Conflicted clocks: Social jetlag, entrainment and the role of chronotype

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Chapter 4

The role of chronotype, time of day, attendance, and study effort in academic performance of university students

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Abstract

Individuals have different sleep times and diurnal preferences. This can be easily quantified and described as a distribution of chronotypes, ranging from very early (larks) to very late (owls). Several studies have found that chronotype and time of day influence performance. For instance, students with a late chronotype obtain on average worse grades, and this effect is more pronounced when examinations are taken in the early morning. Here we aimed to further explore the relationship between chronotype, time of day, and grades in university students. Grades from examinations taken at 9:00 h, 14:00 h, and 18:30 h were collected. In addition, students reported their class attendance rate, study effort, and stimulants consumption. The interaction effect between chronotype and time of day on grades was not significant. Overall, attendance, study effort, and cigarette consumption were the strongest predictors for academic performance. Increased attendance and study effort were associated with better grades, whereas a higher number of cigarettes smoked (per month) was related to worse grades. A late chronotype was associated with decreased attendance, and increased alcohol consumption, as predicted by earlier studies. The number of grades collected at the three times of day was not evenly distributed, and therefore more research is needed to establish how the chronotype-effect on grades varies with time of day in university students. Results from additional studies would be useful for developing policies to optimize lecture and examinations schedules taking chronotype into account.

Introduction

Performance at every level (from cognitive to physical) is sensitive to the influence of sleep and time of day (Alhola & Polo-Kantola, 2007; Blatter & Cajochen, 2007; Lim & Dinges, 2010; Souissi, Sesboüé, Gauthier, Larue, & Davenne, 2003). For instance, cognitive performance is impaired after sleep deprivation and when certain tasks are performed at night (Dijk, Duffy, & Czeisler, 1992; Lo et al., 2012). Further, individuals differ in terms of sleep timing and diurnal preferences (chronotype; Horne & Ostberg, 1976; Roenneberg, Wirz-Justice, & Merrow, 2003). Sleep timing can be easily measured via the Munich ChronoType Questionnaire (MCTQ; Roenneberg et al., 2003). From the answers to the MCTQ, chronotype can be assessed as the midpoint of sleep on work-free days (MSF), corrected for sleep debt accumulated on workdays (MSF_{sc}). The distribution of chronotypes is wide, ranging from early (morning) to late (evening) types (Roenneberg et al., 2007). The influence of chronotype on performance has been extensively studied in high-school students. Although chronotype is later during adolescence, schools generally start early in the morning, leading to a deficit in performance by late chronotypes when compared to early ones (Crowley et al., 2014; Roenneberg et al., 2004; Tonetti, Natale, & Randler, 2015). Many studies have shown that, on average, late chronotypes obtain lower grades compared to early chronotypes (Borisenkov, Perminova, & Kosova, 2010; Díaz-Morales & Escribano, 2013; Kolomeichuk, Randler, & Shabalina, 2016; Preckel et al., 2013; Rahafar, Maghsudloo, Farhangnia, Vollmer, & Randler, 2016; Randler & Frech, 2006; 2009; van der Vinne et al., 2015; Vollmer, Pötsch, & Randler, 2013). In addition, we have recently shown that the chronotype-effect on grades depends on time of day of testing, with late chronotypes underperforming in the morning, but not in the early afternoon (12:00 h – 15:00 h) (van der Vinne et al., 2015). Similarly other studies have found that late chronotypes are particularly impaired when tested in the morning while their performance improves later in the day (Goldstein, Hahn, Hasher, Wiprzycka, & Zelazo, 2007; Lara, Madrid, & Correa, 2014). This phenomenon is known in literature as the synchrony effect (May, Hasher, & Stoltzfus, 1993). Based on this, we hypothesized that students with a late chronotype would obtain better grades than early chronotypes if tested later in the day. This hypothesis is difficult to test in high-school students because usually examinations are scheduled in the first half of the day. A few studies have shown that late chronotypes attending school in the afternoon obtain comparable grades relative to early chronotypes (Itzek-Greulich, Randler, & Vollmer, 2016; Martin, Gaudreault, Perron, & Laberge, 2016). How would the grades of early and late chronotypes change if students were tested even later in the day (evening) is still unknown. Universities have more flexible schedules, and sometimes examinations can be scheduled early in the morning as well as late in the evening, giving us the unique opportunity to expand our knowledge about the interaction effect between chronotype and time of day on grades.

