Insomnia symptoms mediate the association between eveningness and suicidal ideation, defeat, entrapment, and psychological distress in students

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Insomnia symptoms mediate the association between eveningness and suicidal ideation, defeat, entrapment, and psychological distress in students

Daniel R. R. Bradford, Stephanie M. Biello, and Kirsten Russell

School of Psychology, University of Glasgow, Glasgow, UK

ABSTRACT

Chronotype describes a person’s general preference for mornings, evenings, or neither. It is typically conceptualized as a continuous unidimensional spectrum from morningness to eveningness. Eveningness is associated with poorer outcomes across a myriad of physical and mental health outcomes. This preference for later sleep and wake times is associated with increased risk of depression, anxiety, and suicidal ideation in both clinical and community samples. However, the mechanisms underlying the negative consequences of this preference for evenings are not fully understood. Previous research has found that sleep disturbances may act as a mediator of this relationship. The present study aimed to explore the associations between chronotype and affective outcomes in a sample of students. Additionally, it aimed to investigate the potential role of insomnia as a mediator within these relationships. Participants (n = 190) completed an anonymous self-report survey of validated measures online which assessed chronotype, insomnia symptoms, and a range of affective outcomes (defeat, entrapment, suicide risk, stress, and depressive and anxious symptomology). Eveningness was associated with more severe or frequent experiences of these outcomes, with participants that demonstrated a preference for eveningness more likely to report poorer affective functioning and increased psychological distress. Mediation analysis found the relationship between chronotype and these outcome measures was completely or partially mediated by insomnia symptom severity measured by the validated Sleep Condition Indicator insomnia scale. Taken together, these findings add further evidence for the negative consequences of increased eveningness. Additionally, our results show that chronotype and sleep disturbances should be considered when assessing mental well-being. Implementing appropriate sleep-related behavior change or schedule alterations can offer a tool for mitigation or prevention of psychological distress in students that report a preference for later sleep and wake times.

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CONTACT

Daniel R. R. Bradford
0607646b@student.gla.ac.uk
School of Psychology, University of Glasgow, Glasgow, UK

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Chronotype describes a person’s general preference for mornings (M-types), evenings (E-types) or neither (N-types). It is typically conceptualized as a continuous unidimensional spectrum from morningness to eveningness with a broadly normal distribution (Gaspar-Barba et al. 2009; Roenneberg et al. 2004, 2003). Chronotype is a product of both genetics and environment (Facer-Childs et al. 2019; Hu et al. 2016; Lane et al. 2016), and is expressed as diurnal variations in characteristics such as energy levels, affect, and both cognitive and physical performance (Facer-Childs et al. 2018; Goldstein et al. 2007; Merrow et al. 2005; Miller et al. 2015).

Eveningness is associated with poorer outcomes for a wide range of major health issues. This includes all-cause mortality, as well as specific conditions such as arterial hypertension and type 2 diabetes (Au and Reece 2017; Coleman and Cain 2019; Knutson and von Schantz 2018; Partonen 2015; Selvi et al. 2012; Wong et al. 2015). Considering mental health and mood, eveningness is associated with higher odds of lifetime depression, as well as increased depression symptom severity, in both clinical and non-clinical samples (Antypa et al. 2016; Chan et al. 2014; Druyen et al. 2020; Hertenstein et al. 2019; Norbury 2019; Park et al. 2018; Selvi et al. 2012). Hidalgo et al. (2009) found E-types were five times more likely to have moderate–intense depressive symptoms than N-types in a nonclinical sample of adults. In clinical samples of people with depressive disorders, differences in depressive symptom severity due to chronotype tend to be even more pronounced (Gaspar-Barba et al. 2009; Selvi et al. 2010). E-types have also been found to have poorer rates of remission from major depressive disorder (Chan et al. 2014). Other mood- and affect-related outcomes have also been associated with chronotype. Lester (2015) found eveningness to be associated with increased perceptions of defeat and...
mediated the association between eveningness and negative affective outcomes in adolescents and young adults.

