The association between chronotype, internalizing symptoms and depressive disorder during adolescence: A prospective, multi-wave longitudinal study

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Abstract

Evening chronotype (i.e., preferring to go to sleep and wake later in the day than peers) has consistently been shown to be associated with mental health symptoms and disorders. Adolescence is a time of significant developmental changes in chronotype, and a key phase of life for the onset of mental disorders, especially depressive disorders. Although some research suggests an association between greater Eveningness preference and poor mental health in adolescence, the literature has primarily been cross-sectional and/or retrospective. The current study examined the prospective relationships between chronotype and internalizing symptoms and Major Depressive Disorder (MDD) over four waves of assessment during adolescence. Eveningness was prospectively associated with increasing levels of internalizing problems, especially anxiety and depressive symptoms, over multiple waves. Furthermore, the hypothesis that Eveningness would be prospectively associated with greater risk of developing MDD over a 6 year follow up period was also supported. These results suggest that Eveningness has prognostic value as a potential warning sign for emotional dysfunction and mental disorder during adolescence.

Adolescence is a vulnerable psychological period during which multiple social, cognitive and emotional transitions occur and mental health problems, that can have an influence across the lifespan, often begin (Birmaher & Heydl, 2001; Hankin et al., 1998). In particular, anxious and depressive symptoms are common in adolescents and young adults (Cole et al., 1998; Kovaks et al. 1989;1996; Rohde, Lewinsohn & Seely, 1991), and depressive disorders in particular show a marked increase in incidence during this period of life, with 1 in 5 young people developing a case level disorder (Birmhauer & Heydl, 2001).

Depressive disorders have also been consistently linked to abnormalities in the daily rhythms associated with biological and psychological functions (McClung, 2007; Wirz-Justice, 2008). For example, disrupted sleep and waking behavior, diurnal mood variations, and endocrine/metabolic dysregulation, have all been frequently noted amongst patients during depressive episodes (Armitage et al., 2004; Hasler, Buysse, Kupfer & Germain, 2010; Schimitt, Levandovski, Paz & Hidalgo, 2013). Furthermore, it has been suggested depressive disorders are more prevalent in individuals with an abnormally fluctuating or arrhythmic endogenous clock (McClung, 2007).

Individuals adopt a specific temporal relationship to zeitgebers (i.e., external cues that influence circadian rhythms), such as the time difference between sunrise and waking, core body temperature minimum, and melatonin onset. This idiosyncratic relationship between external and internal time determines an individual's chronotype (Roenneberg, 2012). Chronotype reflects an individual's preferred timing of activity and rest during the day, and the terms 'Morningness' and 'Eveningness' are used to differentiate people who endorse consistent diurnal preferences. Individuals who identify themselves as Evening-types show biological rhythms that appear to be *phase delayed* (i.e., they prefer to go to sleep and wake later than others) - in comparison, the

rhythms of Morning-types tend to be *phase advanced* (i.e., they prefer to go to sleep and wake earlier than others; Cavallera & Giudici, 2008).

Chronotype also displays systematic changes with age. Children are generally relatively early chronotypes, while the circadian period progressively delays throughout puberty and adolescence, until it reaches a 'peak' of lateness around 19-20 years of age (Carskadon, Vieira & Acebo, 1993; Roenneberg et al., 2004; Foster & Roenneberg, 2008). From the literature, it is clear that adolescent sleep is characterized by later bed times and wake times, and this "Eveningness" behavioral pattern has been linked to sleep-onset insomnia and sleep debt (Gradisar et al. 2011). In adults, Eveningness has also been associated with lower levels of emotional stability and happiness (Kerkhof, 1985; Giannotti, Cortesi, Sebastiani & Ottaviano, 2002; Tankova et al., 1994; Tonetti et al., 2012), and with depressive symptoms and disorders (Abe et al., 2011; Armitage et al., 2004; Chelminsky et al., 1999; Drennan, Kleiber & Kripke, 1991; Gulec et al., 2013; Hirata et al., 2007; Kitamura et al., 2010; Morelato de Souza & Hidalgo, 2014; Selvi et al., 2007; Taillard et al., 2001).

Various studies have explored the cross-sectional relationship between chronotype and mood in adults, including mood variation (Selvi et al., 2007), seasonality of mood (Natale et al., 2005) and seasonal affective disorder (Murray 2003). They have found Eveningness to be associated with both poor mood in healthy subjects (Selvi et al., 2007) and with depressive disorder (Hirata et al., 2007; Chelminski et al., 1999; Danilenko & Putilov, 2005; Drennan, Klauber & Kripke, 1991; Murray, 2007; Natale et al., 2005; Ong et al., 2007).

More recently, attention has been drawn towards the relationship between chronotype and affective dysfunction amongst adolescents. As noted above, while each individual is more likely to have a later bed-time as they progress throughout

adolescence, there is still trait-like variability in daytime preferences. In other words, regardless of whether an individual is morning or evening type, they will typically have progressively later bed-times across this period, but they can still remain a morning and evening type, respectively. Giannotti and colleagues (2002) found that, amongst a large sample of adolescents aged between 14 to 18 years, chronotype was not only associated with sleep patterns but also with other psychosocial factors such as emotional distress. Consistent with these findings, greater Eveningness in adolescents has been associated with suicidal tendencies (Gau et al., 2007) and depression (Randler, 2011b), while adolescent Morningness preference has been positively associated with wellbeing (Randler, 2007b).

The literature therefore suggests an association between greater Eveningness preference and poor mental health in adolescence; however, literature concerning adolescent chronotype and psychopathological outcomes has primarily been cross-sectional and/or retrospective. Research should therefore aim to address circadian preference/rhythmicity within a longitudinal and developmental framework (e.g., Andershed, 2007; Cofer et al., 1999; Giannotti et al., 2002), which allow for the exploration of temporal associations amongst variables (i.e., if one precedes the other). Indeed, earlier studies investigating the associations between chronotype and depression have suggested that Eveningness may not just be a characteristic of the depressed state, but also a pre-morbid trait or vulnerability factor (Chelminsky et al., 1999; Drennan et al., 1991). Three studies have used longitudinal data to determine the temporal relationships between internalizing symptoms and chronotype in adolescents. Harade, Mullin, and Hankin (2017) examined how depression and chronotype were associated across childhood and adolescence, and found that depressive symptoms prospectively predicted shifts towards eveningness 12 months later. They also found

that eveningness prospectively predicted later increases in depressive symptoms. In a later study using the same sample, initial depression scores predicted later differences in chronotype, but anxiety scores did not (Haraden, Mullin, & Hankin, 2019). Finally, Van den Berg, Kivelä, and Antypa, (2018) found that, within a college sample, preference towards eveningness prospectively predicted depressive symptoms a year later.

There is relatively little research on chronotype and anxiety symptoms specifically, but there are studies that have reported significant associations between Eveningness and neuroticism and other emotionally unstable traits (e.g., Kasof, 2001; Kerkhof, 1985; Mecacci & Rochetti, 1998; Neubauer, 1992; Tankova et al. 1994). Furthermore, a psychophysiological feature of neuroticism is in fact weakened circadian rhythmicity (Murray, Allen, Trinder & Burgess, 2002b). Given that these traits are related to vulnerability for the development of both anxious and depressive conditions (Clark et al., 1994; Griffith et al., 2010; Ormel et al., 2004; Weinstock & Whisman, 2006), it is plausible that anxious symptoms may also be associated with chronotype.

Two types of outcome variables were evaluated for this study: the development of internalizing (i.e., anxious and depressive) symptoms and the first onset of Major Depressive Disorder (MDD) diagnosis. The study focused on the onset of case level depression because of its unique pattern of incidence during the adolescent years (as opposed to anxiety disorders, which tend to show first incidence during childhood and adolescence), allowing us to conduct a truly prospective study with respect to onset of these disorders. The current study sought to establish temporal relationships between eveningness and changes in the severity of depressive and anxious symptoms across four waves of data collection in a longitudinal sample of adolescents. Specifically, consistent with models that propose chronotype as a prospective risk factor for

internalizing symptoms (e.g., Haraden et al., 2019), we predicted that chronotype would prospectively predict changes in depression and anxiety scores. Additionally, we sought to test whether chronotype measured in early adolescence would prospectively predict the onset of Major Depressive Disorder over a six year follow up period. We hypothesized that individuals with a more eveningness chronotype would be more likely to experience the onset of Major Depressive Disorder.

