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# An in-depth look into the association between morningness–eveningness and well-being: evidence for mediating and moderating effects of personality

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## ABSTRACT

Morningness–eveningness and standard personality traits are associated with well-being but few studies have directly compared the two types of construct as correlates of life satisfaction. Influences on well-being common to both chronotype and personality may include shared biological bases for depression and sleep disturbance, tendencies toward social jetlag, and emotion-regulation mechanisms. The current study tested mediation and moderation hypotheses in a sample of 379 Polish adults. The first hypothesis was that conscientiousness and emotional stability traits would mediate the relationship between morningness and life satisfaction. Consistent with previous results, morningness, the two personality traits, and satisfaction tended to be mutually positively correlated. A multiple mediation analysis showed that both traits partially mediated the morningness–satisfaction association. Data are compatible with morningness influencing personality development adaptively, although other causal hypotheses could be advanced. The second hypothesis was that extraversion would moderate the association between chronotype and satisfaction. This hypothesis was supported, with extraverted evening types showing disproportionately high life satisfaction, whereas introverted evening types showed the lowest levels of satisfaction. Level of extraversion may influence whether or not evening types choose to engage in adaptive social activities that boost well-being during the evening hours. Results demonstrate the importance of investigating both chronotype and personality in studies of well-being.

## ARTICLE HISTORY

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## KEYWORDS

Chronotype; morningness–eveningness; well-being; life satisfaction; personality; extraversion; conscientiousness; emotional stability

## Introduction

Human diurnal rhythms can be described with reference to a central dimension termed morningness–eveningness. It is often viewed as a continuum which reflects individual variation in diurnal preferences (Natale and Cicogna 2002). However many authors endorse a typological approach, distinguishing between Morning-types (M-types, colloquially labeled as “larks”), who are situated on one extreme of the continuum, and Evening-types (E-types, also named “owls”) located on the opposite end. The majority of the adult population are actually Neither-types (N-types) which means that they lack any marked diurnal preference (Adan et al. 2012). Larks are characterized by earlier than average bed and rise hours, achievement of their peak mental and physical performance earlier in the day (Adan et al. 2012) and more regular sleep-wake habits than “owls” (Ishihara et al. 1987).

Individuals with different chronotypes vary also in several biological and psychological characteristics. For instance, Griefahn and Robens (2008) observed “larks” showing higher cortisol levels after awakening which may enable them to feel less tired in the morning and prepare better for the day than “owls” (Adan et al. 2012). On the other hand, E-types exhibit a later circadian body temperature phase and a higher amplitude in its fluctuation which explains why they manifest higher tolerance for shiftwork than “larks” (Adan et al. 2012). Many studies also describe the relationships between chronotype and various individual differences, including personality traits (Randler 2008), cognitive capacity (Preckel et al. 2011), time perspectives (with elevated future orientation in M-types; Stolarski et al. 2013) and emotional intelligence (with E-types manifesting higher ability-based EI than M-types; Stolarski and Jankowski 2015).

Diurnal preferences are reflected visibly in people's social functioning habits. M-types experience their peak earlier in the day; hence, they are better adapted to perform at school or work. By contrast, E-types are often forced to act at non-optimal times of the day. This divergence between social requirements and biological tendencies (referred to as "social jet lag") experienced by E-types, results in maladaptive strategies of affect regulation (drinking alcohol, smoking, using drugs) (Wittman et al. 2006). On the other hand, E-types reach the acrophase of their functioning much later in the day (e.g., Jankowski and Ciarkowska 2008), and feel far more comfortable when participating in activities taking place in the evening or at night. This time of day is in the vast majority of cultures typically spent on social activities, meeting with friends, parties, and the like. Individual differences research has tended to focus on personality factors such as extraversion and agreeableness as influences on social behavior (DeYoung et al. 2013). However, the confounding of different forms of social behavior with time of day implies that personality and chronotype may interact to affect social adaptation.

### **Chronotype and personality**

Associations between chronotype and personality have been examined using various temperamental and personality models. Temperamental individual differences emerge early in life and are the basis through which character dimensions develop during life (Cloninger 1994). For example, Strength of Inhibition (an ability to restrain oneself from changing activity or to attenuate responses to internal stimuli) proved to be significantly correlated with morningness (Mecacci and Rocchetti 1998). Inhibition is an indicator of temperamental effortful control, which in turn forms the basis for development of the conscientiousness trait from the Five Factor Model (FFM: Rothbart et al. 2009). Among all personality correlates of chronotype, it is conscientiousness that is considered the most powerful and best empirically supported (Adan et al. 2012; Hogben et al. 2007; Lipnevich et al. 2017; Tonetti et al. 2009). Morningness is also associated with various dimensions that are conceptually associated with conscientiousness,

such as proactivity (Randler 2009), future time perspective (Stolarski et al. 2013), constraint (Bullock et al. 2017), or low procrastination (Díaz-Morales et al. 2008).

