlier in the day, whereas evening types perform best later in the day (see Carrier & Monk 2002 for review; Cavallera et al., 2011). In order to meet societal demands, evening types must try to function in the morning (during non-optimal times) for work and school. Adolescent and young adult student populations are at an age where they are experiencing delay of their circadian phase. This may have detrimental effects on academics, especially for evening types subjected to rigid early morning class schedules. Both times of teaching and time of testing have an impact on academic outcomes (Beşoluk, Önder & Deveci 2011).

A synchrony effect has been found when testing morning and evening types on a fluid intelligence task in either a morning or afternoon testing session (Goldstein et al., 2007). Recent findings show negative correlations between midsleep time and academic performance in a group of morning test takers (Haraszti et al., 2014). During a morning testing session, the odds of being a low achiever were two times higher in late chronotypes than in early chronotypes, meaning that evening types had double the odds of receiving low grades when tested in the morning. No difference was found between chronotypes when tested in the afternoon. Additionally, during an exam period when students had more freedom in their daily schedules, the authors found no relationship between social jetlag and academic performance.

Önyper, Thacher, Gilbert and Gradess (2012) analyzed the effect of class start times and sleep on academic performance in university students. Although later class start times did not directly influence academic performance, the late start allowed for later rise times and an overall increase in sleep duration. Later start times resulted in less daytime sleepiness and reduced likelihood of missing class. Attendance, cognitive performance and alcohol consumption emerged as significant predictors of GPA. Morning types functioned better throughout the day. Students taking later classes were at greater risk for alcohol consumption on weekends.

Beşoluk, Önder and Deveci (2011) found that an early versus late teaching period had a significant effect on final exam grade. The early teaching period consisted mostly of morning types, and morning types were found to have higher GPA than evening types when controlling for class start times, exam grade, age and sex. Morning types also received higher final exam grades than evening or intermediate types when controlling for age, sex and class time. The authors found a synchrony effect between teaching period and testing time. Those taking early classes had higher final exam scores when tested in the morning as compared with those with a late class schedule when tested in the morning.

A study of online learning found no difference between chronotype and academic achievement. They attribute this to lower levels of social jetlag and the students' ability to choose at what time of day they learn the material (Horzum et al., 2014).

2.2. Stimulant and Alcohol Consumption

A review of the literature reveals trends suggesting increased consumption of caffeine, nicotine and alcohol by evening chronotypes. Additionally, consumption of these substances appears to relate to academic performance. A striking correlation was found between chronotype and nicotine consumption, which was significantly higher in evening types of all ages, with exception of those in retirement (Wittmann et al., 2006). Daily consumption of three or more caffeinated beverages per day was 2.5 times higher in evening types compared to morning types. Sixty-nine percent of evening types consumed caffeinated beverages and high caffeine consumption negatively predicted academic performance (Cole, 2014). Consumption of alcohol has also been linked to academics. Greater consumption of alcohol is predictive of low GPA (Önyper et al., 2012). In addition to a direct impact on levels of alertness and cognition, consumption of these substances has profound impact on sleep as well, which may mediate effects of academic performance.

2.3. Body Mass Index

Reference has been made in the literature to relationships between chronotype and body mass index (BMI). Dietary intake is associated with chronotype, as is times of day at which food is consumed. Significant correlations have been found with chronotype and BMI in American adults (Wang, 2014). For individuals with a BMI greater than 25, social jetlag was associated with BMI (Roenneberg et al., 2012). Breakfast times are variable between weekdays and weekends and for evening types, breakfast is consumed later (Fleig & Randler, 2009). Evening types have more irregular mealtimes (Giannotti et al., 2002), consume higher amounts of alcohol (Giannotti et al., 2002), caffeine (Fleig & Randler, 2009) and eat less dairy compared to morning types (Fleig & Randler, 2009). It was found that in a sample of college freshmen, evening types had a greater increase in BMI across a school semester than other chronotypes (Culnan, Kloss & Grandner, 2013). Diet and weight have been linked with academic achievement, and overweight adolescents have been found to have lower levels of academic performance (Taras & Potts Datema, 2009).

Animal research shows that a high fat diet alters period of locomotor activity and expression of clock genes in mice (Kohsaka et al., 2007), giving evidence that high fat diet may lengthen τ of the circadian clock and interact with chronotype.

2.4. Present study

The primary aim of the present study was to gain a deeper understanding of the relationship between chronotype and academic performance, the influence of social jetlag on these variables, and the role of other correlates of chronotype (i.e. stimulant, alcohol consumption and BMI). This was achieved in several ways: First, an attempt was made to replicate previous findings through examination of the relationship between chronotype and two measures of academic performance, provided by GPA (entire academic record) and the grade in a course taken that semester (most recent). Second, three measures of chronotype were used that differ in emphasizing either preferences (the MEQ) or actual behavior, either retrospectively (MCTQ) or in real time (sleep diaries). Third, these measures were compared across time of year, and determine the influence of prior experience completing a chronotype questionnaire and keeping a sleep diary. Finally, psychological and physiological correlates of chronotype were examined in our sample (i.e. social jetlag, stimulant and alcohol consumption and BMI).

To examine variability in chronotype assessments, stability of measurements over time was assessed. It is known that chronotype changes across the lifespan, but at the time of commencement of this study there was little information about the stability of chronotype and its assessments over multiple measurements and across seasons. There may be effects of prior assessment of chronotype on measures of chronotype. As previously mentioned, the MEQ is a psychological questionnaire that once completed may increase self-awareness of time of day preferences and promote comparison of personal preferences with those of peers. This may influence responses on future questionnaires as belief of one's chronotype is subjective and dependent on how they rate their chronotype in relation to others. Measurements from the MCTQ should be less affected by subjective variables since assessment of chronotype from midsleep is a direct measure of behaviour. Nonetheless, if subjects are required to pay attention to their sleep-wake habits, by keeping a sleep diary for example, there is a chance that this would change the assessment of chronotype as measured by questionnaires like the

MCTQ and MEQ, presumably in the direction of making assessments more representative of actual behaviours. This question was examined by testing the participants at two time-points within a university semester while having them complete a sleep diary between testing times.

Seasonal variations in light exposure may affect circadian rhythms and influence measures of chronotype. At the time of starting this study there were no data available regarding the sensitivity of chronotype measures to season. This gap in the knowledge base has been decreasing in recent years; however research still needs to be done to reliably assess changes in chronotype across season. Light is the primary stimulus that synchronizes our internal biological clock with the external environment. Due to varying light exposure dependent on season, individual internal clocks may delay and advance with the changing photoperiods. Given that the internal clock is shifted and synchronized by light, we would expect that there might be differences between sleep timing and circadian phase in different seasonal photoperiods. Chronotype has been found to advance in the summer months in sub-arctic populations where absence of daylight is experienced in the winter and constant light experienced during summer (Friborg et al., 2014; Johnsen et al., 2013). Correlations between chronotype and the timing of the solar light schedule have been shown (Randler, 2008; Roenneberg & Merrow, 2007). Roenneberg, Wirz-Justice and Merrow (2003) found differences in self reported outdoor light exposure between chronotypes. Goulet et al., (2007) also showed differences in light exposure between chronotypes, specifically that, morning types have greater morning light exposure and longer duration of exposure to bright light across the day.

In the present study, participants were recruited from universities where the longest day of the year occurs in June (approximately 16 hours of daylight) and the shortest day is in December when sunrise is delayed and sunset advanced (approximately 8 hours of daylight; see Figure 2.1). It is predicted that later morning light and shorter duration of daylight in winter will delay chronotype, increase social jetlag and negatively impact academic performance. Later morning light exposure in winter months would reduce the amount

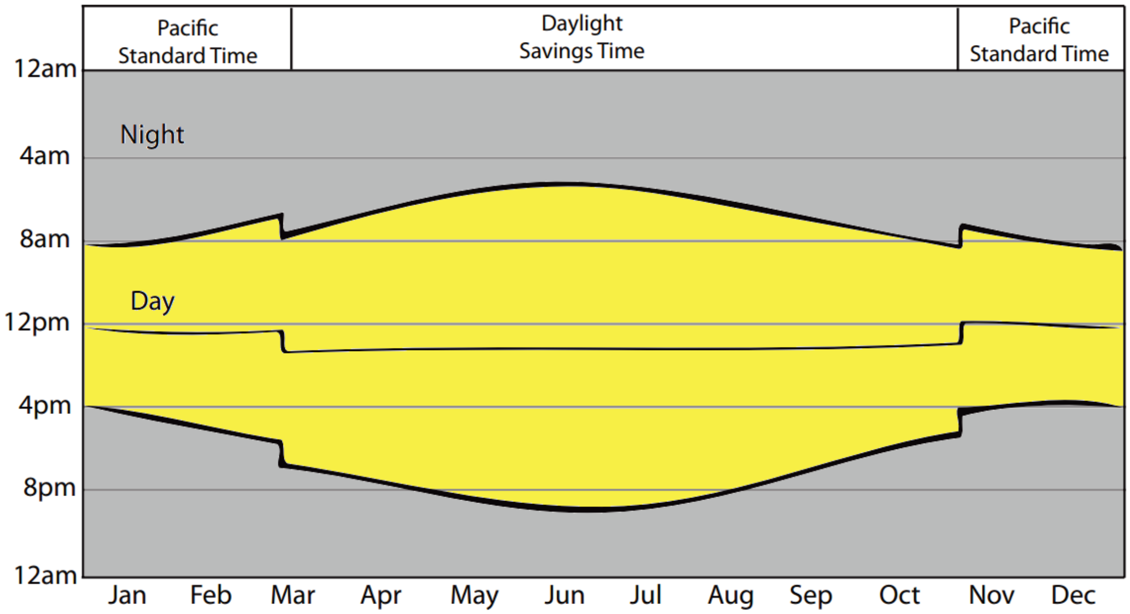

Figure 2.1. Photoperiodic Changes across Season
Average change in day-length in Vancouver, BC, Canada. The longest days of the year occur in June and the shortest in December. During Daylight Savings Time (DST) time is delayed by 1 hour on March 11th and advanced by 1 hour on Nov 4th.

of light falling on the critical period for phase advances, and since light loss in the evening (during the critical period for phase delays) is likely being compensated by artificial lighting this may result in a net delay. Start times of school and work do not delay in the winter months however, meaning that individuals are forced awake by the alarm clock in the absence of this synchronizing stimulus. An attempt was made to sample near the longest and shortest days of the year in order to examine effect of seasonal photoperiod.

2.4.1. Hypotheses

1. The main research question was to determine if chronotype is predictive of academic performance in the present sample, and if this relationship is being mediated by social jetlag. It is hypothesized that evening types will exhibit lower GPA and class grade and that these relationships are mediated by social jetlag.

2. To determine variability in chronotype measurement, three measures of chronotype (MEQ score, midsleep from the MCTQ [MSF_{MCTQ}], and midsleep

from sleep diaries [MSF_{Diary}]) will be compared directly as well as across time-points and seasons. It is suspected that although correlated previously, the measures will show differences since each is based on a different inherent definition of chronotype. It is also predicted that assessment of chronotype as measured by MEQ and MCTQ will change following completion of a sleep diary that requires individuals to track their actual behaviours. Seasonal photoperiod is predicted to alter chronotype measurement; specifically chronotype is suspected to advance during spring and summer school semesters and delay in fall semester. It is hypothesized that social jetlag will be highest during months with shorter photoperiods.

3. It is hypothesized that caffeine, nicotine, alcohol consumption, and BMI will be correlates of chronotype. It is expected that these variables will be positively correlated with eveningness and negatively correlated with academic performance.

Chapter 3.

Methods

3.1. Participants

1,887 undergraduate students from Simon Fraser and Thompson Rivers Universities participated in the present study for partial course credit. Of the total sample, 508 (27%) were males and 1,236 (66%) were female (8% of participants did not report sex). The mean age was 21.78 years (*SD*= 4.24), with a range from 17 – 70 years. Exclusion criteria included incomplete data, full-time permanent night shift workers, and participants who self-identified as taking sleep aid medication.

3.2. Measures and Procedure

Chronotype assessment tools included the Morningness-Eveningness Questionnaire (MEQ; Horne & Östberg, 1976), the Munich Chronotype Questionnaire (MCTQ; Roenneberg, Wirz-Justice & Merrow, 2003) and sleep diaries. All subjects completed questionnaires via an online web survey tool, once at the beginning and once at the end of a university semester (fall, winter or spring). Demographic information such as age and sex was also collected as well as self-reported BMI, GPA and/or class grade. Data were collected over multiple school semesters and in different seasons from 2008 - 2013 (See TableA.7. in Appendix A).

3.2.1. Morningness-Eveningness Questionnaire

The MEQ is a self-report questionnaire focusing on individual timing preferences. Calculated from 19 questions, each participant received a score ranging between 16 and 86. Higher scores indicate a larger degree of morning preference. This score can be used as a continuous variable, or can be grouped as up to five categories based on cut-offs reported by Terman et al., (2001). The MEQ used can be seen in Appendix B.

3.2.2. Munich Chronotype Questionnaire

The 29 questions on the MCTQ request information regarding average daily sleep and wake timing to assess phase of entrainment separately for work and free days. Midsleep time on free days (MSF; the time halfway between sleep onset and wake time on free days) is used as a measure of individual chronotype. This measure has been validated by biological measures (e.g. timing of melatonin onset), and has been found to correlate highly with the MEQ (Kitamura et al., 2014; Zavada et al., 2005). The MCTQ used can be seen in Appendix B.

3.2.3. Sleep Diaries

A subsample of 686 students were asked to complete a daily written sleep diary for a duration ranging from one week to two months during their school semester (mean # of days= 34.43, *SD*= 21.60). This allowed for collection of accurate daily sleep timing information, as opposed to preferences or retrospective self-reported averages of daily behaviours. Participants recorded ‘day type’, indicating which days were work days and which were free days. Free days were defined as days when participants were free to wake at their preferred time. Work days were defined as days when participants were required to wake for social obligations (including school). From the diaries, average sleep onset, wake times, midsleep and sleep duration were calculated separately for work and free days. Within the diaries, nap time and duration as well as daily intake of caffeinated beverages, alcoholic beverages, tea/pop and cigarettes were also recorded. To assess chronotype, midsleep time on free days (MSF_{Diary}) was calculated. See Appendix B for a copy of the sleep diary used.

3.2.4. Academic Performance

To measure academic performance, 793 students reported their GPA obtained to date in their university career. Class grade was obtained for 810 students from a 3rd year Biological Rhythms course taught through the Department of Psychology at Simon Fraser University. The class grade was derived from a midterm and a final examination.

Class lectures (3h duration, once or twice/week) took place in the afternoon or evening (either 14:30 or 18:30).

3.3. Analyses

Analyses were conducted using SPSS Statistics 18. The sample was divided into 3 'Chronotype groups' (ET: evening types [MEQ score of 16 - 41], IT: intermediate types [MEQ score of 42 - 58], MT: morning types [MEQ score of 59 - 86]) based on previously established MEQ score cut-offs (Terman et al., 2001, see Appendix B).

Unless otherwise stated, all analyses used MCTQ and MEQ data from the first questionnaire administration (Time 1; T1). T1 was chosen for two reasons: the months during which T1 data were collected represent extremes of each season, which was more appropriate for seasonal analyses, and the T1 dataset was larger since data had been lost at T2 due to attrition.

3.3.1. Midsleep Calculations

Midsleep times on free days from the MCTQ (MSF_{MCTQ}) and sleep diaries (MSF_{Diary}) were calculated for analysis. Given that population distributions vary, midsleep times were left as continuous variables for analysis. Reliable cut-offs have not been established for grouping of chronotype based on MSF scores as has been done with the MEQ. A median split to categorize MSF was not considered appropriate given the small number of those deemed morning type by MEQ cut-offs (*n*= 59). Midsleep times for the MCTQ and sleep diaries were corrected for sleep latency (the subject's estimate of how long it takes them to fall asleep after lights-out). It is suggested in the literature (Roenneberg et al., 2004) that midsleep times should be corrected for accumulated sleep debt (using a 5 work day, 2 free day formula), however in the present sample school/work schedules were irregular and not necessarily on consecutive days. Since the majority of the student sample did not work 5 days on and 2 days off, it is presumed that sleep debt would not have accumulated across the "work week" in the same way as a 5 : 2 schedule, and thus this correction was not used.

3.3.2. Social Jetlag Calculations

Three variables were calculated to quantify social jetlag: social jetlag midsleep (SJMS); social jetlag sleep duration (SJSD); and percent of sleep loss on work days (%SLW). Individual participants were also classified into social jetlag categories that take into account both change in sleep timing (midsleep) and duration.

