Chronobiology International, Early Online: 1–10, (2014)

ISSN: 0742-0528 print / 1525-6073 online
DOI: 10.3109/07420528.2014.935786

informa
healthcare

ORIGINAL ARTICLE

The influence of sleep complaints on the association between chronotype and negative emotionality in young adults

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A great body of research indicates that eveningness is associated with negative psychological outcomes, including depressive and anxiety symptoms, behavioral dyscontrol and different health impairing behaviors. Impaired subjective sleep quality, increased circadian misalignment and daytime sleepiness were also reported in evening-type individuals in comparison with morning-types. Although sleep problems were consistently reported to be associated with poor psychological functioning, the effects of sleep disruption on the relationship between eveningness preference and negative emotionality have scarcely been investigated. Here, based on questionnaire data of 756 individuals (25.5% males, age range = 18–43 years, mean = 25.3 ± 5.8 years), as well as of the evening-type ($N = 211$) and morning-type ($N = 189$) subgroups, we examined the relationship among sleep problems, eveningness and negative emotionality. Subjects completed the Hungarian Version of the Horne and Östberg Morningness–Eveningness Questionnaire (MEQ-14), The Athen Insomnia Scale (AIS) and the Epworth Sleepiness Scale (ESS). Moreover, a composite score of Negative Emotionality (NE) was computed based on the scores of the Short Beck Depression Inventory (BDI-9), the Perceived Stress Scale (PSS-4) and the General Health Questionnaire (GHQ-12). Morning and evening circadian misalignment was calculated based on the difference between preferred and real wake- and bedtimes. Two possible models were tested, hypothesizing that sleep problems (circadian misalignment, insomniac symptoms and daytime sleepiness) moderate or mediate the association between eveningness and negative emotionality. Eveningness preference was correlated with increased NE and increased AIS, ESS and circadian misalignment scores. Our results indicate that eveningness-preference is an independent risk factor for higher negative emotionality regardless of the effects of age, gender, circadian misalignment and sleep complaints. Nevertheless, while chronotype explained ~6%, sleep problems (AIS and ESS) accounted for a much larger proportion (~28%) of the variance of NE. We did not find a significant effect of interaction (moderation) between chronotype and sleep problems. In contrast, insomniac symptoms (AIS) emerged as a partial mediator between chronotype and NE. These findings argue against the assumption that indicators of mental health problems in evening-type individuals can be explained exclusively on the basis of disturbed sleep. Nevertheless, negative psychological outcomes seem to be partially attributable to increased severity of insomniac complaints in evening-types.

Keywords: Chronotype, mediation, morningness–eveningness, negative emotionality, sleep

INTRODUCTION

Morningness–eveningness refers to inter-individual differences in diurnal rhythmicity (Horne & Östberg, 1977; Roenneberg et al., 2007). These include subjective aspects, such as preferred sleep and wake time, measures of alertness and mental performance (Carrier & Monk, 2000; Kyriacou & Hastings, 2010) and physiological markers of endogenous rhythmicity (Baehr et al., 2000; Duffy et al., 1999; Randler & Schaal, 2010). The individual variations in circadian rhythms seem to be influenced by genetic (Kyriacou & Hastings, 2010; Lázár et al., 2012), perinatal (Reppert, 1995) and to some extent also by environmental factors (Natale et al., 2002; Vollmer et al., 2012). Although morningness–eveningness is defined as a continuum, individuals can be categorized into different chronotypes: morning-type, intermediate or neither-type and evening-type (Prat & Adan, 2013), reflecting underlying genetic

Submitted March 13, 2014, Returned for revision June 13, 2014, Accepted June 13, 2014

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predispositions (Kyriacou & Hastings, 2010; Lázár et al., 2012). Research often focuses on the differences between morning and evening-type individuals. Morning-type individuals wake up early and perform mentally and physically at their best in the morning hours, compared to evening-types who find it difficult to get up in the morning. Accordingly, morning-types find it difficult to stay awake at late-night hours, in contrast to evening-types who plan their daily activities for the afternoon or evening, and prefer to stay out late (Taillard et al., 2003).

Morning- and evening-type individuals also exhibit differences in a wide range of psychological dimensions, such as temperament and character (Adan et al., 2010), thinking-style (Díaz-Morales & Escribano, 2013) or creativity (Giampetro & Cavallera, 2007). Recently, a growing number of studies suggest that evening-types are more susceptible to mental health problems, especially to depression (Levandovski et al., 2011; Merikanto et al., 2013) and more likely to report lower levels of psychological adjustment in comparison to morning-type individuals. For instance, in adolescent samples, evening-type individuals showed more emotional/behavioral problems and health impairing behaviors than morning-types (Hsu et al., 2012; Urbán et al., 2011). Similar findings emerged in a sample of college students, where eveningness correlated with lower scores of mental health (Prat & Adan, 2013), and also in older age groups, where eveningness was associated with lower psychological well-being (Lázár et al., 2012) and reduced positive affect (Biss & Hasher, 2012).