The aim of this study was therefore to investigate how the effect of chronotype on grades is modulated by time of day in university students that take examinations at very different times of day (from 9:00 h until 18:30 h). Based on previous studies, we expected better grades achieved by early chronotypes in the morning; no difference in grades between early and late chronotypes in the afternoon; and late chronotypes obtaining better grades than early chronotypes in the evening. Since many other factors in addition to chronotype and time of day influence grades, we also assessed attendance rate, study effort, and stimulants consumption of the students.

Methods

The study was conducted at the University of Groningen (53° 13' N/6° 33' E), The Netherlands, in February 2016. Students enrolled in the first and second year at the Departments of Biology and Life and Science Technology (Faculty of Science and Engineering) participated in the study. Students were asked to fill in three questionnaires: the Munich ChronoType Questionnaire (MCTQ; Roenneberg et al., 2003), a questionnaire about stimulants consumption, and a questionnaire about lecture attendance and study effort (see Supplementary Information). The MCTQ asks about sleep timing separately on workdays and on work-free days and is used to assess chronotype as the midpoint of sleep on work-free days (MSF), corrected for sleep debt accumulated on workdays (MSF_{sc}). Most of the students (69%) did not have a regular working schedule, and it was therefore not possible to apply the sleep correction (based on number of workdays) to calculate chronotype. For this reason, we chose to use MSF (not sleep corrected) as a proxy for chronotype. We excluded from the analyses the students who used an alarm clock on work-free days (exclusion criterion used for MSF_{sc} as well). The MCTQ allows also the assessment of other sleep-related variables such as sleep duration on lecture/workdays and social jetlag (the mismatch between the circadian and the social clocks; Wittmann, Dinich, Merrow, & Roenneberg, 2006).
In the stimulants questionnaire, students reported their daily/weekly/monthly consumption of alcohol (beer, wine, strong alcohol), coffee, tea, caffeinated drinks, and sleeping pills/aids. The total amount of alcoholic drinks, cigarettes and cups of coffee consumed per month were analyzed. The attendance and study effort questionnaire asked about lecture attendance (%) and about how much effort (on a scale from 1 to 10) the students put in their studying in order to pass an examination.

Grades from examinations taken between January 2015 and January 2016 were retrieved from the online database of the Faculty of Science and Engineering. In the Dutch university system, grades span from 1 (very bad) to 10 (outstanding), with 6 being the minimum grade to pass an examination (International Recognition Department of Nuffic Netherlands Organisation for International Cooperation in Higher Education, 2013). Date and time of day of each examination were also collected. Examinations were taken at three different times of day: morning (9:00 h), afternoon (14:00 h), and evening (18:30 h). Grades were obtained from examinations of 61 different courses, grouped into 13 subject areas: chemistry, ecology, ethics in research, genetics, human biology, imaging techniques, informatics, mathematics, molecular biology, neurobiology, pharmacology, physics, and physiology.

Statistical analyses were done using R software (R version 3.3.0; The R Core team, 2013). Model selection based on the Akaike's Information Criterion (AIC; Akaike, 1973) was run to select the most parsimonious model for the given data. Grades were analyzed as dependent variable. Student ID was entered in the model as random factor. Different combinations of the following explanatory variables were entered in the models: sex, age, attendance, study effort, number of cigarettes per month, number of drinks (beer, wine, strong alcohol) per month, number of cups of coffee per month, chronotype (MSF), social jetlag (absolute MSF-MSW), and sleep duration on work/lecture days. Subject area, month, day of the week, time of day were analyzed as covariates. The estimates of the model are indicated in the results as "b" coefficients. To compare the strength of the effects of the different predictors the coefficients were standardized and are indicated as "β" coefficients.

