Running head: chronotype, time-of-day and mood

Chronotype and time-of-day effects on mood during school day

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Abstract

Existing evidence suggests an association between mood, time-of-day and Morningness-Eveningness (M-E). Since few studies have been carried out among adolescents, in this study daily mood fluctuations were analyzed in the naturalistic school context during two days in order to test how chronotype and time-of-day are related to mood during the school schedule period and check if sleep length is involved in the above relation. A sample of 655 adolescents (12-16 years) reported mood levels (current level of pleasantness) three times during school day (8:10-8:30 h, 10:20-11:40 h, 13:50-14:10 h). They also reported M-E preference and time in bed. Neither age nor sex was related to mood. However, the results indicated that regardless of chronotype mood increased throughout the school day from the lowest morning levels. Moreover, morning types showed better mood compared to other chronotypes, while evening types exhibited the lowest mood. Evening oriented students slept less than other chronotypes, but time in bed was not involved in the relationship between chronotype and mood. These results suggest that it is not shortened sleep duration responsible for decreased mood in evening oriented students.

Keywords: chronotype, time-of-day, mood, affect, daily, school day, adolescents

Introduction

Morningness-Eveningness (M-E), also termed chronotype, is considered an individual characteristic describing preferences for functioning at different times of day. People are typically categorized as morning types (M-types), neither types (N-types), or evening types (E-types). Existing evidence suggests an association between mood, time-of-day and M-E. Eveningness has been related to mood disorders, such as unipolar and bipolar I or II affective disorders (Robillard et al., 2013), or seasonal affective disorder (Murray, Allen & Trinder, 2003), and has been also linked to greater depressiveness in non-clinical samples (Chelminski, Ferraro, Petros & Plaud, 1999; Levandovski et al., 2011).

Overall, affective experience can be described by a circumplex structure with axes of hedonic tone (pleasure – displeasure) and arousal (activation – deactivation) which in different models are rotated or further subdivided (Barrett & Russell, 1999). Thus, more nuanced insights about mood – time-of-day – M-E interrelationships can be inferred from studies considering basal mood dimensions and particularly from those analysing daily fluctuations. It seems that variations in subjective mood are influenced by a non-additive complex interaction of circadian phase and duration of prior wakefulness (Boivin et al., 1997).

Considering a two-dimensional model of mood, eveningness has been related to lower Positive Affect (PA), whereas Negative Affect (NA) was unrelated to M-E (Biss & Hasher, 2012; Hasler et al., 2010). The theoretical position is that Positive Affect (PA), but not Negative Affect (NA) would be closely tied to the individual's internal biological clock, as PA is known to fluctuate according to the 24-hr cycle (Murray, Allen & Trinder, 2002). In a naturalistic setting, PA fluctuated across the waking day, showing a peak in the early afternoon, plateau, and then declining in the late evening. In a constant routine protocol, PA was shown to synchronize to the circadian rhythm in core body temperature even when the sleep-wake cycle was prolonged to 28 hours (Murray et al., 2009). Consequently, particularly consistent differences between chronotypes have been observed in daily fluctuations in PA but not NA. Also, PA variations occur in a continuum between the two extreme chronotypes (Porto et al., 2006). During the morning time-of-day, M-types reported greater overall experience of emotions associated with positive activation, including excitement, cheerfulness, and alertness, compared with individuals with later time of day preferences or E-types.

According to a three-dimensional model, analyses revealed eveningness related to lower hedonic tone (unpleasant–pleasant), lower energetic arousal (tired–energetic) and greater tense arousal (relaxed–nervous) in non-clinical adult sample (Jankowski, 2014a). A more nuanced analysis using prospective recording of momentary mood components showed the above pattern stable all day long from 8:00 to 20:00, with the exception for energetic arousal, which did not differ between chronotypes in the evening hours (Jankowski & Ciarkowska, 2008).