Evening-types were also reported to experience poor subjective sleep quality (Selvi et al., 2012), and the misalignment of circadian and social time, the so-called social jetlag, that was associated with daytime fatigue and emotional dysregulation (Levandovski et al., 2011). Moreover, eveningness is characterized by increased sleep ''debt'' especially during workdays (Taillard et al., 1999), that might be related to reduced homeostatic sleep regulation in evening-type individuals (Mongrain & Dumont, 2007). Poor sleep quality on the long term seems to impair emotional information processing (Soffer-Dudek et al., 2011), and predicts lower positive and increased negative daytime affect (McCrae et al., 2008). Moreover, sleep complaints are associated with a variety of mental health problems, psychological distress and negative emotional states (Baglioni et al., 2010; Lemola et al., 2013; Norlander et al., 2005; Stewart et al., 2011).

In light of these findings, it is reasonable to suggest that the relationship between eveningness and poor psychological functioning (which will be referred to as ''negative emotionality'' in the present article) is mediated partly by sleep disturbances. Nevertheless, results regarding the influence of sleep on the association between chronotype and negative emotionality are far from being uncontroversial. For example, some studies suggest, that poor sleep quality and social jetlag might explain the relationship between eveningness and negative psychosocial functioning (Levandovski et al., 2011; Roeser et al., 2012). More recently, Tavernier & Willoughby (2013) showed that good sleeper evening-types reported better intrapersonal adjustment relative to evening- and also morning-types with poor sleep quality. Moreover, good sleeper evening-type individuals reported equivalent values of psychological functioning to a good sleeper morning-type subgroup (Tavernier & Willoughby, 2013). On the other hand, other findings indicate that eveningness represents an independent risk factor of emotional dysfunctions (Giannotti et al., 2002; Selvi et al., 2012) or altered neural patterns in relation to emotional dysregulation (Hasler et al., 2012; Rosenberg et al., 2014).

In the present study, we aimed to examine the relationship among sleep problems (insomniac symptoms, circadian misalignment and daytime sleepiness), eveningness and indices of mental health problems (negative emotionality). More specifically, two possible models were tested, hypothesizing that sleep problems moderate (Cohen et al., 2003) or mediate (MacKinnon et al., 2002) the association between eveningness and negative emotionality. In our case, a significant effect of moderation would indicate the presence of an interaction between chronotype and sleep disturbances (for instance if evening-types with sleep complaints show relatively increased negative emotionality); while mediation analyses explores whether increased sleep-related problems in evening-type individuals account for the relationship between chronotype and negative emotionality.

METHODS

Participants and procedure

An online questionnaire was presented in the web page of a popular Hungarian psychological magazine for a 2-week time period as a study investigating individual differences in personality, sleep and affective states. The questionnaire was completed by 1156 adults. Subjects' data were excluded from subsequent analyses if they provided positive answers to any of the questions belonging to the exclusion criteria: (1) The occurrence of an extreme life-situation (e.g. accident, loss, trauma) that might influence daily-activities, affective states or sleep schedules in the last month. (2) The presence of diagnosed psychiatric or neurological disorder. (3) The presence of a chronic somatic illness that might affect diurnal rhythms and sleep patterns. After the exclusion criteria, 840 participants remained in the sample. The number of older subjects in our sample was relatively low and skewed towards the younger age range (under 45 years). Therefore, we decided to exclude older subjects in order to examine a sample with normally distributed age range. Moreover, chronotype varies with age, and according to a previous study, needs to be

defined differently in middle-aged (44–58 years) populations (Taillard et al., 2004), therefore, apart from the aim to normalize age distribution, in order to reduce the heterogeneity of our sample, we limited our analyses to an age range between 18 and 43 years. The 18–43 age range made up 90% of the previously included subjects ($n = 840$). This way, 756 completed questionnaires (25.5% males, age: 25.3 ± 5.8) remained in the final database. The study was approved by a local ethical review board and was conducted in accordance with the policies of international chronobiological standards (Portaluppi et al., 2010).