Chronotype is a trait appearing early in life, with detectable chronotype-related differences in affect appearing in children and infants (Chiu et al. 2017; Werner et al. 2009). Significant intranidividual variation in chronotype occurs over the lifespan (Roenneberg et al. 2004), with a delay to circadian rhythms (i.e. a shift toward eveningness) typically occurring in adolescence. As such, the consequences of the mismatch between societal and individual rhythms for E-types may be amplified during later adolescence and early adulthood. The negative effect of this physiological delay on sleep quality is further worsened by young adults viewing sleep as low priority (Barone 2017). This combined change in chronotype and sleep behaviors has significant negative effects on daily functioning and psychological well-being via their effects on sleep. Bakotic et al. (2017) found increased eveningness was associated with depressive mood in a sample of undergraduate students, and sleep quality mediated the link between chronotype and depressive mood. Eveningness has also been associated with more severe suicide-related outcomes (Bahk et al. 2014; Matsumoto et al. 2016; Rumble et al. 2018; Selvi et al. 2011, 2010). Work by Lester (2015) in a non-clinical sample of 194 undergraduate students also found eveningness to be associated with increased perceptions of defeat (r = −.32) and entrapment (r = −.26), both of which are strongly implicated in suicidal behavior (O’Connor 2011; O’Connor and Kirtley 2018; Williams 2014; Winsper and Tang 2014). However, Lester (2015) did not find an association between chronotype and past suicidal ideation or suicide attempts. Further research into the eveningness—affect relationship is of particular importance in students given the high cost of mental ill health in young adulthood (Kessler et al. 2005; McGorry et al. 2019).

Although sleep disturbances have typically been considered symptoms of psychological distress, this relationship is bidirectional. Difficulties with sleep have been shown to better predict subsequent suicidal ideation than depression or hopelessness in young adults (Ribeiro et al. 2012). Poor baseline sleep quality in adolescents has also been associated with higher rates of generalized anxiety disorder at follow-up (Shanahan et al. 2014). Meta-analyses of longitudinal studies of insomnia and subsequent psychopathologies also provide evidence for sleep disturbance as a causal factor of psychological distress (Baglioni et al. 2011; Hertenstein et al. 2019). Interventions to improve sleep also support the bidirectionality between sleep and affect. Cognitive behavioral therapy for insomnia has been shown to significantly reduce the severity of depression and suicidal ideation (Manber et al. 2011; Trockel et al. 2015). Edwards et al. (2015) also demonstrated that improving

entrapment (negative feelings arising from an individual’s experience of a “failed struggle” and the perception that the defeat-generating situation cannot be resolved nor escaped; Gilbert and Allan 1998) in a non-clinical sample of 194 undergraduate students. Additionally, E-types are at increased risk of suicidal ideation and behaviors (Bahk et al. 2014; Gau et al. 2007; Rumble et al. 2018; Sheaves et al. 2016). They are also more likely to attempt to die by suicide in a violent manner (Selvi et al. 2011). These results taken together indicate that a person’s chronotype may well play a significant role in mental health outcomes.

Eveningness is also associated with poorer sleep (Bakotic et al. 2017; Chan et al. 2014; Chiu et al. 2017). E-types struggle to adapt to typical societal rhythms related to work or school start times (Takahashi et al. 2011; Wittmann et al. 2006). They are also more likely to experience social jet-lag and associated chronic sleep deprivation (Harasztzi et al. 2014; Roenneberg et al. 2012). Other examples of sleep disturbances that have been associated with eveningness and have consequences for waking life include increased risk for experiencing nightmares (Selvi et al. 2012) and greater sleep onset latencies (SOL; Barclay et al. 2010). Specifically, this increase in SOL has been linked to a preference for activity in the evenings (Randler et al. 2017) and later bedtimes in E-types (Crowley et al. 2007), in keeping with the increased risk of social jetlag in E-types. Increased SOL will therefore lead to chronic sleep deprivation if a person is obligated to rise at a relatively early time imposed by work or school schedules. This misalignment between endogenous and exogenous circadian rhythms typically prevents E-types attaining adequate quantities of sleep. Sleep deprivation is associated with depression (Conklin et al. 2018) and has also been found to have a causal relationship with increased levels of next-day suicidal ideation (Littlewood et al. 2017). This apparent effect of reduced total sleep time on affect is also compatible with the increased rates of depressogenic cognitions and rumination in E-types (Antypa et al. 2017). Although chronotype is partially dictated by genetic factors (Toomey et al. 2015; Young and Kay 2001) which may also influence affective traits, it is reasonable to assume that poor sleep mediates the chronotype—affect relationship. An example of evidence for this mediated causal relationship between poor sleep and negative affective outcomes is provided by Chiu et al. (2017). Their study found that sleep quality mediated the relationship between chronotype and parental assessment of childhood depression. In sum, chronic sleep deprivation can be caused by a misalignment of social and biological circadian rhythms. In turn, this poor sleep quality appears to
sleep quality led to a significant reduction in the number of people with sleep apnea meeting the clinical cutoff for depression as measured by the PHQ-9 Kroenke et al. 2001, with this proportion reducing from 74.6% to just 3.9% following intervention. Similar results have been demonstrated by others (Balcan et al. 2019; Relia et al. 2018). Since eveningness is associated with reduced sleep quality and duration, we propose that insomnia symptoms can partially explain the prevalence of poorer affective outcomes in E-types, rather than eveningness having an intrinsic detrimental effect on well-being.