Social jetlag for midsleep was calculated as the difference score (in minutes) between midsleep time on free and work days (SJMS: MSF-MSW). Positive values of SJMS indicate a later midsleep time on free days (compared to work days), whereas negative values indicate an earlier midsleep time on free days (compared to work days). Studies to date (i.e. Haraszti et el., 2014) transform SJMS into its absolute value for analysis since the larger the social jetlag score (the greater the distance from zero), the greater the indication of going against one's body clock. The present study, in addition to using absolute value of social jetlag midsleep ($SJMS_{ABS}$) for comparative purposes, used primarily the raw values ($SJMS_{RAW}$) for analysis in order to explore differences between those who have a positive versus a negative social jetlag score.

Social jetlag for sleep duration (SJSD) was calculated as a difference score (in minutes) between sleep duration on free days and work days (SJSD: SDF-SDW). A positive SJSD value indicates longer sleep duration on free days (compared to work days), whereas a negative SJSD value indicates shorter sleep duration on free days (compared to work days). Absolute value of Social jetlag for sleep duration ($SJSD_{ABS}$) as well as raw values ($SJSD_{RAW}$) were used for analysis.

Individual differences exist in duration of sleep required for optimal functioning, and the measures do not take into account whether sleep duration satisfies individual sleep need, thus the percentage of sleep lost on work days was calculated ($\%SLW_{MCTQ}$ and $\%SLW_{Diary}$). A 60 minute loss in sleep (for example) may have a differential impact on a short sleeper versus a long sleeper since it constitutes a different percentage of their overall sleep, thus it is imperative to examine overall % of sleep lost as well as the number of minutes discrepancy (SJSD).

3.3.3. *SJMS/SJSD Categories*

Midsleep times are sensitive to sleep duration; however it was still of interest to examine the relationship between shifting midsleep times and change in sleep duration between work and free days. Presumably, social jetlag accumulates for evening types on work days and for morning types on free days. Evening types are biologically unable to fall asleep until late, but are forced by their alarm clock to wake early on work days. On free days, early types may be forced to stay awake later than they would prefer due to social obligations, yet nevertheless are awakened early the next day spontaneously by their circadian clock. Both of these scenarios reduce sleep duration and push midsleep time later on free days (as compared to work days; see Figure 3.1) resulting in positive social jetlag scores (SJMS+SJSD+). There were three possible outcomes for each SJMS and SJSD: a positive score (SJMS+; later midsleep on free days than work); a negative score (SJMS-; earlier midsleep on free days than work); or no change (SJMS0). The possible outcomes for SJSD were: a positive score (SJSD+; longer sleep duration on free days than work); a negative score (SJSD-; longer sleep duration on free days than work); or no change (SJMS0). Social jetlag scores of -5 to +5 were not considered to represent a meaningful difference between free and work days and thus were classified as no social jetlag (SJMS0 or SJSD0). The combinations of these lead to coding of nine *Social Jetlag Categories* that represent the possible combinations of social jetlag for midsleep and sleep duration (Figure 3.1).

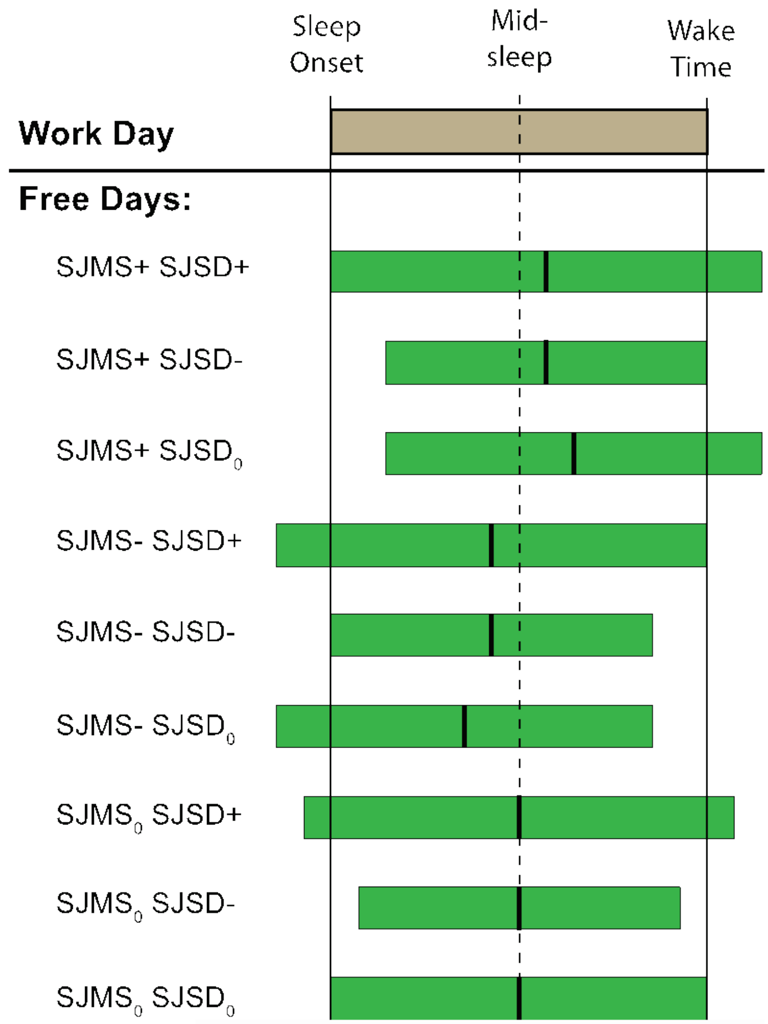

Figure 3.1. Scenarios leading to Social Jetlag Categories
SJMS+: Delay in midsleep on free days compared to work days; SJMS-: Advance in midsleep time on free days compared to work days; SJSD+: Increase in sleep duration on free days compared to work days; SJSD-: Decrease in sleep duration on free days compared to work days; 0: No changes in parameter between free days and work days.

Chapter 4.

Results

4.1. Data Treatment

Extreme scores were detected using the boxplot method. While extreme score detection methods will routinely employ 1.5 x the inter-quartile range (IQR), as is done in SPSS, this cut-off was believed to be too conservative for the presents study as realistic scores would be discarded from analyses. A threshold of 3 x IQR was chosen in order to include representation of realistic although perhaps uncommon data points. A liberal threshold for detecting extreme scores allowed for removal of unidentified shift workers, and uncommon data points due likely to possible participant input errors yet could not be dealt with by the researchers objectively. Using a threshold of 3 x IQR retained data points that, although considered extreme by conventional guidelines, represented what is assumed to be realistic data for the sample based on the observed shape of the distribution.

Although data were collected from 1887 subjects, not all measures were completed by each subject and missing data occurred for each variable. A list-wise deletion strategy was employed to account for this. Use of this strategy resulted in varying sample sizes for each analysis, therefore, individual N's are reported by analysis.

Since the variables used to measure academic performance are innately bounded (GPA range from 0 to 4.33; Class grade range from 0 to 100), it was necessary to transform both into continuous variables for use in correlational and regression analyses. This was done using a Logit transformation with the following formula: logit(w)= log(w)/(1-w), where "w" represents the original variable freed from its bounds i.e. 0< GPA< 4.33; w= ([score - 0]/[4.33 - 0]); 0< Class Grade< 100; w= ([score - 0]/[100 -

0]). GPA was strongly correlated with its transformation (*r*= .978, p< .001) as was class grade (*r*= .992, p< .001).

4.2. Sample Statistics

For complete listing of the information collected from each class/semester refer to Table A.7. in Appendix A. Descriptive statistics tables (Table A.1., A.2. and A.3.) including variables by chronotype and sex are provided in Appendix A. Correlations of all variables of interest are provided in Tables A.4., A.5. and A.6. in Appendix A.

4.2.1. Measures of Chronotype

MEQ Score

Scores on the MEQ ranged from 18 to 74 (out of a possible 16 to 86, *n*= 1136) with a mean score of 43.22, (*SD*= 9.16). MEQ scores were normally distributed with 42.6% of the sample falling in the MEQ cut-off range for evening type (score= 16 - 41), 52.2% as intermediate type (score= 42 - 58) and 5.2% as morning type (score= 59 - 86). See Figure 4.2; Panel A, for the distribution of MEQ scores. Although MEQ scoring guidelines suggest 5 categories, the present sample did not have enough scores in the morning type range for 5 categories to be useful, thus the 3 aforementioned categories were used. A question in the presently used MEQ questionnaire asked participants to rate themselves as one of: 'definitely an evening type'; 'rather more an evening type than a morning type'; 'rather more a morning type than an evening type'; or 'definitely a morning type'. This self-reporting of chronotype significantly correlated with overall MEQ score (*r*= .747, *p*< .01). On the ends of the spectrum, 3.2% believed they were 'definitely a morning type' and 29.8% indicated that they were 'definitely an evening type'. Eight participants who rated themselves as 'definitely a morning type' or 'more of a morning type' had an overall MEQ score that fell within the cut-off range of evening types (see Figure 4.1).

MCTQ Midsleep Free

MSF_{MCTQ} was normally distributed (see Figure 4.2; Panel B) with a range from 2:30am to 9:22am and a mean of 5:53am (*SD*= 1:17, *n*= 1567).

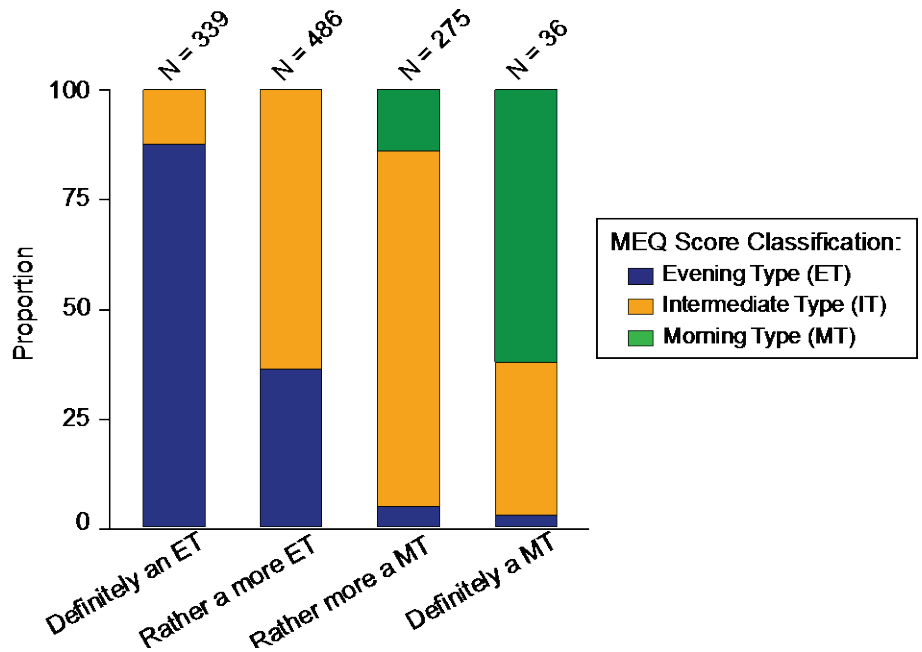

Figure 4.1. **MEQ score compared to response on self-report Question of MEQ: […] what type do you consider yourself to be?**

Sleep Diaries Midsleep Free

MSF_{Diary} was normally distributed with a range from 2:38am to 9:07am and a mean of 5:48am (*SD*= 1:12, *n*= 686) (see Figure 4.2; Panel C).

4.2.2. Measures of Academic Performance

Self-report GPA ranged from 1.5 to 4.24 (out of a possible 4.3) with a mean of 2.88 (*SD*= 0.51, *n*= 793). Class grade ranged from 27 to 94 (out of a possible 100) with a mean of 60.19 (*SD*= 12.15, *n*= 810).

4.2.3. Distribution of Chronotype by Sex

The present sample consisted of 66% females and 27% males (8% did not report sex). See Table 4.1 for distribution of chronotype group by sex. Descriptive statistics by sex and by chronotype group for variables of interest can be seen in Table A.1 and A.2 in Appendix A. Although mean MEQ score did not differ by sex in the present sample, (m_{males}= 42.42, *SD*= 8.87, *n*= 313; $m_{females}$= 43.51, *SD*= 9.24, *n*= 795, independent samples t_{1106}= -1.78, $p > .05$), mean MSF times did differ significantly

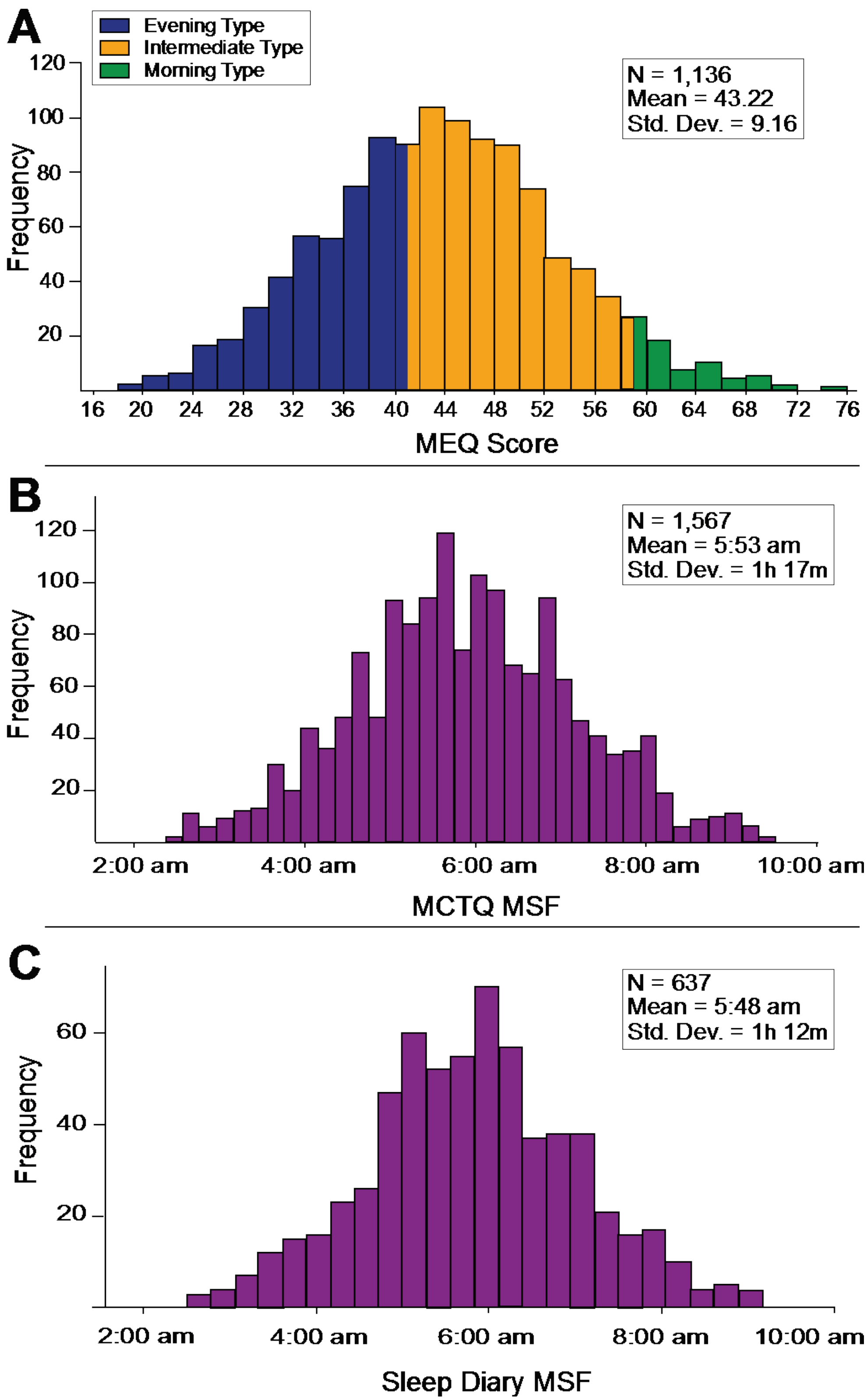

Figure 4.2. Histograms representing distribution of chronotypes
Panel A: MEQ scores; Panel B: MSF_{MCTQ}; Panel C: MSF_{Diary}

Table 4.1. Distribution of Chronotype Group by Sex

Sex	Morning/Early Types	Intermediate Types	Evening/Late Types	Total *n*
% of Males that are:	3.2%	51.8%	45%	313
% of Females that are:	5.9%	52.2%	41.9%	795
Total	5.1%	52.1%	42.8%	1108

Note. Sample sizes based on MEQ score cut-offs for those who reported sex

between males and females. Mean MSF_{MCTQ} was later by 9 minutes in males (*m*= 6:00, *SD*= 1:21, *n*= 451) than females (*m*= 5:51 *SD*= 1:15, *n*= 1116, independent samples t_{1565}= 2.09, $p< .05$) and mean MSF_{Diary} was 18 minutes later in males (*m*= 6:00, *SD*= 1:20, *n*= 174) than females (*m*= 5:42, *SD*= 1:10, *n*=410, independent samples t_{582}= 2.61, $p< .01$).