Instruments

Morningness–Eveningness (MEQ-14)

We applied the Hungarian version of the Horne-Östberg Morningness–Eveningness Questionnaire (Horne & Östberg, 1976; Zavecz et al., submitted manuscript). The original version is a widely used and reliable scale assessing individual differences in morningness–eveningness preference. The items, answered on a four-point Likert scale focus on subjective preferences of sleep–wake schedules, such as preferred rising and sleep times, peak times, morning freshness, as well as optimal time for intellectually or physically demanding activities. Higher scores indicate increased morningness. In the Hungarian version of the questionnaire, we used similar response options. The original scale was translated into Hungarian and after back-translation minor discrepancies were resolved. Since five items (6, 8, 12, 13 and 16) of the original scale showed relatively low (<0.3) item-total correlation coefficients, these were deleted from the questionnaire. Psychometric testing in order to establish the reliability and validity of the Hungarian version of the scale were performed and indicated that the MEQ-14 was a reliable (Cronbach $\alpha = 0.86$) and valid instrument in order to explore different chronotypes. These findings showed that the MEQ-14 could be used as a continuous measure, but it was also applicable for the differentiation of evening and morning chronotypes based on the first and the last quartiles of the MEQ scores, respectively (Zavecz et al., submitted manuscript). The internal consistency of the scale in the present study was high (Cronbach $\alpha = 0.8$).

Morning and Evening Misalignment

We created two additional scales resembling the first and the second item of the MEQ concerning preferred rise and sleep time, respectively. The questions were phrased and scored similarly to the items of the MEQ, but instead of asking about preferred rise and sleep time, subjects had to indicate their usual rise/sleep times on working days. Based on the difference scores between the preferred and real time schedules, we calculated a circadian misalignment score for the morning as well as for the evening. Higher scores indicated earlier wake up- and bedtimes, in comparison to preferred time schedules. Moreover, based on the answers to the items of usual sleep and rise times, we could estimate the time spent in bed (TIB), that we also included in our subsequent analyses.

Athens Insomnia Scale (AIS)

The AIS is a reliable and valid instrument that can be used in epidemiological studies for the measurement of insomnia (Soldatos et al., 2000). The first five items of the scale cover nigh-time symptoms such as increased sleep latency, nocturnal awakenings, perceived sleep duration, early-morning awakening and perceived sleep quality. The last three items refer to the daytime consequences of disturbed sleep (mood, performance and fatigue). The AIS showed acceptable sensitivity and specificity in order to identify possible cases of insomnia (Soldatos et al., 2003). The Hungarian adaptation of the questionnaire (based on the data of a large epidemiological study enrolling >12 000 individuals) proved to be a highly reliable and valid tool in order to assess insomniac symptoms and disrupted sleep in the adult population (Novak et al., 2004). The scale showed good internal consistency in the present study (Cronbach $\alpha = 0.77$).

Epworth Sleepiness Scale (ESS)

The ESS consists of eight items to be scored on a four-point Likert scale, and quantifies daytime fatigue and sleep pressure during different situations (e.g. reading, watching TV, having a conversation, after lunch and driving) (Johns, 1991). The ESS is a widely used questionnaire in clinical sleep research and an effective instrument in order to measure the severity of daytime sleepiness due to non-specific sleep disturbances (Baumgartel et al., 2013; Kyle et al., 2014; Spira et al., 2012). Higher ESS scores reflect the detrimental consequences of disturbed sleep and are indicative of underlying clinical sleep disorders (Johns, 2000). We used the Hungarian validation of the ESS (Novák, 2004) that showed acceptable internal consistency in our sample (Cronbach $\alpha = 0.64$).

Negative Emotionality

In order to measure the extent of mental health problems in general, we applied three well-validated and widely used questionnaires, measuring relatively different aspects of mental health. Subjects completed, the Hungarian version of the *General Health Questionnaire (GHQ-12)* (Balajti et al., 2007; Goldberg, 1992), a well-established scale in order to screen for psychological symptoms, with special focus on affective dysfunctions. The GHQ-12 is a reliable and valid scale with items related to depressive and anxiety symptoms and low self-esteem. The scale is used for representative epidemiological surveys assessing health problems in the Hungarian population, and showed good internal consistency and construct validity (Balajti et al., 2007). In a recent Spanish study, a longer version of the scale was associated to chronotype, with evening-type

subjects showing lower scores of mental health problems. The internal consistency of the scale in the present study was excellent (Cronbach $\alpha = 0.88$). Additionally, we used the nine-item *Beck Depression Inventory – Hungarian version (BDI-H)*, a one-dimensional scale assessing different symptoms of depression, including social withdrawal, indecision, sleep disturbance, fatigue, intense worry about bodily symptoms, work inhibition, pessimism, lack of satisfaction, self-accusation. The scale showed good psychometric properties in previous studies (Rózsa et al., 2001), and good internal consistency in the present study (Cronbach $\alpha = 0.83$). In order to measure the levels of chronic stress, we used the short version of the *Perceived Stress Scale (PSS-4)*. The PSS-4 is a reliable and valid instrument measuring current levels of stress and anxiety (Stauder & Konkoly-Thege, 2006). The scale proved to be a reliable instrument in the present study as well (Cronbach $\alpha = 0.81$).