The present study aimed to explore the associations between chronotype and selected affective outcomes in a sample of students aged 18–24. An additional aim was to explore the role of insomnia as a mediating factor in the chronotype–affect relationship.

**Hypotheses**

H1: Higher morningness will be associated with positive outcomes in measures of wellbeing and mental health.

H2: Insomnia will mediate the relationship between chronotype and affective outcomes where significant associations exist.

**Method**

**Participants and procedure**

The study was designed in line with British Psychological Society guidelines and met the requirements laid out by Portaluppi et al. (2010) for chronobiology research on human participants. Ethical approval was granted by the University of Glasgow College of Science and Engineering Ethics Committee. Participants were recruited via social media, online forums, and university participant pool mailing lists. The inclusion criterion was to be aged 18–24 y old and enrolled as a full-time student. Participants completed an online survey during two data collection periods in different seasons (May–July 2019 and January–February 2020; N.B. data collection ended prior to COVID-19-related restrictions were placed on people’s behaviors). The survey was described as about sleep and its links to mood and/or mental health. Participants were provided with a link to a survey hosted on the University of Glasgow Experimentum platform (https://exp.psy.gla.ac.uk) which complies with the General Data Protection Regulation (EU) 2016/679. An information page with warnings about the sensitive nature of the topic was presented alongside contact details for mental health support services. After reading this page and providing consent, participants were asked to complete the measures described below. A debriefing page thanked participants and restated the contact details for support services.

**Measures**

**Demographics**

Participants reported their age in years and their gender (male, female, or other).

**Chronotype**

The reduced Morningness–Eveningness Questionnaire (rMEQ; Adan and Almirall 1991; Loureiro and Garcia-Marques 2015) is a five-item self-report measure of a person’s chronotype. Items include preferred awakening time, preferred time of day, and self-appraisal as a morning/neither/evening (M-, N-, E-) type. Scores can range from 4 to 25 with higher scores indicating increased morningness. The rMEQ prescribes five clusters of chronotype: definite M-types (22–25), moderate M-types (18–21), N-type (12–17), moderate E-types (8–11), and definite E-types (4–7). In the present study, definite and moderate types were grouped together for categorical analysis. This is suggested by the authors of the scale for use during psychological research (Adan and Almirall 1991) and has been done in previous studies using this scale (e.g. Akram et al. 2018; Hidalgo et al. 2009). The internal consistency of the rMEQ (and all other measures listed below) was assessed by Cronbach’s (1951) \( \alpha \) and McDonald’s (1999) \( \omega_i \) statistics: \( \alpha = .58, \omega_i = .68 \).

**Insomnia**

The Sleep Condition Indicator (SCI; Espie et al. 2014) is an 8-item measure of self-reported insomnia symptoms over the previous month. Each item is scored from 0 to 4, with higher scores typically indicating better sleep quality. However, SCI scores were reversed to allow for more intuitive interpretation of results in the present study. It has good psychometric properties for detecting DSM-5 insomnia disorder, with a score of 17 or more (following reversal of scoring) indicating probable insomnia disorder and clinical levels of dysfunction (Espie et al. 2014; Wong et al. 2017). The internal consistency in the present sample was \( \alpha = .88, \omega_i = .92 \).

**Depression, anxiety, and stress**

The 21-item short form of the Depression, Anxiety, and Stress Scales (DASS-21; Henry and Crawford 2005; Lovibond and Lovibond 1995) is a composite measure.
of depression, anxiety, and stress symptoms. Participants respond to seven questions for each of the three subscales using a 4-point Likert-type scale from 0 ("Did not apply to me at all") to 3 ("Applied to me very much or most of the time"). These subscores are doubled to make comparable with the original 42-item version of the scale and summed to give a total DASS-21 score. Potential scores for each subscale range from 0 to 42 and total scores from 0 to 126. Higher subscale scores, respectively, indicate more frequent or severe experiences of depression, anxiety, and stress symptoms. Internal consistency for overall DASS-21 scale in the present sample was \( \alpha = .94, \omega_t = .95 \).