As further discussed below, morningness tends to be associated with greater well-being and reduced vulnerability to depression (e.g., Jankowski 2014). Thus, it is expected to correlate negatively with personality traits associated with negative affectivity and stress vulnerability, such as neuroticism. Adan's (2012) review of relevant studies using the Eysenck (1967) neuroticism scales showed mixed results, with positive, negative, and null associations reported. By contrast, studies using FFM scales reported a mixture of null findings and negative morningness–neuroticism associations. Lipnevich and colleagues (2017) conducted a meta-analysis of FFM correlates that treated morningness and eveningness as separate dimensions. Neuroticism was negatively associated with morningness, but unrelated to eveningness.

Another personal trait examined in relation to M–E dimension is extraversion. The results were inconsistent in different studies. For example, Jackson and Gerard (1996) found E-types to be marginally more extraverted than M-types. Adan and colleagues (2012) suggest that the effects may depend on various theoretical models used to assess personality (Randler 2008). Lipnevich and colleagues (2017) found that extraversion was associated with eveningness but not morningness. Furthermore, a deeper dive into the extraversion dimension can clarify the matter. According to the Five Factor Model, extraversion consists of 6 facets. One of them, impulsivity, appear to be responsible for the relationship between eveningness and extraversion in some studies while another one—activity—can explain the morningness and extraversion relationship in others (Adan et al. 2012). Impulsivity, which is typical for E-types, is usually seen as dysfunctional regarding self-regulation processes. It may enable "owls" (however, in a rather unhealthy way) to cope with "social jetlag". Activity, on the other hand, correlates positively with the persistence component of the Temperament and Character Inventory (Zuckerman and Cloninger 1996), which is also characteristic for M-types (e.g., Lee et al. 2017). These two contrary associations may be

responsible for the fact that most studies did not found a relationship between extraversion and chronotype (Adan et al. 2012). Present-Hedonistic time perspective (reflecting a present-focused, pleasure-oriented, risk-taking attitude to life), a dimension markedly associated with extraversion, mainly via its excitement seeking facet (Kairys and Liniauskaite 2015), also proved to be a vital predictor of eveningness (Stolarski et al. 2013).

In sum, morningness is reliably associated with higher conscientiousness and lower neuroticism, as well as more narrowly-defined traits conceptually linked to these Big Five factors. Other FFM traits are more weakly associated with chronotype, if at all, although there may be some associations between morningness and specific facets of extraversion, both positive and negative.

### ***Chronotype and emotional functioning***

In general, M-types show greater emotional adjustment than E-types (Diaz-Morales et al. 2015; Jankowski 2014), including reduced vulnerability to depression (Antypa et al. 2016; Hasler et al. 2010; Jankowski 2016), and other mental and medical health issues (Partonen 2015). E-types also score higher on factors related to maladaptive emotional regulation including impulsivity (Adan et al. 2010; Selvi et al. 2010) and drinking alcohol and smoking cigarettes (Adan 1994). A recent large-scale epidemiological study (Knutson and von Schantz 2018) showed that, with demographic and lifestyle factors controlled, eveningness was associated with both psychological disorders as well as physical health conditions including neurological disorders and diabetes. These factors may contribute to the small but significant association between eveningness and mortality from all causes also found in the study.

Morningness–eveningness is also associated with individual differences in diurnal variation in mood. E-types typically experience poorer moods during the working day, but this association may disappear (Jankowski and Ciarkowska 2008) or even reverse (Matthews and Wells 1988; Stolarski et al. 2016) in the evening. The influence of morningness–eveningness may vary with different mood dimensions. Stolarski et al. (2016) found

that M-types experienced generally better moods at 0800 hours. However, at 2200 hours, morningness was associated with lower energetic arousal and poorer hedonic tone, but was not significantly correlated with tense arousal.

There may be several mechanisms contributing to the affective correlates of morningness–eveningness. Behavior genetic studies suggest a biological basis for the trait; a recent twin study found that it shares a significant amount of underlying genetic variance with depression (Toomey et al. 2015). There may be a reciprocal relationship between neural circadian pacemakers and depression (Hidalgo et al. 2009). That is, the pacemaker may influence depression, but depressive symptoms such as sleep disturbance may feed back to further impair pacemaker functioning. Therefore, vulnerability to emotional disorder may in part be intrinsic to eveningness. Second, as we mentioned above, “owls” struggle with “social jet lag” and may experience greater social stress in consequence. Social jet lag refers to the discrepancy between circadian and social clocks resulting from variation in the sleep-wake cycle across weekdays and weekends (Wittman et al. 2006). It is linked to various symptoms of poor mental and physical health (e.g., Takahashi et al. 2018). E-types, who may be prone to a forward phase-shift in sleep at the weekends, are more likely to experience social jet lag (Díaz-Morales and Escribano 2015).