Since the above scales measure different but related constructs, and showed very high correlations in our sample (Pearson $r = 0.63$–0.74), to reduce the number of statistical tests as well as to avoid redundancy in our analyses, we created a composite variable comprising the weighted scores of the three scales. A Principal component analysis indicated that the three variables could be grouped to one factor (the first factor accounted for 80% of the total variance). Variables were standardized and averaged with their respective factor loadings (−0.91, 0.89 and 0.86 for the GHQ-12, BDI-H and PSS-4 respectively) to form a composite score of *Negative Emotionality*.

Data analysis

First, we examined the associations between the scores of the applied scales. Given the large sample size, we examined the assumption of normality based on the skewness and kurtosis of the distributions. If the values of skewness and kurtosis ranged between −1 and +1, we computed the Pearson's, otherwise, we used the Kendall's tau-b correlation coefficients. Since the aim of the present study was to compare morning- and evening-type individuals, we selected a set of evening- and morning-type subjects based on the first and the last quartile of the MEQ-14 scores, respectively. This way, Morningness–Eveningness score was transformed into a binary variable (Evening-type = 1, Morning-type = 2), and the data of 400 subjects, 211 evening-type (67 males) and 189 (40 males) morning-type individuals were used in the subsequent analyses. In order to measure relationships of chronotype and sleep complaints with negative emotionality, we applied a hierarchical linear regression analysis, with Negative Emotionality as criterion, age and gender as control variables, and chronotype, circadian misalignment (Morning and Evening), time in bed (TIB), sleep complaints (AIS and ESS) as predictor variables, that were entered in consecutive steps. In order to examine the effects of moderation (interaction between chronotype and sleep complaints), we followed the procedure described by Cohen et al. (2003): the continuous variables were centered, and interaction (product) terms with the chronotype factor were computed (Chronotype × Morning Misalignment, Chronotype × Evening Misalignment, Chronotype × TIB, Chronotype × AIS, Chronotype × ESS). These product terms were entered in the final step of the regression model. Although the main focus of our analyses was to compare the two extremes of diurnal preferences, we computed the same regression models (main effects and product terms) entering the MEQ-14 score as a continuous predictor variable using the data of the whole sample ($n = 756$). Mediation analyses were carried out by three separate Sobel tests (MacKinnon et al., 2002), with Chronotype (Evening-type and Morning-Type) as the independent, Negative Emotionality as the outcome, and circadian misalignment, AIS and ESS scores as mediator variables, respectively. Path coefficients between the mediators and the outcome variable were controlled for all the other predictors (e.g. age and gender); and Bonferroni correction ($p = 0.05/3 = 0.017$) for multiple comparisons was applied.

RESULTS

Associations among variables

Correlation coefficients and p values for all variables are presented in Table 1. Morningness–Eveningness negatively correlated with Morning and Evening Misalignment, indicating higher circadian misalignment in evening-type individuals. Specifically, eveningness was associated with earlier than preferred wake up times, and earlier than preferred bedtimes, the later presumably reflecting a compensation for sleep ''dept''. Moreover, eveningness preference was associated with increased insomniac symptoms (AIS) and increased Negative Emotionality (NE). Morningness–Eveningness was not associated with Time spent in Bed. As predicted, NE was positively correlated with the AIS as well as the ESS scores.

Hierarchical linear regression and moderation analysis

The results of the different regression models are summarized in Table 2. We examined the main effects as well as the interactions of our variables on NE scores based on the data of morning- and evening-type individuals ($N = 400$). The control variables, gender and age (Step 1) were not significant predictors of NE. In Step 2, Chronotype was entered in the equation, and showed a significant association with NE, explaining ~6% of the total variance. (Evening-type was characterized by higher NE scores.) The addition of Morning Misalignment, Evening Misalignment and Time spent in Bed (Step 3) as independent factors slightly improved the model, according to the explained variance (Table 2). Within this model, Chronotype was

TABLE 1. Correlation coefficients and p values among the examined variables ($N = 756$).

1. MEQ-14	2. MM	3. EM	4. TIB	5. AIS[a]	6. ESS	7. NE
1.	−0.21 ($<1^{-6}$)	−0.19 ($<1^{-6}$)	0.06 (NS)	−0.16 ($<1^{-6}$)	−0.05 (NS)	−0.20 ($<1^{-6}$)
2.		0.36 ($<1^{-6}$)	−0.59 ($<1^{-6}$)	0.08 (9^{-3})	0.06 (NS)	0.04 (NS)
3.			0.15 ($<1^{-6}$)	−0.02 (NS)	−0.01 (NS)	−0.01 (NS)
4.				−0.09 (3^{-3})	−0.04 (NS)	−0.04 (NS)
5.[a]					0.16 ($<1^{-6}$)	0.39 ($<1^{-6}$)
6.						0.23 ($<1^{-6}$)

[a]Kendall's tau-b coefficient.