Internal consistency for subscales: \( \alpha_{\text{depression}} = .92, \omega_t = .95 \), \( \alpha_{\text{anxiety}} = .86, \omega_t = .90 \), \( \alpha_{\text{stress}} = .86, \omega_t = .90 \).

Deaf

The Defeat Scale (Gilbert and Allan 1998) comprises 16 mixed-valence statements related to subjective experiences of feeling defeated, humiliated, or having failed to achieve goals. Participants respond to statements such as "I feel that I am one of life’s losers" using a 5-point Likert-type scale from "I never feel like this" (0) to "I always feel like this" (4). Potential scores range from 0 to 64, with higher scores indicating increased perceptions of defeat. The internal consistency in the present sample was \( \alpha = .95, \omega_t = .96 \).

Entrapment

The Entrapment Scale (Gilbert and Allan 1998) comprises 16 statements related to subjective experiences of being unable to escape from or resolve situations in which an individual feels defeated or to have failed. Subscales measure feelings of entrapment triggered by internal (six items; e.g. "I would like to escape from my thoughts and feelings") and external causes (10 items; e.g. "I feel trapped by other people") entrapment. Responses are given using a 5-point Likert-type scale from "Not at all like me" (0) to "Extremely like me" (4). Potential scores range from 0 to 64, with higher scores indicating increased perceptions of entrapment. The internal consistency in the present sample was \( \alpha = .96, \omega_t = .97 \). The internal consistency for the internal entrapment subscale was \( \alpha = .93, \omega_t = .95 \). The internal consistency for the external entrapment subscale was \( \alpha = .93, \omega_t = .95 \).

Suicidal ideation

The Suicidal Ideation Attributes scale (SIDAS; van Spijker et al. 2014) is a 5-item measure of suicidal ideation severity over the previous month which uses an 11-point Likert-type response scale. Each item asks about a different aspect of suicidal ideation, including the frequency of suicidal thoughts, their impact on daily functioning, and how much control a person has over suicidal thoughts. One item also asks how close a person has come to making a suicide attempt with the option to indicate they have made an attempt. Potential scores range from 0 to 50 with higher scores, indicating increased severity of suicidal ideation. A cutoff score of 20 or greater is suggested to indicate a high suicide risk. Internal consistency for the SIDAS was \( \alpha = .90, \omega_t = .92 \).

Data analysis

Responses were obtained from 191 participants who responded to all measures. Data were screened for partial responses. Individual mean substitution was applied per measure if a participant missed a single item on any or all of the DASS-21 subscales, a single item on the SCI, or up to two items on the Defeat and/or Entrapment Scales. Listwise deletion was applied if more items were missed; one participant’s responses were removed for missing two items on the DASS stress scale. Overall data missingness in this sample was 0.15% (19 items of a possible 12,540).

Data were analyzed using RStudio version 1.4.634 (RStudio Team 2020) built on R version 3.6.3 (R Core Team 2020). The normality of the data was assessed by Shapiro–Wilk tests and all measures were found to deviate from normality. Therefore, nonparametric statistical methods were used throughout the analysis. \( H_1 \) was assessed using bivariate Kendall’s \( \tau_b \) rank correlations and Mann–Whitney U-tests. \( H_2 \) was tested using serial multiple-mediation analysis. Note that the use of mediation analysis on cross-sectional data must be justified based on existing theory (Fairchild and McDaniel 2017; Shrout and Bolger 2002): The role of insomnia as a mediating factor between sleep disturbance and affective outcomes is justified by studies such as those by Chiu et al. (2017) and Simor et al. (2015), as well as other literature discussed above. Mediation analysis was carried out using the lavaan R package (v0.6–3) and nonparametric bootstrap resampling techniques (50,000 bootstrap iterations; Rosseel 2012; Shrout and Bolger 2002).

Results

The sample comprised 34 M-types (17.9%), 96 N-types (50.5%), and 60 E-types (31.6%). Sixty-seven participants met the cutoff score for probable insomnia disorder (35.3%). Thirty-four participants (17.9%) met the cutoff score for high risk in the suicidal ideation measure. Of these 34, 79.4% also met the cutoff for probable clinical insomnia. Self-reported chronotype (Q5 in rMEQ) was strongly associated with the total rMEQ score (Kendall’s \( \tau_b = .79; 95\% \ CI 0.73–0.84; p < .001 \).
Descriptive statistics are presented in Table 1 with bivariate association coefficients.