Third, M-types may regulate emotion more effectively than E-types (Watts and Norbury 2017). This hypothesis suggests that E-types should be lower in emotional intelligence (EI), representing a general ability to monitor and manage emotions, but data suggest a more complex relationship. Antúnez and colleagues (2013) demonstrated in their study, using a self-report measure of EI, that M-types perceive themselves as better emotionally adapted than E-types. However, the results were opposite when a performance-based test was applied: Stolarski and Jankowski (2015) hypothesized that since EI is considered a domain of crystallized intelligence and E-types tend to score slightly higher in IQ tests (Preckel et al. 2011; Roberts and Kyllonen 1999), they may also perform better in ability-based EI measures. To avoid the risk of assessing only self-beliefs but not one’s actual abilities, the

performance Test of Emotional Intelligence (TIE; Śmieja et al. 2014) was used. The results differed depending on the subscales; for instance, “owls” exhibited greater ability to recognize their own and other’s emotions, and to interpret and understand them (Stolarski and Jankowski 2015). On the other hand, there was no significant difference between M- and E-types in assimilating and managing emotions. E-types’ elevated emotional abilities of emotional perception and understanding may prove useful mostly in the evening when they experience social interactions and activities (Stolarski and Jankowski 2015), potentially contributing to elevated mood at this time. Stolarski and colleagues (2016) reported a negative association between morningness and ability EI, using the TIE. They also showed that EI moderated associations between morningness–eveningness and mood at different times of day, implying that the two factors may influence common mood-regulative processes.

Overall, M-types tend to be happier and better-adjusted than E-types according to multiple criteria for well-being. The benefits of morningness may derive from several sources, including neural bases for affect and sleep behavior, freedom from social jetlag, and superior emotion-regulation, although E-types may be superior in emotion perception and understanding.

### **Chronotype and life satisfaction**

Life satisfaction represents a longer-term evaluation of personal well-being than emotional states and includes both affective and cognitive elements (Pavot and Diener 2008). As previously discussed, M-types exhibit better mood in the morning (Díaz-Morales et al. 2015; Jankowski and Zajenkowski 2016) and consequently during the majority of the day (Jankowski and Ciarkowska 2008). The repeated experience of positive moods is likely to feed into greater life satisfaction. In addition, M-types are likely to manage the challenges and opportunities of life more effectively, due to their greater conscientiousness, inhibition, and proactivity (Randler 2009). Better adjustment to work and other social environments is likely to foster greater satisfaction. Furthermore, morningness is positively related to Future Time Perspective which is reflected in a capacity to plan

for long-term personal success and to refrain from instant pleasure (Stolarski et al. 2013) resulting in higher life satisfaction (Zhang et al. 2013).

“Larks” also develop a more balanced time perspective, which means that they can more effectively adapt their perception of time to different life challenges—balanced time perspective remains a vital predictor of subjective well-being, explaining as much as 40% of its variance (Zhang et al. 2013). This ability to behave in a more harmonious, organized and healthier way seems consistent with the notion that morningness is positively related to subjective well-being and positive affectivity (Biss and Hasher 2012). Similarly, a study by Randler (2008) found a small positive association between morningness and satisfaction with life ( $r = .177$ ). The result has been replicated in Polish (Jankowski 2012) and Spanish (Díaz-Morales et al. 2013) samples. Thus, consistent with the preceding section on emotional well-being, M-types also show higher affective and cognitive satisfaction with life, compared to E-types.

### **Personality and life satisfaction**

There has been extensive research on personality and life satisfaction within the framework of the FFM. The most reliable findings, supported by meta-analysis (Steel et al. 2008), are that satisfaction relates positively to extraversion and negatively to neuroticism. These associations in part reflect temperament-based associations between these traits and positive and negative affectivity, respectively (Watson 2000), which may in turn reflect individual differences in brain reward and punishment systems (Corr 2009). Neuroticism is also associated with numerous indices of poorer mental and physical health (Lahey 2009). Studies of the Five Factor Model also implicate higher conscientiousness and agreeableness in well-being (Soto 2015; Steel et al. 2008).

