

The influence of circadian type, time of day and class difficulty on students' grades

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Abstract

Introduction. In this paper we investigate how students' class grades are affected by individual differences in circadian rhythm, class time-of-day and class difficulty.

Method. Using a sample of university students, we assessed morningness and eveningness personality type, and then obtained students recalled classes as well as their university-recorded classes and grades.

Results and Conclusions. The results of our analysis revealed that, for very difficult classes, "optimal-time-of-day" played a significant role in determining students' grades. Our results also suggest that eveningness-type individuals appear to be most affected by standard class times. Analysis of our findings also revealed optimal-time-of-day effects for recall of the previous semester's classes. Aside from obvious implications for students, we mention implications also for teachers and administrators.

Introduction

Certainly anyone who has worked through the required classes for a college degree can relate to how the struggle to understand class material can sometimes seem greater than other times. Trying to understand how students may be differentially affected by classes is important for researchers, students and educators alike. In this paper we focus on a set of factors that have important implications for students' performance in the classroom.

Circadian typologies.

We have all experienced times in which the pronouncement is made "I am a morning person" or "I am an evening person". Sometimes these statements are not so direct and may simply be anecdotal such as "I do my best writing in the evening" or "I enjoy getting up early to get started on things". Nevertheless, these testimonials all refer to what time of the day an individual performs or "feels" their best. Research investigating this time-of-day feeling has shown that these "circadian rhythms" have physiological correlates such as body temperature and alertness (Bailey & Heitkemper, 1991; Dijk, Duffy & Czeisler, 1997; Tankova, Adan, & Buela-Casal, 1994). These cycles are also relatively stable (e.g., Sverko & Fabulic, 1985) and represent valid underlying constructs (e.g., Kerkof, 1998; Larsen, 1985).

Researchers investigating the effects of circadian rhythms normally refer to individuals who have their peak or "optimal" performance time during the early morning hours as morningness-types. Conversely, the eveningness-type refers to individuals who experience their optimal performance in the evening hours (Horne & Osterberg, 1976). Researchers investigating circadian rhythm effects often observe the match and mismatch between the morningness/eveningness types and the time of day a particular task is performed. Optimal-time-of-day refers to early morning hours for morningness types and evening hours for eveningness types. For clarity purposes, we refer to the match between circadian type and time-of-day as optimal-time-of-day.

Related Research

A good deal of research has demonstrated the effects of circadian rhythm on individual performance and abilities (Tankova, Adan & Buela-Casal, 1994). Because some of these

factors may be related to abilities in the classroom, we shall review some of the relevant topics. For example, research has shown that individuals tend to have greater depth of processing at their optimal-time-of-day (Chebat, Limoges & Gélinas-Chebat 1997; Martin & Marlington, 2005), better mental efficiency (Colquhoun, 1971), decreased stereotype reliance (Bodenhausen 1990) better recall from long-term memory (Anderson, Petros, Beckwith, Mitchell & Fritz, 1991) and better performance on immediate recognition tasks (Natale & Lorenzetti, 1997).

Recent research by Natale, Alzani and Cicogna (2003) investigated how morningness and eveningness types differed across the day on various cognitive-type tasks. They observed participants' performance on visual, logical, spatial and math related tasks. Overall, they found greater performance for optimal time of day only in the visual search task. This effect is somewhat surprising but the thorough analysis by Natale, Alzani and Cicogna revealed additional findings. Their in-depth analysis revealed that the predicted optimal-time-of-day effect occurred for the cognitive efficiency task but only in extreme morning-evening types. Further analysis revealed the predicted optimal-time-of-day effect for logical and math based tasks but only for extreme times-of-day (i.e., 8:00am and 11:00pm).

Cognitive Demand

Another issue that arises when dealing with circadian rhythm and task performance is the level of task difficulty. Specifically, optimal-time-of-day effects may have little influence on tasks that are relatively low in the cognitive demands they require. On the other hand, tasks that are cognitively demanding may be more affected by the optimal-time-of-day. One study by Monk & Leng (1986) indirectly addresses this issue. In this study, they compared the performance levels of morningness-types and eveningness-types on a relatively simple serial-search task and a more complex logical reasoning task. They found the predicted optimal-time-of-day results for both tasks. However, they found the effect to be significantly stronger for the more cognitively demanding – logical reasoning task. In another study, Petros, Beckwith, & Anderson (1990) observed the influence of circadian rhythms on time-of-day for recall. In this study, they had participants recall a passage they had read a short time before. Importantly, the passage was either high or low in difficulty. Similar to the Monk &

Leng (1986) study, they found the strongest optimal-time-of-day effects occurred for the high difficulty passages.