4.3. Comparison of Day Type

During completion of sleep diaries, participants identified each day as either a work day or a free day. Of the participants who completed sleep diaries, 4.4% (*n*= 30) recorded having zero free days. For those with no free days, only 1 participant reported having children or pets which may have been the cause of waking early (thus considered a 'work' day). Ten participants (1.5%) recorded having no work days. In the MCTQ, participants were asked to indicate 'normal' work start time: 35.8% normally start work in the morning, 27% started mid-day and 27.8% started work in the afternoon. A small proportion of the sample (1%) began work in the evening (22:00 – 1:59 a.m.). These individuals on average had the highest MEQ score (representing higher degree of morningness), yet had one of the latest MSF_{MCTQ} compared to other work start times (Table 4.2). Table 4.2 shows chronotype measurements and percentage of sleep lost on work days corresponding to different work start times.

4.3.1. Sleep Timing

Means and standard deviations for all variables discussed in this section are reported in Table A.2. and A.3. in Appendix A.

Table 4.2. Chronotype and % Sleep Lost on Work Days by Work Start Time

Normal Work Start Time	Morning 6:00-9:59	Mid-day 10:00-13:59	Afternoon 14:00-17:59	Evening 18:00-21:59	Night 22:00-1:59	Early Morning 2:00-5:59	Varies
% of Sample	35.8%	27%	27.8%	5.3%	1.0%	1.3%	1.8%
MEQ score	45.19 ± 9.13	41.70 ± 9.14	42.37 ± 8.57	41.59 ± 9.21	48.75 ± 5.39	45.27 ± 10.98	41.79 ± 6.68
MSF_{MCTQ}	5:40 ± 1:16	6:05 ± 1:15	5:56 ± 1:15	5:45 ± 1:24	6:04 ± 1:01	5:18 ± 1:32	5:52 ± 1:28
MSF_{Diary}	5:36 ± 1:13	5:46 ± 1:07	5:58 ± 1:10	5:55 ± 1:20	5:34 ± 1:28	4:28 ± 0:37	5:58 ± 1:50
$\%SLW_{MCTQ}$	13.16% ± 15.21	6.99% ± 12.58	7.53% ± 14.60	8.75% ± 15.55	9.70% ± 20.16	7.78% ± 14.39	5.48% ± 10.99
$\%SLW_{Diary}$	13.83% ± 14.13	11.10% ± 11.12	11.65% ± 12.87	4.96% ± 11.51	14.50% ± 22.49	20.70% ± 16.51	15.15% ± 16.46

Note. Mean ± SD, Total n= 1106

To assess differences in sleep onset, wake time, sleep duration and midsleep time between work and free days measured by the MCTQ, paired samples *t*-tests were utilized. After Bonferroni correction to account for family-wise error, significant differences were found for all variables. Sleep onset was approximately 1 hour later on free days than work days, [t_{1556}= -36.91, p< .001] and wake time was later by approximately 2 hours on free days compared to work days [t_{1561}= -50.30, p< .001]. Sleep duration was 62 minutes longer on free days than on work days [t_{1521}= -26.78, p< .001]. Midsleep time was approximately 1.5 hours delayed on free days compared to work days [t_{1523}= -53.23, p< .001].

The pattern of results was similar when comparing work and free days based on measurement from sleep diaries. Paired samples *t*-tests showed significant differences in sleep onset, wake time, sleep duration and midsleep time between work and free days after Bonferroni correction. Sleep onset from sleep diaries was 31 minutes later on free days than work days [t_{635}= -13.75, p< .001] and wake time was delayed by approximately 1.5 hours on free days compared to work days [t_{607}= -30.87, p< .001]. Sleep duration was 62 minutes longer on free days than on work days [t_{615}= -21.55, p< .001]. Midsleep time was approximately 1 hour later on free days than work days [t_{614}= -29.81, p< .001].

Despite similar patterns within each measure, differences between work and free day sleep onset, wake time, and midsleep time were less pronounced when comparing between the MCTQ and Sleep Diaries. The average sleep duration increase from work to free days was the same between measures (62 minutes); however, average sleep duration for both work and free days was shorter by 20 minutes as reported in sleep diaries compared to the MCTQ.

4.3.2. Midsleep Time

Means and standard deviations for all variables discussed in this section are reported in Table A.2. and A.3. in Appendix A.

Day Type x Sex

To examine differences in midsleep time for work and free days by sex, a 2 (sex: males, females) x 2 (day type: MSW_{MCTQ}, MSF_{MCTQ}) repeated measures ANOVA was performed. No main effect of sex was found [$F(1,1522) = 3.10$, $p > .05$], yet as expected, there was a main effect of day type [$F(1,1522) = 2384.21$, $p < .01$]. MSF_{MCTQ} was significantly later than MSW_{MCTQ} by approximately 90 minutes. No interaction was found between sex and day type [$F(1,1522) = 2.62$, $p > .05$].

When the same analysis was conducted using midsleep times from sleep diaries, a main effect of sex emerged [$F(1,560) = 5.55$, $p < .05$], where midsleep times were later in males by approximately 10 minutes. Day type also showed a significant main effect [$F(1,560) = 708.74$, $p < .01$], where midsleep times were later on free days by approximately 1 hour. No interaction was found between sex and day type [$F(1,560) = .56$, $p > .05$]. The lack of interaction indicates that social jetlag is consistent between sexes.

Day Type x Chronotype Group

A 3 (chronotype group: MT, IT, ET) x 2 (day type) repeated measures ANOVA was conducted. Using the greenhouse geisser correction for homogeneity of variance, a main effect of day type [$F(1,921) = 585$, $p < .001$], and a main effect of chronotype group, [$F(2,921) = 247.88$, $p < .001$] were found. Post hoc comparisons showed significant differences between all chronotype groups ($p < .001$). Relative to morning types (MTs), average MSF_{MCTQ} was approximately 1 hour later in intermediate types (ITs) and 2 hours

19 minutes later in evening types (ETs). Midsleep time on work days followed the same trend between chronotype groups, yet was approximately 1.5 hours earlier than on free days. The day type x chronotype group interaction emerged significant as well, [$F(2,921) = 10.88$, $p < .001$].

The same 3 x 2 repeated measures ANOVA was conducted using sleep diary data. There was a main effect of day type, $F(1,557) = 293.82$, $p < .001$, and a main effect of chronotype group, $F(2,557) = 97.07$, $p < .001$. Post hoc comparisons showed significant differences between all chronotype groups ($p < .001$). Relative to MTs, average MSF_{Diary} was 1 hour and 20 minutes later in ITs and 2 hours 19 minutes later in ETs. On work days, MSW_{Diary} followed a similar trend but was 53 minutes earlier than on free days. Day type x chronotype group did not yield a significant interaction, $F(1,577) = 1.35$, $p > .05$.

The significant main effect of chronotype group within the MCTQ and sleep diaries shows, as expected, that the midsleep times of ETs are delayed relative to ITs and MTs, and that the midsleep time of ITs are delayed relative to MTs. The main effect of day type confirms that sleeping behaviours change from work days to free days, with midsleep time delaying on free days. The significant interaction found using MCTQ data suggests that at least one of the chronotype groups is differentially affected by day type, although this was not found to be significant using sleep diary data (Figure 4.3). Upon visual inspection of Figure 4.3 it appears that the largest discrepancy between MSF_{MCTQ} and MSW_{MCTQ} (equivalent to social jetlag midsleep; SJMS) occurs in the ET group, although this was not tested for significance. To adequately test the amount of social jetlag accrued between chronotype groups, multiple ANOVAs would be conducted, inflating family-wise error and decreasing the probability of detecting a meaningful difference. Correlational analyses were performed in Section 4.7 to address this research question.

The vast majority of evening types use an alarm on work days (97%) and few wake before their alarm (8.7%). It is common for individuals in each chronotype group to nap more often on work days compared to free days (see Table 4.3).

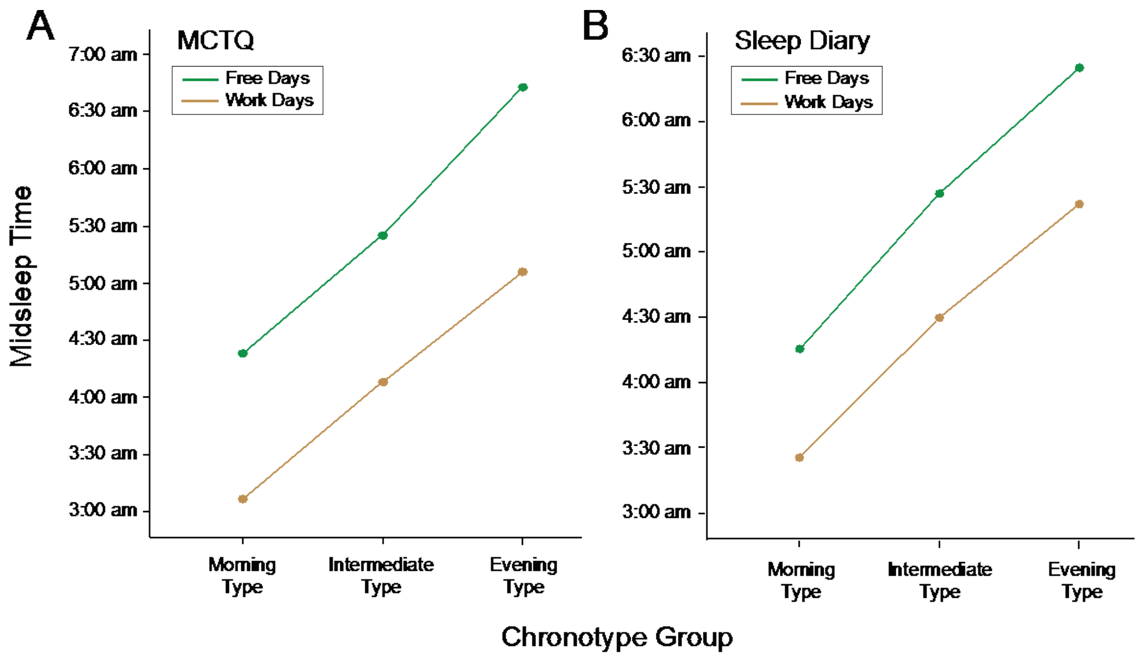

Figure 4.3. Midsleep Times by Chronotype Group for Free and Work days
Panel A: MCTQ data; Panel B: Sleep diary data

Table 4.3. Average daily activities by Chronotype Group

	Work Days			Free Days		
	Morning Type	**Intermediate**	**Late Type**	**Morning Type**	**Intermediate**	**Late Type**
Use Alarm	81.1%	93.0%	97.0%	32.1%	21.5%	20.7%
Often Wake Before Alarm	54.9%	24.5%	8.7%	55.1%	24.1%	14.9%
Nap Often	1.9%	7.2%	11.6%	0.0%	2.6%	2.1%
Nap Time	*n*= 24 14:30 ± 0:59	*n*= 263 15:36 ± 1:44	*n*= 257 16:04 ± 1:49	*n*= 21 14:47 ± 1:13	*n*= 208 15:11 ± 1:38	*n*= 169 15:50 ± 1:54
Nap Duration (mins)	*n*= 25 43.40 ± 19.66	*n*= 263 61.98± 34.49	*n*= 257 73.90 ± 38.06	*n*= 22 53.30 ± 33.25	*n*= 214 67.89 ± 37.49	*n*= 176 73.36 ± 40.58
Daily Time Outside (mins)	*n*= 51 146.32 ± 111.92	*n*= 470 160.43 ± 129.02	*n*= 411 155.37 ± 127.57	*n*= 51 188.53 ± 99.65	*n*= 465 171.04 ± 103.42	*n*= 405 169.46 ± 102.37

Means ± SD

4.4. Comparison of Measures

4.4.1. MEQ and MSF measures

Chronotype measures were correlated to confirm significant correlation of all 3 measures in the present sample (Figure 4.5). MEQ score, where a higher score indicates higher degree of morningness, negatively correlated with MSF_{MCTQ}, (r= -.643, p< .001, n= 958) and MSF_{Diary} (r= -.622, p< .001, n= 582). MSF_{MCTQ} and MSF_{Diary} were found to correlate positively (r= .580, p< .001, n= 563).

The MEQ scoring key includes guidelines for validating MEQ scores using comparison to sleep and wake times (Terman et al., 2001). For example, someone with an MEQ score between 59 – 86 (morning type) would be expected to begin sleeping between 9:00 - 10:45pm and wake between 4:00 - 6:30am (corresponding midsleep range: 12:30am to 2:38am). In the present sample, the average MSF_{MCTQ} and MSF_{Diariy} for each chronotype group falls under the MEQ guideline of what is expected for intermediate and evening types regardless of MEQ score, suggesting that midsleep times are shifted later in the present sample. Table 4.4 shows the midsleep guidelines, and the actual midsleep times for each chronotype group.

Table 4.4. MSF Time by Chronotype Group based on MEQ Cut-offs

	Morning Types (MEQ Score 59-86)	Intermediate (MEQ Score 42-58)	Evening Types (MEQ score 16-41)
MEQ Scoring Key Midsleep Guidelines	12:30am - 2:38am	2:38am - 4:38am	4:38am - 7:00am
MSF_{MCTQ}	*n*= 47 **4:23 am** ± 1:11	*n*= 491 **5:25 am** ± 1:05	*n*= 420 **6:44 am** ± 1:06
MSF_{Diary}	*n*= 29 **4:15 am** ± 0:43	*n*= 297 **5:26 am** ± 1:02	*n*= 234 **6:24 am** ± 1:02

Means ± SD

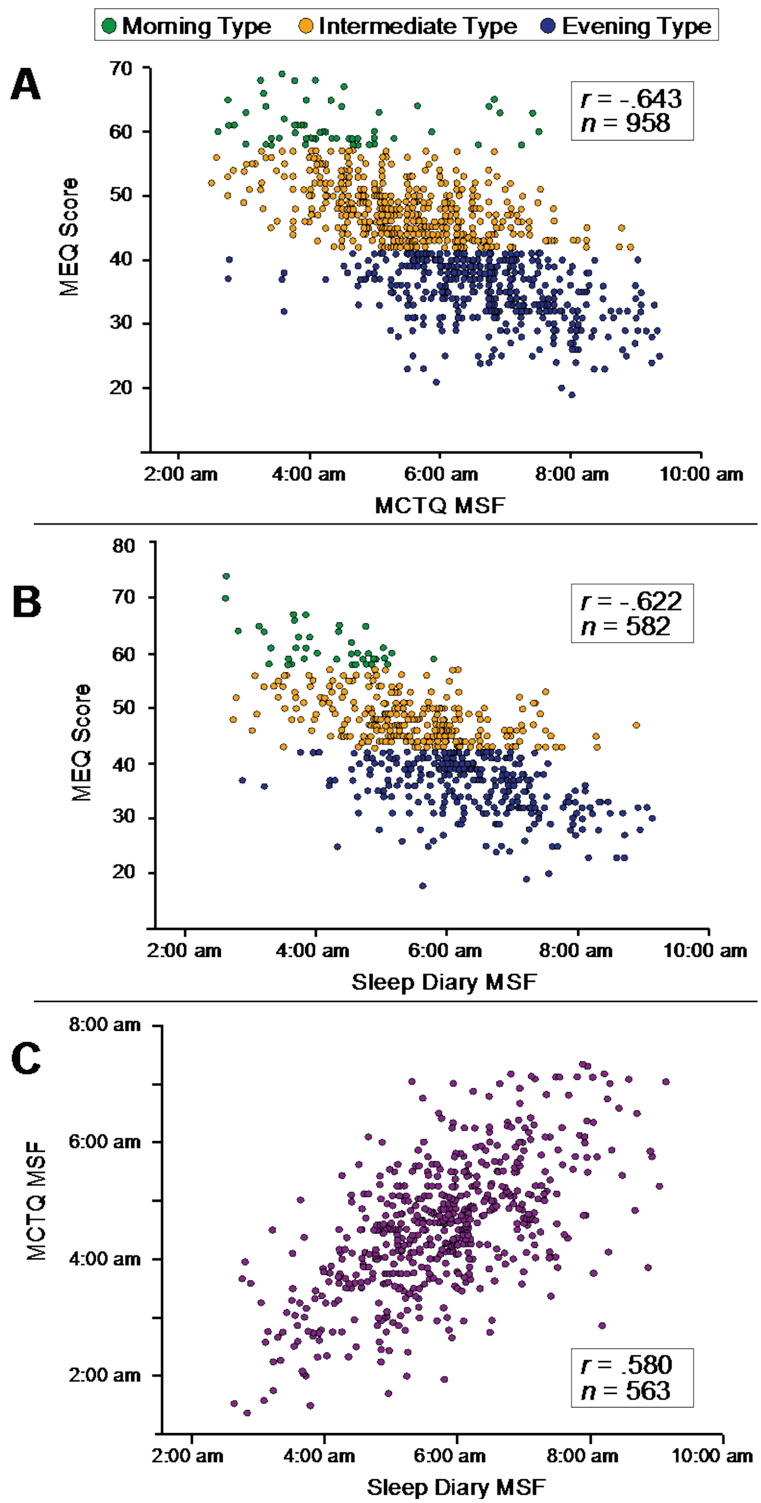

Figure 4.4. Correlations between Chronotype Measures
Panel A: MEQ score & MSF_{MCTQ} ; Panel B: MEQ score & MSF_{MCTQ}; Panel C: MSF_{MCTQ} & MSF_{Diary}

4.4.2. MCTQ and Sleep Diaries

Table 4.5 shows descriptive statistics for sleep and social jetlag variables as measured by MCTQ and sleep diaries for participants who completed both measures. A paired samples *t*-test comparing MSF between MCTQ and sleep diaries showed that there is a significant discrepancy between the two measures [t_{562}= 3.47, p< .01, n= 563]. For those who completed both the MCTQ and a sleep diary, mean MSF from the MCTQ was 10 minutes later than when measured by sleep diary. Figure 4.6 shows the differences in MSF by measure according to chronotype group, illustrating that MSF_{MCTQ} is more delayed across chronotype groups than MSF_{Diary}.