SD, standard deviation; MEQ-14, Morningness–Eveningness Questionnaire (Hungarian version); MM, Morning Misalignment; EM, Evening Misalignment; TIB, Time spent in bed; AIS, Athen Insomnia Scale; ESS, Epworth Sleepiness Scale; NE, Negative Emotionality; NS, not significant.

TABLE 2. Hierarchical linear regression analysis with Chronotype as a binary variable ($N = 400$). Dependent Variable: Negative Emotionality. The summary of different models (steps) as well as regression coefficients and p values of the entered variables are presented below.

Entered variables (adjusted R^2 and significance of the model)	Standardized beta	p Value
Step 1: $R^2 = 0.003$; $p =$ NS		
Gender	0.05	NS
Age	−0.08	NS
Step 2: $R^2 = 0.065$; $p < 0.0001$		
Gender	0.08	NS
Age	−0.05	NS
Chronotype	−0.26	<0.0001*
Step 3: $R^2 = 0.074$; $p < 0.0001$		
Gender	0.08	NS
Age	−0.08	NS
Chronotype	−0.28	<0.0001*
Morning Misalignment (MM)	−0.18	0.02
Evening Misalignment (EM)	0.04	NS
Time spent in Bed (TIB)	−0.13	<0.05
Step 4: $R^2 = 0.353$; $p < 0.0001$		
Gender	0.05	NS
Age	−0.09	0.03
Chronotype	−0.14	0.001*
MM	−0.16	0.013
EM	0.06	NS
TIB	−0.06	NS
AIS	0.51	<0.0001*
ESS	0.11	0.008*
Step 5: $R^2 = 0.349$; $p < 0.0001$		
Gender	0.05	NS
Age	−0.09	0.03
Chronotype	−0.14	0.002*
MM	−0.34	NS
EM	0.10	NS
AIS	0.56	<0.0001*
ESS	0.19	NS
Chronotype × MM	0.16	NS
Chronotype × EM	−0.12	NS
Chronotype × TIB	0.12	NS
Chronotype × AIS	−0.05	NS
Chronotype × ESS	−0.08	NS

*Significant after Bonferroni correction.

AIS, Athen Insomnia Scale; ESS, Epworth Sleepiness Scale; MM, Morning Misalignment; EM, Evening Misalignment; TIB, Time spent in bed.

significantly associated with NE scores and Morning Misalignment and Time spent in Bed showed a trend. When variables assessing sleep complaints (AIS and ESS) were entered (Step 4), the explained variance increased substantially (with 28%). In the fourth equation, Chronotype, insomniac symptoms (AIS) and sleepiness (ESS) scores were significant predictors of Negative Emotionality and Morning Misalignment ($p = 0.013$) and age ($p = 0.03$) showed a marginally significant contribution. Morningness, earlier than preferred wake up times and age were negatively associated to NE scores while AIS and ESS scores were positively associated. In the final equation (Step 5), we added the product (interaction) terms of Chronotype and circadian misalignment scores, of Chronotype and Time spent in Bed as well as of Chronotype and variables assessing sleep complaints (AIS and ESS). The change of explained variance from the fourth (main effects) to the fifth (moderation) model was not significant. Chronotype and AIS yielded significant main effects, but none of the interaction terms were significant. The best equation (Step 4) explained 35% of the total variance, and indicated that Chronotype was significantly associated with Negative Emotionality even if we controlled for age, gender, circadian misalignment, Time spent in Bed and sleep complaints (Figure 1). Similar findings emerged when we computed the same models in the whole sample ($n = 756$) using the continuous Morningness–Eveningness score (MEQ-14). Results of the hierarchical regression analyses are detailed in Table 3. Significant predictors of Negative Emotionality were MEQ-14, AIS and ESS scores, and age showed a trend. None of the interaction terms emerged as significant predictors. The best model (Step 4) explained 33% of the total variance, and indicated that morningness preference (as a continuous variable) and age were negatively associated to Negative Emotionality scores while insomniac symptoms and daytime fatigue were positively associated.