Method

Research Design

The current study was part of a larger longitudinal project titled the Orygen Adolescent Development Study (ADS), conducted in Melbourne Australia. The ADS aimed to identify risk and resilience factors involved in the development of mental illness during adolescence.

This research employed both cross-sectional and prospective methods drawing on four waves of ADS data collection (spanning from 2004 to 2011). There was an initial screening assessment for recruitment of participants, and four subsequent waves of intensive data collection (conducted at approximately 2 to 3 year intervals and referred to as T1, T2, T3 and T4) that included a diagnostic interview and a battery of questionnaires (including symptom rating scales and assessment of chronotype). Ages at the assessment waves were as follows: T1 (11-12years), T2 (14-15years), T3 (15-16years), and T4 (17-19years).

Recruitment and Screening of Participants

The ADS sample was recruited from primary schools in metropolitan Melbourne, Australia, targeting grade 6 students. Grade 6 corresponds to the final year of primary school and students are aged between 10 to 12 years. 175 primary schools were

selected providing a sampling population of 4,587 students, of which 2453 participated in the screening.

The aim of the screening was to identify a representative sample of early adolescents based on temperamental risk factors for psychopathology. Scores on the Early Adolescent Temperament Questionnaire – Revised (EATQ-r; Ellis & Rothbart, 2001) determined a selection of 415 students representing the full range of temperament scores. Specifically, equal numbers of adolescents were selected with scores on the higher order EATQ-r factors of Negative Emotionality and Effortful Control that were 0-1, 1-2, and 2-2.5 standard deviations (SD) above and below the mean. This produced a sample that showed even variation across each of the higher order traits of interest with some emphasis in the distribution at the tails.

Of the 415 students selected from the screening, 245 families agreed to participate (50.60% female students) in the first intensive assessment phase. These 245 adolescents were referred to as the ADS sample. Finally, due to missing data (see below), participants were excluded from multiple imputation and subsequent analyses if they had fewer than three timepoints available for any one variable. Thus, our final sample was a total of 116 participants.

As one of the main aims of this research was to explore the onset of certain mental disorders during adolescence, only participants without a history of MDD, psychosis or substance use disorders were included in the sample. Thus the initial assessment included administration of The Kiddie Schedule for Affective Disorder and Schizophrenia for School-Aged Children, Present and Lifetime version (K-SADS-PL, Orvaschel & Puig-Antich, 1994).

Measure of Chronotype

Horne and Ostberg's Reduced Morningness-Eveningness Questionnaire – MEQ-r. The reduced version of Horne and Ostberg's Morningness-Eveningness Questionnaire (MEQ-r; Adan and Almirall, 1991) was used to measure chronotype at each of the four assessment waves. The MEQ-r is a self-report questionnaire comprised of items that indicate life rhythms and habits such as sleep and rising times, preferred time of physical and mental performance, alertness before going to bed and after rising. The five items of the reduced scale give a range of scores (from 4-25) reflecting Morningness/Eveningness (M/E). Scores were treated as a continuum, with lower scores reflecting greater Eveningness.

Measures of Depressive Disorder and Internalizing Symptoms

The following measures were administered at each of the four assessment waves.

K-SADS. The K-SADS-PL (Kaufman, Birmhaer, Brent & Rao, 1997) is a semistructured diagnostic interview. It is designed to assess current and lifetime symptoms and diagnoses of Axis I disorders in children and adolescents (aged 6 to 18 years) according to DSM-III-R and DSM-IV criteria (only DSM-IV symptoms and diagnoses were considered in this research). Inter-rater reliability was found to be very high across diagnoses with an average Kappa coefficient of 0.84.

Centre for Epidemiological Studies – Depression (CES-D). The CES-D (Radloff, 1977) is a 20 item self-report questionnaire designed to measure depressive symptoms over the past week.

Beck Anxiety Inventory (BAI). The BAI is a self-report questionnaire that measures the severity of anxiety in adults and adolescents (Beck & Steer, 1988; Beck, Epstein &

Brown, 1988). The inventory consists of 21 items that describe the emotional, physiological and cognitive symptoms of anxiety measured over the past week.

Statistical Analyses

All analyses were carried out using R (Version 3.5.2). We utilized Structural Equation Modelling (SEM) procedures in order to determine whether morningness-eveningness was prospectively associated with changes in internalizing symptoms across the four waves. Specifically, we ran random-intercept cross-lagged panel models (RI-CLPM) in R, as proposed by Hamaker, Kuiper, and Grasman (2015). These models tested the association between MEQ scores at each wave and depression or anxiety scores at the subsequent waves, and are thought to have benefits over the traditional CLPM as they separate out the variance associated with an individual's stable score over time. In other words, these models generate a random-intercept for each participant that allowed us to predict their expected score at the following timepoint, and therefore we could model whether the degree to which the observed score deviated from their predicted score was associated with the predictor variable at the previous wave. In order to compensate for missing data (see below for more details), we used the *lavaan.mi* function within the semTools package to conduct the SEM, as these packages are specifically designed specifically to work with multiply imputed datasets.

Missing Data

In the current research, missing data occurred mainly as a result of a planned-missingness design. Specifically, the MEQ was only given to a random subset of the participants at each time point (by design). As a consequence, the total percentage of missing data from the entire dataset of variables used in this study was 7%. However, when looking at only the MEQ data at all time points, the percentage of missing data was 18%. Due to the random nature of this missing data, we conducted multiple imputation

to account for the missingness in the data with the Amelia package, which can account for missing time-series data.

Results

Descriptive Statistics

Table 1 presents the mean, standard deviation, and bivariate correlations for each of the study variables. While MEQ, CESD, and BAI scores are somewhat stable from timepoint to timepoint, the larger the temporal distance between timepoints, the less intercorrelated the variables are (e.g., MEQ_1 ~ MEQ_4). This is unsurprising, as this is a developmental sample, and chronotype, as well as internalizing symptoms, are known to shift throughout adolescence. While there are significant intercorrelations between the same variables measured at different timepoints, it should be noted that the MEQ does not appear to be associated with either BAI or CESD scores at the concurrent timepoint (except for CESD and MEQ at Time Point 3).

Statistical Analyses

In order to test the fit of these models, we first created models that did not allow for individual specific random intercepts and was non-crossed (i.e., MEQ only predicted BAI or CESD, not the other way around). The model fit for the model in which MEQ predicted CESD scores at each subsequent wave had a poor overall fit, $\chi^2(18, N = 118) = 68.8, p < 0.001, RMSEA = 0.16, CFI = 0.54, SRMR < 0$. We then added in the cross-predictors and random-intercepts to separate out individual-level stability for CESD (see Figure 1), which had an acceptable fit, $\chi^2(9, N = 118) = 17.05, p < 0.05, RMSEA = 0.09, CFI = 0.93, SRMR < 0$. Additionally, model comparison

demonstrated that this model was significantly better than the base model, $F(9,282.93) = 5.21, p < 0.001$.

We then used the same approach to determine if MEQ scores predicted changes in BAI scores at subsequent waves. Again, the base model, with no random intercepts and no cross-predictors, had an overall poor model fit, $\chi^2(18, N = 118) = 68.8, p < 0.001, RMSEA = 0.16, CFI = 0.54, SRMR < 0$. After adding back in the cross-predictors and random-intercepts (see Figure 2), the model had an overall acceptable fit, $\chi^2(9, N = 118) = 16.35, p = 0.06, RMSEA = 0.08, CFI = 0.94, SRMR < 0$. When comparing the RI-CPLM predicting anxiety with the base model, the RI-CPLM was a significantly better fit, $F(9,209.99) = 4.79, p < 0.001$.