In addition, we ran a separate linear mixed model with grades as dependent variable and chronotype, time of day, and the interaction between chronotype and time of day as explanatory variables. Chronotype and time of day were analyzed as categorical variables. Students were divided into two equal-sized groups of early (MSF ≤ 5.50) and late (MSF > 5.50) chronotypes. The variable time of day had three levels: morning (9:00 h), afternoon (14:00 h), and evening (18:30 h). Based on the model selection previously described, student ID was analyzed as random factor, and subject area and day of the week when the examinations had been taken were analyzed as covariates.

To investigate the influence of sex, age, and sleep-related variables on attendance, effort and stimulants consumption different regression analyses were run based on the distribution of the dependent variables. To account for negative skewedness in the attendance data, we ran a quantile regression aiming to estimate the conditional median. The effort data were normally distributed allowing the use of linear regression. To account for excessive zeros and over dispersion of the stimulants data we used a zero-inflation model with negative binomial distribution. Model selection based on the AIC was again applied.

The study was conducted according to the principles of the Medical Research Involving Human Subjects Act (WMO, 2012), and the Declaration of Helsinki (64^{th} WMA General Assembly, Fortaleza, Brazil, October 2013). The Medical Ethical Committee of the University Medical Centre of Groningen (NL) approved the study. All participants signed an informed consent.

Results

A total of 258 students (141 females and 117 males, mean age 20.11 ± 1.50 SD; age range 18-27 years) participated in the study. Of these students, 36 reported using an alarm clock on work-free days and were therefore excluded from all analyses. The final sample size was of 222 students (121 females and 101 males, mean age 20.15 ± 1.52 SD, age range 18-27 years). 1241 grades (average number of grades per student: 5.59) from examinations taken between January 2015 and January 2016 were collected. 548 grades were collected from examinations taken in the morning (9:00 h), 620 grades from examinations taken in the afternoon (14:00 h) and 73 grades from examinations taken in the evening (18:30 h). The students filled in three questionnaires: the MCTQ, a questionnaire about stimulants consumption, and a questionnaire about lecture attendance and study effort. The descriptive statistics of the data collected with these questionnaires are summarized in Table 1.

Chronotype, time of day, and grades

First we ran a mixed model with chronotype and time of day as independent variables to test the hypothesis that grades in university students depend on the interaction between chronotype and time of day of testing. Subject area and day of the week were analyzed as covariates. We did not find any significant interaction effect between chronotype and time of day on grades ($F_{2,998} = 2.622$, $p = 0.0732$). Overall, late chronotypes obtained lower grades (main effect of chronotype: $F_{1,220} = 6.377$, $p = 0.0123$), but the chronotype-effect on grades was not modulated by time of day.

Table 1. Demographics of 121 female and 101 male first- and second-year university students (data from the Munich ChronoType Questionnaire).

Outcome measure	Average (± SD)	Range
Age (years)	20.15 (1.52)	18 - 27
Chronotype (MSF, h)	5.71 (1.12)	2.63 - 11
Social Jetlag (h)	1.68 (0.83)	0 - 5.38
Sleep onset on work/lecture days (h)	0.22 (0.95)	-2.75 - 3.08
Sleep end on work/lecture days (h)	7.83 (0.99)	5.75 - 12
Sleep duration on work/lecture days (h)	7.61 (1.05)	5 - 10.97
Sleep onset on work-free days (h)	1.32 (1.26)	-1.75 - 6
Sleep end on work-free days (h)	10.09 (1.24)	7 - 16
Sleep duration on work-free days (h)	8.77 (1.11)	5.17 - 12.5
Attendance (scale 0-100)	88 (15.06)	2 - 100
Effort (scale 0-10)	6.88 (1.28)	3 - 10
Alcohol (number drinks per month)	33.30 (36.25)	0 - 168
Coffee (cups per month)	27.79 (36.36)	0-180
Cigarettes (per month)	6.57 (36.53)	0 - 360
Grades	6.72 (1.40)	0.5-10