In light of this prior research, we propose that extreme eveningness/morningness types will be most affected by the time-of-day that their class occurs. Further, we propose that the difficulty of the class may also be a factor such that, optimal-time-of-day will have the greatest impact on more difficult classes. Therefore, in our present study we will examine the interactive effect of morningness/eveningness, class time-of-day and class difficulty on students' grades.

Method

Participants and Design. In this experiment, two-hundred and fifty four students from Appalachian State University took part in our study. Our sample included one-hundred forty five females and one-hundred nine males. Each participant reported on their classes from the previous semesters which were subsequently checked for accuracy from registrar records (Note: in the US University system the registrar is responsible for record keeping of students grades). This yielded a total sum of one-thousand two hundred and nineteen classes across all of our participants. Our study consisted of a 2 (circadian rhythm: morningness type, eveningness type) x 2 (class time: morning, evening) x 2 (class difficulty: low, high) factorial design. The dependent variable in our study was class grade that was obtained from registrar records.

Materials. We assessed participants' morningness/eveningness type by providing them with the revised and shortened version of the Horne and Östberg (1976) inventory. The rH&O circadian rhythm inventory (Adan & Almirall, 1991) has been shown to be a valid measure of morningness/eveningness type (e.g., Chelminski, Petros, Plaud & Ferraro 2000; Natale, 1999). The rH&O consists of 5-items designed to assess indicators of circadian rhythm type such as; time of day individuals need sleep, time of "feeling best" and peak time. Individual responses are totaled and can range from 4 to 25. Participants can be classified as Definitely Morning, Definitely Evening, Moderately Morning, Moderately Evening or Neither.

Procedure

In order to avoid potential time-of-day-effects on participants' ability to recall particular classes, we avoided extreme morning or evening hours and only conducted our study between the hours of 10:00am and 2:00pm. Participants in our study were first presented with the rH&O questionnaire (Adan & Almirall, 1991; Chelminski, Petros, Plaud & Ferraro 2000). After completion of the rH&O, we asked participants to recall information about the previous semester. We first, asked them to recall each class they had taken. We then asked them to recall their grade for each respective class. Afterward, we asked them several questions regarding general aspects of the class.

After the experiment was completed, participants' classes and grades for the previous semester were obtained through registrar records and stored along with the recalled classes and grades for analysis. This yielded a total sum of one-thousand two hundred and nineteen classes across all of our participants. Our study consisted of a 2 (circadian rhythm: morningness type, eveningness type) x 2 (class time: morning, evening) x 2 (class difficulty: low, high) factorial design. The dependent variable in our study was class grade that was obtained from registrar records.

Results

In order to examine our results we first observed participants classification as morning or evening type. Consistent with the findings of previous research (e.g, Almirall, 1993; Natale, Alzani & Cicogna 2003) we included only those participants who fell under the classification of definitely morning and definitely evening types. To determine whether a class would be considered a morning or evening class, we used the criteria of before 10:00am for morning and after 2:00pm for evening. In order to determine class difficulty, the departmental academic advisor classified every class on a 1 to 5 scale. Classes that were determined to be relatively easy (1 & 2 on our scale) were classified as "Low difficulty" and classes that were classified as being relatively difficult (4 & 5 on our scale) were classified as "High difficulty" classes.

To examine our central question, we wanted to test the influence of morning/eveningness, time of class and class difficulty on participants' class grades (obtained from registrar records). Because of individual variability in whether participants had taken a morning or evening course, we used a regression model to examine our results. We dummy coded each of our independent variables and performed a regression analysis to examine the influence of these variables on participants grades.

This analysis revealed significant main effects for all three independent variables; morning eveningness $F(1, 342) = 6.48, p < .05$, time of class $F(1, 342) = 4.1, p < .05$ and class difficulty $F(1, 342) = 4.14, p < .05$. The analysis also revealed an interaction between morning/eveningness and time of class $F(1, 342) = 4.96, p < .05$ as well as morning/eveningness and class difficulty $F(1, 342) = 12.16, p < .01$. More importantly however, the omnibus three-way interaction between morning/eveningness, time of class and class difficulty was also significant $F(1, 342) = 7.32, p < .01$.

Table 1. Mean student grades as a function of morning/eveningness, class time of day and class difficulty.