Morning-Eveningness and Depression

Examination of the RI-CPLM (see Figure 1) revealed that MEQ scores at Time 1 and Time 2 prospectively predicted changes in depression scores at Time 2 and Time 3 respectively. Specifically, MEQ at time 1 negatively predicted CESD scores at Time 2, when accounting for CESD scores at Time 1 ($\beta = -0.211, p = 0.045$). MEQ at Time 2 also prospectively predicted changes in CESD scores at Time 3 ($\beta = -0.248, p = 0.032$), but MEQ at time 3 did not significantly predict CESD scores at Time 4 ($\beta = -0.253, p = 0.253$). This indicates that, at least for timepoints 1 and 2, lower scores on the MEQ (or more evening-like traits) prospectively predicted increases in depressive scores at the subsequent timepoint. Interestingly, CESD scores at Time 1 ($\beta = 0.011, p = 0.926$), Time 2 ($\beta = -0.218, p = 0.051$), and Time 3 ($\beta = 0.037, p = 0.831$), were not significant prospective predictors of changes in Morning-Eveningness scores at subsequent timepoints.

Morning-Eveningness and Anxiety

When BAI scores were used in the RI-CPLM (see Figure 2), MEQ scores at Time 1 significantly predicted changes in BAI scores at Time 2 ($\beta = -0.278, p = 0.007$), but MEQ scores at Time 2 and 3 did not significantly predict changes in BAI scores at Time 3 ($\beta = -0.067, p = 0.498$) or Time 4 ($\beta = -0.230, p = 0.079$) respectively. BAI scores at Time 1 and time 3 did not significantly predict subsequent changes in MEQ scores, but Time 2 BAI scores did significantly predict changes in MEQ at Time 3 ($\beta = -0.283, p = 0.005$).

Morning-Eveningness and Depressive Diagnosis

Finally, we ran a logistical model in order to determine whether morning-eveningness preference at Time 1 would predict the likelihood that an individual would be clinically diagnosed with a first onset of Major Depressive Disorder over the next 3 waves (i.e., at any point before Time 4). MEQ scores at Time 1 did significantly predict incidence of MDD over the six year follow up period ($\beta = -0.238, p = 0.009$; See Figure 3). Odds-ratio analyses revealed that each change of one unit in MEQ score towards eveningness increased the odds of an individual being diagnosed with depression by 1.27 ($95\%\ confidence\ interval[CI] = 1.0705,1.538$).

Discussion

The results of this study partially supported the hypothesis that greater eveningness would prospectively predict changes in internalizing symptoms. Additionally, the model comparison revealed that, for both anxiety and depression, there was a better model fit when individual trait-like stability was accounted for. Specifically, MEQ at Time 1 and Time 2 (but not Time 3) predicted increases in depressive symptoms at the following time point, not only accounting for previous depressive scores, but also for within-subject stability over time. Specifically, because trait-like stability was accounted for in

this model, MEQ prospectively predicted deviations from stable, trait-like expected changes in scores at any given timepoint. In other words, greater eveningness scores were predictive of increased depressive symptoms, over and above the changes we would have expected to find for a given individual. While this holds true for the prediction of changes in anxiety at Time 2 by eveningness at time 1, this was not the case for eveningness at Time 2 and 3. Additionally, we also found that anxiety at Time 2 was predictive of greater eveningness at Time 3. Finally, eveningness prospectively predicted the first onset of major Depressive Disorder over the next 3 waves of data collection. This indicates that early adolescents who have more evening-like traits are at a heightened risk for experiencing a depressive episode later in adolescence.

The present findings are consistent with previous studies revealing associations between Eveningness and greater likelihood of experiencing internalizing symptoms (Abe et al., 2011; Armitage et al., 2004; Chelminsky et al., 1999; Drennan, Kleiber & Kripke, 1991; Giannotti et al., 2002; Gulec et al., 2013; Hirata et al., 2007; Kitamura et al., 2010; Morelato de Souza & Hidalgo, 2014; Selvi et al., 2007; Tankova et al., 1994; Taillard et al., 2001). However, it has only been in the last two decades that studies have investigated this association amongst adolescents, with an emphasis on community samples (Giannotti et al., 2002; Gau et al., 2004; 2007; Randler et al., 2011; Tzischinsky & Shochat, 2011; Negriff & Dorn, 2009; Merikanto et al., 2013; Morelatto de Suza & Hidalgo, 2014). Other recent adolescent studies have also implicated delayed phase as a risk factor for mood dysfunction (Negriff & Dorn, 2009; Merikanto et al., 2013; Morelatto de Souza & Hidalgo, 2014). For example, Negriff and Dorn (2009) found that adolescent girls with evening preference experienced more negative affect and anxiety, and Merikanto and colleagues (2013) found that late bedtimes, especially later than 11.30pm (which would be associated with Eveningness tendencies in many cases),

increased the odds ratio for depressive symptoms and other health related issues in adolescents (14 to 20 years). Finally, research by Morelatto de Souza and Hidalgo (2014) found that girls and male and female evening types were present at higher frequencies in groups of teens classified as 'more depressed' with the depression group displaying a consistent delay for midpoint of sleep (i.e., more phase delayed). That is, sleep phase was significantly related to higher levels of depression.

Furthermore, previous research has had a tendency to combine anxiety and depression under broad categories such as "emotional dysfunction" (e.g., Giannotti et al., 2002; Tzschinsky & Shochat, 2011; Randler, 2011), with a particular emphasis on depressive symptoms. Although overlap exists, the present study distinguished between anxious and depressive symptoms by measuring each independently. As noted above, a highlight of the present study is not only the longitudinal approach, but the disaggregation of the within-subjects effect and the between-subjects effects.

The emergence of a consistent link between Eveningness and depression that is replicated across multiple waves of the study supports the notion that Eveningness might be associated with premorbid traits that are related to vulnerability to depressive symptoms. Furthermore, Eveningness is associated with a tendency to longer endogenous circadian cycles, which require greater adjustment under conditions of change, such as changes in the seasons, routines, stress levels or variations in sleep schedules. This may lead to a greater likelihood of dysregulation of biological rhythms amongst more Evening-type individuals, which can eventually affect the efficient functioning and synchronization of underlying mechanisms involved in the regulation of emotion and mood.

The hypothesis that Eveningness amongst adolescents would be associated with an increased likelihood of developing MDD over a follow up period was also supported by

the observation that greater Eveningness at T1 significantly predicted the onset of a MDD diagnosis across the longitudinal period T1 to T4. This finding is consistent with prior studies that have reported a significant link between Eveningness and depression. For example, one of the pioneering studies to chronicle the prevalence of Eveningness tendencies amongst clinically depressed individuals was conducted by Drennan and colleagues (1991), revealing that outpatients with MDD consistently displayed greater Eveningness typology. Subsequent explorations have also revealed an association between Eveningness (or delayed phase) and depressive symptoms in nonclinical populations (Chelminsky et al., 1999; Taillard et al., 2001; Takeuchi et al., 2005).

These findings are inconsistent with the original 'phase advance hypothesis', which suggested that depression is associated with an advanced phase of circadian rhythm (Kripke et al., 1979; Wehr et al., 1979). This theory was proposed in response to the frequency of early morning awakenings noted amongst clinically depressed populations. However, with greater understanding of circadian functioning and the characteristics reflecting underlying endogenous rhythmicity such as 'sleep onset latency', it has become increasingly evident that Eveningness chronotype is more consistently associated with the depressed state. Furthermore, circadian preference for Eveningness has been increasingly associated with greater severity of depressive episodes (Corruble et al., 2014; Gulec et al., 2013; Selvi et al., 2010, 2011), whereas a reduction in Eveningness, or progressive phase advances towards Morningness, has been linked to improvements in clinical outpatients, suggesting that Eveningness may represent a risk state (Corruble et al., 2014). Kim et al. (2010) demonstrated a stronger association between Eveningness and depression in younger and much older adults than in the middle aged, suggesting a moderating effect of age. Thus, the present study

contributes to the hypothesis that amongst a young age group greater phase delay or extreme Eveningness is significantly related to depression.

The present study adds to a small number of studies that have examined the prospective association between Eveningness traits amongst a community sample of adolescents and the subsequent emergence of MDD. The first community sample to date to link evening preference with depressive status (diagnosis) was by Kitamura and colleagues (2010). This investigation was conducted with an adult population ranging in age from 20 to 59 years. The significant association between Eveningness typology and depressed state led the authors to suggest that Eveningness may increase susceptibility to the induction of mood disorders, via possible functional associations between mood adjustment and biological clock systems that regulate diurnal preference (Kitamura, Hida, Watanabe, Enomoto, Aritake-Okada, Moriguchi, Kamei, Mishima, 2010). Haraden et al. (2017) was the first, however, to employ this methodology within an adolescent sample. Much like our current study, they also found that eveningness increased the likelihood of adolescents experiencing the onset of a depressive episode. Taken together, these results indicate that, across developmental periods, eveningness (and greater shifts towards eveningness) may serve as an early indicator for risk of??? the onset of depressive disorders.