Data concerning chronotype, sleep onset and sleep end refer to external clock time and are reported in decimals (clock times before midnight are expressed with negative numbers). Data concerning lecture attendance, study effort, stimulants consumption, and grades are also reported.

However, only 5% of the grades were collected in the evening (45% in the morning and 50% in the afternoon), decreasing the predictive power of the model for the evening grades (higher standard deviation; SD morning: 1.26; SD afternoon: 1.44, SD evening: 1.93). Therefore, we decided to repeat the same analysis and exclude the evening examinations. When only the examinations taken in the morning and in the afternoon were considered, the interaction effect between chronotype and time of day was significant ($F_{1,927}$ = 5.740, p = 0.0168). Post hoc tests (with Bonferroni correction for multiple comparisons) revealed that early chronotypes obtained higher grades (almost half grade higher) in the afternoon compared to late chronotypes, while this difference was not significant in the morning (afternoon: b = 0.4, t (329.5) = 2.47, p = 0.02; morning: b = 0.2, t (410.4) = 1.48, p = 0.28, Fig. 1).

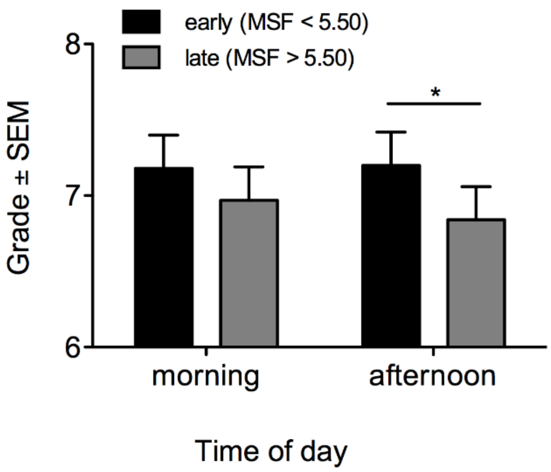

Figure 1. Interaction effect between chronotype and time of day of examinations on grades.
Bars represent means with standard error of the mean (SEM) of grades from examinations taken at two times of day: morning (9:00 h) and afternoon (14:00 h). Black bars represent grades from early chronotypes (MSF ≤ 5.50), and grey bars represent grades from late chronotypes (MSF > 5.50). Means and SEM were derived from the multilevel model used to fit the data and therefore represent the estimated means and SEM. The interaction effect between chronotype and time of day was significant: early chronotypes obtained better grades in the afternoon (14:00 h) compared with late chronotypes. *p < .05 (post hoc tests with Bonferroni correction).

The influence of attendance, study effort, and cigarettes consumption on grades

The most parsimonious model to describe the variance in grades had attendance, study effort, and cigarettes consumption among the predictors. Subject area and day of the week were also significantly associated with grades in this model, and were analyzed as covariates. A complete overview of the models considered is reported in Table S1 (Supplementary Information). For both attendance and study effort the correlation with grades was positive (attendance: b = 0.020, t (218) = 5.112, p < .0001; study effort: b = 0.137, t (218) = 2.912, p = 0.0040). The model predicts that if a student increases the attendance rates of 10%, his/her average grade will increase with a factor of 0.2 (on a scale from 1 to 10). The model also predicts that if a student increases the study effort of 1 unit (on a scale from 1 to 10), his/her average grade will increase with a factor of 0.14. The number of cigarettes consumed per month negatively correlated with grades (b = -0.004, t (218) = -2.377, p = 0.0183). For each additional cigarette consumed per month, the model predicts a decrease in grades with a factor of 0.004. Attendance showed the strongest association with grades (β = 0.223), followed by study effort (β = 0.124), and cigarettes consumption (β = -0.093).