**Groupwise comparisons**

Kruskal–Wallis tests indicated significant differences between chronotype groups on all outcome measures but showed no difference in age. Subsequent Mann–Whitney U-tests showed no significant differences between M- and N-types except for chronotype. However, E-types had significantly poorer scores for all outcomes compared to both M- or N-types (see Tables 2 and 3). These results support H1 and show that even- ingness is associated with more severe psychological distress and poorer sleep.

**Mediation analysis**

Mediation analysis with chronotype as the independent variable and insomnia as the mediator showed this indirect pathway to be significant for all outcome variables (see Figure 1 and Table 4). For both stress and suicidal ideation, the inclusion of insomnia as a mediator rendered the direct effect of chronotype on these outcomes insignificant. This provides support for H2 and suggests that the poorer affective outcomes associated with eveningness may be at least partially explained by the poor sleep experienced by E-types.

**Discussion**

This study examined the relationship between chronotype and affective outcomes, as well as the mediating role of insomnia symptoms in a sample of students. Our analyses provide support for H1: increased eveningness was negatively associated with all outcome measures with the exception of stress. Additionally, results of the mediation analyses provide partial support for H2: insomnia partially mediated significant proportions of the total effect of chronotype on affective outcomes and completely mediated the relationships between chronotype and stress, as well as chronotype and suicidal ideation. These results combine to suggest that E-types are at an increased risk of poorer mental health outcomes, but this risk may be attributable to the negative effects of poor sleep quality.

The results and effect sizes found in the present study are in keeping with existing literature on the chronotype–affect relationship (e.g. Bakotic et al. 2017; Simor et al. 2015; You et al. 2020). The poorer affective outcomes of E-types in the present sample reflect the results of Tan et al. (2020) and their sample of undergraduates where E-types scored lower on a measure of happiness than N- and M-types. Similarly, the results of our mediation analyses that of Chiu et al. (2017) where sleep quality mediated the chronotype–depression relationship. The role of insomnia as a mediating factor between chronotype and negative emotionality found by Simor et al. (2015) in their sample of adults (mean age = 25.3 ± 5.8y) is also supported by the present study. However, our results show that the mediating role of sleep quality in the relationship between chronotype and depression/stress appears to extend to a broader range of affective outcomes. These outcomes include perceived defeat and entrapment, as well as suicidal ideation.

Our findings – combined with the broader literature – suggest that an evening chronotype is not necessarily an intrinsic source of negative affect. The poorer outcomes most often associated with higher eveningness appear to be partially consequences of poor sleep quality related to this preference for evenings. This poor sleep is a result of misalignment of preferred daily rhythms and external constraints, such as school and work schedules. This is in keeping with findings such as those of Dimitrov et al. (2018) where depressive mood was associated with sleep midpoint on work/school days but not on days where participants had more control over their schedule (i.e. weekends and holidays). The implications of these findings are that the negative outcomes associated with being an E-type are malleable. Future studies investigating the associations between fixed/flexible schedules and chronotype, or the interaction of chronotype and potential protective factors against negative affect, would be informative. For example, E-types high in trait extraversion can benefit from engaging in social occasions which typically take place later in the day, a time when they feel their best (Drezno et al. 2019). By aligning internal and external daily rhythms, the link between eveningness and negative mental health outcomes can be mitigated.

Alternatively, if the alignment of internal and external rhythms cannot be achieved, then we can look to behavioral change for improvement in affective outcomes. The abundance of research into the treatment of insomnia and delayed sleep-wake phase disorder has produced a number of behavior-modifying approaches including clinically effective cognitive-behavioral therapies for insomnia (CBTI) interventions (Trauer et al. 2015; van der Zweerde et al. 2019). However, chronotype may act as a moderator on the effectiveness of CBTI. Bei et al. (2015) examined the effect of a 6-week group CBTI on insomnia intervention in an outpatient clinical sample of people experiencing insomnia. Their results showed significantly smaller improvement in depressive mood in E-types than in N-types, with
Table 1. Bivariate associations (Kendall’s τ, with 95% confidence intervals in parentheses) and descriptive statistics. Mdn = median, IQR = interquartile range, M = mean, S = standard deviation.

