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Chronotype, Class Times, and Academic Achievement of University Students

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Abstract

Numerous studies over the years have documented an effect of human chronotypes on physiological and psychological processes. Studies evaluating the impact of an individual's chronotype on his/her academic achievement have indicated that morning chronotypes have an academic advantage over evening chronotypes. However, these studies did not account for the time of day in which the participants were being evaluated. The goal of the present study was to examine whether morning chronotypes do have an academic advantage over evening chronotypes when the time-of-day of classes and exams is taken into consideration. We obtained morningness-eveningness scores and course grades from 207 university students who took classes (and exams) at different times of the day. We confirmed that morning chronotypes attain better grades than evening chronotypes, although the association is weak ($r^2 = 0.02$). The difference persisted even after the time-of-day of classes and exams was taken into consideration. This is probably due to the fact that evening chronotypes are generally more sleep deprived than morning chronotypes as a result of the early schedule of most schools, which can impair their performance both early and late in the day.

Keywords: academic achievement, chronotype, student learning, university students

Introduction

Different animal species align their activity rhythms with the daily cycle of light and darkness in diverse manners, the extremes of this continuum being represented by fully diurnal and nocturnal species (Bennie et al., 2014; Phillips et al., 2013; Refinetti, 2008). There is also variability within each species, the extent of variability being species-dependent (Refinetti et al., 2016). Horne and Östberg (1976) called attention to this variability in humans, referring to early risers as “morning types” and to late risers as “evening types”. Numerous studies over the years have revealed that these “chronotypes” differ from each other in the timing of physiological variables, such as body temperature (Baehr et al., 2000; Lack et al., 2009) and melatonin secretion (Laberge et al., 2000; Martin & Eastman, 2002; Roemer et al., 2003), as well as in psychological variables, such as alertness (Smith at al., 2002), happiness (Dagys et al., 2012), psychopathology (Hasler et al., 2010), risk-taking (Ponzi at al., 2014), and sentence recognition (Natale & Lorenzetti, 1997).

Many studies have been conducted evaluating the potential impact that an individual's chronotype has on his/her academic achievement. It has long been known that academic achievement is strongly dependent on intelligence and personality traits (Aluja-Fabregat & Blanch, 2004; Laidra et al., 2007; Lounsbury et al., 2003) as well as on study

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strategies (Putnam et al., 2016). Many studies have indicated that academic performance is also related to sleep patterns and the timing of classes and exams (reviewed by Wolfson & Carskadon, 2003). In particular, studies have indicated that morning types have an academic advantage over evening types, as indicated by better grades earned by morning types in evaluations of learning (Kolomeichuk et al., 2016; Medeiros et al., 2001; Preckel et al., 2013; Rahafar et al., 2016; Randler & Frech, 2006; Smarr, 2015). A meta-analysis of the data from 13 such studies identified a small ($r^2 = 0.03$) but significant association between morningness and academic achievement (Preckel et al., 2011).

Studies of the relation between chronotype and academic achievement have generally not accounted for the time of day when the participants were evaluated. Individuals with morning chronotypes and evening chronotypes have been usually evaluated on the same standard academic schedule (with classes and exams held early in the day), which accommodates individuals with morning chronotypes more so than individuals with evening chronotypes. This inherent bias might explain the perceived academic advantage of morning chronotypes, and additional research is necessary to examine whether morning chronotypes still have an academic advantage over evening chronotypes when the time-of-day of classes and exams is taken into consideration. In essence, internal time may be an important variable in this situation. Evening types taking classes and exams in the evening might perform just as well as morning types taking classes and exams in the morning. This hypothesis has received some attention recently. Three studies with high-school students attempted to dissociate internal time from external time (Beşoluk et al., 2011; Itzek-Greulich et al., 2016; van der Vinne et al., 2015). Unfortunately, these studies did not have optimal experimental designs. In two of these three studies, groups of students took classes at two different times-of-day but were all tested at the same time-of-day (Beşoluk et al., 2011; Itzek-Greulich et al., 2016) and, in the third study, students were tested at two different times-of-day but they all took classes at the same time-of-day (van der Vinne et al., 2015). Because the mismatch between internal time and external time might affect either learning or test-taking (or both), a proper study must provide students with test times that match the time-of-day of learning. The current study was conducted to compare the academic performance of university students of varying chronotypes who took classes and were tested early or late in the day.