The influence of sex, age, chronotype, and attendance on study effort

The stepwise backward linear regression analysis revealed that the most parsimonious model to describe the variance in study effort had sex, age, chronotype, and attendance among the predictors. Males had a lower score on this scale compared to females (b = -0.415, t (196) = -2.258, p = 0.0251). In particular, the model predicts that the study effort in a male student is 0.4 points lower than for females on a scale from 1 to 10. Students who were older and attended more often the lectures were characterized by an increased study effort (age: b = 0.111, t (196) = 1.990, p = 0.0480; attendance: b = 0.012, t (196) = 2.087, p = 0.0382). Finally, chronotype was negatively associated with study effort (b = -0.257, t (196) = -3.014, p = 0.0029, Fig. 2A). The model predicts that a student with 1-hour later chronotype shows a decrease in study effort of a factor of 0.3 (on a scale from 1 to 10). The effect on study effort was strongest for chronotype (β = -0.216), followed by sex (β = -0.160), age (β = 0.130), and attendance (β = 0.144).

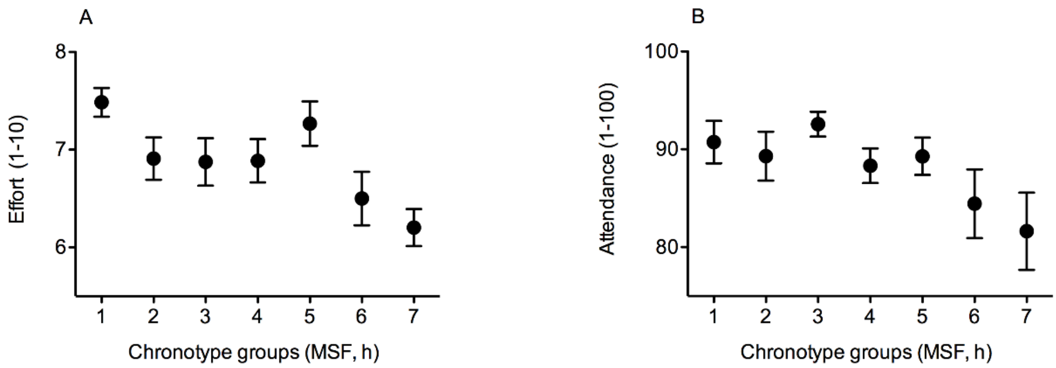

Figure 2. Influence of chronotype on study effort and attendance rates.
Data points represent mean study effort scores (A) and attendance rates (B) with standard error of the mean (SEM) of 7 equal-sized chronotype groups, with 1 being the earliest and 7 the latest chronotype group. The ranges of chronotype for each group are: (1) 2.63-4.66, (2) 4.67-5.08, (3) 5.09-5.38, (4) 5.39-5.64, (5) 5.65-6.21, (6) 6.22-6.85, and (7) 6.86-11. Late chronotypes were more likely to put less effort in studying and to attend fewer lectures.

The influence of chronotype, social jetlag, sleep duration, and stimulants consumption on attendance

The stepwise backward quantile regression analysis revealed that the most parsimonious model to describe the variance in attendance had chronotype, social jetlag, sleep duration on lecture/workdays, alcohol and cigarettes consumption among the predictors. Although cigarettes consumption was not significantly associated with attendance (b = -0.44, t (216) = -

1.786, p = 0.0755), removing this predictor from the model increased the AIC from 1529.6 to 1533.8 (worse fit). Chronotype, sleep duration on lecture/workdays, and alcohol consumption were negatively associated with attendance (chronotype: b = -2.413, t (216) = -2.693, p = 0.0076; sleep duration: b = -1.502, t (216) = -2-080, p = 0.0279; alcohol consumption: b = -0.094, t (216) = -2.544, p = 0.0117). Social jetlag was positively correlated to attendance (b = 2.934, t (216) = 2.213, p = 0.0279). The model predicts that a student with 1-hour later chronotype has a 2% decrease in attendance (Fig. 2B).