Beyond basic brain influences, cognitive and social processes may also partially mediate associations between traits and satisfaction. Both extraversion and low neuroticism are associated with more constructive appraisals of challenging events, preference for adaptive coping strategies, more effective strategies for mood-regulation, and higher trait emotional intelligence (Carver and Connor-Smith 2010; Matthews et al. 2009;

Petrides et al. 2007). Greater engagement in social activities may also promote well-being in extraverts (Matthews et al. 2009), whereas high neuroticism individuals are prone to social dysfunction. More adaptive times perspectives may also contribute to associations between personality traits and well-being. Zhang and Howell (2011) reported partial mediation of the personality (neuroticism and extraversion)--life satisfaction associations by time perspectives (past-negative, past-positive, present-hedonistic and future), though both the Five Factor Model (FFM) and dimensions of time perspective predicted unique parts of the variance in satisfaction. Similar findings were reported by Stolarski and Matthews (2016).

Thus, individuals high in extraversion, conscientiousness and agreeableness, as well as those low in neuroticism, resemble morning types in experiencing higher life satisfaction and well-being. Personality and chronotype are psychometrically distinct constructs, but there is likely some degree of overlap in the processes shaping well-being that are sensitive to morningness--eveningness and FFM traits, and research is needed to distinguish their respective influences.

### Present study

Chronotype is related both to personality traits and to life satisfaction. Since personality factors associated with morningness--eveningness dimension are also directly linked to subjective well-being, they may be also responsible for the higher levels of life satisfaction of M-types. The strongest correlation between chronotype and personality trait was observed for conscientiousness and was replicated in many studies (Adan et al. 2012; Lipnevich et al. 2017). "Larks" appear to be generally more conscientious (Randler 2008) and less neurotic (Hsu et al. 2012) in comparison to "owls". Low conscientiousness and high neuroticism also were shown to be crucial predictors of poor sleep (Duggan et al. 2014), which remains one of the most maladaptive features of evening chronotype (particularly during weekdays; Vitale et al. 2015). Sleep quality, more than quantity, is a significant

predictor of various aspects of well-being (Pilcher et al. 1997). We presume that elevated happiness in M-types may not result directly from their morningness, but can be explained by these personality traits. We expected that (H1) conscientiousness and emotional stability mediate the relationship between morningness and subjective well-being.

Morningness--eveningness may also interact with dispositional social tendencies to affect well-being. M-types achieve their peak performance effectiveness earlier in the day (Horne and Ostberg 1976) and therefore they are more adapted to benefit from activities that require being "an early bird", i.e., attending school, studying, working etc. (Stolarski et al. 2013; Wittman et al. 2006). Judging from the fact that M- and E-types vary in their acrophases, the predictors of life satisfaction in the two types are likely to differ as well. If conscientiousness appears to be the trait critical for "larks", which helps them to regulate behavior adaptively and hence to be "happier", an analogous trait which favors "owls" should also exist. In case of E-types, extraversion may play a key role in moderating their hedonistic orientation and preference for late-hours activities. It is likely that this trait is much more adaptive for leisure social functioning than it is at work or school (where conscientiousness and emotional stability are fundamental; see Hurtz and Donovan 2000; O'Connor and Paunonen 2007). In this context, extraversion may be crucial for "owls" to improve daily mood and then to achieve higher and more stable life satisfaction, through benefiting from evening social activities such as parties and leisure time with friends. Extraverts may possess greater social skills and motivations (Matthews et al. 2009) but they require the greater night-time energy (Stolarski et al. 2016) and mood-regulation capabilities (Stolarski and Jankowski 2015) to translate social competencies into more adaptive outcomes from evening social encounters.

Given the inconsistency in studies of extraversion and eveningness (Adan et al. 2012), we did not expect that extraversion would mediate associations with well-being. Instead, we tested a moderator hypothesis, i.e., that extraversion would be more strongly associated with well-being in

E-types than in M-types. We expected that (H2) chronotype moderates the relationship between extraversion and subjective well-being.

## Methods

### Measures

*Chronotype* was assessed using the Composite Scale of Morningness (CSM; Smith et al. 1989) translated to the Polish language by Jankowski (2015a). CSM consists of 13 items constituting the morningness–eveningness continuum. Morningness is indicated by higher scores, whereas eveningness (lower morningness) is indicated by lower scores. The Cronbach  $\alpha$  for the Polish adaptation of CSM was .84 (in the present study: .88).

*Big Five personality traits* were measured with the Polish adaptation (Strus et al. 2017) of the 50-item set of International Personality Item Pool Big Five Factor Markers (IPIP-BFM-50) questionnaire (Goldberg 1992). The measure comprises five subscales: extraversion, agreeableness, conscientiousness, emotional stability and intellect/imagination and has five-point Likert-type response format, from 1-very inaccurate to 5-very accurate. Psychometric properties of the Polish version were tested on a large sample, showing sufficient internal consistency (Cronbach  $\alpha$ s ranging from .73 to .91) and proper convergent validity (associations with other established Big Five measures).