Materials and Methods

Participants volunteered to participate through the subject pool of a large introductory psychology course at Boise State University, a state-funded university with 20,000 students in the northwestern United States. A total of 207 students (123 women and 84 men) completed the Morningness-Eveningness Questionnaire (MEQ) (Horne & Östberg, 1976) online during the Spring 2016 semester. The students ranged in age from 17 to 38 years, with a mean of 21 years and a standard deviation of 4 years. In American universities, students are generally expected to complete their studies in 4 academic years, and in this study 117 students were freshmen, 51 were sophomores, 26 were juniors, and 13 were seniors.

The students' course grades in the semester during which they completed the MEQ (Spring 2016) were obtained from the registrar's records at the end of the semester. This same database contained information about the time of day when the classes were taken. Final exams in each class were scheduled at the same time of day as the class meeting times. We separated class (and exam) times into early classes (classes starting before or at noon, namely, 07:30, 09:00, 10:30, or 12:00) and late classes (classes starting in the afternoon or evening, namely, 13:30, 15:00, 16:30, or 18:00). Early classes accounted for 55% of all classes (and late classes accounted for the remaining 45%).

Different students took different courses, with some overlap. In the American system of higher education, about one-third of all courses taken by university students are general education courses that are taken by all students regardless of their intended specialization. Because more than 80% of the participants in this study were freshmen or sophomores, and because most general education courses are taken during the first two years, we assumed that variations in courses taken by different students would be random and that grades did not have to be analyzed separately by discipline (which would greatly reduce sample size and, consequently, statistical power). We confirmed the legitimacy of this assumption for the study of chronotype differences by comparing the distributions of courses taken by morning types and evening types using a Kolmogorov-Smirnov test (see Results section).

After the course grades were retrieved and stored, the student identification numbers were erased from the records to ensure confidentiality. The protocol for the study was approved by the university's Institutional Review Board.

Course grades in the United States are usually assigned in a letter system, in which A is excellent, B is good, C is fair, D is poor, and F is failure. The registrar's office assigns numerical grades so that A = 4, B = 3, C = 2, D = 1, and F =0, with decimals in between. For the analysis of correlation between MEQ and course grades, data from 10 subjects had to be discarded because of missing course grades. Thus, although MEQ scores were obtained for 207 students, the analysis of course grades involved data from only 197 students. Because most students took more than one class, a total of 750 course grades were available, with a mean grade of 3.0 and standard deviation of 0.8. For display purposes, course grades were converted from the registrar's office's 0-4 scale back to a 0-100 scale by simple proportionality.

In the statistical analysis of the data, the Kolmogorov-Smirnov test was used to compare frequency distributions. Pearson's correlation coefficient (computed by the method of least squares) was used to calculate the degree of association between two numerical variables. Pairs of group means were compared with t tests or Tukey's HSD tests (parametric) and Mann-Whitney tests (non-parametric). Analysis of variance was used to compare more than two group means at a time in all cases, as this test is very tolerant of small violations of the normality assumption (Refinetti, 1996).

Results and Discussion

Figure 1 shows the distribution of MEQ scores for all the students. The scores have a symmetrical distribution with a mean of 46 and standard deviation of 10, but the distribution deviates significantly from a normal distribution, as determined by a Kolmogorov-Smirnov test ($D = 0.242$, $p < 0.001$). The mean MEQ score of 46 obtained in this sample of 207 American university students is similar to the mean score of 48 obtained in a sample of 2,135 Spanish-Italian university students (Adan & Natale, 2002) and to the mean score of 49 obtained in a sample of 2,481 Dutch university students (Zavada et al., 2005). Using Horne and Östberg (1976)'s original classification, 21 students were morning types (MEQ > 58) and 63 students were evening types (MEQ < 42). This arbitrary cutoff left 123 students (59% of the subjects) in the intermediary group.

Although it is well established that morningness-eveningness varies with age, with a tendency towards morningness before puberty and again later in life (Roenneberg et al., 2007), we did not find a significant correlation between MEQ score and age in our data set ($r = 0.03$, $p > 0.10$). This negative finding is not surprising given the very narrow range of ages in our sample (with 82% of the subjects between 18 and 22 years of age). A slight trend towards morningness in women, as compared to men, has been noted in some studies but not in others, and age may be a confound in this relationship (Roenneberg et al., 2007). In our data set, men showed a slightly larger variance in the distribution of MEQ scores ($F(83, 122) = 1.49$, $p < 0.05$), but the means of men (47.05 ± 1.18 SEM) and women (45.95 ± 0.80 SEM) were not significantly different ($t(103) = 0.769$, $p > 0.10$; $U = 4729$, $p > 0.10$).