4.5. Multiple Assessments

Students filled out the MCTQ and MEQ questionnaires at the beginning and the end of a university semester (T1 vs T2). To determine if self-monitoring of sleep/wake patterns by completion of sleep diaries would influence assessment of chronotype, *t*-tests were used to measure the difference between assessment at T1 and T2 for those who completed sleep diaries between time-points. Paired samples *t*-tests revealed no significant difference in MSF_{MCTQ} at T1 (*m*= 5:59am, *SD*= 1:21) compared to T2 [(*m*= 6:01, *SD*= 1:22), t_{621}= -.56, p> .05, n= 622]. The MEQ score was found to be significantly higher at T1 compared to T2 [t_{657}= 3.28, p< .01, n= 658], but the difference was only 0.72 of a point on a scale out of 70, and both T1 and T2 scores fell within the cut-off for the intermediate type. Despite having recorded sleep diaries for a week or more between the two questionnaire time-points, this did not alter chronotype outcome as measured by the MSF_{MCTQ} and MEQ score.

Table 4.5. Comparison of MCTQ and Sleep Diaries by Work and Free Days

	MCTQ		Sleep Diaries		
	Work Days	Free Days	Work Days	Free Days	Saturdays (Free Sundays)
Sleep Onset	*n* = 608 0:39 am ± 1:18	*n*= 603 1:42 ± 1:29	*n* = 675 1:09 ± 1:23	*n* = 649 1:39 ± 1:21	*n* = 528 1:59 ± 1:26
Sleep Latency (min)	*n* = 594 22.16 min ± 15.13	*n*= 603 19.58 ± 15.65	*n* = 637 16.18 ± 10.12	*n* = 606 14.49 ± 9.15	*n* = 519 14.13 ± 10.64
Wakeup Time	*n* = 603 8:28 am ± 1:33	*n*= 607 10:20 ± 1:33	*n* = 661 8:35 ± 1:15	*n* = 633 10:02 ± 1:21	*n* = 524 10:15 ± 1:24
Sleep Duration (mins)	*n* = 592 465.62 ± 78.39	*n* = 612 518.43 ± 69.14	*n* = 662 443.31 ± 58.35	*n* = 640 506.24 ± 64.12	*n* = 523 497.99 ± 73.42
Midsleep Time	*n* = 598 4:32 am ± 1:08	*n* = 597 6:01 ± 1:22	*n* =662 4:50 ± 1:10	*n* =637 5:48 ± 1:12	*n* = 520 6:05 ± 1:16

Means ± SD

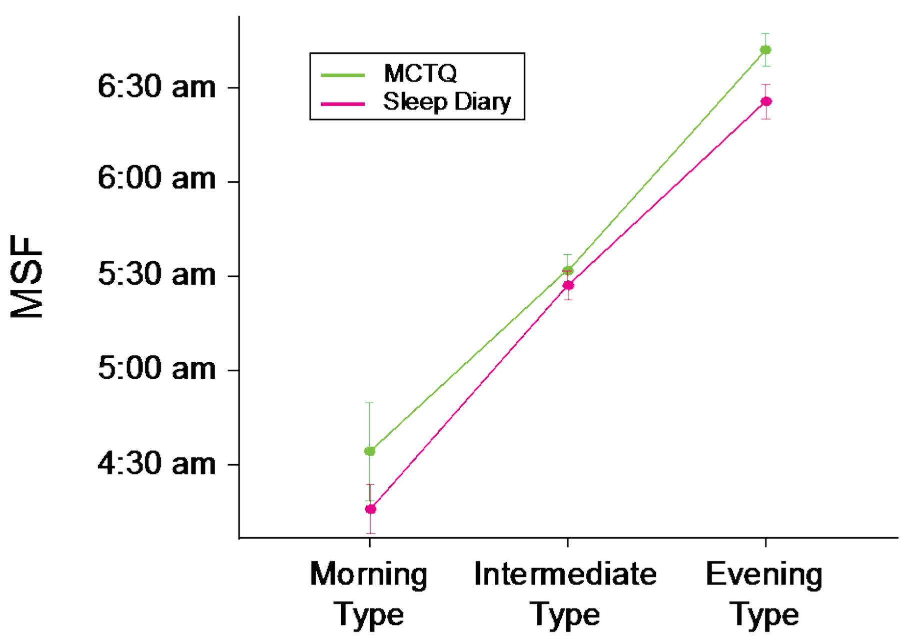

Figure 4.6. Midsleep Free (MSF) for Chronotype Group by Measure

4.6. Seasonal Effects

Table 4.5 shows descriptive differences in chronotype, sleep timing and social jetlag during extremes of seasonal photoperiod. The most noticeable difference occurs in MSW, which is latest in May than the other seasons, when the photoperiod is longest. Discrepancy between free day and work day midsleep (SJMS) as well as sleep duration (SJSD) is greatest in January, suggesting that jetlag is increased during short photoperiods. Sleep diaries were not completed during all seasons; therefore sleep diary data were not included in this section. To determine how chronotype changes across season, repeated assessments of chronotype were examined across school semesters. During spring semesters, chronotype as measured by MEQ and MSF_{MCTQ} tended to advance, and delay in fall semesters (Table 4.6).

Table 4.6. Chronotype and Social Jetlag Characteristics by Season

T1 MCTQ Data	January	May	September
MEQ Score	*n*= 67 42.93 ± 9.76	*n*= 538 42.75 ± 9.56	*n*= 531 43.74 ± 8.65
MSF_{MCTQ}	*n*= 383 5:54 am ±	*n*= 562 5:58 am ±	*n*= 622 5:49 ±
MSW_{MCTQ}	*n*= 383 4:15 am ± 0:03	*n*= 567 4:34 am ± 0:02	*n*= 620 4:19 am ± 0:02
$SJMS_{RAW.MCTQ}$	*n*= 381 97.43 min ± 61.06	*n*= 554 83.00 min ± 65.90	*n*= 619 87.56 min ± 61.94
$SJSD_{RAW.MCTQ}$	*n*= 348 63.21 min ± 76.12	*n*= 533 47.67 min ± 73.44	*n*= 589 48.39 min ± 73.39
$\%SLW_{MCTQ}$	*n*= 342 11.35% ± 14.64	*n*= 529 8.72% ± 14.09	*n*= 584 8.81% ± 14.15

Mean ± SD

Table 4.7. Change in Chronotype across Multiple Assessments by Season

Chronotype Measure	School Semester	*n*	T1	T2	Difference Score	Phase Shift
MSF_{MCTQ}	Spring	251	6:04 ± 1:10	5:54 ± 1:18	-10 min	Advance
	Summer	514	5:58 ± 1:20	5:55 ± 1:20	-3 min	Advance
	Fall	505	5:47 ± 1:16	5:58 ± 1:21	+11 min	Delay
MEQ Score	Spring	65	43.11 ± 9.83	44.12 ± 9.33	-1.01	Advance
	Summer	448	43.18 ± 9.70	42.67 ± 9.47	+0.51	Delay
	Fall	339	43.22 ± 8.55	41.86 ± 8.84	+1.36	Delay

Mean ± SD. Spring Semester: T1= January; T2= April; Summer Semester: T1= May; T2= June-August; Fall Semester: T1= September; T2= December

4.7. Social Jetlag

4.7.1. SJMS, SJSD and %SLW

In the present sample, 96.5% of respondents (*n*= 1515) had some level of social jetlag compared to 3.5% showing no jetlag (no jetlag defined as less than 5 minute difference between work and free days at the individual level). Conventional study of social jetlag focuses exclusively on the absolute value of social jetlag midsleep (SJMS; as opposed to raw scores and other metrics). Using social jetlag scores that have not been converted to absolute value (i.e. raw) makes it possible to differentiate between potentially distinct jetlag types that would have previously been combined together. This allows for direction of the jetlag to be considered in addition to magnitude. Means and standard deviations for both raw and absolute social jetlag can be seen in Table 4.7. In the present sample SJMS values ranged from -77.5 minutes to 270 minutes and social jetlag sleep duration (SJSD) values ranged from -135 minutes to 225 minutes. As can be inferred from the average raw social jetlag values, in addition to an 88 minute advance in sleep timing, participants slept on average 51 minutes less on work days, compared to free days.

Table 4.8. Comparison of Social Jetlag between MCTQ and Sleep Diaries

	MCTQ		Sleep Diaries	
% SLW	n= 573 8.54% ± 14.23		n= 616 11.28% ± 13.22	
	Absolute	Raw	Absolute	Raw
SJMS	n= 589 91.19 min ± 59.22	n= 589 88.36 min ± 63.37	n= 626 60.06 min ± 42.31	n= 626 57.06 min ± 46.28
SJSD	n= 576 71.79 min ± 55.05	n= 576 51.64 min ± 74.29	n= 621 72.96 min ± 55.46	n= 621 60.79 min ± 68.60

Mean ± SD

Significant correlations were found between measures of chronotype and social jetlag. In order to remain consistent and comparable to previous research findings, absolute measures of social jetlag were used for correlations. Significant correlations emerged between each metric of social jetlag and midsleep time on free days from both MCTQ and sleep diaries. MSF_{MCTQ} correlated with $SJMS_{ABS.MCTQ}$ (r= 0.52, p< .001, n= 1533), $SJSD_{ABS.MCTQ}$ (r= 0.14, p< .001, n= 1443) and $\%SLW_{MCTQ}$ (r= 0.12, p< .01, n= 1533). MSF_{Diary} correlated with $SJMS_{ABS.Diary}$ (r= .29, p< .001, n= 616), $SJSD_{ABS.Diary}$ (r= .19, p< .001, n= 609), and $\%SLW_{Diary}$ (r= 0.22, p< .001, n= 603). MEQ scores (where a higher score indicates higher degree of morningness) also correlated with social jetlag calculated from the MCTQ and calculated from sleep diaries. MEQ score correlated negatively with social jetlag from the MCTQ [$SJMS_{ABS.MCTQ}$ (r= -.195, p< .001, n= 952); $SJSD_{ABS.MCTQ}$ (r= -.136, p< .001, n= 922); $\%SLW_{MCTQ}$ (r= -.130, p< .001, n= 914)] as well as sleep diaries [$SJMS_{ABS.Diary}$ (r= -.12, p< .001, n= 572); $SJSD_{ABS.Diary}$ (r= -.22, p< .001, n= 565); $\%SLW_{Diary}$ (r= -.17, p< .001, n= 562)]. Higher social jetlag and larger percentage of sleep lost on work days was associated with lower MEQ score as well as later midsleep times on free days, indicating that larger degree of eveningness is related to higher levels of social jetlag.

4.7.2. SJMS/SJSD Categories

As discussed in Section 4.31, sleep onset and wake times on free days were significantly later than on work days. On average, individuals are going to bed ~1 hour later and waking up ~2 hours later on free days, leading to a delay in midsleep time

(SJMS+ = ~1.5hours) and an increase in sleep duration (SJSD+ =~1 hour) on free days. Although, as reflected by the mean scores, the majority of the sample (67%) followed this pattern (SJMS+SJSD+), through categorizing individual participants into social jetlag categories that considered both timing and duration of sleep, other patterns emerged (see Table 4.8).

As can be seen in Table 4.8, 3.4% of the present sample had no social jetlag ($SJMS_0SJSD_0$), meaning they went to bed and awoke at roughly the same time on work and free days. 92.1% of respondents went to bed later on free days. This includes, 67% who went to bed later and slept for longer (SJMS+SJSD+), 19.9% who went to bed later and slept less (SJMS+SJSD-) and 5.2% of the sample who went to bed later but slept the same duration on free days as compared to work days ($SJMS+SJSD_0$). 2.7% of the sample went to bed earlier but slept for longer on free days as compared to work days. Descriptive statistics are provided in Table 4.8.

All social jetlag categories yielded an average MEQ score within the intermediate type range. Those with no social jetlag had the highest MEQ score. MEQ score of the most common group, SJMS+SJSD+ fell right at the cut-off for evening type, and this group had the latest average MSF's of all the category's (although still close to the general average MSF and an hour different from MSF of evening type group). The range of MEQ scores that fell within this category indicates that this category encompasses the whole spectrum of morning to evening types. See Table 4.9.

Table 4.9. Social Jetlag by Category

Interaction Category	n	Work Days Sleep Onset	Work Days Wake Time	Free Days Sleep Onset	Free Days Wake Time	Sleep Duration Difference	Midsleep Time Difference
SJMS+SJSD+	1015 (67.0%)	0:36 ± 1:08	7:58 ± 1:16	1:32 ± 1:17	10:23 ± 1:19	88.87min	100.77min
SJMS+SJSD-	302 (19.9%)	0:16 ± 1:12	8:52 ± 1:24	2:00 ± 1:19	9:49 ± 1:25	-46.97min	80.53min
SJMS+SJSD$_0$	79 (5.2%)	0:22 ± 1:11	8:49 ± 1:21	1:39 ± 1:16	10:06 ± 1:26	0.05min	77.41min
SJMS-SJSD+	41 (2.7%)	1:14 ± 1:08	9:03 ± 1:16	23:55 ± 1:12	9:17 ± 1:07	90.42min	-39.86min
SJMS-SJSD-	12 (0.8%)	0:45 ± 1:12	9:45 ± 1:21	1:00 ± 1:05	8:53 ± 1:19	-63.46min	-20.77min
SJMS-SJSD$_0$	2 (0.1%)	0:34 ± :16	8:45 ± :21	23:47 ± :38	8:00 ± :00	1.50min	-45.75min
SJMS$_0$SJSD+	13 (0.9%)	0:47 ± 1:16	8:53 ± 1:35	0:16 ± 1:05	9:20 ± 27	50.46min	-1.54min
SJMS$_0$SJSD-	0	NA	NA	NA	NA	NA	NA
SJMS$_0$SJSD$_0$	51 (3.4%)	0:28 ± 1:14	8:49 ± 1:22	0:28 ± 1:13	8:49 ± 1:22	-0.14min	0.07min
Total	1515	0:33 ± 1:12	8:17 ± 1:24	1:33 ± 1:22	10:10 ± 1:26	52.64min	86.32min

Means ± SD. Used Raw values of SJMS and SJSD for difference columns; *n*'s based on # that have MSF. Difference scores calculated at the individual level, hence why different from averages.

4.8. Free Days versus Weekends: Saturday Nights

Since social obligations that occur on weekends frequently take place in the evening, sleep diary data were analysed to see if Saturday nights (when Sunday was reported as a free day) were different from free nights on average. Sleep timing is later on Saturday nights than other free days. Participants go to bed on average 20 minutes later and wake up 13 minutes later. Table 4.10 shows means and standard deviations along with paired samples *t*-statistics and Bonferroni corrected *p* values.