Although this study has many strengths there are also a number of limitations that should be borne in mind. The measures employed in this study were primarily self-report questionnaires and as such the limitations associated with subjective measures must be taken into consideration. It should be noted that objective measures of circadian rhythmicity obtained by methods such as actigraphy recordings are valuable, however participant compliance is difficult to implement on a large scale, and research shows that self-report measures of circadian typology are extremely reliable and valid

(Adan & Almiral, 1991; 2012; Natale et al., 2006). Furthermore, while the utilization of a prospective longitudinal design facilitates inference of causality and was thus a strength of this research, it is correlational in nature and therefore cannot be considered absolute proof of the relationship between chronotype and the emergence of negative emotional and behavioral outcomes in adolescence.

In addition, given the strong associations between sleep deficits and internalizing symptoms in the literature (Alfano et al., 2007; Gregory et al., 2005; Mooney, 1985), the hypothesis the sleep difficulties are a salient mediator of the prospective relationships between Eveningness and internalizing symptoms and disorders that were revealed in the present findings cannot be ruled out. Unfortunately, sleep problems were not assessed in the present study. It is, however, well documented that, as a result of typical societal demands that dictate early morning starts, evening types are more likely to experience the effects of sleep loss and sleep debt, which have also been implicated in adolescent dysfunctional outcomes (Touitou, 2013). Future studies should therefore include prospective analysis of both the effects of sleep problems and chronotype is recommended. A comparison of the effects of sleep and chronotype in relation to levels of anxiety and an investigation into the potential mediating effects of sleep problems such as sleep duration, debt and variability would add further clarification to the findings of this study.

Overall, this study complements and significantly extends previous research on the relationship between circadian rhythmicity, anxiety and depression. The longitudinal methodology allowed for inferences to be made regarding temporal associations, in addition to the disaggregation of the within- and between- subjects effects of chronotype on internalizing symptoms. The present study also supported the temporal hypothesis suggesting that Eveningness precedes depression. In effect, these results

help assign predictive value to extreme Eveningness as a potential warning sign for emotional dysfunction during childhood and adolescence. This study also adds to the growing literature exploring potential factors that might contribute to the onset of emotional and behavioral problems during adolescence. As this is such a vulnerable phase of human development, any new knowledge that contributes to the successful implementation of early intervention and prophylactic strategies is of great importance.

References

Abe, T., Inoue, Y., Komada, Y., Nakamura, M., Asaoka, S., Kanno, M., et al. (2011). Relation between morningness-eveningness score and depressive symptoms among patients with delayed sleep phase syndrome. *Sleep Medicine*, *12*(7), pp. 680–684.

Adan, A., & Almirall, H. (1991). Horne and Ostberg Morningness-Eveningness Questionnaire: A Reduced Scale. *Personality and Individual Differences*, *12*(3), pp. 241–253.

Adan, A., & Natale, V. (2002). Gender differences in morningness-eveningness preference. *Chronobiology International*, *19*(4), pp. 709–720.

Adan, A., Archer, S. N., Hidalgo, M. P., Di Milia, L., Natale, V., & Randler, C. (2012). Circadian Typology: A Comprehensive Review. *Chronobiology International*, *29*(9), pp. 1153–1175.

Alfano, C. A., Beidel, D. C., Turner, S. M., & Lewin, D. S. (2006). Preliminary evidence for sleep complaints among children referred for anxiety. *Sleep Medicine*, *7*(6), pp. 467–473.

Alfano, C. A., Ginsburg, G. S., & Kingery, J. N. (2007). Sleep-Related Problems Among Children and Adolescents with Anxiety Disorders. *Jaac*, *46*(2), pp. 224–232.

Alfano, C. A., Pina, A. A., Zerr, A. A., & Villalta, I. K. (2009). Pre-Sleep Arousal and Sleep Problems of Anxiety-Disordered Youth. *Child Psychiatry and Human Development*, *41*(2), pp. 156–167.

Andershed, A.-K. (2007). *In Sync with Adolescence*. Springer Science & Business Media, Inc. New York.

Armitage, R., Hoffmann, R., Emslie, G., Rintelman, J., Moore, J., & Lewis, K. (2004). Rest-Activity Cycles in Childhood and Adolescent Depression. *Journal of the American Academy of Child & Adolescent Psychiatry*, *43*(6), pp. 761–769.

Aschoff, J., & Wever, R. (1981). The circadian system of man. In J.Aschoff (Ed.), *Biological Rhythms*. (pp. 311-331). Springer, NY, USA.

Beck, A. T., & Steer, R. A. (1988). Beck anxiety inventory (BAI).

Beck, A. T., Epstein, N., & Brown, G. (1988). An inventory for measuring clinical anxiety: psychometric properties. *Journal of Consulting and Clinical Psychology, 56 (6), pp. 893-897.*Birmaher, B., & Heydl, P. (2001). Biological studies in depressed children and adolescents. *The International Journal of Neuropsychopharmacology*, *4*(02), pp. 149–157.

Blascovich, J., & Tomaka, J. (1996). The biopsychosocial model of arousal regulation. *Advances in Experimental Social Psychology*, 28, pp. 1-151.

Carskadon, M. A., Vieira, C., & Acebo, C. (1993). Association between puberty and delayed phase preference. *Sleep*, *16*, pp. 258–258.

Cavallera, G. M., & Giudici, S. (2008a). Morningness and eveningness personality: A survey in literature from 1995 up till 2006. *Personality and Individual Differences*, *44*(1), pp. 3–21.

Chelminski, I., Ferraro, F. R., Petros, T. V., & Plaud, J. J. (1999). An analysis of the "eveningness–morningness" dimension in 'depressive' college students. *Journal of Affective Disorders,* 52(1-3), pp. 19-29.

Clark, L. A., Watson, D., & Mineka, S. (1994). Temperament, personality, and the mood and anxiety disorders. *Journal of Abnormal Psychology*, 103(1), pp. 103-116.

Cofer, L. F., Grice, J. W., Sethre-Hofstad, L., Radi, C. J., Zimmermann, L. K., Palmer-Seal, D., & Santa-Maria, G. (1999). Developmental Perspectives on Morningness-Eveningness and Social Interactions. *Human & Veterinary Medicine*, *42*(4), pp. 169–198.

Cole, D. A., Peeke, L. G., Martin, J. M., Truglio, R., & Seroczynski, A. D. (1998). A longitudinal look at the relation between depression and anxiety in children and adolescents. *Journal of Consulting and Clinical Psychology*, *66*(3), p. 451.

Corruble, E., Frank, E., Gressier, F., Courtet, P., Bayle, F., Llorca, P.-M., et al. (2014). Morningness –eveningness and treatment response in major depressive disorder. *Chronobiology International*, *31*(2), pp. 283–289.

Crowley, S. J., Acebo, C., & Carskadon, M. A. (2007). Sleep, circadian rhythms, and delayed phase in adolescence. *Sleep Medicine*, *8*(6), pp. 602–612.

Danilenko, K. V., & Putilov, A. A. (2005). Melatonin Treatment of Winter Depression Following Total Sleep Deprivation: Waking EEG and Mood Correlates. *Neuropsychopharmacology*, 30, pp. 1345-1352.

Díaz-Morales, J. F., & Pilar Sánchez-López, M. (2008). Morningness-eveningness and anxiety among adults: A matter of sex/gender? *Personality and Individual Differences*, *44*(6), pp. 1391–1401.

Drennan, M. D., Klauber, M. R., & Kripke, D. F. (1991). The effects of depression and age on the Horne-Ostberg morningness-eveningness score. *Journal of Affective Disorders,* 23(2), pp. 93-98.

Ellis, L., & Rothbart, M. (2001). Revision of the early adolescent temperament questionnaire. *Poster Presented at the 2001 biennial meeting of the society for research in child development.* Minneapolis, MN.

Essau, C. A., Lewinsohn, P. M., Seeley, J. R., & Sasagawa, S. (2010). Gender differences in the developmental course of depression. *Journal of Affective Disorders*, *127*(1-3), pp. 185–190.