Mediation analysis

The change in the regression coefficient of Chronotype (Table 2) after controlling simultaneously for circadian misalignment, TIB and sleep complaints suggests that the later variables might mediate the relationship

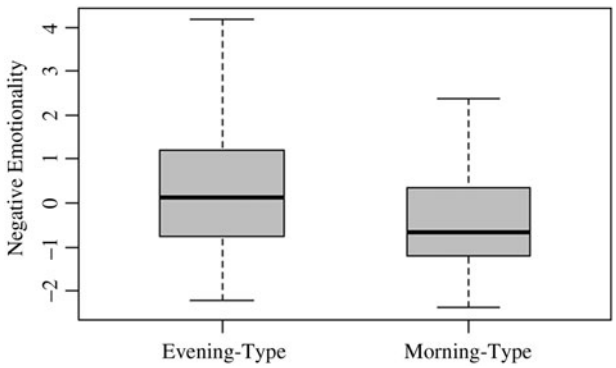

FIGURE 1. Adjusted Scores of Negative Emotionality in Evening- and Morning-type individuals after controlling for age, gender, circadian (Morning and Evening) misalignment, time in bed and sleep complaints (insomniac symptoms and sleepiness). Morning-types showed increased scores of Negative Emotionality in contrast to Evening-types ($F = 10.3$, $p = 0.001$). Black lines represent the medians, grey boxes the first and third quartiles, whiskers show the lowest data point within 1.5 inter-quartile range of the lower quartile, and the highest data point within 1.5 inter-quartile range of the upper quartile.

between Chronotype and Negative Emotionality. Therefore, we performed separate models of mediation (MacKinnon et al., 2002), with three different mediators between Chronotype (the independent variable) and Negative Emotionality (the outcome variable). We applied the Sobel test of mediation for those variables that were significant predictors (AIS, ESS) in the fourth Model of the regression analyses or showed a trend (MM).

The findings indicate that only insomniac symptoms emerged as a significant partial mediator of the relationship between Chronotype and Negative Emotionality. According to the separate Sobel tests, the indirect effect of Chronotype to Negative Emotionality through AIS ($z = -4.7$, $p < 0.0001$) was significant (Figure 2), but through MM ($z = -1.29$, $p = 0.19$) and ESS it was not ($z = -0.88$, $p = 0.36$).

The proportion of the total effect of Chronotype on Negative Emotionality that was attributable to the significant mediator (AIS) was 51% (see Figure 3 for a detailed representation of the mediated effect; Fritz & MacKinnon, 2008).

TABLE 3. Hierarchical linear regression analysis with Morningness–Eveningness as a continuous variable ($N = 756$). Dependent Variable: Negative Emotionality. The summary of different models (steps) as well as regression coefficients and p values of the entered variables are presented below.

Entered variables (adjusted R^2 and significance of the model)	Standardized beta	p Value
Step 1: $R^2 = 0.008$; $p = 0.018$		
Gender	0.08	NS
Age	−0.07	NS
Step 2: $R^2 = 0.044$; $p < 0.0001$		
Gender	0.09	0.01
Age	−0.05	NS
MEQ-14	−0.2	<0.0001*
Step 3: $R^2 = 0.044$; $p < 0.0001$		
Gender	0.09	0.01
Age	−0.05	NS
MEQ-14	−0.21	<0.0001*
Morning Misalignement (MM)	−0.04	NS
Evening Misalignment (EM)	−0.03	NS
Time in Bed (TIB)	−0.05	NS
Step 4: $R^2 = 0.333$; $p < 0.0001$		
Gender	0.04	NS
Age	−0.07	0.02
MEQ-14	−0.09	0.003*
MM	−0.06	NS
EM	0.02	NS
TIB	−0.03	NS
AIS	0.52	<0.0001*
ESS	0.12	<0.0001*
Step 5: $R^2 = 0.329$; $p < 0.0001$		
Gender	0.04	NS
Age	−0.07	0.02
MEQ-14	−0.09	0.005*
MM	−0.07	NS
EM	0.01	NS
AIS	0.52	<0.0001*
ESS	0.12	<0.0001*
MEQ-14 × MM	0.04	NS
MEQ-14 × EM	−0.03	NS
MEQ-14 × TIB	0.03	NS
MEQ-14 × AIS	−0.002	NS
MEQ-14 × ESS	−0.008	NS

*Significant after Bonferroni correction.

AIS, Athen Insomnia Scale; ESS, Epworth Sleepiness Scale; MEQ-14, Morningness–Eveningness Questionnaire; MM, Morning Misalignment; EM, Evening Misalignment; TIB, Time spent in Bed.