Table 4.10. Social Jetlag Categories by Chronotype

Social Jetlag Category	MEQ	MEQ Range	MSF_{MTQ}	MSF_{Diary}
SJMS+SJSD+	N=586 41.82 ± 8.76	19-74	N=1015 5:58 ± 1:11	N=330 5:47 ±1:10
SJMS+SJSD-	N=196 44.13 ± 9.06	23-68	N=302 5:56 ± 1:17	N=119 5:47 ± 1:16
$SJMS+SJSD_0$	N=47 42.87 ± 9.75	23-70	N=79 5:58 ± 1:11	N= 34 5:52 ± 1:24
SJMS-SJSD+	N=25 43.24 ± 10.35	20-64	N=41 4:47 ± 1:31	N=20 6:00 ± 0:55
SJMS-SJSD-	N=7 42.71 ± 8.14	31-57	N=12 5:04 ± 0:55	N=5 5:58 ± 1:00
$SJMS-SJSD_0$	-	-	N=2 3:53 ± 0:19	-
$SJMS_0SJSD+$	N=7 45.57 ± 12.75	33-63	N=13 4:48 ± 1:07	N=2 6:36 ± 0:39
$SJMS_0SJSD-$	NA			
$SJMS_0SJSD_0$	N=35 47.23 ± 10.27	30-68	N=51 4:41 ± 0:59	N=17 5:11 ± 1:13
Total	N=903 43.12	19-74	N=1515 5:52 ± 1:15	N=527 5:47 ± 1:12

Means ± SD

Table 4.11. Free days versus Weekends

Sleep Diary	Sleep Onset	Wake Time	MSF_{Diary}	Sleep Duration (mins)	$SJMS_{Diary}$
Free Days	1:39 ± 1:21	10:02 ± 1:21	5:48 ± 1:12	506.24 ± 64.12	57.06 ± 46.28
Weekends	1:59 ± 1:26	10:15 ± 1:24	6:05 ± 1:16	497.99 ± 73.42	74.70 ± 56.96
Paired samples *t*	t_{527}= 10.35, p<.001	t_{519}= 5.98, p<.001	t_{516}= 9.65, p<.001	t_{517}= 4.35, p<.001	t_{506}= -9.87, p<.001

Note. Only Saturday nights when following Sunday was a free day were analyzed. Free days sleep onset times also indicate the sleep onset time the night before a free days.

4.9. Stimulant and Alcohol Consumption

Daily intake of caffeine, alcohol and nicotine intake was recorded by 221 students for between 7 and 14 days. Participants were asked to record number of cups of coffee, tea/pop, alcoholic beverages, and number of cigarettes consumed daily, from which average daily intake was calculated. The number of participants who consumed these substances and their mean daily consumption can be seen in Table 4.11.

For those who consumed these substances, no significant correlations emerged between mean daily consumption and chronotype (MEQ score or MSF). Daily tea/pop consumption positively correlated with $SJMS_{Diary}$ (r=.182, p< .05, n= 162) as did daily alcohol consumption (r= .472, p< .01, n= 30), suggesting that those who have a larger discrepancy in midsleep times between work and free days consume more tea/pop and alcohol. Mean daily coffee consumption correlated positively with BMI (r= .316, p< .01, n= 73). Number of cigarettes consumed daily correlated positively with daily coffee consumption (r= .351 p< .05, n= 32). When eliminating more casual coffee drinkers and looking solely at those who consumed two or more cups of coffee per day, a significant positive correlation emerged between coffee consumption and class grade (r= .463, p< .05, n= 23).

Measures of chronotype were compared between those who consume or don't consume those substances (see Table 4.12). The largest chronotype differences are between those who do not consume nicotine and those who do, in the direction that those who smoke have later chronotype.

Table 4.12. Descriptives Statistics for Stimulant and Alcohol Consumption

	Cigarettes	Alcohol	Coffee	Coffee ≥ 2 cups	Tea/Pop	Tea/Pop ≥ 2 cups
n	37	56	149	23	183	16
Range of Daily Consumption	.07 – 17	.09 – 1	.07 – 5.73	2 – 5.73	.07 – 9.75	2 – 9.75
Mean Daily	5.50 ± 5.12	0.32 ± .20	1.06 ± .94	2.78 ± .83	0.90 ± 1.01	2.97 ± 1.86

Means ± SD

Table 4.13. Stimulant and Alcohol Consumption by Chronotype

	Cigarettes		Alcohol		Coffee			Tea/Pop		
	Don't Consume	Consume	Don't Consume	Consume	Don't Consume	Consume	Consume ≥ 2 cups	Don't Consume	Consume	Consume ≥ 2 cups
MEQ Score	*n*= 169 43.72 ± 8.57	*n*= 36 41.25 ± 9.71	*n*= 58 43.00 ± 8.55	*n*= 49 42.22 ± 8.70	*n*= 67 42.78 ± 8.90	*n*= 139 43.45 ± 8.90	*n*= 60 43.72 ± 9.51	*n*= 35 43.51 ± 8.38	*n*= 172 43.15 ± 8.99	*n*= 16 40.19 ± 9.22
MSF_{MCTQ}	*n*= 158 5:52 ± 1:24	*n*= 33 6:10 ± 1:16	*n*= 52 6:05 ± 1:26	*n*= 46 5:56 ± 1:33	*n*= 65 6:02 ± 1:24	*n*= 127 5:53 ± 1:22	*n*= 52 5:54 ± 1:30	*n*= 34 6:08 ± 1:21	*n*= 159 5:54 ± 1:23	*n*= 15 6:00 ± 1:32
MSF_{Diary}	*n*= 121 5:56 ± 1:27	*n*= 23 6:30 ± 1:21	*n*= 54 5:45 ± 1:34	*n*= 46 6:03 ± 1:19	*n*= 64 5:46 ± 1:21	*n*= 134 5:47 ± 1:21	*n*= 57 5:45 ± 1:21	*n*= 36 4:45 ± 1:06	*n*= 174 4:46 ± 1:10	*n*= 14 5:58 ± 1:19

Means ± SD

4.10. Body Mass Index

BMI correlates significantly with MSF_{Diary} (r= -.220, p< .05, n= 90). BMI also negatively correlated with MSW_{Diary} (r= -.319, p< .001, n= 99). BMI showed a stronger correlation with sleep onset time on work days (r= -.204, p< .05, n= 105) and wake up time on free days (r= -.291, p< .01, n= 89). As stated in Section 4.9, mean daily coffee consumption correlated positively with BMI (r= .316, p< .01, n= 73).

To replicate analyses conducted by Roenneberg, Allebrandt, Merrow & Vetter (2012), BMI was split between those with a score of ≥ 25 and < 25. In participants with a BMI of 25 or greater, no correlation emerged with social jetlag or sleep duration, as was reported in the literature. In these participants BMI was found to negatively correlate with MSF_{MCTQ} (r= -.207, p< .05, n= 105). In those with a BMI of less than 25, it was found to negatively correlate with $\%SLW_{Diary}$ (r= -.241, p< .05, n= 71).

4.11. Academic Performance

Correlations for the total sample between GPA and other variables of interest are reported in Table A.4. in Appendix A. Correlations between MCTQ variables and sleep diary variables independently are reported in Tables A.5. and A.6. respectively, in Appendix A.

The present data-set consists of two sub-samples in which academic performance can be measured; class grade was collected from 810 participants; and GPA was collected from 793 participants. Due to the bounded nature of these variables, it was necessary to transform them into continuous variables appropriate for analysis (see preliminary analysis, section 4.1 for detail). GPA and class grade were significantly positively correlated (r=.653, p<.001, n=81).

4.11.1. Grade Point Average

Significant, negative correlations were evident between GPA and MSF_{MCTQ} (r= -.173, p< .001, n= 618; Figure 4.5), MSW_{MCTQ} (r= -.169, p< .001, n= 623) and MSW_{Diary} (r= -.269, p< .05, n= 71). For work days, significant negative correlations were also evident between GPA and MCTQ sleep onset (r= -.136, p< .001, n= 632), MCTQ wake up time (r= -.116, p< .001, n= 626) and sleep diary wake up time (r= -.254, p< .05, n= 70). On free days, negative correlations were also evident between GPA and MCTQ sleep onset (r= -.086, p< .05, n= 617), wake up time (r= -.184, p< .001, n= 630) and sleep duration (r= -.084, p< .05, n= 608). Thus, overall, later sleep and wake times may be predictive of a lower GPA. GPA did not correlate significantly with MEQ score, MSF_{Diary} or social jetlag measures.

4.11.2. Class grade

No significant correlations emerged with class grade and any measure of chronotype or social jetlag.

For work days, sleep duration from sleep diaries (r= -.145, p< .001, n= 638) negatively correlated with GPA. For free days, class grade negatively correlated with MCTQ wake time (r= -.088, p< .05, n= 731) and sleep duration from sleep diaries (r= -.089, p< .05, n= 617).

As mentioned in Section 4.9, a positive correlation emerged between coffee consumption and class grade in those who drank 2 or more cups of coffee daily (r= .463, p< .05, n= 23).

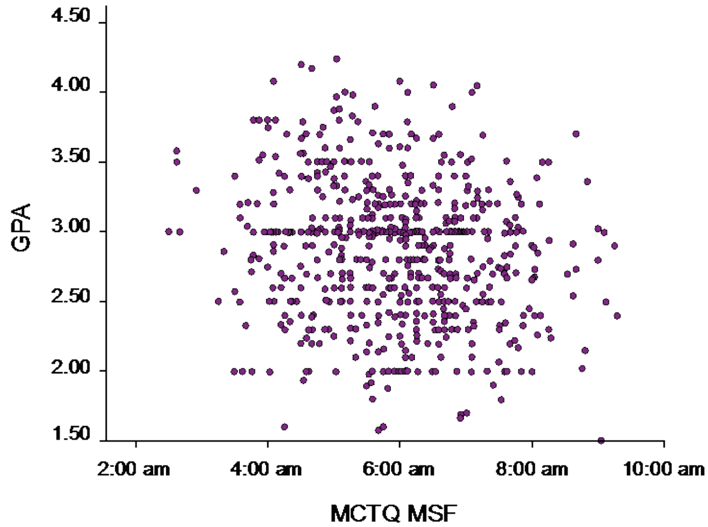

Figure 4.5. Correlation between GPA and MSF_{MCTQ}
Correlation Coefficient r= -.173, p< .001, n= 618.

4.11.3. Predicting Academic Performance

The primary research question of the present study was whether chronotype predicts academic performance and if so, whether this relationship is mediated by social jetlag. A hierarchical linear regression was employed to test for the predictive value of chronotype on GPA. GPA was chosen as the outcome variable because no significant relationship was found between chronotype and class grade. Separate regressions were conducted for males and females, since previous research suggests that GPA differs between sexes. Age and season were tested as covariates but were not found to account for a significant proportion of the variance in GPA, and thus were not included in the final model. The first block included MSF_{MCTQ}. In order to determine if $SJMS_{MCTQ}$ was acting as a mediator of the relationship between chronotype and GPA, it was placed into the second block. A summary of the regression can be seen in Table 4.13.

In females, the overall model was found to be statistically significant [Adjusted R^2= .038, F(2,419)= 9.26, p< .001]. The regression model revealed that MSF_{MCTQ} significantly predicted academic performance by accounting for 3.8% of the variance in GPA [R= .038, F(1,420)= 17.55, p< .001]. $SJMS_{MCTQ,}$ did not account for a statistically significant change in R^2 [ΔR^2= .002, ΔF(1,419)= .968, p> .05] thus did not account for a significant proportion of the variance in GPA above that of MSF_{MCTQ}. When examining the standardized regression coefficients of each predictor, MSF_{MCTQ} (β= -.230, t_{419}= -4.19, p< .001) independently accounted for a significant proportion of the variance in

GPA, although $SJMS_{MCTQ}$ did not [β= .055, t_{419}= .984, p> .05]. For every standard deviation change in MSF_{MCTQ} from the mean there was a .23 change in GPA. The unstandardized coefficient (B value) was -.092, meaning for every 1 hour delay in MSF_{MCTQ}, GPA decreased by .09 units. Social jetlag was not mediating the relationship with GPA and chronotype.

In males, the regression model was not significant [Adjusted R^2= .010, F(2,189)= 1.93, p> .05]. Neither MSF_{MCTQ} [R^2= .006, F(1,190)= 2.178, p> .05], nor $SJMS_{MCTQ,}$ [ΔR^2= .004, ΔF(1,189)= 1.678, p> .05] significantly predicted GPA. When examining the standardized regression coefficients of each predictor, MSF_{MCTQ} [β= -.165, t_{190}= -1.94, p> .05] and $SJMS_{MCTQ}$ [β= .110, t_{190}= .130, p> .05] did not account for a significant proportion of the variance in GPA in the male sample.

Social Jetlag Categories

It was of interest to further investigate if within specific scenarios of social jetlag (i.e. sleep loss or sleep gained), a stronger relationship between chronotype and GPA exists. The assumption is that on free days, sleep duration is lengthened (and wake time delayed) in order to recover from sleep lost on work days (therefore SJMS+SJSD+). In Section 4.7.2, social jetlag categories revealed that 20% of individuals are sleeping less on free days as compared to work days, indicating that the assumed scenario is not the only scenario. Separate correlations were conducted between academic performance and MSF_{MCTQ} for the two largest social jetlag categories: SJMS+SJSD+ and SJMS+SJSD-. Negative correlations emerged between MSF_{MCTQ} and GPA within both categories [SJMS+SJSD+: r= -.157, p< .01, df= 385; SJMS+SJSD-: r= -.328, p< .01, df= 98]. To test whether the correlation coefficient between MSF and GPA are equivalent between social jet lag categories, a z-test based on the Fischer Transform was employed. The results show that the correlation coefficients between SJMS+SJSD+ and SJMS+SJSD- were not significantly different [z= 1.60, p> .05].

Table 4.14. Regression Summary by Sex

Pre0dictor: GPA	Males					Females				
	β	*t*	R^2	*F*	*p*	*β*	*t*	R^2	*F*	*p*
Step 1: Chronotype (MSF_{MCTQ})	-.165	-.194	.006	2.18	> .05	-.230	4.19	.038	17.55	< .001
Step 2: Social Jetlag ($SJMS_{MCTQ}$)	.110	.130	Δ= .004	Δ= 1.68	> .05	.055	.984	Δ= .002	Δ= .968	> .05

Note. Predictor Variable is self- report GPA in university students.

Chapter 5.

Discussion

The present findings add to the body of work that has emerged in recent years to delineate relationships between chronotype, social jetlag and academic performance.

5.1. Variability in Chronotype Measures

It was important for the aims of the present study to thoroughly compare the assessment measures of chronotype. Although previous research has validated the measures through correlation, they are not measuring the same construct. There is debate whether chronotype should be defined based on personal preferences or daily behaviours and how well these measures represent the internal biological clock. Preferences are assumed by some to be more representative of underlying biological differences equating to morning and evening types, whereas midsleep times are directly impacted by social factors and as a consequence are not representative of unrestricted endogenous timing. Conversely, it can also be argued that In societies impacted by artificial light and social clocks, individuals may be unable to live by their preferences, and that actual behaviour may be a more accurate measure of chronotype or may exhibit stronger associations with variables related to performance, health and well-being. There is still debate regarding the best form of classification and definition of chronotype and none of the methods to date are without fault. The present findings highlight important differences between measures.

Although all three measures of chronotype were highly correlated, discrepancy between measures emerged throughout the present study. Compared to other work start times, individuals who normally began work in the late evening (22:00 – 1:59 a.m.), had the highest MEQ scores yet late MCTQ midsleep times, suggesting a potentially important difference in measurements for those who have these types of work schedules. Participants who had an MEQ score within the cut-offs for morning and intermediate type groups all had corresponding midsleep free times that fell within the guidelines suggested by Terman et al., (2001) to be midsleep times appropriate for evening types. The developers of the MEQ, Horne and Östberg (1976), noted that MEQ score may not always have the same relationship with sleep timing because, for example, a bedtime indicative of a morning type in a student population (i.e. 23:30) could represent that of an evening type in middle aged adults. The MEQ was originally validated for a young adult, student population (Horne & Ostberg, 1976), and thus, sleep timing of the present sample using the validated cut-offs should have corresponded to the recommended guidelines for sleep timing. This finding may reflect a dissociation between preferences (MEQ) and reality (MSF).

Self-reported chronotype based on a single question from the MEQ showed differences with overall MEQ score in eight participants. When asked to rate their chronotype on a four point scale eight participants who reported that they were "*more of a morning type*" or a *"definite morning type"*, had MEQ scores that fell within the cut-off for evening type. Self-reporting likely reflects a measure that is highly influenced by extraneous variables (i.e. comparison to peers) and not where one falls within the population distribution.

Chronotype as measured by the MCTQ was significantly later than chronotype measured by sleep diary reports. However, the difference in midsleep time on free days between the two measures was only 10 minutes. A concern is that sleep diaries may not be completed accurately by students who gain course credit for completion, but the close correspondance between the MCTQ and the sleep diaries suggest that the diaries do yield meaningful data. Conversely, MCTQ measures self-reported averages of sleep and wake times which may not be as accurate as measurement of daily sleep patterns from sleep diaries (providing diaries are completed accurately).