Figure 2 shows that early types had slightly better grades overall, as indicated by the significant positive correlation between a person's MEQ score and his/her average grade in the semester ($r = 0.15$, $p < 0.03$). This finding is in agreement with the findings of previous studies involving high school students (Beşoluk et al., 2011; Kolomeichuk et al., 2016; Preckel et al., 2013; Rahafar et al., 2016; Randler & Frech, 2006) as well as university students (Medeiros et al., 2001; Smarr, 2015).

Different students in our study took different courses, according to their academic programs and personal preferences, although the general education requirements forced most students to take a number of core courses. The courses that most students took were in the disciplines of psychology, mathematics, and writing. Many students also took courses in the disciplines of accounting, anthropology, art, biology, chemistry, communication, history, philosophy, and political science, as well as an interdisciplinary course required of all students in the university ("university foundations"). A Kolmogorov-Smirnov test comparing the frequency distributions of courses taken in these disciplines by "definitely early types" (MEQ > 58) and "definitely late types" (MEQ < 42) showed that the two distributions were not significantly different from each other ($D = 0.06$, $p > 0.05$).

In order to isolate the effect of chronotype from the effect of class time, we separated class times into early classes (classes starting before noon) and late classes (classes starting in the afternoon or evening). The top panel of Figure 3 shows the results for all subjects using MEQ = 50 as the breakpoint between early types and late types ("median split"). ANOVA indicated an overall group effect: $F(3, 746) = 3.40$, $p = 0.02$. Both early types and late types seemed to perform slightly better in classes taken later in the day, but post hoc analysis indicated that this difference was not significant (bars with the same lower case letters above them are not significantly different). Late types had significantly lower grades than early types in classes taken early in the day, but their grades were comparable in classes taken later in the day.

Recognizing that a breakpoint of MEQ = 50 obscures the separation of early types from late types, we recalculated the class grades using only "extreme" types, that is, "definitely early types" (MEQ > 58) and "definitely late types" (MEQ < 42). As shown in the lower panel of Figure 3, this approach increased the statistical power to detect group differences. ANOVA indicated an overall group effect: $F(3, 313) = 3.97$, $p = 0.01$. Post hoc analysis indicated that late types had lower grades than early types both in classes taken early in the day and in classes taken later in the day. For neither group was there a significant difference in grades between early classes and late classes, despite a minor (non-significant) trend for grades to be higher in late classes than in early classes.

These results confirm previous observations that early types attain better grades than late types (Beşoluk et al., 2011; Kolomeichuk et al., 2016; Medeiros et al., 2001; Preckel et al., 2013; Rahafar et al., 2016; Randler & Frech, 2006; Smarr, 2015) and contradict our expectation that class time affects the academic achievement of different chronotypes differently. Why early types should tend to perform better than late types in university classes (irrespective of class time) cannot be determined from these correlational data, but possible explanations can be discussed. A survey of university students at Michigan State University identified modest ($r < 0.30$) but significant correlations between morningness and both achievement tendency and aversion to time wasting (Watts, 1982). Similarly, a survey of students at a small university in Canada found that evening types have lower self-control and greater tendency for procrastination than morning types do (Digdon & Howell, 2008). Thus, morning types may be slightly more diligent and goal-oriented than evening types, which would make them slightly better students. Perhaps even more importantly, evening types are generally more sleep deprived than morning types as a result of the early schedule of most schools, which can impair their performance both early and late in the day (Medeiros et al., 2001; Smarr, 2015). In any event, we note that the association that we found between chronotype and academic performance was modest ($r^2 = 0.02$), which is consistent with the findings of a meta-analysis of 13 previous studies (Preckel et al., 2011).