Better understanding of mood variations in non-clinical participants has the potential to advance our understanding of circadian processes which may partly cause affective disorders (Murray, 2007). Amongst various explanations of the mechanisms linking eveningness and lowered mood in non-clinical samples a decreased sleep duration has been proposed as a missing link (Warner, Murray & Meyer, 2008). Eveningness-sleep-mood relations seem to emerge in adolescence, when a shift toward eveningness is observed while school starts remain scheduled at morning hours (Díaz-Morales, Escribano, Jankowski, Vollmer & Randler, 2014). Consequently, evening pupils have decreased sleep duration during school days, what has been proposed to result in lowered mood (Warner et al., 2008), and lowered mood resulting from decreased sleep has been postulated a main cause of lowered performance in class and grades (Wong, Lau, Wan, Cheung, Hui & Mok**,** 2013). However, the eveningness-sleep-mood relationship has not been tested using prospective measurements of momentary mood, but rather using retrospective measures referring to the recent past, whose reliability may be susceptible to memory bias (Short, Gradisar, Lack & Wright, 2013; Warner et al., 2008; Wong et al., 2013). Moreover, studying mood from the recent past does not allow to precise whether lowered mood in adolescents indeed appears during the time of classes, while such case might be of particular importance, in the short term, for class performance and, in the long-term, for prevention of common affective disorders which often have their onset during the adolescence.

One study analyzed daily fluctuations in momentary mood among students of seventh-grade (Barber, Jacobson, Millen & Petersen, 1998) and found that happiness, cheerfulness, and friendliness increased from early morning (Wake-11:30 h) to peak during late morning-early afternoon (11:30-15:30 h) and late afternoon-early evening (15:30-19:30 h) before falling to the lowest level during late evening (19:30-Sleep). However, the above research did not test effects of chronotype and did not analyze potential sleep role.

In the present study, daily mood levels were evaluated in the naturalistic school context during two days, trying to answer two questions (a) how chronotype and time-of-day is related to mood during the school schedule period at high school; (b) whether sleep length is involved in the above association. We hypothesized that mood would increase throughout the school day and M-types would report better mood than N- and E-types.

Method

Participants

A sample of 655 adolescents (346 girls) aged between 12 and 16 (M = 14.10, SD = 1.32) participated in this study. Distribution by age and sex was (total: girls and boys): 12 (88: 47 and 41), 13 (153: 79 and 74), 14 (138: 66 and 72), 15 (151: 88 and 63), and 16 (125: 66 and 59) years. Sex distribution was not different across age groups, $\chi^2_{(4)} = 3.81$, $p = 0.43$. All participants were studying in three high schools in Madrid (Spain). The board of school directors authorized the study after obtaining the parents' permissions. Participation was voluntary, unpaid and anonymous. The study was conducted in accordance with the ethical standards of the journal (Portaluppi et al., 2010).

Variables and instruments

Chronotype. Morningness/Eveningness Scale for Children (*MESC*) was used as a measure of circadian preference among adolescents (Carskadon, Vieira, & Acebo, 1993; Díaz-Morales, Dávila, & Gutiérrez, 2007). The scale has 10 items about the preferred timing of activities such as spare time, tests, sleep timing, and so forth. It has a response scale with four or five response options for each item. Score ranges from 10 (*eveningness*) to 43 (*morningness*). The reliability of the scale was α =.72 (Cronbach's alpha).

Mood. The *Faces Scale* (Andrews & Withey, 1976) was used as a measure of momentary mood. It uses a Likert-type scale with seven simple drawings of faces, arranged in a horizontal line. The mouths of the faces varied from very downturned (indicating not at all happy) to very upturned (indicating very happy). The ends of the row of faces were anchored with the words ‘‘most unhappy'' and ‘‘most happy.'' Adolescents rated their mood indicating how happy they felt "in that precise moment". Thus, this scale measured the current degree of pleasantness (happiness), also called pleasure-displeasure (valence) dimension or hedonic tone (Barrett & Russell, 1999).