5.1.1. Measurement Consistency: Multiple Assessment & Seasonality

It was hypothesized that keeping a sleep diary between assessments of chronotype by both the MEQ and MCTQ would influence measurement, due to increase in self-awareness of behaviours. However, no meaningful change in chronotype occurred from the first to the second assessment, in either the MCTQ or MEQ, in subjects that kept a sleep diary. Although a significant change in MEQ score was evident, the magnitude was trivial, at less than 1 point on a scale of 70, with both T1 and T2 scores in the intermediate type range.

The hypothesis that Chronotype, defined by midsleep times, would change across seasons was unsupported. Midsleep on work days was latest in spring (May), while midsleep on free days remained relatively stable across seasons. Later midsleep times on work days in the spring may be due to less rigid school start times common to the summer schedule. Social jetlag measurements were highest in January, compared to May and September, supporting the hypothesis that social jetlag increases with shorter photoperiods, although differences between seasons were small. Multiple assessments within semester allowed for tracking change in chronotype across season. It was expected that chronotype would advance from T1 to T2 in spring semesters due to increasing light exposure from January to April and delay in fall semesters due to decreasing light exposure from September to December. During changing photoperiods, light exposure is altered in both the morning and the evening, yet there may be less of an apparent change caused by evening light since individuals already substitute artificial light for the lack of evening light in winter. Chronotype did delay in the fall semester (from September to December), consistent with the intuition that delays will occur as the days grow short, with less phase advancing natural light early in the day, and thus a greater impact of evening artificial light.

5.2. Correlates of Chronotype

5.2.1. Social Jetlag

The use of the absolute value of social jetlag in previous studies may obscure relationships between social jetlag and outcome variables. There may be important differences in those that go to sleep earlier on free days, which are being missed in the literature. For this reason, the original distribution of social jetlag was maintained by using raw values. Social jetlag categories were established to identify potentially distinct groups which would have otherwise been classified as a single group (SJMS). There is an assumption that sleep duration is increased on free days as a rebound from accumulation of sleep debt accrued across work days. A large proportion of the sample follows this pattern, however, approximately 20% show sleep loss on free days despite later midsleep time. The conventional measure of social jetlag is SJMS, nevertheless, use of SJMS alone would have shown the ~20 minute difference in midsleep time, but would have overlooked the ~2.5 hour discrepancy in sleep duration between the groups.

As indicated by the delay in MSF on Saturday nights compared to other free days, it can be assumed that social obligations also occur in the evening (for example, occasions for socialization or students working jobs late into the evening), which can delay bedtime, just as morning work schedules can advance wake up time. Sixty-seven percent of the sample fell into the category of SJMS+SJSD+ (they went to bed later and slept for longer on their free days) which is what would be expected of evening types (or a sample of this age group characteristic of delayed phase) with accumulated sleep debt. Twenty percent of the sample who went to bed later on free days yet slept less (SJMS+SJSD-) could be representative of morning types who are staying up later for social obligations, are entrained to their morning wake time or receive adequate sleep amounts prior to work days and are not in need of recovery sleep. A small proportion of the sample (2.7%) went to bed earlier on free days and slept more which is likely representative of individuals who are sleep deprived and homeostatic pressure for sleep is overriding circadian preference. Those with no jetlag had the earliest MSF times and the highest MEQ score.

5.2.2. Stimulant, Alcohol Consumption and Body Mass Index

For those who consumed these substances, no significant correlations emerged between mean daily consumption and chronotype (MEQ score or MSF), however those who smoked had later MSF times than those who did not. As social jetlag (measured by midsleep time from sleep diaries) increased, so did daily consumption of tea/pop as well as alcohol. When eliminating more casual coffee drinkers and looking solely at those who consumed two or more cups of caffeine per day, coffee consumption emerged as a predictor of class grade.

BMI was not found to be a correlate of chronotype in the present sample, although weak correlations with sleep onset times did exist suggesting relationships with

BMI and sleep parameters. Mean daily coffee consumption correlated positively with BMI.

5.3. Academic Performance

A significant relationship emerged between GPA and chronotype showing that later midsleep time on free days (as measured by MCTQ) is predictive of low GPA, although regression analysis revealed this was only the case for females. No association was found between chronotype and class grade. One potential explanation for this is that classes in which class grade were obtained were taught in the afternoon and evening thus reducing the negative effects of social jetlag (sleep restriction and asynchrony) that would impact later chronotypes. The relationship between MSF_{MCTQ} and GPA shows that in females, 3.8% of the variance in GPA is accounted for by chronotype, and regression analysis showed that in the present study, this relationship was not mediated by social jetlag. This percentage of variance accounted for by chronotype is similar to that found in previous literature (e.g. Preckel et al., 2013) and was not expected to be much larger since many other variables (that were not examined in the present study) influence academic achievement (e.g., personality traits, intelligence, socioeconomics, motivation, frequency of classes, etc. [Diaz-Moralez & Escribano, 2013; Dills & Hernández-Julián, 2008; Önder et al., 2014; Roeser et al., 2013]). It is not known why chronotype in males in the present sample was not predictive of GPA, but the smaller sample size may have contributed. A very recent study did report a significant relationship between MSF and GPA for both sexes (Önder et al., (2014).

The relationship between GPA and MSF_{MCTQ} may be larger in populations with more rigid school schedules. Students in many Canadian universities choose their own elective courses and develop their own class schedules. This may lead to self-selection into classes occurring at times of day that suit peak time of performance. It is possible that natural accommodation of their circadian cycles thus reduces the effect of time of day on academic performance. This distinguishes university from high schools, in which all individuals start their day at or close to the same time, leading to larger discrepancy between chronotypes in levels of social jetlag. One potential downfall to self-selected schedules is that this may result in more variation in sleep timing from day to day, which has been shown to negatively predict academic performance (e.g. variability in sleep duration on work days predicts grades; Smarr, 2014, June). This warrants further investigation.

5.4. Limitations

There are limitations to the present findings that should be addressed in future studies of this kind. The present sample was sex biased with a larger proportion of females than males. This does have ecological validity within the psychology departments at Simon Fraser and Thompson Rivers Universities where the data were collected.

Sleep duration measures in the present study (including SJSD) may be a better approximation of time spent in bed, and not necessarily time asleep. Data collected with the MCTQ give no indication of time spent awake during the night. Time spent awake during the night was recorded in sleep diaries, but not subtracted from sleep duration in order to keep measurements from the sleep diaries as close as possible to those from the MCTQ for meaningful comparison between the two. As such, sleep duration does not speak to sleep quality, and no measurement of quality was taken in the present study.

5.5. Implications

The lack of association with chronotype and class grade is thought to be due to late class start times which remove the consequences of social jetlag. Similarly, Haraszti and colleagues (2014) found the relationship between social jetlag and academic performance disappeared during a time when students had more freedom in their daily schedules. A recent study by Horzum, Önder and Beşoluk (2014) found no association with academic performance and chronotypes in participants taking online classes, which would reduce asynchrony effects by allowing the individual freedom to learn material at times of day suitable for them. Dills and Hernández-Julián (2008) found higher grades in courses taken later in the day and suggest that early morning classes are particularly bad for student grades. Taken together, this supports the implementation of later class start times for adolescents and young adults.

Although findings from studies investigating the effect of later school start times show inconclusive effects on academic performance, this does not negate the findings of the benefits of later school start times. School start time delays (even as small as half an hour) produce significant increases in sleep duration, less daytime fatigue and depressed mood, increase in school attendance, enrolment and decrease in tardiness predictive of academic performance (Owens et al., 2010; Wahlstrom, 2002), and striking decreases in teenage vehicle crash rates (Danner & Philips, 2008).

5.6. Concluding Thoughts: What is Chronotype?

Much remains to be understood regarding the interaction between imposed social schedules and chronotype. Gaps in understanding of these interactions leads to the question “what, precisely, is chronotype?” It is known that daily social schedules control exposure to artificial lighting, presumably exacerbating differences in chronotype reporting (Wright et al, 2013). Nonetheless, to some extent, chronotype also dictates social schedules. Does chronotype represent stable preferences dictated by underlying biology, or is chronotype something that is altered in response to imposed scheduling, instead, representing daily behaviours? It has been found that evening types suffer social jetlag when forced into an early morning routine, but perhaps individual chronotype is more adaptable to social schedules than previously thought.

Social conformity (Haraszti et al., 2014) refers to the reduction in social jetlag by “evening types” who keep an earlier schedule, even on weekends. Work demands modify the preference of the individual to be more in line with such requirements (Adan, 1992; Mecacci and Zani, 1983). True diurnal preferences are masked by work and social requirements. Future research will need to determine if people that are conforming are different from those biologically inclined to morning type behaviours. If this is the case, it would indicate that underlying biology remains an important consideration even when behavioural patterns between individuals are similar.

Studies looking at varied school times show a greater number of early chronotypes in the morning classes (i.e. Beşoluk, et al., 2011; Haraszti et al., 2014). It is not known if this is due to self-selection or is due to early class start times causing increased morning light exposure and thereby advancing the circadian system (i.e. conformity). Even large amounts of sleep restriction common in evening types living on a morning schedule could promote earlier sleep timing due to homeostatic pressure, which would decrease evening light, increase morning light and cause an advance in chronotype.

Endogenous period of the circadian clock has been shown to correlate with chronotype (measured by the MEQ), but only in young adulthood (Brown et al., 2008; Duffy et al., 2001). Despite an advance in chronotype in middle age, the endogenous period of the clock in humans may not shorten with age (Duffy et al., 2002). Change in chronotype across the lifespan is generally thought to be mainly under biological control, and not social factors. Perhaps the advance of chronotype in middle age is due to social conformity because of increased morning commitments (e.g. families, full time jobs, etc.), which results in a loss of the relationship between current chronotype measurements and endogenous period. The observed delay of chronotype in adolescence could be a result of increased freedom to delay due to a decrease in parental restrictions on bedtime with age. Additionally, Roenneberg (2004) indicates that it cannot be distinguished whether chronotypes become earlier with age or whether chronotypes independent of age have become later over the last decades. Prevalence of light emitting electronic devices has drastically increased in recent years and use of computer, tablets and cell phones late into the biological night are certainly pushing chronotype later. Roenneberg (2004) acknowledges that environmental and behavioural factors influencing age and sex differences in chronotype cannot be separated. Under constant conditions, chronotype would be a manifestation of period, but under entrained conditions, the complex interaction between biology and environment (social and synchronizing stimuli, i.e. light) results in the range of outcomes that are measured by traditional chronotype measures.

Conclusions regarding the best measure of chronotype cannot be reached in the present study. Individuals are unable to live according to true diurnal preference due to social obligations on both work and free days. Midlseep on free days (usually corrected for sleep debt from work days) is presumed to be the best available measure of natural timing preferences; however, as evidenced by later midsleep on Saturday nights, this does not seem to be true due to the influence of evening social obligations on sleep timing. A better measurement would be one in which a free day is defined as a day where neither bedtime nor wake time is altered due to social obligations. Additionally, if social conformity is occurring, it would alter measures of MSF (thus altering "chronotype"), making it difficult to distinguish between those biologically inclined towards morningness from those with early MSF time. It remains to be seen if this difference is important.

Neither MEQ score, nor midsleep time on free days is a perfect measure because neither captures the important complexity in how humans adapt to temporal features in their environment. The MEQ lacks a measure of actual behaviour, which can be self-controlled to a large enough degree that it can alter physiological entrainment, not just mask it behind forced early bedtimes and alarm mediated wake up times. Midsleep assessments of chronotype do capture this behavioural aspect but run the risk of overlooking important biological differences between individuals with the same midsleep. In environments dominated by social clocks, biologically determined preferences can be overridden with behaviour that alters the timing of light exposure, but the difference in the ease with which this is achieved between individuals (e.g. differences in ability to advance or delay between individuals) may in part explain the range of observed chronotypes within any particular environmental context. Despite this, midsleep assessments may be the better measure, but only within the environment in which it was observed.

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Appendix A.

Descriptive Statistics and Correlations

Table A.1. Descriptive Statistics by Sex and Chronotype Group

	MSF MCTQ	MSF Diaries	MEQ Score	SJMS $_{Raw}$	SJSD$_{Raw}$	% Sleep Loss	BMI	GPA	Grade
Range	2:30-9:22	2:38-9:07	18-74	-77.5-270	-135-225	-34.63-53.59	14.52-39.24	1.5-4.24	27-94
Total	*n*= 1567 5:53am ±1:17	*n*= 637 5:48am ±1:12	*n*= 1136 43.22 ±9.16	*n*= 1554 88.36 ±63.37	*n*= 1470 51.64 ±74.29	*n*= 616 11.28 ±13.22	*n*= 744 21.99 ±3.56	*n*= 793 2.88 ±0.51	*n*= 810 60.19 ±12.15
Sex									
Male	*n*= 451 6:00am ± 1:21	*n*= 174 6:00am ± 1:20	*n*= 315 42.22 ± 8.49	*n*= 420 92.12 ± 66.82	*n*= 420 52.40 ± 75.44	*n*= 162 12.37% ± 15.36	*n*= 209 23.08 ± 3.59	*n*= 230 2.89 ± .51	*n*= 208 61.39 ± 12.88
Female	*n*= 1116 5:51am ± 1:15	*n*= 410 5:42am ± 1:10	*n*= 797 43.15 ± 9.06	*n*= 1029 86.84 ± 61.89	*n*= 1029 50.67 ± 73.70	*n*= 402 13.95 ± 15.33	*n*= 520 21.59 ± 3.49	*n*= 513 2.87 ± .51	*n*= 541 60.13 ± 11.94
Chronotype Group									
MT	*n*= 47 4:23am ± 1:11	*n*= 32 4:08am ± 0:47	*n*= 59 62.53 ± 3.49	*n*= 51 67.05± 69.03	*n*= 51 31.59 ± 64.18	*n*= 32 4.59% ± 11.38	*n*= 11 23.89 ± 6.20	*n*= 15 2.96 ± .46	*n*= 46 60.35 ± 14.01
IT	*n*= 491 5:25am ± 1:05	*n*= 301 5:26am ± 1:03	*n*= 593 48.18 ± 4.41	*n*= 484 76.29 ± 58.59	*n*= 461 38.69 ± 69.34	*n*= 297 10.92% ±12.85	*n*= 159 21.78 ± 3.08	*n*= 177 2.91 ± .51	*n*= 373 60.80 ± 11.65
ET	*n*= 420 6:44am ± 1:06	*n*= 249 6:27 ± 1:05	*n*= 484 34.78 ± 4.99	*n*= 417 96.54 ± 65.88	*n*= 410 57.14 ± 75.14	*n*= 233 13.25% ±13.52	*n*= 108 21.05 ± 3.08	*n*= 113 2.85 ± .53	*n*= 363 60.07 ± 12.61

Means ± SD

Table A.2. Descriptives of MCTQ Variables by Work and Free Day

MCTQ	Work Days						Free Days					
	MSW	Sleep Onset	Wake Time	Sleep Duration (mins)	Sleep Latency (mins)	Wake Latency (mins)	MSF	Sleep Onset	Wake Time	Sleep Duration (mins)	Sleep Latency (mins)	Wake Latency (mins)
Total	*n*= 1570 4:23am ± 1:05	*n*= 1600 0:33am ± 1:14	*n*= 1591 8:16am ± 1:27	*n*= 1568 459.72 ± 81.09	*n*= 1571 21.12 ± 13.95	N= 1546 11.96 ± 9.24	*n*= 1567 5:53am ± 1:17	*n*= 1578 1:35 ± 1:24	*n*= 1576 10:15 ± 1:29	*n*= 1574 521.75 ± 73.44	*n*= 1584 19.04 ± 14.22	*n*= 1576 22.15 ± 15.83
Sex												
Male	*n*= 456 4:26am ± 1:08	*n*= 468 0:39 ± 1:17	*n*= 463 8:17 ± 1:31	*n*= 462 455.14 ± 79.87	*n*= 461 20.75 ± 13.70	*n*= 455 11.79 ± 9.52	*n*= 451 6:00am ± 1:21	*n*= 457 1:44 ± 1:25	*n*= 467 10:20 ± 1:36	*n*= 455 519.81 ± 72.21	*n*= 470 18.55 ± 14.22	*n*= 466 20.66 ± 15.76
Female	*n*= 1113 4:22am ± 1:03	*n*= 1131 0:31 ± 1:31	*n*= 1127 8:15 ± 1:26	*n*= 1105 461.63 ± 81.59	*n*= 1109 21.28 ± 14.06	*n*= 1090 12.03 ± 9.12	*n*= 1116 5:51 ± 1:15	*n*= 1121 1:31 ± 1:23	*n*= 1125 10:13 ± 1:25	*n*= 1119 522.53 ± 73.95	*n*= 1114 19.24 ± 14.22	*n*= 1110 22.77 ± 15.83
Chronotype Group												
MT	*n*= 52 3:00am ± 0:51	*n*= 53 22:58 ± 1:04	*n*= 53 6:58 ± 1:13	*n*= 51 479.51 ± 62.59	*n*= 52 16.35 ± 12.27	*n*= 52 6.74 ± 7.01	*n*= 47 4:23am ± 1:11	*n*= 50 23:54 ± 1:17	*n*= 51 8:36 ± 1:37	*n*= 48 519.71 ± 58.37	*n*= 53 14.89 ± 12.10	*n*= 49 17.09 ± 14.44
IT	*n*= 489 4:07am ± 0:56	*n*= 495 0:07 ± 1:01	*n*= 496 8:08 ± 1:22	*n*= 482 473.98 ± 72.02	*n*= 487 20.33 ± 14.13	*n*= 475 11.59 ± 8.67	*n*= 491 5:19am ± 1:05	*n*= 490 1:07 ± 1:12	*n*= 495 9:44 ± 1:15	*n*= 490 517.18 ± 65.94	*n*= 488 19.08 ± 14.85	*n*= 487 21.39 ± 15.37
ET	*n*= 410 5:07am ± 1:02	*n*= 428 1:22 ± 1:06	*n*= 421 9:00 ± 1:33	*n*= 421 456.06 ± 87.02	*n*= 418 23.59 ± 15.07	*n*= 405 13.98 ± 9.73	*n*= 420 6:44 ± 1:06	*n*= 423 2:24 ± 1:14	*n*= 425 11:07 ± 1:18	*n*= 437 522.40 ± 65.94	*n*= 426 19.27 ± 15.13	*n*= 422 23.99 ± 17.52