*Life satisfaction* was measured with the Satisfaction with Life Scale (SWLS; Diener et al. 1985) translated into Polish by Jankowski (2015b). SWLS contains five items scored with a 7-point Likert scale. Lower satisfaction with life is indicated by lower scores of the SWLS. The internal

consistency of the SWLS assessed by the Cronbach  $\alpha$  was .86 (in the present study: .88).

### Participants and procedure

All subjects gave a written, informed consent to participate in the study. The research was conducted with accordance with international ethical standards (Portaluppi et al. 2010) and approved by the institutional review board of the Faculty of Psychology at the University of Warsaw. The sample was nonclinical and consisted of 130 men and 249 women, aged between 18 and 69 years ( $M = 36.2$ ,  $SD = 13.0$ ). Participants filled the abovementioned set of self-report measures of personality, chronotype and well-being. The subjects were rewarded with 40 PLN (equivalent of 10 USD).

## Results

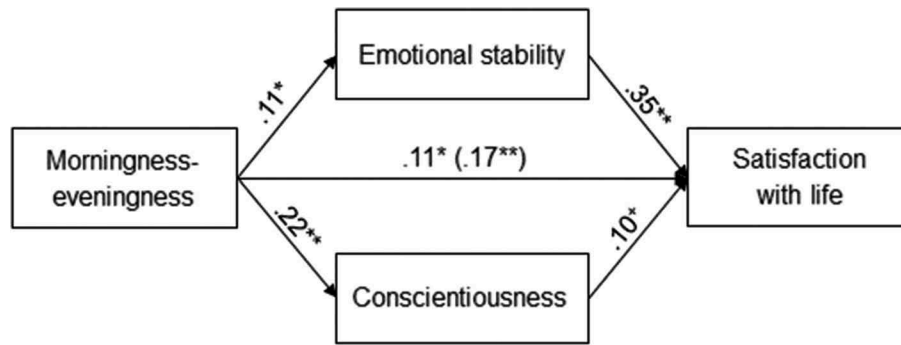
Descriptive statistics, reliabilities of applied measures, as well as Pearson's correlations between measured variables are provided in Table 1.

The correlational analyses showed that morningness was associated with modestly greater life satisfaction (.17). The result was thus in line with earlier research reports (e.g., Jankowski 2012; Randler 2008). Furthermore, three of the Big Five personality traits proved significantly associated with M–E, namely: Conscientiousness, emotional stability, and Intellect/imagination. All five personality traits were significantly related to well-being, however, as in most studies, the greatest effects were observed for extraversion and emotional stability (see, e.g., Costa and McCrae 1980).

**Table 1.** Means, standard deviations, Cronbach's  $\alpha$  and Pearson's correlation coefficients between gender, morningness–eveningness (M–E), life satisfaction (SWLS), and Big Five personality traits (IPIP-BFM-50) (below the diagonal) and respective partial correlations controlling for age and gender (above the diagonal).

	<i>M</i>	<i>SD</i>	$\alpha$	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. Gender	–	–	–									
2. Age	36.23	13.02	–									
3. M–E	34.82	7.60	.88	–.07	.22**	–	.17**	–.02	–.07	.22**	.11*	–.17**
4. SWLS	19.57	6.37	.88	–.01	–.20**	.11*	–	.33**	.15**	.20**	.38**	.10
5. Extraversion	33.32	7.99	.88	–.01	.04	–.01	.32**	–	.23**	.19**	.31**	.34**
6. Agreeableness	38.99	5.93	.81	.30**	–.02	–.10	.15**	.22**	–	.20**	.10	.35**
7. Conscientiousness	34.68	6.92	.81	.11*	.09	.22**	.18**	.20**	.22**	–	.22**	.10*
8. Emotional stability	28.06	7.78	.87	–.21**	.10	.14**	.34**	.31**	–.01**	.20**	–	–.04
9. Intellect	36.06	5.82	.74	–.09	–.31**	–.22**	.15**	.31**	.31**	.06	–.05	–

Note.  $N = 379$ ; \*  $p < .05$ ; \*\*  $p < .01$  (two tailed).