Fava, M., Rankin, M. A., Wright, E. C., Alpert, J. E., Nierenberg, A. A., Pava, J., & Rosenbaum, J. F. (2000). Anxiety disorders in major depression. *Comprehensive Psychiatry*, *41*(2), pp. 97–102.

Foster, R. G., & Roenneberg, T. (2008). Human Responses to the Geophysical Daily, Annual and Lunar Cycles. *Current Biology*, *18*(17), R784–R794.

Gaspar-Barba, E., Calati, R., Cruz-Fuentes, C. S., Ontiveros-Uribe, M. P., Natale, V., De Ronchi, D., & Serretti, A. (2009). Depressive symptomatology is influenced by chronotypes. *Journal of Affective Disorders*, *119*(1-3), pp. 100–106.

Gau, S.S.F., & Merikangas, K.R., (2004). Similarities and Differences in Sleep-Wake Patterns among Adults and Their Children. *Sleep*, 27(2), pp. 299-304.

Gau, S. S. F., Shang, C. Y., Merikangas, K. R., Chiu, Y. N., Soong, W. T., & Cheng, A. T. A. (2007). Association between Morningness-Eveningness and Behavioral/Emotional Problems among Adolescents. *Journal of Biological Rhythms*, *22*(3), pp. 268–274.

Giannotti, F., Cortesi, F., Sebastiani, T., & Ottaviano, S. (2002). Circadian preference, sleep and daytime behaviour in adolescence. *Journal of Sleep Research*, *11*(3), pp. 191–199.

Gotlib, I. H., Lewinsohn, P. M., & Seeley, J. R. (1995). Symptoms versus a diagnosis of depression: Differences in psychosocial functioning. *Journal of Consulting and Clinical Psychology*, *63*(1), pp. 90–100.

Graham, J.W., Olchowski, A.E., & Gilreath, T.D. (2007). How many imputations are really needed? Some practical clarifications of multiple imputation theory. *Society for Prevention Research*, 8, pp. 206-213.

Gradisar, M., Gardner, G., & Dohnt, H. (2011). Recent worldwide sleep patterns and problems during adolescence: A review and meta-analysis of age, region and sleep. *Sleep Medicine*, *12*(2), pp. 110–118.

Gregory, A. M., Rijsdijk, F. V., Dahl, R. E., McGuffin, P., & Eley, T. C. (2006c). Associations Between Sleep Problems, Anxiety, and Depression in Twins at 8 Years of Age. *Pediatrics*, *118*(3), pp. 1124–1132.

Gregory, A. M., & Sadeh, A. (2012). Sleep, emotional and behavioural difficulties in children and adolescents. *Sleep Medicine Reviews*, 16(2), pp. 129-136.

Griffith, J. W., Zinbarg, R. E., & Craske, M. G. (2010). Neuroticism as a common dimension in the internalizing disorders. *Psychological Medicine,* 40(7), pp. 1125-1136.

Gulec, M., Selvi, Y., Boysan, M., Aydin, A., Oral, E., & Aydin, E. F. (2013). Chronotype effects on general well-being and psychopathology levels in healthy young adults. *Biological Rhythm Research*, *44*(3), pp. 457–468.

Hankin, B. L., Abramson, L. Y., Moffit, T. E., Siva, P. A., McGee, R., & Angell, K. E. (1998). Development of Depression From Preadolescence to Young Adulthood: Emerging Gender Differences in a 10-Year Longitudinal Study. *Journal of Abnormal Psychology*, *107*(1), 128–140.

Haraden, D. A., Mullin, B. C., & Hankin, B. L. (2017). The relationship between depression and chronotype: A longitudinal assessment during childhood and adolescence. *Depression and anxiety, 34*(10), 967-976.

Haraden, D. A., Mullin, B. C., & Hankin, B. L. (2019). Internalizing symptoms and chronotype in youth: A longitudinal assessment of anxiety, depression and tripartite model. *Psychiatry research,* 272, 797-805.

Hasler, B. P., Buysse, D. J., Kupfer, D. J., & Germain, A. (2010), Phase relationships between core body temperature, melatonin, and sleep are associated with depression severity: Further evidence for circadian misalignment in non-seasonal depression. *Psychiatry Research*, 178(1), pp. 205–207.

Hirata, F.C., Lima, M.C.O., de Bruin, V.M.S., Nóbrega, P. R., Wenceslau, G.P., & de Bruin, P.F.C., (2007). Depression in Medical School: The Influence of Morningness-Eveningness. *Chronobiology International*, *24*(5), pp. 939–946.

Kasof, J. (2001). Eveningness and bulimic behavior. *Personality and Individual Differences*, *31*(3), pp. 361–369.

Kaufman, J., Birmaher, B., Brent, D., & Rao, U. (1997). Schedule for affective disorders and schizophrenia for school-age children-present and lifetime version (K-SADS-PL): initial reliability and validity data. *Journal of the American Academy of Child and*

Adolescent Psychiatry, 36(7), pp. 980-988.Kerkhof, E. A. (1985). Inter-individual differences in the human circadian system: a review. *Biological Psychology*, *20*, pp. 83–112.

Kerkhof, E. A. (1985). Inter-individual differences in the human circadian system: a review. *Biological Psychology*, *20*, pp. 83–112.

Kim, S.J., Lee, Y.J., Kim, H., Cho, I.H., Lee, Y.J., Cho, J.J. (2010). Age as a moderator of the association between depressive symptoms and morningness-eveningness. J Psychosom Res, 68, pp. 159-164.

Kitamura, S., Hida, A., Watanabe, M., Enomoto, M., Aritake-Okada, S., Moriguchi, Y., et al. (2010). Evening preference is related to the incidence of depressive states independent of sleep-wake conditions. *Chronobiology International*, *27*(9-10), pp. 1797–1812.

Klein, D. N., Shankman, S. A., & Lewinsohn, P. M. (2009). Subthreshold depressive disorder in adolescents: predictors of escalation to full-syndrome depressive disorders. Journal of the American Academy *Of Child & Adolescent Psychiatry,* 48(7), pp. 703-710.

Kovacs, M., Gatsonis, C., Paulauskas, S. L., & Richards, C. (1989). Depressive disorders in childhood. *Archives of General Psychiatry*, *46*(9), pp. 776–782.

Kovaks, M. (1996). The course of childhood-onset depressive disorders. *Psychiatric Annals*, *26*(6), pp. 326–330.

Kraemer, H.C., Wilson, G.T., Fairburn, C.G., & Agras, W.S., (2002). Mediators and moderators of treatment effects in randomized clinical trials. *Arch Gen Psychiatry*, 59, pp. 877-883.

Kripke, D.F., Mullaney, D.J., Atkinson, M.L., Huey, L.Y., Hubbard, B. (1979). Circadian rhythm phases in affective illness. *Chronobiologia*, 6, pp. 365-375.

Lazarus, R. S. (1991). Cognition and motivation in emotion. *American Psychologist*, 46(4), pp. 352-367.

Lewinsohn, P. M., Rohde, P., & Seeley, J. R. (1998). Major depressive disorder in older adolescents: prevalence, risk factors, and clinical implications. *Clinical Psychology Review*, *18*(7), pp. 765–794.

Lewinsohn, P. M., Solomon, A., & Seeley, J. R. (2000). Clinical implications of" subthreshold" depressive symptoms. *Journal of Abnormal Psychology,* 109(2), pp. 345-351.

Lund, R. (1974). Personality Factors and Desynchronization of Circadian Rhythms. *Pychosomatic Medicine*, *36*(3), pp. 224–228.

Matthews, G. (1988). Morningess-eveningness as a dimension of personality: Trait, state and psychophysiological correlates. *European Journal of Personality*, *2*, pp. 277–293.

Marcks, B. A., Weisberg, R. B., Edelen, M. O., & Keller, M. B. (2010).The relationship between sleep disorders and the course of anxiety disorders in primary care patients. *Psychiatry Research*, *178*(3), pp. 487–492.

McClung, C. A. (2007). Circadian genes, rhythms and the biology of mood disorders. *Pharmacology & Therapeutics*, *114*(2), pp. 222–232.

Mecacci, L., & Rocchetti, G. (1998). Morning and evening types: stress-related personality aspects. *Personality and Individual Differences*, *25*, pp. 537–542.