Means ± SD

Table A.3. Descriptives of Sleep Diary Variables by Work and Free Day

Diary	Work Days					Free Days				
	MSW	Sleep Onset	Wake Time	Sleep Duration (mins)	Sleep Latency (mins)	MSF	Sleep Onset	Wake Time	Sleep Duration (mins)	Sleep Latency (mins)
Total	*n*= 662 4:50 ± 1:10	*n*= 675 1:09 ± 1:22	*n*= 661 8:35 ± 1:15	*n*= 662 443.31 ± 58.35	*n*= 637 16.08 ± 10.12	*n*= 637 5:48 ± 1:12	*n*= 649 1:39 ± 1:21	*n*= 633 10:02 ± 1:21	*n*= 640 506.24 ± 64.12	*n*= 606 14.49 ± 9.15
Sex										
Male	*n*= 166 4:57 ± 1:05	*n*= 174 1:22 ± 1:23	*n*= 170 8:39 ± 1:19	*n*= 168 440.67 ± 59.97	*n*= 163 17 ± 9.31	*n*= 174 6:00 ± 1:20	*n*= 177 1:55 ± 1:22	n= 171 10:09 ± 1:28	*n*= 175 495.56 ± 64.84	*n*= 168 15.61 ± 9.15
Female	n= 435 4:46 ± 1:12	*n*= 440 1:04 ± 1:22	*n*= 431 8:32 ± 1:15	*n*= 435 443 ± 57.98	*n*= 415 15.86 ± 10.31	*n*= 410 5:42 ± 1:10	*n*= 418 1:31 ± 1:20	*n*= 408 9:58 ± 1:18	*n*= 413 510 ± 62.65	*n*= 386 14.18 ± 9.16
Chronotype Group										
MT	*n*= 33 3:21 ± 0:45	*n*= 35 23:27 ± 0:55	*n*= 35 7:02 ± 0:54	*n*= 35 448.17 ± 42.72	*n*= 35 15.06 ± 9.77	*n*= 32 4:08 ± 0:47	*n*= 33 0:22 ± 1:01	n= 30 8:10 ± 0:47	*n*= 33 470.64 ± 60.29	*n*= 31 10.94 ± 7.11
IT	*n*= 307 4:29 ± 1:00	*n*= 308 0:42 ± 1:05	*n*= 301 8:17 ± 1:05	*n*= 307 447.07 ± 60.07	*n*= 294 16.39 ± 10.1	*n*= 301 5:26 ± 1:03	*n*= 303 1:14 ± 1:11	*n*= 302 9:40 ± 1:11	*n*= 301 506.94 ± 58.39	*n*= 288 14.96 ± 9.12
ET	*n*= 259 5:24 ± 1:05	*n*= 269 1:54 ± 1:18	*n*= 263 9:05 ± 1:15	*n*= 259 434.96 ± 57.83	*n*= 248 16.17 ± 10.26	*n*= 249 6:27 ± 1:05	*n*= 257 2:16 ± 1:16	*n*= 245 10:41 ± 1:14	*n*= 252 509.17 ± 69.64	*n*= 235 14.72 ± 9.56

Means ± SD

Table A.4. Correlation Table with all Measures by Day Type (Work and Free Days)

		Academic Performance		Chronotype			Sleep Variables Work Days **MCTQ**				Sleep Variables Free Days **MCTQ**			Social Jetlag **MCTQ**		
		GPA	Class Grade	MEQ	MSF MCTQ	MSF Diary	MSW MCTQ	Sleep Onset	Wake Time	Sleep Duration	Sleep Onset	Wake Time	Sleep Duration	SJMS MCTQ RAW	SJSJ MCTQ RAW	%SLW MCTQ
Academic Performance	GPA	*r*=	**.653**	.033	**-.173**	-.082	**-.169**	**-.136**	**-.116**	.049	**-.086**	**-.184**	-.084	-.032	-.012	-.004
		p=	**.000**	.564	**.000**	.505	**.000**	**.001**	**.004**	.226	**.032**	**.000**	.039	.423	.776	.922
		n=	**81**	305	**618**	68	**623**	**632**	**626**	621	**617**	**630**	608	614	565	557
	Class Grade			.017	-.048	-.024	-.039	-.022	-.043	-.027	-.017	**-.083**	-.035	-.023	-.034	-.015
				.634	.197	.553	.302	.556	.250	.480	.649	**.026**	.341	.540	.373	.685
				746	718	614	708	730	725	709	722	**731**	733	711	695	689
Chronotype	MEQ				**-.643**	**-.622**	**-.581**	**-.628**	**-.407**	**.113**	**-.591**	**-.599**	-.034	**-.189**	**-.128**	**-.130**
					.000	**.000**	**.000**	**.000**	**.000**	**.000**	**.000**	**.000**	.293	**.000**	**.000**	**.000**
					958	**582**	**951**	**976**	**970**	**954**	**963**	**971**	975	**952**	**922**	**914**
	MSF_{MCTQ}					**.580**	**.578**	**.617**	**.390**	**-.097**	**.879**	**.888**	.034	**.529**	**.077**	**.079**
					1.00	**.000**	**.000**	**.000**	**.000**	**.000**	**.000**	**.000**	.187	**.000**	**.004**	**.003**
						563	**1524**	**1546**	**1540**	**1514**	**1545**	**1562**	1539	**1533**	**1443**	**1428**
	MSF_{Diary}	-.082	-.024	**-.622**	**.580**		**.622**	**.632**	**.444**	-.007	**.519**	**.560**	.073	**.094**	.049	.055
		.505	.553	**.000**	**.000**	1.00	**.000**	**.000**	**.000**	.873	**.000**	**.000**	.080	**.026**	.256	.199
		68	614	**582**	**563**		**551**	**567**	**562**	552	**566**	**572**	573	**553**	541	538
Sleep Variables Work Days **Sleep Diaries**	MSW_{Diary}	**-.269**	.002	**-.541**	**.585**	**.758**	**.685**	**.629**	**.532**	.036	**.502**	**.549**	.030	.030	-.002	.000
		.023	.969	**.000**	**.000**	**.000**	**.000**	**.000**	**.000**	.390	**.000**	**.000**	.467	.479	.959	.992
		71	638	**599**	**582**	**615**	**571**	**585**	**582**	568	**583**	**590**	588	569	553	550
	Sleep Onset	-.184	.032	**.580**	**.579**	**.771**	**.620**	**.675**	**.426**	**-.102**	**.554**	**.523**	-.015	**.093**	.077	.082
		.120	.412	**.000**	**.000**	**.000**	**.000**	**.000**	**.000**	**.014**	**.000**	**.000**	.708	**.025**	.067	.051
		73	650	**612**	**589**	**624**	**579**	**597**	**593**	**581**	**593**	**598**	601	**580**	565	562
	Wake Time	**-.254**	-.044	**-.488**	**.512**	**.640**	**.641**	**.492**	**.575**	**.164**	**.420**	**.525**	**.085**	-.021	**-.088**	**-.093**
		.034	.271	**.000**	**.000**	**.000**	**.000**	**.000**	**.000**	**.000**	**.000**	**.000**	**.039**	.622	**.040**	**.029**
		70	636	**599**	**580**	**612**	**572**	**586**	**584**	**568**	**582**	**588**	**588**	570	**552**	**549**
	Sleep Duration	-.039	**-.145**	**.089**	-.042	**-.098**	.023	**-.188**	**.206**	**.378**	**-.136**	.034	**.167**	**-.119**	**-.191**	**-.207**
		.748	**.000**	**.029**	.312	**.015**	.591	**.000**	**.000**	**.000**	**.001**	.409	**.000**	**.005**	**.000**	**.000**
		71	**636**	**601**	579	**611**	571	**586**	**585**	**572**	**583**	588	**590**	**570**	**556**	**553**

		GPA	Class Grade	MEQ	MSF MCTQ	MSF Diary	MSW MCTQ	Sleep Onset	Wake Time	Sleep Duration	Sleep Onset	Wake Time	Sleep Duration	SJMS MCTQ RAW	SJSJ MCTQ RAW	%SLW MCTQ
Sleep Variables Free Days **Sleep Diaries**	Sleep Onset	-.114	.017	**-.526**	**.511**	**.893**	**.529**	**.596**	**.318**	**-.110**	**.505**	**.464**	-.040	**.099**	.057	.065
		.352	.680	**.000**	**.000**	**.000**	**.000**	**.000**	**.000**	**.009**	**.000**	**.000**	.333	**.019**	.185	.132
		69	626	**593**	**572**	**637**	**562**	**578**	**573**	**562**	**576**	**581**	583	**561**	549	546
	Wake Time	.079	-.047	**-.577**	**.553**	**.910**	**.564**	**.516**	**.448**	**.096**	**.438**	**.569**	**.171**	**.111**	.042	.044
		.520	.249	**.000**	**.000**	**.000**	**.000**	**.000**	**.000**	**.025**	**.000**	**.000**	**.000**	**.010**	.335	.313
		68	610	**577**	**559**	**629**	**548**	**563**	**558**	**547**	**561**	**568**	**568**	**549**	537	534
	Sleep Duration	.013	**-.084**	**-.123**	**.098**	**.159**	.074	-.028	**.160**	**.219**	-.045	**.207**	**.330**	.035	.051	.040
		.918	**.036**	**.003**	**.019**	**.000**	.079	.506	**.000**	**.000**	.289	**.000**	**.000**	.414	.239	.353
		68	**617**	**586**	**564**	**627**	557	573	**567**	**555**	568	**574**	**576**	554	543	540
Social Jetlag **Sleep Diaries**	SJMSDiary RAW	.212	.049	**-.098**	-.017	**.288**	-.082	**-.054**	**.154**	**-.115**	-.009	-.021	.020	.071	**.098**	**.109**
		.088	.227	**.019**	.695	**.000**	.056	**.000**	**.000**	**.007**	.832	.623	.638	.099	**.023**	**.012**
		66	605	**572**	555	**616**	542	**554**	**554**	**543**	556	563	563	545	**532**	**529**
	SJSDDiary RAW	.030	.042	**-.200**	**.118**	**.194**	.040	**.108**	-.059	**-.158**	.070	**.139**	**.120**	**.134**	**.220**	**.228**
		.806	.304	**.000**	**.006**	**.000**	.353	**.011**	.166	**.000**	.100	**.001**	**.004**	**.002**	**.000**	**.000**
		69	599	**565**	**547**	**609**	541	**554**	551	**537**	549	**556**	**556**	**538**	**525**	**522**
	%SLW Diary	.016	.048	**-.170**	**.116**	**.222**	.047	**.131**	-.060	**-.170**	.069	**.132**	**.117**	**.131**	**.215**	**.226**
		.895	.241	**.000**	**.007**	**.000**	.280	**.002**	.162	**.000**	.108	**.002**	**.006**	**.002**	**.000**	**.000**
		67	594	**562**	**544**	**603**	538	**550**	548	**533**	546	**553**	**552**	**534**	**521**	**522**

Note. Bolded values indicate *p*< .05.

Table A.5. Correlation Table for MCTQ Sleep Variables by Day Type

		Work Days MCTQ						Free Days MCTQ					
		Sleep Onset	Sleep Latency	Wake Time	Wake Latency	Sleep Duration	MSW	Sleep Onset	Sleep Latency	Wake Time	Wake Latency	Sleep Duration	MSF
Work Days	Sleep Onset	1.00	**.181** **.000** **1556**	**.386** **.000** **1556**	**.131** **.000** **1526**	**-.388** **.000** **1552**	**.786** **.000** **1567**	**.656** **.000** **1557**	**.130** **.000** **1564**	**.456** **.000** **1569**	**.055** **.030** **1551**	**-.175** **.000** **1548**	**.617** **.000** **1546**
	Sleep Latency			.038 .133 1542	**.100** **.000** **1503**	**-.082** **.001** **1527**	**.105** **.000** **1527**	**.103** **.000** **1531**	**.593** **.000** **1553**	**.059** **.021** **1542**	**.100** **.000** **1526**	-.013 .625 1521	**.083** **.001** **1519**
	Wake Time				**.112** **.000** **1519**	**.579** **.000** **1554**	**.852** **.000** **1567**	**.267** **.000** **1549**	.023 .363 1551	**.430** **.000** **1562**	.025 .331 1543	**.174** **.000** **1541**	**.390** **.000** **1540**
	Wake Latency					-.007 .773 1495	**.140** **.000** **1502**	**.089** **.001** **1502**	**.066** **.010** **1511**	**.086** **.001** **1516**	**.301** **.000** **1513**	.001 .974 1496	**.108** **.000** **1492**
	Sleep Duration						**.154** **.000** **1533**	**-.242** **.000** **1528**	-.045 .076 1533	**.055** **.030** **1537**	-.018 .473 1521	**.331** **.000** **1522**	**-.097** **.000** **1514**
	MSW							**.506** **.000** **1532**	**.081** **.001** **1534**	**.518** **.000** **1544**	.027 .296 1523	.027 .296 1520	**.578** **.000** **1524**
Free Days	Sleep Onset								**.100** **.000** **1545**	**.595** **.000** **1559**	**.090** **.000** **1530**	**-.337** **.000** **1539**	**.879** **.000** **1545**
	Sleep Latency									.020 .428 1555	**.132** **.000** **1538**	**-.059** **.020** **1535**	**.063** **.014** **1532**
	Wake Time										**.106** **.000** **1547**	**.431** **.000** **1552**	**.888** **.000** **1562**
	Wake Latency											.042 .102 1529	**.106** **.000** **1520**
	Sleep Duration												.034 .187 1539

Note. Bolded values indicate $p < .05$.

Table A.6. Correlation Table for Sleep Diary Sleep Variables by Day Type

		Work Days					Free Days				
		Sleep Onset	Sleep Latency	Wake Time	Sleep Duration	MSW	Sleep Onset	Sleep Latency	Wake Time	Sleep Duration	MSF
Work Days	Sleep Onset		.041 .299 637	**.685** **.000** **660**	**-.339** **.000** **662**	**.914** **.000** **662**	**.758** **.000** **636**	**.091** **.027** **595**	**.596** **.000** **620**	**-.092** **.021** **627**	**.771** **.000** **624**
	Sleep Latency			.057 .153 623	-.025 .530 626	.058 .149 628	.068 .096 601	**.725** **.000** **580**	.064 .122 590	.007 .860 592	.090 .028 592
	Wake Time				**.319** **.000** **648**	**.905** **.000** **653**	**.511** **.000** **622**	**.123** **.003** **580**	**.585** **.000** **608**	**.130** **.001** **613**	**.640** **.000** **612**
	Sleep Duration					.007 .866 650	**-.254** **.000** **623**	-.001 .976 583	.033 .414 607	**.324** **.000** **616**	**-.098** **.015** **611**
	MSW						**.682** **.000** **625**	**.112** **.007** **585**	**.647** **.000** **615**	.011 .781 617	.758 .000 615
Free Days	Sleep Onset							.062 .127 606	**.648** **.000** **633**	**-.247** **.000** **639**	**.893** **.000** **637**
	Sleep Latency								.065 .115 594	.020 .625 598	**.081** **.048** **597**
	Wake Time									**.470** **.000** **626**	**.910** **.000** **629**
	Sleep Duration										**.159** **.000** **627**

Note. Bolded values indicate $p < .05$.