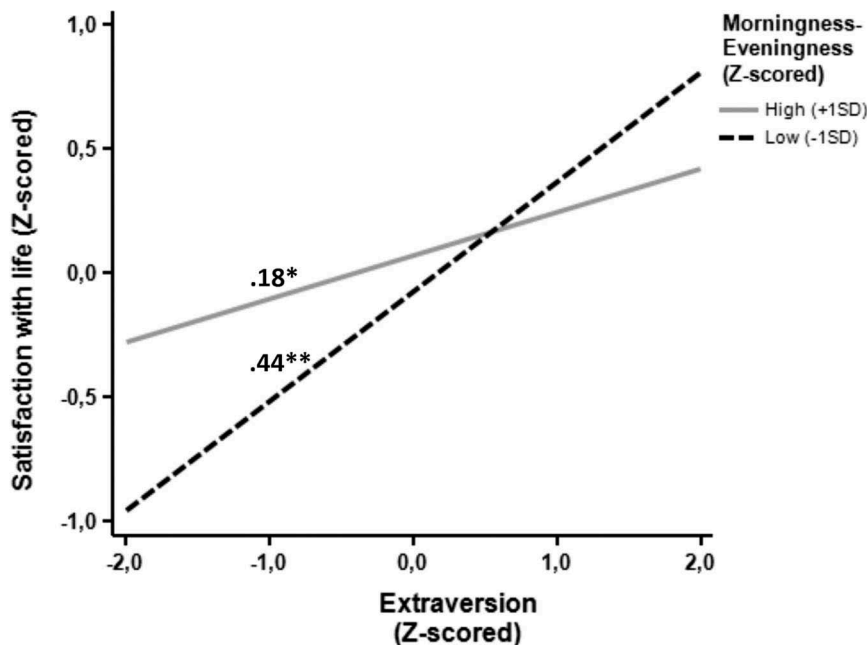
**Figure 1.** Mediation of the association between morningness–eveningness and satisfaction with life by emotional stability and conscientiousness (controlling for gender and age). Note. +  $p = .05$ , \*  $p < .05$ , and \*\*  $p < .01$ .

In order to test the first hypothesis, we have conducted a multiple mediation analysis, with the two hypothesized mediators—emotional stability and conscientiousness—using Hayes’ PROCESS macro for SPSS for Windows (see Figure 1). Age and gender were introduced as control variables.

The analysis revealed that both emotional stability and conscientiousness acted as mediators in the association between morningness and life satisfaction. The total indirect effect amounted to .06, (95% confidence intervals: .01–.06). The individual mediator effects were as follows: .04 for conscientiousness (95% CI: .00–.08) and .02 for emotional stability (95% CI: .00–.05). The latter effect was marginally significant. The ratio of

indirect to total effects amounted to .34; thus, approximately a third part of the effect may be explained with personality. In all, we may conclude that the results supported hypothesis 1. However, it should be emphasized that the mediation, albeit clearly significant, remains only partial.

In order to test the second hypothesis we have conducted a moderation analyses using Hayes’ PROCESS macro for SPSS for Windows. The regression model including morningness, extraversion and interaction term, and controlling for age and gender, proved significant,  $F(5, 373) = 16.98$ ,  $p < .001$  and explained 18.5% of variance in life satisfaction. Effects of extraversion and morningness were both significant ( $\beta = .33$ ,  $p < .001$ , and



**Figure 2.** Morningness–eveningness as a moderator of the association between extraversion and satisfaction with life. Note. \*  $p = .01$  and \*\*  $p < .0001$ .



$\beta = .16, p < .01$ , respectively), as was the interaction term,  $\beta = -.10, p < .05$ . The analyses revealed that the positive effect of extraversion on well-being increases with eveningness (see Figure 2 for the graphical presentation of the effect). Thus, hypothesis 2 was also supported.

In order to provide a deeper insight into the obtained interaction effect, a floodlight technique (Spiller et al. 2013) was applied. The method tests the effect of primary predictor on the dependent variable at all levels of the moderator (i.e., from low to high scores on moderator). To identify Johnson–Neyman region(s) of the moderator where the effect of the primary variable was (non)significant, Hayes (2013) PROCESS software was applied. Results of the analysis are provided in Figure 3. The floodlight technique revealed that the Johnson–Neyman point (i.e., the threshold for significance of the respective effect) was located at 1.22 SD in morningness. Above this value of moderator (i.e., in individuals with high morning preference), extraversion was not related to well-being.

Given the importance of conscientiousness as a possible mediator of the benefits of morningness, a similar analysis was run to test for moderator effects of this trait. No such effects reached significance, indicating that high conscientiousness is

positively associated with life satisfaction irrespective of chronotype.