|---|--------|-------------|---------------|------------|-----------|-----------|-----------|---------------------|---------|

N-types in turn showing significantly smaller improvement than M-types. In contrast, an internet-based CBTI intervention study using midlife adults by Lien et al. (2019) found similar improvements in depressive mood and insomnia severity in both M- and E-types. Further exploration of the interaction between CBTI-effectiveness and chronotype is required. Combined with the knowledge that lifelong health-behavior change can be effectively implemented by altering automatic and habitual behaviors during emerging adulthood (e.g. Cleo et al. 2017), E-types may benefit more from approaches focused on maintaining habitual good sleep hygiene routines if CBTI is less effective in this group. Although chronotype is partially defined by genetics, it is possible to modify through behavioral interventions. Modifying sleep–wake behaviors can thus mitigate some of the consequences of being an E-type bound to societal schedules related to a conventional 9–5 work day. Facerc-Childs et al. (2019) carried out a randomized control trial of advancing sleep–wake timings by approximately 2h in a sample of E-types. Compared to the control group (also E-types) that received no intervention, the treatment group experienced significant improvements in measures of depression and cognitive performance. The intervention was relatively unintrusive, mainly focusing on the timing of meals, exercise, and light exposure. Additionally, even less intensive interventions based on sleep-related psychoeducation may bring about similar changes in sleep behaviors of young adults and adolescents high in eveningness (Harvey et al. 2018). Chung et al. (2019) found that higher eveningness was associated with increased bedtime procrastination (e.g. TV watching) in young adults, highlighting a potential daily opportunity to improve sleep quality through habit formation or modification. Whilst these initial findings (obtained within a real-world setting) are promising, further replication is required given the complex relationship between light therapy, sleep timing, and severity of mood state in individuals with an evening chronotype. However, in sum, there are multiple existing methods for improving sleep quality which can mitigate the suggested negative effect of eveningness on affective outcomes.

Chronotype in the present study was measured using the short form of the Morningness–Eveningness questionnaire. This measure asks about a person’s activity preferences on free days (i.e. those where sleep–wake times are not dictated by external factors, such as work or school). A more in-depth analysis of the misalignment between externally dictated sleep–wake/schedule requirements and personal preferences would provide more insight into the role of chronotype and sleep disturbance on affective outcomes.
Table 2. Two-tailed Mann–Whitney U-test statistics for M-types v. E-types. Mdn = median, IQR = interquartile range, U = Mann–Whitney U-test statistic, $r$ = effect size ($|Z|/\sqrt{N}$; Field et al. 2012, 665). Significance levels of between-group differences: * $p < .05$, ** $p < .01$, *** $p < .001$. Holm-Bonferroni corrected for 30 tests (3 pairings of chronotype, with 10 variables each) significance levels: † $p < .05$, †† $p < .01$, NS not significant. If no daggers, then no change to significance level following correction. No significant difference in age between groups.

<table>
<thead>
<tr>
<th></th>
<th>M-types ($N = 34$)</th>
<th>E-types ($N = 60$)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td>Mdn</td>
<td>IQR</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insomnia***</td>
<td>20</td>
<td>20–23</td>
</tr>
<tr>
<td>Chronotype***</td>
<td>11</td>
<td>5–15.5</td>
</tr>
<tr>
<td>DASS-21***</td>
<td>19</td>
<td>18–20</td>
</tr>
<tr>
<td>Depression***</td>
<td>21</td>
<td>14–52</td>
</tr>
<tr>
<td>Anxiety**NS</td>
<td>6</td>
<td>2–15.5</td>
</tr>
<tr>
<td>Stress**NS</td>
<td>12</td>
<td>8–18</td>
</tr>
<tr>
<td>Defeat**NS</td>
<td>18</td>
<td>10.25–26.75</td>
</tr>
<tr>
<td>Entrapment***</td>
<td>7.5</td>
<td>1.25–2375</td>
</tr>
<tr>
<td>Suicidal Ideation**NS</td>
<td>2.5</td>
<td>0–14.25</td>
</tr>
</tbody>
</table>

Table 3. Two-tailed Mann–Whitney U-test statistics for N-types v. E-types. Mdn = median, IQR = interquartile range, U = Mann–Whitney U-test statistic, $r$ = effect size ($|Z|/\sqrt{N}$; Field et al. 2012, 665). Significance levels of between-group differences: * $p < .05$, ** $p < .01$, *** $p < .001$. Holm-Bonferroni corrected for 30 tests (3 pairings of chronotype, with 10 variables each) significance levels: † $p < .05$, †† $p < .01$, NS not significant. If no daggers, then no change to the significance level following correction. No significant difference in age between groups.