Sleep habits. Adolescents reported their bedtime the night before testing as well as their rise time the day they were tested for mood. Time in bed was calculated from these data and was used as a proxy measure of sleep length. Specific questions were: *What time did you go to sleep last night?*, and *what time did you get up this morning?*

Procedure and data analyses

All participants were tested in groups of about 20 adolescents during the school day and in their own classroom during the month of October. In total six measures of mood were reported: at the beginning (8:10-8:30 h), in the middle (10:20-11:40 h) and at the end of the school day (13:50-14:10 h) during two consecutive Wednesdays. The second day, M-E was also evaluated. Paired *t*-tests were run to test potential differences between testing days in mood and time in bed. Analysis of variance with repeated measures (rm-ANOVA) were run to determine differences in mood between chronotypes (inter-subject factor: M-, N- and E-types) and time-of-day (intra-subject factor: before classes, in the middle of school day, after classes). Analysis of covariance with repeated measures (rm-ANCOVA) was run in the same manner, but controlling for time in bed. Partial eta squared (η_p^2) was used as an effect size measure. It indicates proportion of variance in a dependent variable linked to a given factor excluding other factors from the total nonerror variation, and after multiplying by 100% it shows a percentage of a common variance between dependent and independent variables. The Statistical Program for the Social Sciences was used (SPSS Inc, Chicago, IL, USA).

Results

Paired *t*-tests indicated no differences between both testing days in time in bed, $t_{(579)} = 0.87$, $p = .38$. Similarly, there were no differences between the two testing days in mood at the beginning, $t_{(506)} = -.585$, $p = .56$, nor in the middle of the school day, $t_{(489)} = -1.11$, $p = .27$, although statistical differences were found at the end, $t_{(473)} = -2.24$, $p < .05$. Nevertheless, preliminary analyses conducted for both Wednesdays separately indicated the same pattern of results, thus mood levels were averaged across both testing days to increase reliability of mood measure.

Next, rm-ANOVA indicated non-significant effects of sex (boys and girls) and age (12, 13, 14, 15 and 16 years) on repeated measures of mood, $F_{(1,701)} = 0.22$, $p = 0.63$ and $F_{(1,701)} = 1.40$, $p = 0.23$, respectively. As was expected, differences in time in bed between chronotypes were statistically significant, M- (8:02±0:55), N- (7:51±0:56) and E-types (7:29±1:01), $F_{(2,571)} = 10.18$, $p < 0.001$, $\eta_p^2 = 0.034$. Finally, M-types (7:08±0:26) got up earlier in comparison to N- (7:20±0:26) and E-types (7:25±0:28), $F_{(2,573)} = 18.63$, $p < 0.001$, $\eta_p^2 = 0.061$, while E-types (23:56±0:59) went to bed later in comparison to N- (23:28±0:54) and M-types (23:05±0:51), $F_{(2,572)} = 28.60$, $p < 0.001$, $\eta_p^2 = 0.091$.

MESC values of 22/29, corresponding to 20/80th percentiles, were used to categorize M-, N- and E-types (179, 326 and 150 adolescents, respectively). These cut off values coincide with those obtained in previous Spanish adolescent samples using MESC: 21/29 (Díaz-Morales, Dávila, & Gutiérrez, 2007), 22/28 (Díaz-Morales, Delgado, Escribano, Collado, & Randler, 2012), 22/28 (Collado, Díaz-Morales, Escribano, Delgado & Randler, 2012), 21/30 (Muro, Gomà-i-Freixanet, & Adan, 2013), and 22/29 (Escribano & Díaz-Morales, 2014). The rm-ANOVA revealed statistically significant effects of chronotype ($F_{(2, 652)} = 12.70$; $p < 0.001$; $\eta_p^2 = .037$) and time-of-day ($F_{(2, 1304)} = 35.66$; $p < .001$; $\eta_p^2 = .052$; $\varepsilon = .95$), while their interaction was statistically non-significant ($F_{(4, 1304)} = 1.93$; $p = .107$; $\eta_p^2 = .006$; $\varepsilon = .95$). The effect of chronotype explained 3.7% of the variance in mood and was due to M-types showing better mood, than N-types and E-types, while N-types were happier than E-types ($p < .05$). The effect of time-of-day explained 5.2% of the variance in mood – at the beginning of the school day all pupils were the least happy, and their mood was increasing as the school day progressed (see figure 1).

Next, we rerun the above analyses controlling for time in bed, to test whether the effect of chronotype on mood was due to shorter time in bed related to eveningness. Thus, rm-ANCOVA was conducted, including time in bed as a covariate, which revealed, as in the previous analysis, statistically significant effects of chronotype ($F_{(2, 651)} = 13.407$; $p < 0.001$; $\eta_p^2 = .040$) and time-of-day ($F_{(2, 1302)} = 35.71$; $p < .001$; $\eta_p^2 = .052$; $\varepsilon = .95$), and non-significant interaction ($F_{(4, 1304)} = 2.05$; $p = .085$; $\eta_p^2 = .006$; $\varepsilon = .95$).