A recent study by van der Vinne and colleagues (2015) involving high-school students found that late types did have poorer academic achievement than early types in morning exams but not in afternoon exams. This is what we expected to find, but was not actually found, in our study. There was a major methodological difference between the two studies: in our study, class time and examination time varied together (because students had different class schedules), whereas in the study by van der Vinne and colleagues only the examination time varied (because class times were the same for all students). A likely consequence of this methodological difference would be a greater, not a smaller, effect of class time in our study. Thus, this methodological difference cannot explain the difference in the results. Another methodological difference resides in the fact that van der Vinne and colleagues used a median split of chronotypes, similar to the one used in the top panel of our Figure 3 (where late types did not perform significantly worse in late classes than early types did). It is possible that, if van der Vinne and colleagues had used more extreme chronotype groups (as we did in the lower panel of Figure 3), they would have detected a difference between chronotypes in afternoon exams (as we detected in this study). The difference in the results of the two studies may also be partially due to the difference in the student populations (high school versus university), as a meta-analysis of 31 studies found a weaker effect of chronotype on academic achievement in university students than in high-school students (Tonetti et al., 2015). Presumably, university students are more resilient and, consequently, their academic performance is less dependent on class time than that of high-school students.

Two other studies have attempted to dissociate the effects of chronotype and class time on academic achievement of high-school students. Beşoluk and colleagues (2011) found that early types obtained better grades than late types regardless of whether the classes were taken early or late in the day, which is in agreement with our own findings. We note, however, that all students in the study by Beşoluk and colleagues took exams in the morning, which could have given an advantage to morning types. Itzek-Greulich and colleagues (2016) found that morning types achieved better grades than evening types in classes taught in the morning but not in classes taught in the afternoon, which is what we expected to find but we did not find. These authors did not use a median split as was the case in the study by van der Vinne and colleagues (2015), and we can attribute the discrepancy in results only to the difference in the student populations (high school versus university).

In short, we found that early chronotypes perform better academically than late chronotypes in the university setting regardless of whether they take classes (and exams) early or late in the day. This is probably due to the fact that evening chronotypes are generally more sleep deprived than morning chronotypes as a result of the early schedule of most schools, which may impair their performance both early and late in the day (Carskadon, 2011).

Conflict of Interest

The authors declare that they have no conflict of interest.

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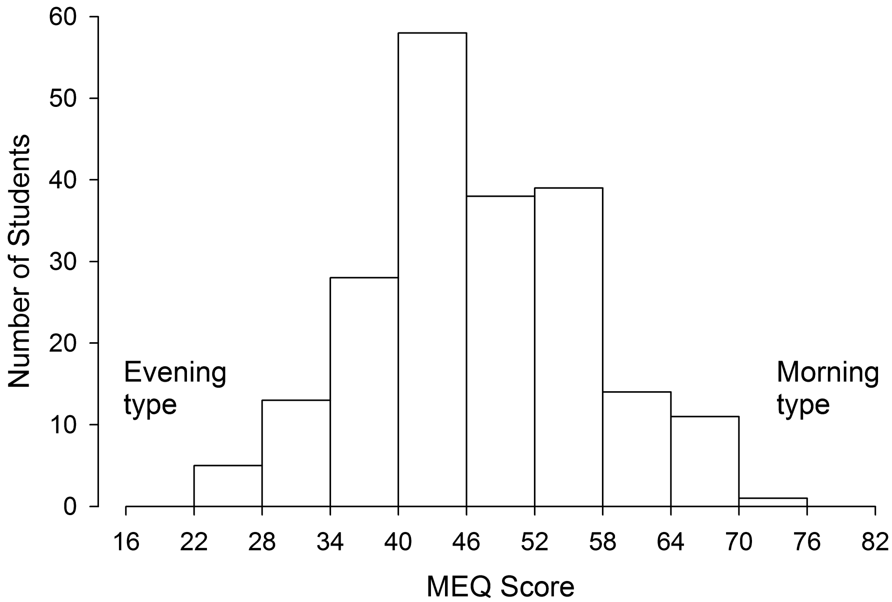

Figure 1. Frequency distribution of MEQ scores of the 207 participants. Lower scores are associated with eveningness and higher scores with morningness. The overall mean was 46 and the mode was 41.