		Mean grade		
		High Difficulty		Low Difficulty
		SD	Mean	SD
Morning type				
Time of day				Mean
	Morning	1.07	3.05	.96
	Evening	1.2	2.82	.94
Evening type				
Time of day				
	Morning	1.46	1.98	1.01
	Evening	.93	3.0	.95

As can be seen in Table 1, the strength of our results seems to be due primarily to the high difficulty classes. Therefore in order to further investigate our findings, we performed an analysis within both the high and low difficulty conditions. In the low difficulty condition, we found no significant main effects and the larger morning/eveningness x time of class interaction was also non-significant $F(1, 250) = .24, p < .6$. However, the analysis within our high difficulty condition did reveal a significant morning/eveningness main effect $F(1, 92) = 9.6, p < .01$ as well as a significant morning/eveningness x time of class interaction $F(1, 92) = 8.74, p < .05$.

It also appears that eveningness-type individuals are more affected by time-of-day (see Table 1). In order to investigate this potential difference, we performed subsequent contrasts to determine whether the grades of morningness and eveningness-type individuals differed significantly across the morning and evening high difficulty classes. These analyses revealed that the morning and evening class grades of eveningness-type individuals did differ significantly $F(1, 92) = 9.82, p < .01$ whereas morningness-type individuals did not differ across the different times-of-day $F(1, 92) = .36, p > .5$.

Table 2. Percentage of failures to recall previous semester classes.

	Morning Type	Evening Type
Time of day	Percentage	Percentage
Morning	22%	25%
Evening	25%	14%

Another indication of the impact that optimal time-of-day has on students is whether they are able to recall the class from the previous semester. Specifically, would morningness and eveningness type individuals differ in their ability to recall classes taken in the morning versus those taken in the evening the semester before? In order to investigate this question, we again performed a regression analysis with morningness/eveningness-type and class time-of-day as our independent variables. The results from this analysis revealed a significant interaction between morningness/eveningness-type and class time-of-day $F(1, 535) = 4.46, p <$

.05. As can be seen in Table 2, morningness-type participants had more failures for recalling evening classes than morning classes whereas the opposite was true for eveningness-type participants.

Discussion or Conclusions

Prior research examining circadian rhythm effects has established that individuals should perform better at their optimal-time-of-day and that this effect may be limited to certain tasks that are more cognitively demanding in nature. Based upon this research, we examined the relationship between circadian rhythm, class-time-of-day and class difficulty. Our findings revealed that, in classes that are relatively difficult, an individual's optimal time-of-day has a powerful influence on student grades.

This effect appears to be exclusive to classes that are relatively difficult. We found no optimal-time-of-day influence on students' grades for less difficult classes. Consistent with prior research (Monk & Leng, 1986; Petros, Beckwith, & Anderson, 1990) we attribute this finding to the role of cognitive demand. Specifically, classes that required less cognitive functioning were less sensitive to the advantage and disadvantage of optimal and non-optimal time-of-day.

Another finding that poses limitations for our study is the relatively weaker time-of-day effect for morningness types. Although the means were in the predicted direction, the time-of-day difference is clearly nonsignificant. It is our suspicion that the nonsignificant decline in evening grades for morningness students is due to the fact that regular university classes simply are rarely carried out during later evening hours.

The finding that students were better able to recall classes they had taken during their optimal-time-of-day is interesting for future research. As discussed earlier, the Anderson, Petros, Beckwith, Mitchell & Fritz, 1991 study provided evidence that optimal time-of-day provided an advantage for better recall from long-term memory. In our study all of our stu-

dents were recalling this information during the middle part of the day. Yet, we still found that morningness/eveningness types were better able to recall classes that they had taken during their optimal-time-of-day. One possibility for this finding is that students may simply be avoiding experiences that were relatively more negative for them.

While our findings seem most relevant for students, the implications for professors and administrators are also important. Anyone who has taught a morning class has sympathized (or perhaps empathized) with the eveningness-type individuals. However, beyond empathy, the act of making students aware of the real influence that this match or mismatch between circadian rhythm and time-of-day can have may potentially help students with their class performance. Although speculative, simply making students aware of the deficit incurred because of the mismatch may increase their class effort to compensate and thereby increase their grade. However, a potential drawback is that it also offers excuses for those students seeking justification for not putting forth effort into their class work.

Administrators might also give their students a benefit in learning by avoiding extreme class times; early morning or late evening. As anyone in academia is aware, this latter implication is many times more complicated than the former. Nevertheless, we feel that both may have value for student learning and, consequently, have real potential for future research.

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