<table>
<thead>
<tr>
<th></th>
<th>N-types ($N = 96$)</th>
<th>E-types ($N = 60$)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td>Mdn</td>
<td>IQR</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insomnia***</td>
<td>20.5</td>
<td>19–23</td>
</tr>
<tr>
<td>Chronotype***</td>
<td>10.5</td>
<td>5–16</td>
</tr>
<tr>
<td>DASS-21***</td>
<td>14</td>
<td>13–15.5</td>
</tr>
<tr>
<td>Depression***</td>
<td>28</td>
<td>15.5–52.5</td>
</tr>
<tr>
<td>Anxiety**NS</td>
<td>8</td>
<td>2–18</td>
</tr>
<tr>
<td>Stress**NS</td>
<td>7</td>
<td>2–14</td>
</tr>
<tr>
<td>Defeat**NS</td>
<td>13</td>
<td>7.5–20</td>
</tr>
<tr>
<td>Entrapment***</td>
<td>16.5</td>
<td>11–27.25</td>
</tr>
<tr>
<td>Suicidal Ideation**NS</td>
<td>2</td>
<td>0–9</td>
</tr>
</tbody>
</table>

Figure 1. Mediation model for chronotype and outcomes via insomnia.

Comparison of school/work days with free days could be made by using an alternative measure of circadian preference, such as the Munich Chronotype Questionnaire (Roenneberg et al. 2003). Analysis of the differences between free and constrained days could explore potential dose–response relationship in terms of rhythm misalignment. This would build on work by You et al. (2020) that found that the amplitude of variation in
Table 4. Bootstrapped point estimates and 95% bias-corrected confidence intervals (in parentheses) for direct and indirect effects as represented in Figure 1. Point estimates and 95% confidence intervals of indirect and direct pathways resulting from multiple serial mediation analysis. Generated using 50,000 bootstrapping iterations. Italics indicate insignificant relations (i.e. where confidence intervals include zero). \( P_m \) = proportion mediated as a percentage of total effect size using point estimates \( = a \times b/(c' + a \times b) \). Ratio = ratio of scale-normalized change in outcome variable to scale-normalized change in chronotype (e.g. a ratio value of \(-0.39\) means that a 10% increase in chronotype score is associated with a 3.9% decrease in outcome score).

<table>
<thead>
<tr>
<th>Outcome</th>
<th>a</th>
<th>b</th>
<th>a \times b</th>
<th>c’</th>
<th>a \times b \times c’</th>
<th>( P_m ) (%)</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>DASS-21</td>
<td>-0.62</td>
<td>-0.90</td>
<td>-0.33</td>
<td>2.13 (1.74, 2.49)</td>
<td>-1.32 (−1.98, −0.72)</td>
<td>-1.03 (−1.86, −0.21)</td>
<td>-2.34 (−3.41, −1.30)</td>
</tr>
<tr>
<td>Depression</td>
<td>-0.62</td>
<td>-0.90</td>
<td>-0.33</td>
<td>0.73 (0.55, 0.90)</td>
<td>-0.45 (−0.71, −0.24)</td>
<td>-0.50 (−0.86, −0.13)</td>
<td>-0.95 (−1.36, −0.52)</td>
</tr>
<tr>
<td>Anxiety</td>
<td>-0.62</td>
<td>-0.90</td>
<td>-0.33</td>
<td>0.66 (0.51, 0.82)</td>
<td>-0.41 (−0.63, −0.23)</td>
<td>-0.37 (−0.69, −0.06)</td>
<td>-0.78 (−1.16, −0.41)</td>
</tr>
<tr>
<td>Stress</td>
<td>-0.62</td>
<td>-0.90</td>
<td>-0.33</td>
<td>0.74 (0.58, 0.89)</td>
<td>-0.46 (−0.70, −0.25)</td>
<td>-0.16 (−0.47, 0.15)</td>
<td>-0.46 (−0.70, −0.25)</td>
</tr>
<tr>
<td>Defeat</td>
<td>-0.62</td>
<td>-0.90</td>
<td>-0.33</td>
<td>1.00 (0.81, 1.18)</td>
<td>-0.62 (−0.97, −0.33)</td>
<td>-0.48 (−0.91, −0.05)</td>
<td>-1.10 (−1.64, −0.57)</td>
</tr>
<tr>
<td>Entrapment</td>
<td>-0.62</td>
<td>-0.90</td>
<td>-0.33</td>
<td>0.90 (0.66, 1.11)</td>
<td>-0.56 (−0.89, −0.30)</td>
<td>-0.98 (−1.52, −0.46)</td>
<td>-1.54 (−2.15, −0.93)</td>
</tr>
<tr>
<td>Suicidal Ideation</td>
<td>-0.62</td>
<td>-0.90</td>
<td>-0.33</td>
<td>0.75 (0.54, 0.96)</td>
<td>-0.47 (−0.76, −0.24)</td>
<td>-0.10 (−0.51, 0.30)</td>
<td>-0.57 (−1.04, −0.09)</td>
</tr>
</tbody>
</table>