## Discussion

The present study aimed to investigate the interplay between personality and chronotype in predicting satisfaction with life. Based on previous research, three personality dimensions were expected to play a significant role in these interactions. Conscientiousness and emotional stability were hypothesized to mediate the association between morningness–eveningness and life satisfaction. The mediation effect proved indeed significant but it explained less than half of the effect of diurnal preference, with conscientiousness being a more powerful predictor (.04) than emotional stability (.02). Extraversion was identified as a possible moderator of the chronotype–well-being association and this hypothesis was also supported: the predicted interaction effect was clearly significant and the association between extraversion and life satisfaction was significantly greater in individuals with higher levels of extraversion than in their introvert counterparts.

In the introduction, we identified three mechanisms that may contribute to associations between eveningness and low well-being: biological



**Figure 3.** Estimated simple effects of extraversion on Satisfaction with life for different levels of moderator (morningness–eveningness). Note. LLCI and ULCI = lower and upper levels for confidence intervals. Regions for which the effect is not significant are shadowed in gray.

elements of the trait associated with depression and sleep-disturbance (Toomey et al. 2015), social jetlag (Wittman et al. 2006), and poorer emotion-regulation (Watts and Norbury 2017). All three types of mechanism may also contribute to the mediating effects of personality. First, conscientiousness and low neuroticism are the two FFM factors that best predict good sleep hygiene and sleep quality (Duggan et al. 2014). Common biological bases for chronotype and these personality traits may contribute to these associations. Second, the association between eveningness and social jetlag is evident even in preschool children attending kindergarten or childcare centers (Doi et al. 2015), as well as in older, school-age children (Díaz-Morales and Escribano 2015), raising the possibility that social jetlag may influence personality development. Relationships between standard personality traits and social jetlag have been rather neglected, although Randler (2008) reported a negative conscientiousness–jetlag correlation. Future research could test whether childhood jetlag tends to increase neuroticism and decrease conscientiousness. Third, while relationships between morningness–eveningness and emotion-regulation are somewhat complex, eveningness is associated with some generally maladaptive strategies such as greater use of suppression and reduced cognitive reappraisal (Watts and Norbury 2017). Neuroticism and low conscientiousness also tend to be associated with maladaptive emotion-regulation (Ioannidis and Siegling 2015), including in children (Gresham and Gullone 2012). Again, the chronotypes associated with these traits may be one factor that contributes to these associations.

The lack of full mediation suggests that other potential links between M–E and well-being should be taken into consideration. First, additional personality dimensions derived from different theoretical models (such as impulsivity, Selvi et al. 2015; or Dark Triad traits, see Jonason et al. 2013) could capture the unexplained portion of variance in life satisfaction. Other mechanisms separate from personality may also contribute to this effect. Probably the most obvious of such mechanisms is diurnal variation in daily activities; for example, M-types may in some circumstances perform better at work and in school (e.g., Preckel

et al. 2013, whereas eveningness may be associated with an unhealthy lifestyle (Urbán et al. 2011).

The second hypothesis was supported as well. Chronotype moderated the relationship between extraversion and subjective well-being. The analysis showed that the positive effect of extraversion on well-being increases with eveningness but is not significant in individuals with elevated levels of morning preference. Previous studies have suggested a robust association between extraversion and greater life satisfaction (Steel et al. 2008). However, further analysis of the interaction showed that being extraverted only serves “owls” and—to a lesser degree—neither-types, but does not matter for “larks” when it comes to subjective well-being. The moderation effect can be also viewed from a different angle: among extraverts, “owls” proved generally happier than “larks”. Strikingly, the typical positive association between morningness and life satisfaction (Díaz-Morales et al. 2013) appeared to reverse for the most extraverted individuals.

The moderator effect raises two linked questions. First, why is extraversion substantially linked to well-being in E-types, but is less important for M-types? Second, why are extraverted E-types so happy, given that eveningness is typically linked to lower well-being? The answer to the first question may relate to the unstructured nature of evening social activity. For most adults, social behavior during the earlier part of the day is structured around work or educational schedules. Assuming that activities in this part of the day are the primary driver of adaptive outcomes in M-types, the role of extraversion may be reduced (though not entirely eliminated). Both introverted and extroverted “larks” may generally benefit from a stable lifestyle centered on work or school activities, with extraverts enjoying some extra satisfaction from the biological and cognitive characteristics of the trait (e.g., Watson 2000). However, in the evening social activities are more dependent on the individual’s voluntary choices, and so there may be more variation in outcome, depending on personality.