Merikanto, I., Lahti, T., Kronholm, E., Peltonen, M., Laatikainen, T., Vartiainen, E., et al. (2013). Evening types are prone to depression. *Chronobiology International*, *30*(5), pp. 719–725.

Morelato de Souza, C. M., & Hidalgo, M. P. L. (2014). Midpoint of sleep on school days is associated with depression among adolescents. *Chronobiology International*, *31*(2), pp. 199–205.Murray, G. (2003). Seasonality and circadian phase delay: prospective evidence that winter lowering of mood is associated with a shift towards Eveningness. *Journal of Affective Disorders*, *76*(1-3), pp. 15–22.

Murray, G., Allen, N. B., & Trinder, J. (2002a). Mood and the circadian system: investigation of a circadian component in positive affect. *Chronobiology International*, *19*(6), pp. 1151–1169.

Murray, G., Allen, N. B., Trinder, J., & Burgess, H. (2002b). Is weakened circadian rhythmicity a characteristic of neuroticism? *Journal of Affective Disorders*, *72*(3), pp. 281–289.

Murray, G. (2007). Diurnal mood variation in depression: A signal of disturbed circadian function? *Journal of Affective Disorders*, *102*(1-3), pp. 47–53.

Natale, V., Adan, A., & Scapellato, P. (2005). Are seasonality of mood and eveningness closely associated? *Psychiatry Research*, *136*(1), pp. 51–60.

Natale, V., & Danesi, E. (2002). Gender and circadian typology. *Biological Rhythm Research*, *33*(3), pp. 261–269.

Negriff, S., & Dorn, L. D. (2009). Morningness/eveningness and menstrual symptoms in adolescent females. *Journal of Psychosomatic Research*, *67*(2), pp. 169–172.

Neubauer, A. C. (1991). Psychometric comparison of two circadian rhythm questionnaires and their relationship with personality. *Personality and Individual Differences*, *13*(2), pp. 125–131.

Ong, J. C., Huang, J. S., Kuo, T. F., & Manber, R. (2007). Characteristics of insomniacs with self-reported morning and evening chronotypes. *Journal of Clinical Sleep Medicine: JCSM: Official Publication of the American Academy of Sleep Medicine*, *3*(3), p. 289.

Ormel, J., Rosmalen, J., & Farmer, A. (2004). Neuroticism: a non-informative marker of vulnerability to psychopathology. *Social Psychiatry and Psychiatric Epidemiology,* 39(11), pp. 906-912.

Orvaschel, H., & Puig-Antich, J. (1987). Schedule for Affective Disorder and Schizophrenia for School-age Children (K-SADS), (1994 ed.).

Piccinelli, M. (2000). Gender differences in depression: Critical review. *The British Journal of Psychiatry*, *177*(6), 486–492.

Preacher, K., & Hayes, A. F. (2004). SPSS and SAS procedures for estimating indirect effects in simple mediation models. *Behavior Research Methods, Instruments & Computers*, *36*(4), pp. 717–731.

Radloff, L. S. (1977). The CES-D Scale a self-report depression scale for research in the general population. *Applied Psychological Measurement*, 1(3), pp. 385-401.

Randler, C., & Frech, D. (2009). Young people's time-of-day preferences affect their school performance. *Journal of Youth Studies*, *12*(6), pp. 653–667.

Randler, C., & Kretz, S. (2011). Assortative mating in morningness–eveningness. *International Journal of Psychology*, *46*(2), pp. 91–96.

Randler, C., & Vollmer, C. (2013). Aggression in young adults – a matter of short sleep and social jetlag? 1. *Psychological Reports*, *113*(3), pp. 754–765.

Randler, C., Bilger, S., & Díaz-Morales, J. F. (2009). Associations among sleep, chronotype, parental monitoring, and pubertal development among German adolescents. *The Journal of Psychology*, *143*(5), pp. 509–520.

Randler, C. (2007b). Morningness–Eveningness and Satisfaction with Life. *Social Indicators Research*, *86*(2), pp. 297–302.

Randler, C. (2011b). Association between morningness–eveningness and mental and physical health in adolescents. *Psychology, Health & Medicine*, *16*(1), pp. 29–38.

Randler, C., Vollmer, C., Beşoluk, Ş., Önder, İ., & Horzum, M. B. (2014). Age and gender differences in morningness–eveningness in Turkish adolescents and young adults. *Biological Rhythm Research*, *45*(2), pp. 277–284.Roenneberg, T., Kuehnle, T., Pramstaller, P. P., Ricken, J., Havel, M., Guth, A., & Merrow, M. (2004). A marker for the end of adolescence. *Current Biology*, *14*(24), R1038–R1039.

Reid, K. J., Jaksa, A. A., Eisengart, J. B., Baron, K. G., Lu, B., Kane, P., et al. (2012). Systematic evaluation of Axis-1 DSM diagnoses in delayed sleep phase disorder and evening-type circadian preference. *Sleep Medicine*, *13*(9), pp. 1171–1177.

Roenneberg, T. (2012). What is chronotype? *Sleep and Biological Rhythms*, *10*(2), pp. 75–76.

Rohde, P., Lewinsohn, P. M., & Seeley, J. R. (1991). Comorbidity of unipolar depression: II. Comorbidity with other mental disorders in adolescents and adults. *Journal of Abnormal Psychology,* 100(2), pp. 214-222.

Schafer, J. L., & Graham, J. W. (2002). Missing data: Our view of the state of the art. *Psychological Methods*, *7*(2), pp. 147–177.

Schimitt, R., Levandovski, R., & Hidalgo, M. P. L. (2013). Relations between social rhythm, sleep phase, and minor psychiatric symptoms in healthy workers. *Biological Rhythm Research*, *44*(3), pp. 403–409.

Sheeber, L. B., Davis, B., Leve, C., Hops, H., & Tildesley, E. (2007). Adolescents' relationships with their mothers and fathers: Associations with depressive disorder and subdiagnostic symptomatology. *Journal of Abnormal Psychology*, *116*(1), pp. 144

Schimitt, R., Levandovski, R., & Hidalgo, M. P. L. (2013). Relations between social rhythm, sleep phase, and minor psychiatric symptoms in healthy workers. *Biological Rhythm Research*, *44*(3), pp. 403–409.

Selvi, Y., Gulec, M., Agargun, M. Y., & Besiroglu, L. (2007). Mood changes after sleep deprivation in morningness–eveningness chronotypes in healthy individuals. *Journal of Sleep Research*, *16*(3), pp. 241–244.

Selvi, Y., Aydin, A., Gulec, M., Boysan, M., Besiroglu, L., Ozdemir, P. G., & Kilic, S. (2011). Comparison of dream anxiety and subjective sleep quality between chronotypes. *Sleep and Biological Rhythms*, *10*(1), pp. 14–22.

Suls, J. (2001). Affect, stress, and personality. In J.P Forgas (Ed.), Handbook of Affect and Social Cognition (pp. 392-409). NJ. Lawrence Ehrlbaum Associates Publishers.

Taillard, J., Philip, P., & Bioulac, B. (1999). Morningness/eveningness and the need for sleep. *Journal of Sleep Research*, *8*(4), pp. 291–295.

Taillard, J., Philip, P., Chastang, J. F., Diefenbach, K., & Bioulac, B. (2001). Is Self-Reported Morbidity Related to the Circadian Clock? *Journal of Biological Rhythms*, *16*(2), pp. 183–190.

Takeuchi, H., Oishi, T., & Harada, T. (2005). Association Between Moringness-Eveningness Preference and Mental/Physical Premenstrual Symptoms in Japanese Females 12 to 31 Years of Age. *Chronobiology International*, *22*(6), pp. 1055–1068.

Tankova, I., Adan, A., & Buela-Casal, G., (1994). Circadian typology and individual differences: A review. *Personality and Individual Differences*, 16, pp. 674-684.

Tompson, M. C., McKowen, J. W., Asarnow, J. R., & Allen, N. B. (2008). *Adolescent mood disorders and familial processes*. In, N. B. Allen & L. Sheeber (Eds.), *Adolescent Emotional Development and the Emergence of Mood Disorders* (pp. 280–298).

Tonetti, L., Fabbri, M., Natale, V. (2009). Relationship between circadian typology and big five personality domains. *Chronobiology International*, 26(2), pp.337-347.