Discussion

Previous studies revealed that morningness is associated with better mood across the day among adults (Clark, Watson, & Leeka, 1989; Hasler, Allen, Sbarra, Bootzin, & Bernert, 2010; Jankowski & Ciarkowska, 2008). In this study, mood fluctuations among adolescents and during the school day were considered. The results indicated that at the beginning of the school day, all pupils, regardless of chronotype, reported the lowest mood, which increased progressively up to the end of a school day. As expected, M-types reported better mood than both N- and E-types, and the latter group reported the worst mood.

Recently, the effects of the morning school schedule on E-type adolescents have been increasingly acknowledged. Several researches suggested that the asynchrony between biological (evening preference) and social rhythms (early school schedule), also known as *social jetlag* (Wittman et al., 2006), influences E-types in a negative way, particularly affecting their school performance (e.g. Díaz-Morales & Escribano, 2013), sleep length (e.g. Collado et al., 2012), and health (e.g. Delgado, Díaz-Morales, Escribano, Collado & Randler, 2012). Such misalignment between circadian and social time may be a risk factor for developing depression (Levandovski et al., 2011), and a recent study suggested that a 30-minute delay in school start time can have a positive effect on alertness, mood and health (Owens, Belon & Moss, 2010). Also, daily fluctuations of attention indicated a progressive increase throughout the school day, when boys reached higher attention than girls and evening type boys reached higher attention than evening type girls (Escribano & Díaz-Morales, 2014). Daily fluctuations in cognitive and non-cognitive performance (i.e. mood), the so-called "school-rhythms", lie in exploring the most favourable time-of-day for learning, taking into account individual differences (Vollmer, Pötsch & Randler, 2013). Diurnal variation is a feature of mood in healthy participants, and compelling evidence suggests potential benefits of adjusting school schedule to circadian preference. Delaying high school start could be considered as a recommendation to schools for adolescents in order to improve their academic performance, subjective health and prevent future affective disorders (Sawyer et al., 2012). Our results showed, however, that probably sleep length per se is not a factor contributing to lowered mood in E-types. Thus, the positive effect of delaying school starts on mood could be not a resultant of prolonged sleep but of increased sleep quality due to sleep timing more in sync with adequate phase of circadian rhythm.

The fact that adolescents were tested when their *workday* has just started and also when it is almost over, might have influenced to some extent the progressive improvement of mood. Nevertheless, it is worth noting that chronotype effects appeared. Barber et al. (1998) found inverted U shape of diurnal patterns in PA and arousal, whereas stress levels were highest during early morning and decreased steadily throughout the rest of the day, to the lowest levels in the late evening (19:30-Sleep). In the present study, adolescents' mood showed a similar pattern considering the three testing times within a school day. Ideally, future research on adolescents' mood could be prolonged for the whole day (i.e. adolescents' activity also out of school). It might be possible that there is some abnormal increase of pleasantness in adolescents which prevents them from going to bed on time and could partly explain the robust shift toward eveningness in this developmental stage (Jankowski, 2014b).

Diurnal variation in subjective measures of mood has been related to depression (Wirz-Justice, 2008), whereas eveningness is considering to be a risk factor making more prone to depression (Gaspar-Barba et al. 2009). Common affective disorders often have their onset during the adolescence and the study of non-clinical samples could help to adopt prevention actions. For example, we know that regular bedtimes imposed by parents, on one hand foster morningness, but on the other, are associated with lower depressiveness in adolescents (Gangwisch et al., 2010). The imposition of curfew by parents is also associated with regular sleep habits in children and, in turn, may promote a healthier lifestyle (Gaina et al., 2006). Young patients with depression show a delayed sleep phase more consistently, being especially good candidates for interventions aimed at sleep phase advance (Robillard et al., 2013). Recently, it has been found that chronotypes differed in their daily patterns in both self-reported PA and associated brain regions. E-types displayed diurnal variations of PA characterized by phase delay and smaller amplitude compared with those of M-types with insomnia (Hasler et al., 2012).