The influence of sex and chronotype on stimulants consumption

The model with sex and chronotype as predictors was the most parsimonious model to describe the variance in alcohol consumption. Chronotype influenced the likelihood of consuming alcohol (b = -0.804, z = -2.638, p = 0.0083; Fig. 3). A student with a 1-hour earlier chronotype had 2 times larger odds of never consuming alcohol. Chronotype and sex were both positively associated with the amount of alcohol consumed, with late chronotypes and male students consuming significantly more alcohol (chronotype: b = 0.258, z = 3.587, p = 0.0003; sex: b = 0.456, z = 3.250, p = 0.0012).

Finally, none of the variables of interest was found to be significantly associated with cigarettes consumption and coffee intake.

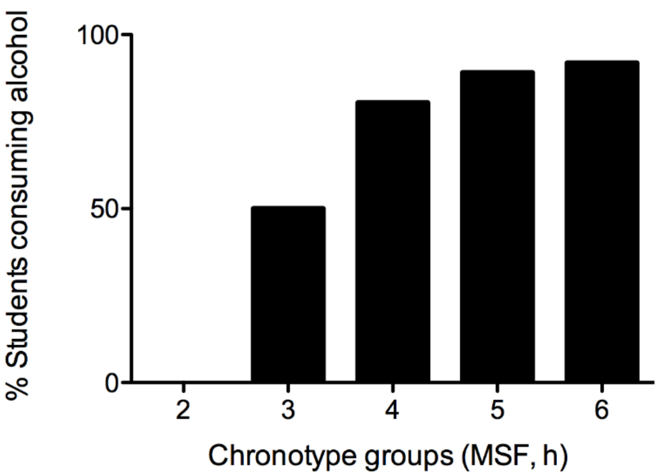

Figure 3. Influence of chronotype on alcohol consumption.

The percentages of students drinking at least one alcoholic drink per month were calculated in relation to the entire sample and per hourly bin based on the students' MSF. Among the students with a late chronotype there is an increased number of students drinking at least one alcoholic drink per month. The number of students per each hourly MSF bin was: 1 (MSF = 2), 8 (MSF = 3), 41 (MSF = 4), 92 (MSF = 5), 49 (MSF = 6).

Discussion

The influence of chronotype on academic performance has been shown both in high school and university students. In general, late chronotypes report lower achievements compared to early chronotypes (Beşoluk, Önder, & Deveci, 2011; Borisenkov et al., 2010; Preckel, Lipnevich, Schneider, & Roberts, 2011; Tonetti et al., 2015). Several studies have suggested that this difference in performance might be related to the early school/university starting times that handicap students with a late chronotype (Preckel et al., 2013; Randler & Frech, 2006; 2009; van der Vinne et al., 2015; Vollmer et al., 2013). The importance of timing of examination has been shown in recent studies where late chronotypes obtained lower grades in the morning, while no difference in performance between early and late chronotypes was found in the afternoon (Itzek-Greulich et al., 2016; Martin et al., 2016; van der Vinne et al., 2015).