energy and motivation across the course of the day was a much stronger correlate with stress than chronotype directly (\( r = .39 \) and \( r = .14 \), respectively). Again, a more detailed exploration of the potentially multifactorial nature of chronotype (Konttinen et al. 2014; Preckel et al. 2019; Putilov 2017; Putilov et al. 2015, 2019) may generate more interesting and useful results for how to handle negative affective consequences of circadian rhythm misalignment. As highlighted in a review by Taylor and Hasler (2018), future studies of chronotype will ideally include more prospective research and increased use of objective sleep and wake measurements.

A strength of this study is the use of validated measures throughout. The use of validated measures for sleep quality and suicidal ideation addresses the specific criticism of sleep-related suicide research made by Tubbs et al. (2019) which was that too often only single-item measures are used for these constructs. Another strength of this study is the broadening of outcomes to include more than depression, which is commonly the only outcome assessed in similar studies related to chronotype. If circadian/social rhythm misalignment leads to negative effects on a variety of mental health outcomes (as opposed to depression or mood alone) then correction of this misalignment offers a simple and practical transdiagnostic intervention. Further, if the causative role of this misalignment – and its effects on sleep – can be established by prospective studies, then the underlying pathways can be better understood.

This cross-sectional study cannot inform the direction of potential causal pathways between eveningness and negative affective outcomes. Whilst prospective research does point to the possibility that evening chronotype may precede depression (Haraden et al. 2017; Van Den Berg et al. 2018), more longitudinal work is needed to determine the directionality of this relationship. These studies have the potential to provide valuable insights into whether (i) eveningness predisposes individuals to an increased risk of depression, (ii) depressive symptomology influences individuals chronotype or (iii) the relationship between depression and chronotype is bi-directional (Au and Reece 2017; Kivelä et al. 2018). Particular caution around presumptions of this directionality must be exercised due to the complex and idiopathic relationships between sleep–wakefulness and affective outcomes, such as depressive symptom severity. However, research on insomnia’s effect on subsequent mood and mental health outcomes (e.g. Bernert et al. 2017; Littlewood et al. 2019) combined with research on chronotype’s causal association with poor sleep quality points toward a directional chronotype–insomnia–affect pathway (Bakotic et al. 2017; Facer-Childs et al. 2019; Konjarski et al. 2018). This putative causal relationship is supported by the results of the present study. Additional prospective research is needed to better establish this pathway. Preferably this would include objective sleep–wake behavior tracking along with ecological momentary assessment studies that measure affect and circadian-informed variables (e.g. energy levels, motivation, sleepiness) coincidentally. Additionally, as insomnia provides only partial mediation of the chronotype–affect relationship, other explanatory factors must also be investigated to better resolve the association of eveningness with poorer mental health outcomes.

Conclusion

This study has shown that eveningness is associated with poorer affective outcomes in young adult students. It has also demonstrated the potential role of insomnia as a mediating factor within this relationship. Taken together, these findings have the potential to improve the assessment and prevention of psychological distress in young adults who report a preference for later sleep and wake times. Our results suggest that interventions that target insomnia and sleep-related behavior change have the potential to mitigate the effect of poor sleep quality related to misalignment of internal and external rhythms in this population. Ultimately, these interventions may protect against or mili-
gate a range of negative affective outcomes in young adult students.

Declaration of Interest Statement

The authors have no conflicts of interest to report.

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ORCID

Daniel R. R. Bradford http://orcid.org/0000-0002-7523-8764
Stephany M. Biello http://orcid.org/0000-0002-3497-5215
Kirsten Russell http://orcid.org/0000-0002-7034-2749

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