DISCUSSION

The aim of the present study was to examine the influence of sleep disturbances on the relationship between chronotype and mental health problems. A great body of research has indicated that evening-type individuals were characterized by impaired psychosocial functioning in comparison with morning-type individuals (Biss & Hasher, 2012; Hsu et al., 2012; Lázár et al., 2012; Merikanto et al., 2013; Prat & Adan, 2013). In line with previous findings, we showed that eveningness was associated with increased negative emotionality, increased insomniac complaints and daytime sleepiness. Eveningness was also correlated with increased circadian misalignment: evening-type individuals seemed to exhibit earlier than preferred wake- and bedtimes. The correlation between morning and evening misalignment scores might indicate the subjects' effort to compensate for the early awakenings by going to bed earlier, relative to their preferred schedules. Presumably, due to this effort morningness–eveningness was not associated with the time spent in bed.

Although research has consequently demonstrated an association between eveningness and different sleep complaints (Levandovski et al., 2011; Selvi et al., 2012; Taillard et al., 1999), relatively few studies investigated the contribution of disrupted sleep to the association between chronotype and mental health outcomes. Here, we showed that evening chronotype *per se* was an independent risk factor of higher negative emotionality, regardless of the effects of age, gender, circadian misalignment, time spent in bed and sleep complaints. Nevertheless, the chronotype factor explained a relatively low amount (6%) of the variance of negative emotionality score. In contrast, sleep complaints (insomniac symptoms and daytime sleepiness) accounted for a large part (28%) of the variance. These results resemble the findings of an earlier study among adolescents, in which an independent but small effect of evening preference, and an independent but relatively much greater effect of sleep problems on emotional adjustment was reported (Giannotti et al., 2002). Our findings argue against the assumption that negative psychological indices in evening-type individuals can be explained exclusively on the basis of disturbed sleep characteristics (Roeser et al., 2012; Wittmann et al., 2006). On the contrary, chronotype and sleep complaints were independently associated with negative emotionality: Eveningness preference and sleep complaints were predictive of increased negative emotionality. We should note however, that the applied questionnaires, the Athen Insomnia Scale and the Epworth Sleepiness Scale were designed to measure the clinically relevant features of disordered sleep. Therefore, we cannot exclude the possibility that more subtle, clinically non-relevant differences in sleep characteristics between chronotypes might explain the relationship between eveningness and psychological complaints (Tavernier & Willoughby, 2013). Although, our findings indicate that chronotype was associated with negative emotionality regardless of the effects of circadian misalignment, the time spent in bed and sleep complaints, it is still possible that other (not examined) sleep related measures (sleep duration, subjective sleep quality and attitudes towards sleep) might have influenced the main effect of chronotype.

Moreover, the unique role of chronotype in the association with mental health problems remains to be unexplained. Interestingly, while diurnal preferences are related to mental health problems, a genetic determinant of morningness–eveningness preference (the variable number tandem repeat polymorphism in the PERIOD3 gene) did not affect measures of mental health outcomes (Lázár et al., 2012). Evening- and morning-type individuals might exhibit differences in several domains other than the timing of sleep and daily

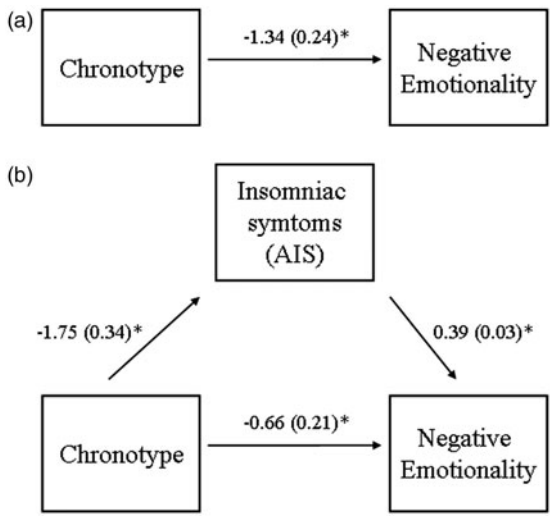

FIGURE 2. Total effect (a) and indirect and direct (b) effects with insomniac symptoms as a mediator of Chronotype on Negative Emotionality. Path coefficients (Unstandardized *B* values) and SEs are presented. Asterisks indicate significance level of $p < 0.0001$. The estimates between the variables are controlled for age, gender and circadian misalignment.