Here, we aimed to better elucidate how the chronotype-effect on grades changes with time of day by collecting grades from examinations taken in the morning, afternoon, and evening (9:00 h, 14:00 h, and 18:30 h). The interaction effect between chronotype and time of day of testing was not significant. However, the number of grades collected at the three times of day was not evenly distributed, with fewer grades (5%) collected during evening examinations compared to morning (45%) and afternoon (50%) examinations. When we considered only the examinations taken in the morning and in the afternoon, we found that early chronotypes obtained better grades in the afternoon, whereas there was no significant difference between early and late chronotypes in the morning. This finding did not support our hypothesis that late chronotypes would obtain worse grades in the morning and better grades later in the day compared to early chronotypes. However, we based our hypothesis on previous studies done in high-school students, but university and high-school students differ in many aspects. For instance, the chronotype of university students is on average later than high-school students: chronotype starts delaying during adolescence and reaches the peak in lateness when young adults are around 20 years old (mean age in our sample was 20.15 years; Roenneberg et al., 2004). For this reason, the morning examination session might have been too early even for early chronotypes, with the afternoon session being their optimal time for taking an examination. In addition, the more flexible schedules typical of university might have reduced the overall chronotype and time of day influence on grades. This idea is supported by the findings of a recent meta-analysis where the chronotype-effect on grades was found to be stronger in high-school students, that usually have regular schedules starting early in the morning, compared with university/college students (Tonetti et al., 2015).

Further, our results suggest that attendance rate and study effort could be more important variables for academic success than chronotype in university students. The most parsimonious model to predict grades had attendance rate and study effort, but not chronotype, among the significant predictors. Chronotype was significantly associated with grades, only when the other predictors, such as attendance and study effort, were not added to the model. In line with these results, previous studies have found that other variables, such as stimulants consumption and class attendance, are more strongly associated with academic achievements

(Gomes, Tavares, & de Azevedo, 2011; Onyper, Thacher, Gilbert, & Gradess, 2012). This suggests that a complex interaction of many factors influence school and academic performance, requiring future studies to systematically assess all these variables, trying to discern the strength of their unique contribution in determining grades. For instance, similarly to our previous results (chapter 3), we found that chronotype was significantly associated with attendance, with late chronotypes being more likely to attend fewer lectures than early chronotypes. In the same study, absenteeism was found to be negatively associated with grades. Together, these data suggest that early schedules (both at the school and university level) challenge students with a late chronotype, influencing negatively their attendance and possibly their grades.

In line with previous studies, we found that chronotype was related to stimulants consumption, with late chronotypes consuming more alcohol (Adan, 1994; Randler, 2008; Wittmann et al., 2006; Wittmann, Paulus, & Roenneberg, 2010). We did not find any significant influence of stimulants consumption on grades. However, Onyper and colleagues found that alcohol consumption was the strongest among different predictors of academic achievements in university students (Onyper et al., 2012). The relationship between chronotype, stimulants consumption, and school/academic performance needs therefore further elucidation.

A limitation of this study is the correlational approach, not making possible any causal inference. In addition, we used questionnaires (to assess attendance rate and study effort) that had not been previously validated. Finally, we were not able to definitively confirm or reject our hypothesis of an interaction effect between chronotype and time of day on grades because of the uneven number of exams taken at the three different times of day considered.

Taken together, although we did not find a significant association between chronotype, time of day, and grades in university students, chronotype was still found to be associated with reduced attendance and increased stimulants consumption, which in turn have been found to be negatively related to grades in our and previous studies (chapter 3; Gomes et al., 2011; Onyper et al., 2012; Roby, 2004). More research is needed in university students to clarify the role of chronotype and other variables such as stimulants consumption and class attendance in relation to academic performance. Moreover, future studies should assess in more detail the academic performance of early and late chronotypes at different times of day, considering also the lecture schedules that could influence a student's ability to learn and prepare for the examination.

Acknowledgments

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Supplementary Information

Questionnaire about stimulants consumption, lecture attendance, and study effort.

Deelnemersenquête

Beste deelnemer, wees ervan verzekerd dat alle informatie uit deze enquête anoniem geanalyseerd wordt. Alle data is aan strikte geheimhouding onderworpen, en zal niet aan derden doorgegeven worden.