Table A.7. Semester and Season of Data Collected

Location	Year	School Semester	N	T1 Date	T2 Date	Time of class instruction	MCTQ T1	MCTQ T2	MEQ T1	MEQ T2	Sleep Diaries	GPA	BMI	Caffeine/ Nicotine/ Alcohol
Burnaby	2008	Spring	69	February	March		x	x	x	x				
Burnaby	2008	Intersession	88	May	June	1:30-4:30	x	x	x	x	x			
Burnaby	2008	Fall	37	September	December	2:30-5:30	x	x	x	x	x			
Burnaby	2009	Intersession	73	May	June	2:30-5:30	x	x	x	x	x			
Burnaby	2010	Intersession	156	May	June	2:30-5:30	x	x	x	x	x			
Burnaby	2011	Intersession	107	May	June	2:30-5:30	x	x	x	x	x			
Burnaby	2011	Fall	96	September	Nov	2:30-5:30	x	x	x	x	x	x	x	
Burnaby	2012	Intersession	112	May	June	2:30-5:30	x	x	x	x	x			x
Burnaby	2012	Fall	147	September	Dec	5:30-8:30	x	x	x	x	x	x		x
Burnaby	2012	Fall	192	September	December		x	x	x	x		x		
Kamloops	2009	Fall	136	September	November		x	x				x	x	
Kamloops	2010	Spring	107	January	April		x	x				x	x	
Kamloops	2010	Summer	57	May	Jun/Aug		x	x	x	x		x	x	
Kamloops	2011	Spring	130	January	April		x	x				x	x	
Kamloops	2011	Fall	112	September	December		x	x				x	x	
Kamloops	2012	Spring	95	Jan/Feb	NA		x	NA		NA		x	x	
Kamloops	2012	Summer	45	May	Jun/Jul/Aug		x	x	x			x	x	
Kamloops	2012	Fall	128	September	October			x	x					

Note: x denotes data that was collected for that measure. Total Sample Sizes by measure; MEQ *n*= 1136; MCTQ *n*= 1567; Sleep Diaries *n*= 637. Total Sample size by academic measure: GPA *n*= 793; Class grade *n*= 810 (class grade was collected from Burnaby students only). Total sample size by season: January *n*= 401; May *n*= 565; September *n*= 811.

Appendix B.

Chronotype Assessment Measures

Morningness-Eveningness Questionnaire

The MEQ (Horne & Östberg, 1976) is a self-report questionnaire focusing on individual timing preferences. Calculated from 19 questions, each participant received a score ranging between 16 and 86. Higher scores indicate a larger degree of morning preference. This score can be used as a continuous variable, or can be grouped as up to five categories based on cut-offs reported by Terman et al., (2001).

psyc106-MEQ-Time2

- This preview shows all your questions on one page, the actual survey delivery will display one question per page for clarity
- Answer the required questions and click "Submit" to see what the "submitted" questions look like
- Click Edit to change an answer
- Click Close when you are finished previewing

Welcome

Horne-Ostberg "Morningness-Eveningness" Scale This questionnaire asks about your preferences.

Q1 . Please enter your identification information:

Student number : ________ *

SFU email address : ________ *

Q2 . Approximately what time would you get up if you were entirely free to plan your day?

- ○ 5 - 6:30 am
- ○ 6:30 - 7:45 am
- ○ 7:45 - 9:45 am
- ○ 9:45 - 11 am
- ○ 11 - noon
- ○ noon - 5 pm

Q3 . Approximately what time would you go to bed if you were entirely free to plan your evening?

- ○ 8 - 9 pm
- ○ 9 - 10:15 pm
- ○ 10:15 - 12:30 pm
- ○ 12:30 - 1:45 am
- ○ 1:45 - 3 am
- ○ 3 - 8 am

Q4 . If you usually have to get up at a specific time in the morning, how much do you depend on an alarm clock?

- ○ not at all
- ○ slightly
- ○ somewhat
- ○ very much

Q5 . How easy do you find it to get up in the morning (when you are not awakened unexpectedly)?

- ○ very difficult
- ○ somewhat difficult
- ○ fairly easy

- very easy

Q6 . How alert do you feel during the first half hour after you wake up in the morning?

- not at all alert
- slightly alert
- fairly alert
- very alert

Q7 . How hungry do you feel during the first half hour after you wake up?

- not at all hungry
- slightly hungry
- fairly hungry
- very hungry

Q8 . During the first half hour after you wake up in the morning, how do you feel?

- very tired
- fairly tired
- fairly refreshed
- very refreshed

Q9 . If you had no commitments the next day, what time would you go to bed compared to your usual bedtime?

- seldom or never late
- less than 1 hour late
- 1-2 hours late
- more than 2 hours late

Q10 . You have decided to do physical exercise. A friend suggests that you do this for one hour twice a week, and the best time for him is between 7-8 am. Bearing in mind nothing but your own internal "clock", how do you think you would perform?

- would be in good form
- would be in reasonable form
- would find it difficult
- would find it very difficult

Q11 . At approximately what time in the evening do you feel tired, and, as a result, in need of sleep?

- 8 - 9 pm
- 9 - 10:15 pm
- 10:15 - 12:45 am
- 12:45 - 2 am
- 2 - 3 am

Q12 . You want to be at your peak performance for a test that you know is going to be mentally exhausting and will last two hours. You are entirely free to plan your day. Considering only your internal "clock," which one of the four testing times would you choose?

- 8 - 10 am
- 11 - 1 pm
- 3 - 5 pm
- 7 - 9 pm

Q13 . If you got into bed at 11 pm, how tired would you be?

- not at all tired
- a little tired
- fairly tired
- very tired

Q14 . 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 are you most likely to do?

- will wake up at usual time, but will not fall back asleep
- will wake up at usual time and will doze thereafter
- will wake up at usual time, but will fall asleep again
- will not wake up until later than usual

Q15 . One night you have to remain awake between 4-6 a.m. in order to carry out a night watch. You have no time commitments the next day. Which one of the alternatives would suit you best?

- would not go to bed until the watch was over
- would take a nap before and sleep after
- would take a good sleep before and nap after
- would sleep only before the watch

Q16 . You have to do two hours of hard physical work. You are entirely free to plan your day. Considering only your internal "clock", which one of the following times would you choose?

- 8 - 10 am
- 11 - 1 pm
- 3 - 5 pm
- 7 - 9 pm

Q17 . You have decided to do physical exercise. A friend suggests that you do this for one hour twice a week. The best time for her is between 10-11 pm. Bearing in mind only your own internal "clock", how well do think you would perform?

- would be in good form
- would be in reasonable form

- would find it difficult
- would find it very difficult

Q18 . Suppose you can choose your own work hours. Assume that you work a five-hour day (including breaks), your job is interesting and you are paid based on your performance. At approximately what time would you choose to begin?

- 5h starting between 4 am - 8 am
- between 8 - 9 am
- between 9 am - 2 pm
- between 2 - 5 pm
- between 5 pm - 4 am

Q19 . At approximately what time of day do you usually feel your best?

- 5 - 8 am
- 8 - 10 am
- 10 am - 5 pm
- 5 - 10 pm
- 10 pm - 5 am

Q20 . One hears about "morning types" and "evening types." Which one of these types do you consider yourself to be?

- definitely a morning type
- rather more a morning type than an evening type
- rather a more evening type than a morning type
- definitely an evening type

Q21 . My current body weight is approximately

indicate whether pounds or kilograms : ________ *

Q22 . My height is

enter feet and inches : ________

Q23 . I smoke cigarretes

- one or more daily
- every week but not every day
- not every week
- never

Submit

Close

 Session Expires: 2013-05-06 06:19 PM

INTERPRETING AND USING YOUR MORNINGNESS-EVENINGNESS SCORE

This questionnaire has 19 questions, each with a number of points. First, add up the points you circled and enter your total morningness-eveningness score here:

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

16-30	31-41	42-58	59-69	70-86
definite evening	moderate evening	intermediate	moderate morning	definite morning

Occasionally a person has trouble with the questionnaire. For example, some of the questions are difficult to answer if you have been on a shift work schedule, if you don't work, or if your bedtime is unusually late. Your answers may be influenced by an illness or medications you may be taking. *If you are not confident about your answers, you should also not be confident about the advice that follows.*

One way to check this is to ask whether your morningness-eveningness score approximately matches the sleep onset and wake-up times listed below:

Score	16-30	31-41	42-58	59-69	70-86
Sleep onset	2:00-3:00 AM *(02:00-03:00 h)*	12:45-2:00 AM *(00:45-02:00 h)*	10:45 PM-12:45 AM *(22:45-00:45 h)*	9:30-10:45 PM *(21:30-22:45 h)*	9:00-9:30 PM *(21:00-21:30 h)*
Wake-up	10:00-11:30 AM *(10:00-11:30 h)*	8:30-10:00 AM *(08:30-10:00 h)*	6:30-8:30 AM *(06:30-08:30 h)*	5:00-6:30 AM *(05:00-06:30 h)*	4:00-5:00 AM *(04:00-05:00 h)*

If your usual sleep onset is earlier than 9:00 PM *(21:00 h)* or later than 3:00 AM *(03:00 h)*, or your wake-up is earlier than 4:00 AM *(04:00 h)* or later than 11:30 AM *(11:30 h)*, you should seek the advice of a light therapy clinician in order to proceed effectively with treatment.

MEQ Cut-off Guidelines; (Terman et al., 2001).

Munich Chronotype Questionnaire

The MCTQ (Roenneberg, Wirz-Justice & Merrow, 2003) gathers self-report information regarding average daily timing to assess phase of entrainment separately for work and free days. Midsleep time on free days (MSF; the time halfway between sleep onset and wake time on free days) is used as measure of individual chronotype. Later midsleep times represent increased tendency towards lateness.

psyc106-MCTQ-Time2

- This preview shows all your questions on one page, the actual survey delivery will display one question per page for clarity
- Answer the required questions and click "Submit" to see what the "submitted" questions look like
- Click Edit to change an answer
- Click Close when you are finished previewing

Welcome to the Munich Chronotype Questionnaire

The questions in this questionnaire will provide information about when you actually go to sleep and wake up (which may be different from when you would PREFER to go to sleep and wake up). Please do your best to be accurate.

Q1 . What is your student number and SFU email address?

Student number : ______ *

SFU email address : ______ *

Q2 . What is your age?

Age : ______

Q3 . What is your gender?

- ○ Female
- ○ Male

Work days

The next set of questions refers to **work days**. For people who work 9-5, monday to friday, work days are easily defined (i.e., they are monday to friday). For students, lets define a work day as any day when you have to set an alarm or otherwise wake up at a specific time to go to class, to work, or to some other commitment (if you happen to be a parent, this can include getting up to look after kids in the morning). A 'free day' is one where you can wake up spontaneously, without an alarm, or with an alarm set later than usual. What we are trying to find out is when you would spontaneously wake up after a night of sleep, and the difference between that time, and the times when you are forced to wake up. For some of you, there may be no days when you are forced to wake up (for example, if you have only afternoon classes, and can wake up whenever you want in the morning). In that case, you would enter nothing in the work days.

Q4 . [On work days] What is your usual bedtime?

Usual bedtime - if 11pm, enter 23:00, if 12:30am enter 0:30 : ______

Q5 . [On work days] What is your usual lights out time (if different from bedtime, e.g., if you read etc for a while)?

Usual lights out time : ______

Q6 . [On work days] how long does it usually take to fall asleep)?

minutes to fall asleep (enter a single number, e.g., if 10 minutes, then enter 10 : ______

Q7 . [On work days] What is your usual wake up-time?

Usual wake up time : ______

Q8 . [On work days] How long do you lay in bed after waking up in the morning (if you always get up immediately, enter 0)

minutes before getting up : ______

Q9 . [On work days] Do you use an alarm?

- ◯ Yes
- ◯ No

Q10 . [On work days] Do you wake up before the alarm?

- ◯ often
- ◯ sometimes
- ◯ rarely

Q11 . [On work days] Do you take naps?

- ◯ often
- ◯ sometimes
- ◯ rarely

Q12 . If yes, what is your most typical naptime and nap duration?

Most typical nap time e.g., if 2pm, enter 14:00 : [ ]

Most typical nap duration in minutes : [ ]

Q13 . [On work days] How much time do you typically spend outdoors between sunrise and sunset?

Estimated time spent outside (in minutes) : [ ] *

Free days

The next set of questions refers to **free days**. Free days are those days when you don't have to set an alarm, or you can set one at whatever time you like.

Q14 . [On free days] What is your usual bedtime?

Usual bedtime : [ ]

Q15 . [On free days] What is your usual lights out time (if different from bedtime, e.g., if you read etc for a while)?

Usual lights out time : [ ] *

Q16 . [On free days] How long does it usually take to fall asleep?

minutes to fall asleep : [ ]

Q17 . [On free days] What is your usual wake-up time?

Usual wake-up time : [ ]

Q18 . [On free days] How long do you lay in bed after waking up?

average # of minutes : [ ]

Q19 . [On free days] Do you use an alarm?

- ◯ Yes
- ◯ No

Q20 . [On free days] If you do use an alarm, is this because you have

children?

- ◯ Yes
- ◯ No

Q21 . [On free days] If you do use an alarm, is this because you have pets?

- ◯ Yes
- ◯ No

Q22 . [On free days] Do you wake up before the alarm?

- ◯ often
- ◯ sometimes
- ◯ rarely

Q23 . [On free days] Do you take naps?

- ◯ often
- ◯ sometimes
- ◯ rarely

Q24 . If yes, what is your most typical naptime and nap duration?

Most typical nap time e.g., if 2pm, enter 14:00 : ____

Usual nap duration, e.g., if 1 h, enter minutes, ie., 60 : ____

Q25 . [On free days] How much time do you spend outdoors between sunrise and sunset)?

typical # of minutes : ____

Q26 . Work (excluding school)

Number of days / week : ____ *

Number of hours / week : ____ *

Usual start time : ____ *

Q27 . School

Number of courses this semester : ____ *

Q28 . Do you regularly (1 or more times/week) read from a tablet (e..g, an iPad) or computer while in bed, or immediately prior to turning out the lights to sleep?

- ◯ Yes
- ◯ No

Q29 . What is your current grade point average? [responses are coded and kept confidential]

Answer : ____

Q30 . How many course credits do you currently have [not counting this semester]

Answer :

Q31 . I have taken 1 or more university biology courses.

- Yes
- No

Q32 . Testing your knowledge of the brain: The resting membrane potential of a typical neuron is negative.

- yes
- no
- don't know
- did know, have forgotten

Q33 . testing your knowledge of the brain: The typical neuron has more than one axon.

- yes
- no
- don't know
- have forgotten

Submit

Close

Sleep Diaries

Daily sleep diary records (recorded for a duration ranging from one week to two months) allow collection of accurate daily sleep timing information. Participants recorded 'day type', indicating which days were work days and which were free days. Free days were defined as days when participants were able to set their own preferred wake up time. Work days were defined as days when participants were required to wake for social obligations (including school or work). From the diaries, average sleep onset, wake times, midsleep and sleep duration were calculated separately for work and free days. In order to assess chronotype, midsleep time on free days (MSF_{Diary}) was calculated.

Instructions:

1. Enter information twice daily: at bedtime and wake-up time
2. Enter clocktimes in military format (for example 11pm is 23:00) **Or please be sure to enter AM or PM**
3. Many people go to bed after midnight. Bedtime for Thursday May 17 might actually be on Friday morning on May 18 (e.g. 1:00 AM), but you should still enter that as the bedtime for Thursady May 17. We will understand what it means.
4. A 'work' day is defined as a day when you have to get up to go to work, school or other obligstions. A 'free' day is a day where you are free to set your own prefferred wake up time.

	FILL IN DATE		Enter this information at bedtime						Enter this information when you get up in the 'morning'					
			If you had a nap			Caffeinated drinks								
	date	day	nap onset **time**	nap end **time**	cigarettes smoked? **number**	coffee **#cups**	tea or softdrink **#cups**	bedtime (lights out) **clocktime**	wakeup time **clocktime**	did you use an alarm to wake up **yes/no**	how long did it take to fall asleep last night? **minutes**	if you woke in the night what time? **clocktime**	how long did you stay awake? **minutes**	is today a (f)ree or or (w)ork day? **letter**
Example	1/1/2014	Monday	13:00	14:00	0	2	1	23:30	7:30	y	10	2:00	20	F
1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
13														
14														
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