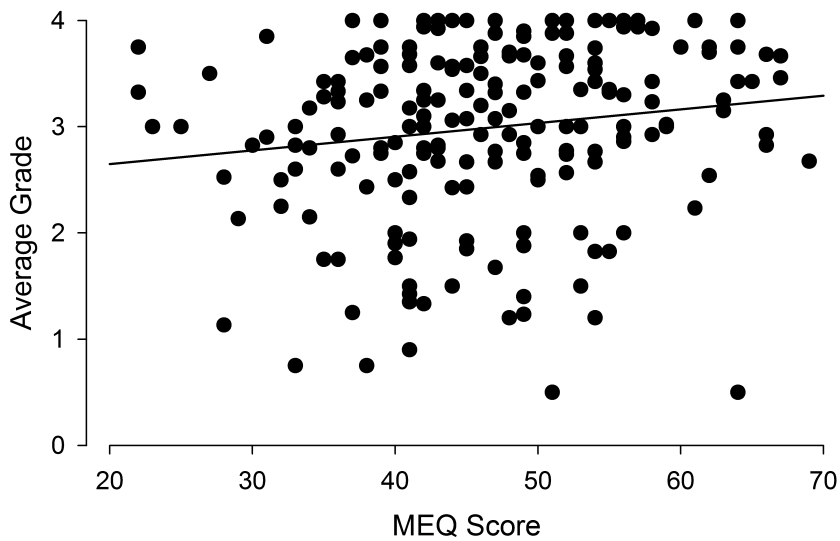

Figure 2. Average grade in the semester as a function of MEQ score for 197 students. There is a small but significant correlation between the two variables ($r = 0.15$, $p < 0.03$), indicating that early chronotypes tend to have higher grades.

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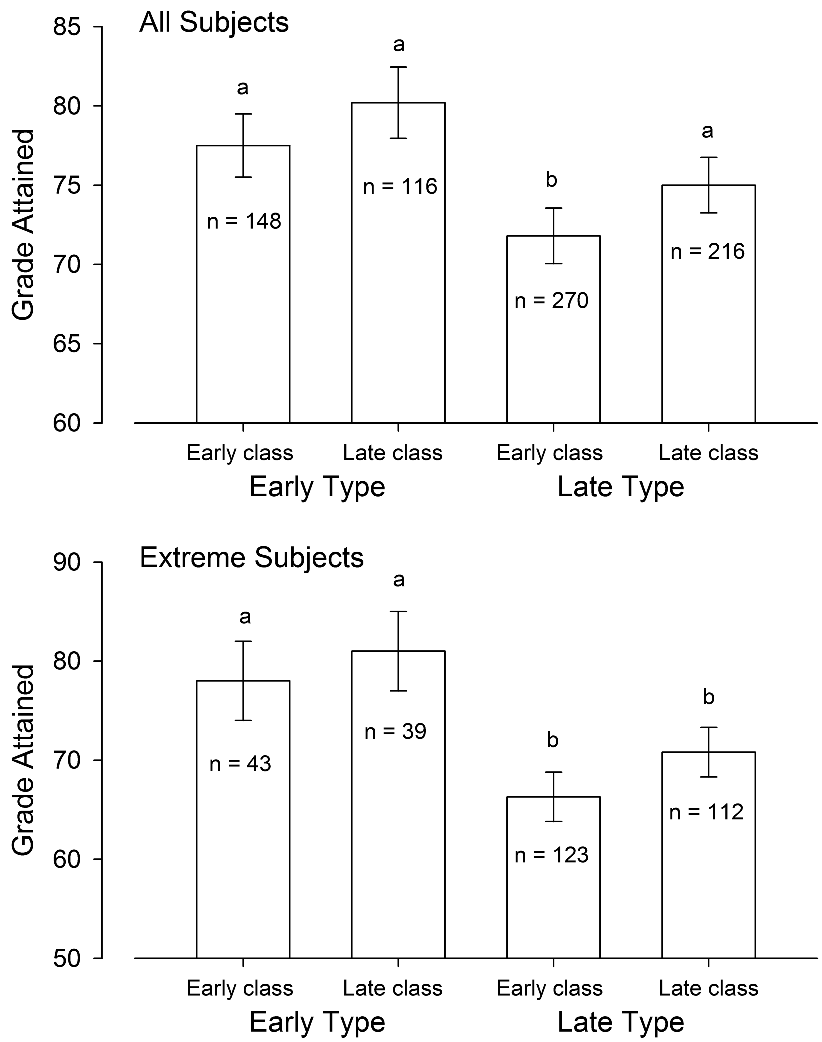

Figure 3. Grades attained by early types and late types when taking early classes (morning) or late classes (afternoon and evening). The height of the bars denotes the mean for each condition. The whiskers indicate the standard error of the mean. Top panel: early and late types defined as MEQ scores below or above 50, $F(3, 746) = 3.40$, $p = 0.02$. Lower panel: early types defined as MEQ > 58 and late types defined as MEQ < 42, $F(3, 313) = 3.97$, $p = 0.01$. In each panel, bars with the same letter (a or b) are not significantly different from each other, as determined by pairwise comparisons with Tukey's HSD test. The number of grades used is indicated for each category.