Datum ____________
Studentnummer____________

Consumptie (a.u.b. gemiddelde waarden aangeven!) per →	**dag**	**week**	**maand**
a) Ik rook _____ sigaretten ...	☐	☐	☐
b) Ik drink _____ glazen bier ...	☐	☐	☐
c) Ik drink _____ glazen wijn …	☐	☐	☐
d) Ik drink _____ glazen sterke drank (jenever/whisky/wodka/etc.) …	☐	☐	☐
e) Ik drink _____ koppen koffie …	☐	☐	☐
f) Ik drink _____ koppen zwarte thee ...	☐	☐	☐
g) Ik drink _____ blikjes cafeïne houdende frisdrank …	☐	☐	☐
h) Ik neem slaap bevorderende medicamenten _____ maal in ...	☐	☐	☐

Motivatie
a) Ik ben gemiddeld aanwezig bij _____% (percentage aangeven) van mijn colleges/werkcolleges/practica.
b) Ik besteed gemiddeld op een schaal van 1-10 _____ tijd en moeite om een vak met een voldoende cijfer af te sluiten.

Bedankt voor het invullen van onze enquête!

Table S1. Description of the 10 models used to explore the influence of the explanatory variables (chronotype, sleep duration on workdays, social jetlag, attendance rate, study effort, and stimulants consumption) on grades.

Model	Explanatory variables	K	AICc	Delta AICc	AICcWt	ER	LER
1	Attendance rate, study effort, chronotype (MSF)	22	4045.9	5.1	3.7 e-2	12.9	1.1
2	Cigarettes, alcohol, and coffee consumption (monthly), chronotype (MSF)	23	4046.2	5.4	3.1 e-2	15.1	1.2
3	Attendance rate, study effort, alcohol consumption (monthly), chronotype (MSF)	23	4047.4	6.7	1.7 e-2	28.0	1.4
4	Attendance rate, study effort, social jetlag (SJL)	22	4045.8	5.0	3.9 e-2	12.2	1.1
5	Attendance rate, study effort	21	4044.4	3.7	7.6 e-2	6.2	0.8
6	**Attendance rate, study effort, cigarettes consumption (monthly)**	**22**	**4040.8**	**0**	**4.8 e-1**	**1**	**0**
7	Attendance rate, study effort, sleep duration workdays (SDw)	22	4045.0	4.2	5.7 e-2	8.3	0.9
8	Attendance rate, study effort, cigarettes consumption (monthly), chronotype (MSF)	23	4042.6	1.8	1.9 e-1	2.5	0.4
9	Attendance rate, study effort, cigarettes and alcohol consumption (monthly), chronotype (MSF)	24	4044.4	3.7	7.6 e-2	6.2	0.8
10	Chronotype (MSF)	20	4079.1	38.4	2.2 e-9	214,298,059.6	8.3

The number of estimated parameters (K) for each model is indicated. The most parsimonious model for the given data was model 6 (lowest AICc score = 4040.8). The differences in AICc scores (delta AICc) are calculated for each model relative to model 6. AICcWt indicates the weight of evidence for that model to be the best fit for the given data. Model 6 received 48% of the total weight of the models considered. The evidence ratio (ER) is the ratio between the weight of the best model (model 6) and the weight of each single model. The log evidence ratio (LER) can be used to compare the models. We used the following guidelines to compare the models: LERs greater than 0, 0.5, 1, and 2 indicate respectively "minimal", "substantial", "strong", and "decisive" evidence for model 6 to be the most parsimonious relative to the other models (Kass & Raftery, 1995). There was minimal evidence for model 6 to be a better fit of the data compared to model 8. The two models had the same sets of predictors, except for chronotype (MSF) that was only present in model 8. However, chronotype was not significantly associated with grades ($b = -0.028$, $t(217) = -0.504$, $p = 0.6149$) in model 8, and therefore we decided to report the results of model 6. There was substantial evidence for model 6 to be a better fit of the data compared to models 5, 7, and 9. There was strong evidence for model 6 to be a better fit of the data compared to models 1,2, 3, and 4. Finally there was decisive evidence for model 6 to be a better fit of the data compared to model 10.