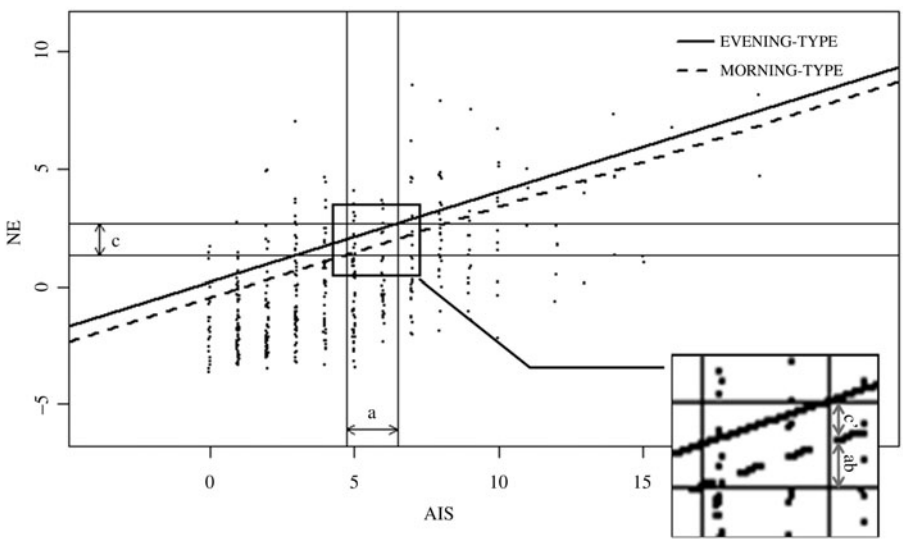

FIGURE 3. Graphical representation of the mediated effect. Independent variable: Chronotype. Mediator: Athen Insomnia Scale (AIS). Outcome: Negative Emotionality (NE). Arrows represent the total effect of Chronotype on NE (c), the effect of Chronotype on AIS scores (a), the indirect (ab) and the direct effect (c′). (Overlapping data points are slightly jittered on the *x*-axes for better visualization). The plot was designed following the description of Fritz & McKinnon (2008).

activities, therefore future studies are warranted to explore other underlying (biological, psychological or even social) factors that might contribute to emotional vulnerability in different circadian phenotypes.

Our findings indicate that evening-type individuals reporting insomniac symptoms and daytime sleepiness are specifically vulnerable for the presence of mental health problems (depressive and anxiety symptoms). These results are in coherence with an earlier study reporting relatively more severe waking distress in evening-type insomniac patients than expected in association with the severity of insomniac complaints (Ong et al., 2007). Based on the findings of Ong et al. (2007), an interaction between eveningness preference and insomnia could be assumed, suggesting that eveningness might exacerbate the detrimental effects of impaired sleep quality (or the other way around: insomniac complaints might exacerbate the negative consequences of eveningness.) Nevertheless, we did not find an interaction between chronotype and the extent of circadian misalignment or the time spent in bed, or between chronotype and sleep complaints (insomniac symptoms and daytime fatigue) either.

Although chronotype emerged as an independent predictor of negative emotionality in the regression analyses, the slope of the regression line (Standardized Beta value of Chronotype) has changed considerably after controlling for sleep complaints (insomnia and daytime fatigue). This indicates, that sleep disturbances might partially mediate the relationship between eveningness preference and mental health problems. Accordingly, mediation analyses indicated that the presence of insomniac symptoms partially mediated the association between chronotype and negative emotionality. In contrast, daytime fatigue and circadian misalignment did not emerge as mediators between the above variables. Negative emotionality in evening-type individuals seemed to be partially (~50%) attributable to increased severity of insomniac complaints. Our findings accentuate the relevance of assessing the severity of insomniac complaints, especially in subjects with eveningness preference who are more vulnerable for the development of mental health problems and maladaptive, health-impairing behaviors (Urbán et al., 2011). The investigation of the association between chronotype, sleep problems and related waking dysfunctions might also facilitate the development of more personalized preventive programs and interventions.

Some limitations of the study should be considered. First, our sample cannot be considered representative for the population, and due to the readership of the online magazine might have included several participants with special interest about and attention to psychological processes. More importantly, we did not control for the confounding effects of alcohol consumption. Although the relationship between diurnal preference and alcohol consumption is not fully conclusive (Haraszti et al., 2014; Tavernier & Willoughby, 2013), it is possible that increased alcohol intake in evening-type individuals might influence insomniac symptoms and negative emotionality.

Moreover, the cross-sectional nature of our study design does not allow for causal inferences. Longitudinal investigations, and more preferentially, studies involving special intervention programs (e.g. sleep hygiene) among subjects with different chronotypes might shed more light on the causal relationship between chronotype, sleep quality and psychosocial outcomes. Similarly, future studies with experimental manipulations and more objective measurements (e.g. with actigraphy or polysomnography) of sleep architecture in subgroups with different diurnal preference are warranted.

DECLARATION OF INTEREST

The authors report no conflict of interest. The authors alone are responsible for the content and writing of this article. This research was realized in the frames of TÁMOP 4.2.4. A/1-11-1-2012-0001 ''National Excellence Program – Elaborating and operating an inland student and researcher personal support system''. The project was subsidized by the European Union and co-financed by the European Social Fund.

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