Extraverts tend to have stronger social motivations and larger social networks, contributing to their greater well-being (Zhu et al. 2013). Extraverted E-types may thus be especially likely to take advantage

of the social opportunities of the evening hours (Matthews and Harley 1993). Social integration and social support, along with low levels of negative social interaction are well-established influences on well-being (Cohen 2004). Thus, the high satisfaction of extraverted E-types may in part reflect the advantages of a vibrant social life. Other factors may also play a part. Extraverts typically cope more effectively than introverts with stress (Carver and Connor-Smith 2010), so that extraverted E-types may manage social jetlag more effectively than introverted E-types. On the other hand, given that both extraversion (Graham et al. 2017) and eveningness (Adan et al. 2010) are associated with impulsive behaviors, one might suspect a high-risk downside to the combination of these traits, which is not evident in the present life satisfaction data. Possibly, the elevated ability-based emotional intelligence (Stolarski et al. 2016) that is characteristic of E-types restrains reckless behaviors in social contexts.

Social opportunities that may be more available to E- than to M-types include those for sexual activity, which shows its major circadian peak in the evening (Jankowski et al. 2014). Matchock (2018) confirmed that E-types report higher levels of sexual activity, stronger dispositions toward casual sex, and greater interest in uncommitted sex. It is also well-established that extraversion is associated with greater sexual activity (Heaven et al. 2003), including high risk activities (Graham et al. 2017). In a study restricted to men Randler et al. (2012) found that both extraversion and eveningness were associated with mating success, although they did not test for interaction between the factors. Randler et al. (2012) fitted a model to their data which showed that both traits influenced mating success directly, and indirectly, via a propensity to stay out late. A further study of both genders demonstrated that eveningness was associated with willingness to engage in uncommitted sexual relations (Randler et al. 2016). Sexual satisfaction contributes to general well-being in both genders (Stephenson and Meston 2015). Thus, extraverted E-types may be the individuals most likely to seek and obtain sexual partners, raising their life satisfaction.

By contrast, introverted E-types may not capitalize on social opportunities. The evening hours provide scope for choosing solitary leisure activities which may be less beneficial to well-being than socializing. Such activities include computer gaming. Problematic

behaviors such as excessive time spent gaming are associated with lower life satisfaction, lower sociability, and lower social support in both adolescents and adults (Festl et al. 2013). Computer game addiction is associated with both introversion, and, in a study of adolescents, with eveningness (Vollmer et al. 2014). While more research is needed on causal processes linking pathological gaming to lower satisfaction (Lemmens et al. 2011), excessive computer gaming provides a possible example of a maladaptive way of occupying time in the evening that introverted E-types may favor.

Morningness and conscientiousness appeared to have additive rather than interactive effects on life satisfaction, as shown in the moderator analysis, implying that conscientiousness may be beneficial regardless of time day. Presumably, high conscientiousness supports better adaptation to both work/study activities earlier in the day and to leisure activities later in the day.

Even though the present study was conducted on a substantial number of participants, there are some limitations that need to be mentioned. The study has all the limitations typical for cross-sectional designs, e.g., it can test whether relationships between variables are compatible with theory but not causal hypotheses. Limitations particular to self-report measurement should also be pointed out, as at least some of the associations reported here may be inflated by shared evaluative biases (Schimmack et al. 2008). Substantiating the explanations we have suggested for the observed relationships between chronotype and life satisfaction requires assessment of variation in activities and their outcomes at different times of day. Moreover, within the sample there was uneven representation of age groups (greater number of young adults), and females were overrepresented, although these factors were controlled in all relevant analyses.

In conclusion, the present analyses help to better understand the relationships between chronotype, personality and well-being. Pathways through which chronotype and personality traits may influence life satisfaction include common biological bases, vulnerability to social jetlag, and emotion-regulation. The linear models analyzed here are compatible with chronotype influencing personality development, but other causal models including reciprocal relationships between the two constructs could also be investigated.

We attributed the moderator effect of extraversion on its role in shaping whether or not E-types choose to spend the evening hours in adaptive social encounters.

Further studies should attempt to replicate these results on more age- and gender-balanced samples. They may also expand analyses adding other personality traits or testing mediation models including other established chronotype correlates such as time perspectives or emotional intelligence, that have proven to be associated with both chronotype and various aspects of well-being (Antúnez et al. 2013; Stolarski et al. 2016, 2013; Zhang et al. 2013). It would be also interesting to determine whether the moderating effect of extraversion is unique for this dimension, or if it is associated with a broader range of related variables, such as sensation seeking (Aluja et al. 2003), or present-hedonistic time perspective (Stolarski and Matthews 2016). Finally, future studies could address in greater depth the chronobiology of individual difference factors. Bullock et al. (2017) found that chronotype relates not only to circadian phase, but also to internal phase angle, i.e., the timing of sleep relative to phase. Individual differences might be characterized in terms of parameters of biomathematical models that include processes for circadian variation along with wake-sleep behavior, supporting a deeper understanding of how chronotype and personality may jointly influence well-being.

## Disclosure Statement

The authors report no conflict of interest.

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