Tonetti, L., Fabbri, M., Martoni, M., & Natale, V. (2012). Circadian type and mood seasonality in adolescents. *Psychiatry and Clinical Neurosciences*, *66*(2), pp. 157–159.

Touitou, Y. (2013). Adolescent sleep misalignment: a chronic jet lag and a matter of public health. *Journal of Physiology Paris*, pp. 1–4.

Tzischinsky, O., & Shochat, T. (2011). Eveningness, Sleep Patterns, Daytime Functioning, and Quality of Life in Israeli Adolescents. *Chronobiology International*, *28*(4), pp. 338–343.

Van den Berg, J. F., Kivelä, L., & Antypa, N. (2018). Chronotype and depressive symptoms in students: An investigation of possible mechanisms. *Chronobiology international, 35*(9), 1248-1261.

Wehr, T. A., Wirz-Justice, A., Goodwin, F. K., Duncan, W., & Gillin, J. C. (1979). Phase advance of the circadian sleep-wake cycle as an antidepressant. *Science*, *206*(4419), pp. 710–713.

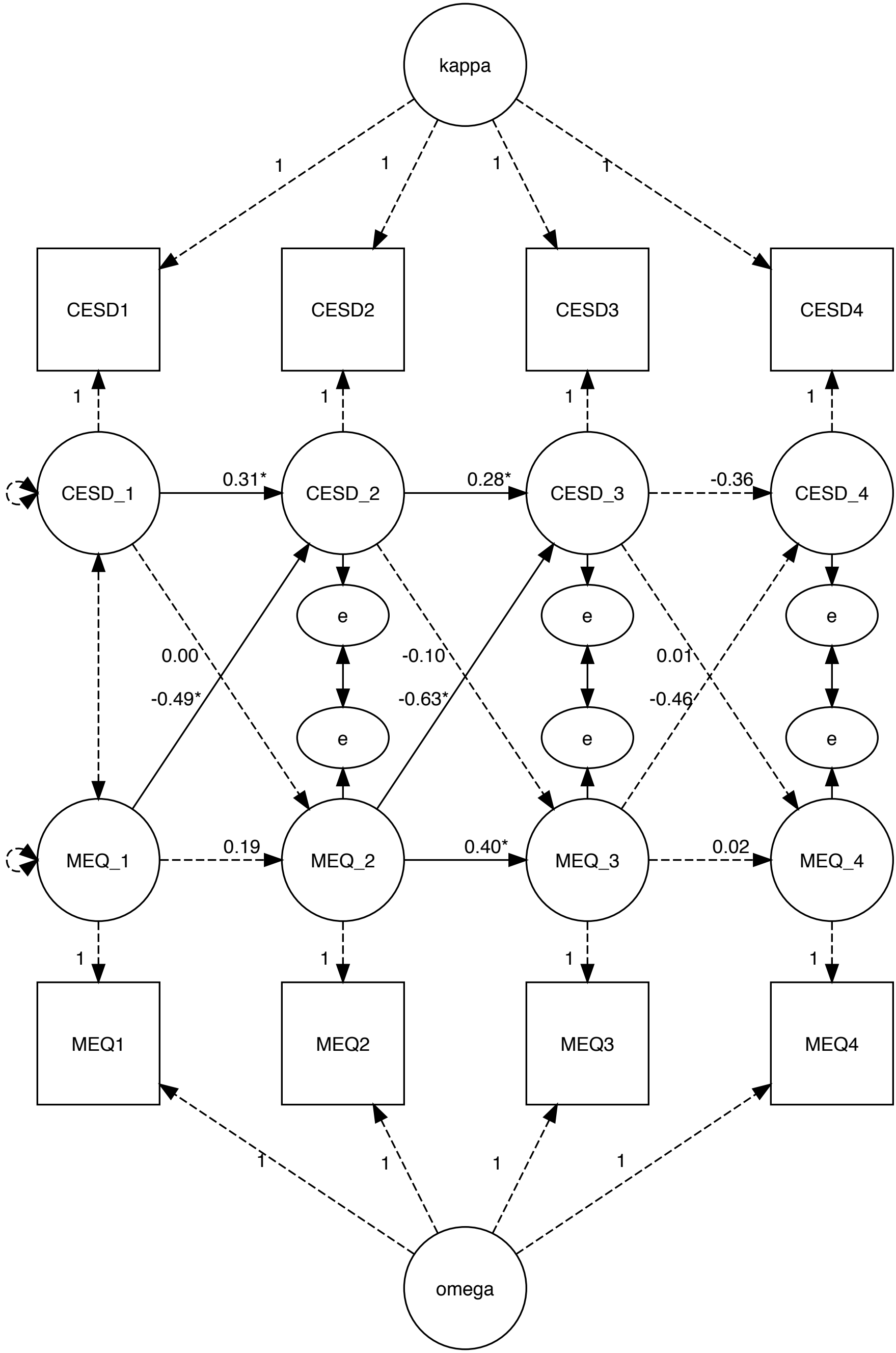
Weinstock, L. M., & Whisman, M. A. (2006). Neuroticism as a common feature of the depressive and anxiety disorders: a test of the revised integrative hierarchical model in a national sample. *Journal of Abnormal Psychology*, 115(1), pp. 68-74.

Wetzler, S., & Katz, M. M. (1989). Problems with the differentiation of anxiety and depression. *Journal of Psychiatric Research*, *23*(1), pp. 1–12.

Wirz-Justice, A. (2008). Biological Rhythms and Depression: Treatment Opportunities. *WPA Bulletin on Depression*, *13*(36).

Wittmann, M., Dinich, J., Merrow, M., & Roenneberg, T. (2006). Social Jetlag: Misalignment of Biological and Social Time. *Chronobiology International*, *23*(1-2), pp. 497–509.