In contrast to the retrospective methodology (Gorin & Stone, 2001), mood in the present study was reported three times a day, two consecutive Wednesdays. As adolescents reported their present mood, memory bias was minimized, increasing the reliability of the data. Moreover, since adolescents experience wider and quicker mood variations (Buchanan, Eccles, & Becker, 1992; Larson, Csikszentmihaly, & Graef, 1980), it seems desirable to test mood more than once a day. However, sleep timing was assessed only in reference to the night prior to testing session and using self-report, thus additional recording of objective sleep measures, like actigraphy could strengthen our results. Although we recorded time in bed for only two nights it seems enough to find the results similar to the previous ones – apparent sleep reduction during the week in adolescents, especially among E-types (Collado et al., 2012).

In conclusion, the result showing lowered mood in E-types throughout the school day might shed more light on the relationship between M-E, performance and health. Future studies should consider how mood fluctuations influence cognitive tasks and academic grades. Also, the quadratic waveform found in pleasantness, resembling typical diurnal pattern in PA under normal sleep-wake conditions, could be tested during the weekends, when adolescents are free to choose time-of-day for activities and delay their rise and bedtimes. During the school days a significant sleep debt is accumulated, especially in E-types, which is repaired on weekend by extending time in bed. This fact might contribute to the adolescents' mood in general, but sleep length was not the factor explaining differences in mood profile between chronotypes. As adolescents overall are shifted toward eveningness, even greater lateness in E-type adolescents seems not to be the factor lowering their mood compared to adolescents with earlier chronotypes. In this context, mood fluctuation during the weekend could be considered in order to analyze how different alignment between homeostatic and circadian influences on mood (Murray, 2007). Thus, explanation of lowered mood in E-types needs further investigation – recent study indicated that eveningness might be a compound of broader temperamental profile predisposing to lowered mood (Jankowski, 2014a).

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Conflict of Interest

The authors declared no conflict of interests.

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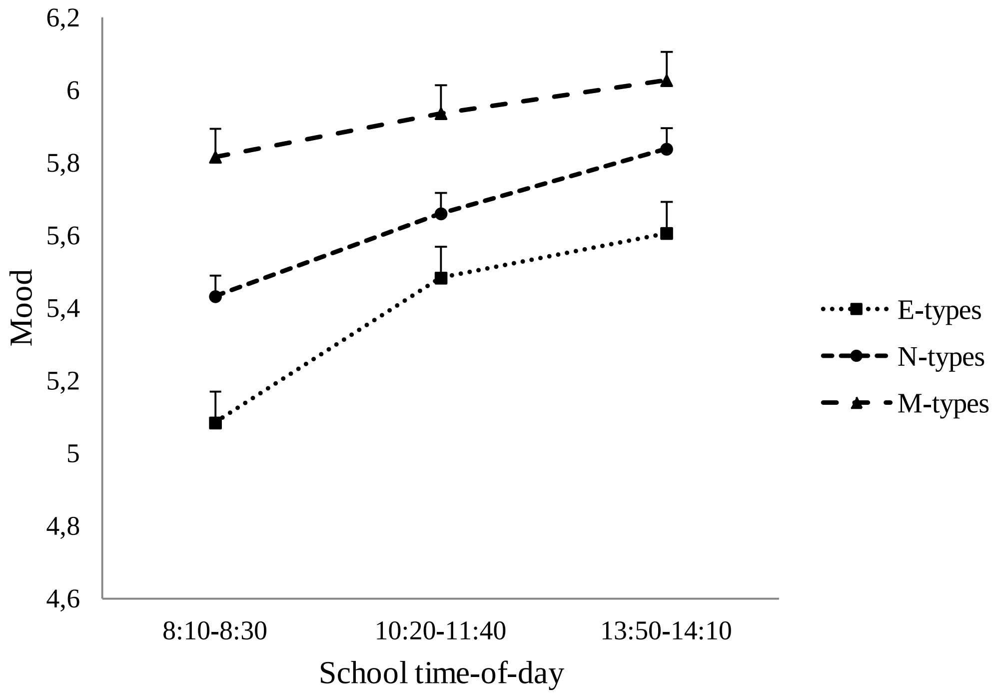

Figure 1: Mood means according school time-of-day and chronotypes (covariate: time in bed).