Wolfson, A. R., & Carskadon, M. A. (2003). Understanding adolescent's sleep patterns and school performance: a critical appraisal. *Sleep Medicine Reviews*, *7*(6), pp. 491–506.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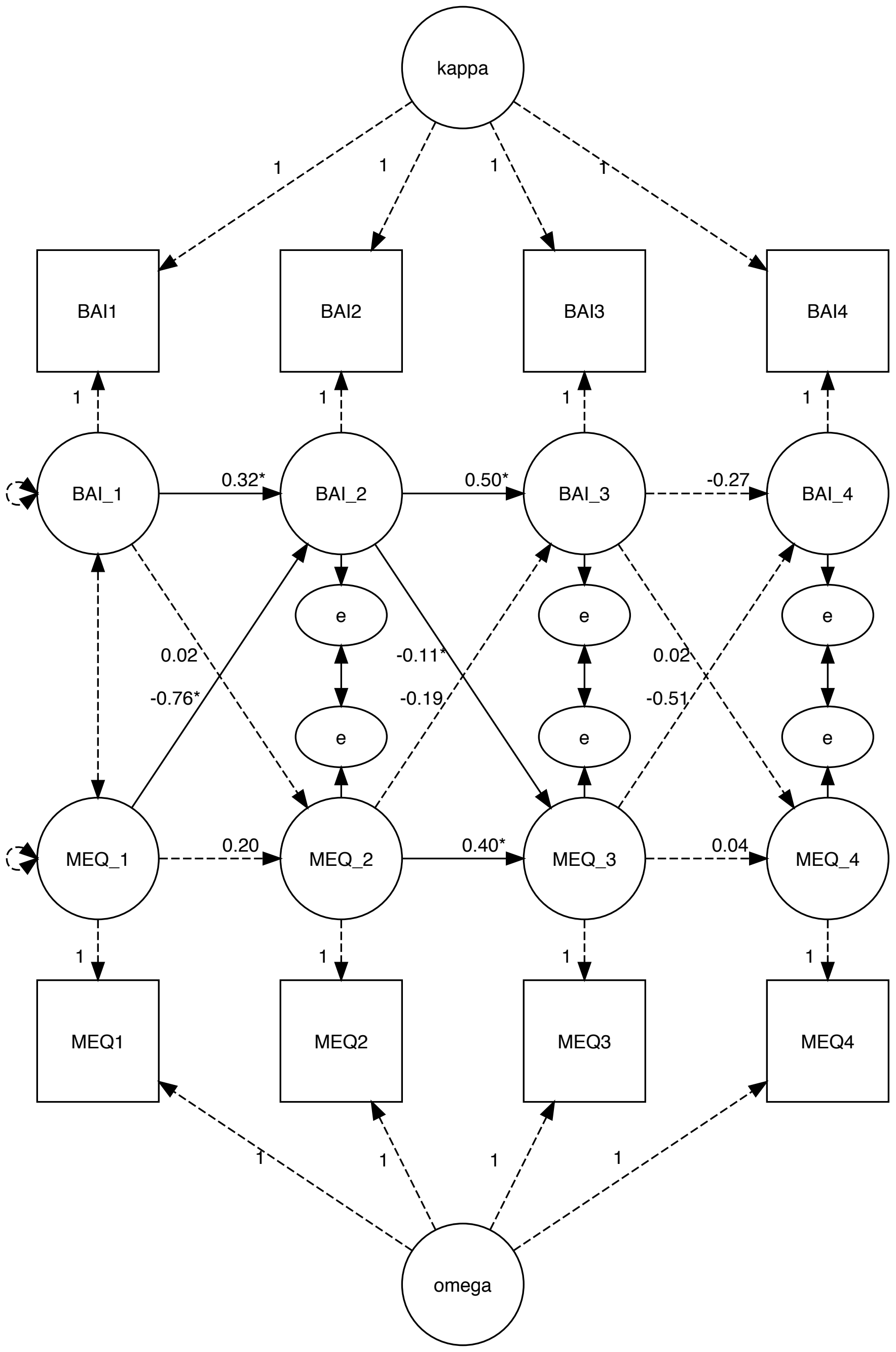
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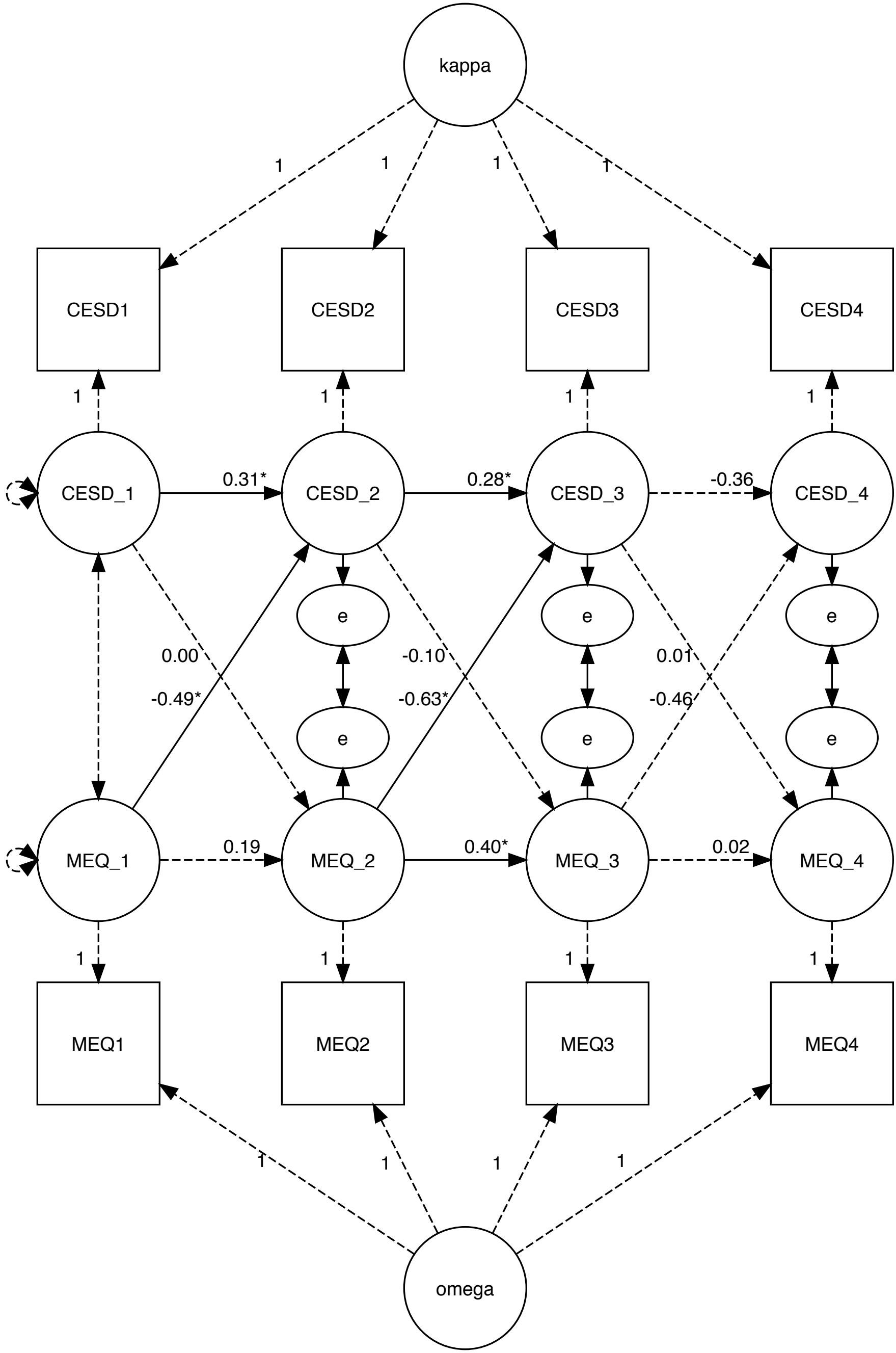
Table 1

Means, standard deviations, and correlations with confidence intervals for Morning Eveningness Scores (MEQ), Depression Scores (CESD), and Anxiety Scores (BAI), for all 4 time points.

Variable	*M*	*SD*	1	2	3	4	5	6	7	8
1. MEQ Time 1	14.70	3.10								
2. MEQ Time 2	12.40	2.85	.48** [.25, .67]							
3. MEQ Time 3	12.33	3.32	.55** [.39, .68]	.63** [.46, .76]						
4. MEQ Time 4	13.56	1.62	.16 [-.06, .37]	.31* [.04, .54]	.32** [.13, .49]					
5. CESD Time 1	30.83	9.23	-.09 [-.28, .11]	-.17 [-.39, .06]	.07 [-.12, .25]	-.06 [-.26, .14]				
6. CESD Time 2	29.20	7.66	-.21* [-.39, -.01]	-.15 [-.38, .08]	-.17 [-.35, .01]	-.10 [-.29, .11]	.51** [.36, .64]			
7. CESD Time 3	29.90	7.80	-.16 [-.35, .03]	-.35** [-.54, -.12]	-.25** [-.42, -.07]	-.01 [-.20, .19]	.30** [.13, .46]	.45** [.30, .59]		
8. CESD Time 4	31.75	8.82	.01 [-.18, .21]	.09 [-.14, .32]	-.03 [-.21, .16]	.07 [-.13, .26]	.04 [-.14, .22]	.10 [-.08, .28]	-.03 [-.21, .16]	
9. BAI Time 1	8.10	8.73	-.09 [-.29, .10]	-.13 [-.35, .11]	.06 [-.13, .24]	-.13 [-.32, .07]	.70** [.59, .78]	.54** [.40, .66]	.13 [-.05, .31]	.04 [-.15, .22]

10. BAI Time 2	9.36	8.42	-.32** [-.49, -.13]	-.22 [-.43, .02]	-.31** [-.47, -.13]	-.18 [-.36, .02]	.37** [.20, .52]	.72** [.62, .80]	.47** [.32, .60]	.08 [-.10, .26]
11. BAI Time 3	7.98	7.99	-.17 [-.36, .03]	-.28* [-.48, -.05]	-.15 [-.33, .04]	.04 [-.17, .23]	.23* [.05, .39]	.44** [.28, .57]	.63** [.51, .73]	-.09 [-.27, .09]
12. BAI Time 4	7.56	7.21	-.01 [-.21, .19]	.08 [-.16, .31]	-.16 [-.33, .03]	-.17 [-.35, .04]	-.08 [-.26, .10]	.09 [-.09, .27]	-.04 [-.22, .15]	.66** [.55, .75]

Note. M and *SD* are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. The confidence interval is a plausible range of population correlations that could have caused the sample correlation (Cumming, 2014). * indicates $p < .05$. ** indicates $p < .01$.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