Original Article

The Role of Morningness and Endurance in Mood and Attention During Morning and Evening Hours

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Abstract. This study aimed at testing the effects of morningness-eveningness and endurance on mood and selective attention during morning and evening hours. University students ($N = 80$) completed the Polish version of the Morningness-Eveningness Questionnaire, the Formal Characteristics of Behaviour-Temperament Inventory, and two testing sessions scheduled during the morning and evening hours. Each testing session consisted of completing the UWIST Mood Adjective Checklist composed of three scales: energetic arousal (EA), tense arousal (TA), and hedonic tone (HT), and a computerized visual search task. Without consideration of morningness and endurance, a time-of-day effect appeared in the visual attention but not in affect: participants were more accurate and faster in the evening than in the morning. Considering morningness and endurance, neither of them influenced the selective attention but they did influence mood. Morningness influenced diurnal variations in EA and HT in such a way that from morning to evening hours, morning chronotypes showed a decrease and evening types an increase in EA and HT. During morning hours, morningness was related to higher EA and HT and lower TA, but endurance was not. During evening hours, morningness was unrelated to mood, but endurance was linked to higher EA. It is concluded that morningness and endurance impact mood differently throughout the day, with the role of morningness decreasing and the role of endurance increasing as the day progresses.

Keywords: chronotype, owls and larks, Regulative Theory of Temperament, time of day, affect

Morningness-eveningness, also termed chronotype, describes individual differences in functioning at different times of day. In more morning oriented people, as compared to evening ones, phases of circadian rhythms are shifted toward earlier hours and this shift is considered a temperamental trait with probably the best evidenced biological basis among various traits studied in the field of differential psychology. Individual differences in chronotype can be observed not only in human beings, but also in animal world, for instance, in other mammals (e.g., rodents; Vivanco, Rol, & Madrid, 2010), birds (Lehmann, Spoelstra, Visser, & Helm, 2012), or insects (Vaze, Kannan, Abhilash, & Sharma, 2012). Genetic factors explain around 50% of the variance in human morningness-eveningness (Koskenvuo, Hublin, Partinen, Heikkilä, & Kaprio, 2007), and they are related to polymorphisms in clock genes (Pedrazzoli et al., 2010). On the physiological level, evening oriented individuals, as compared to morning ones, have longer period of the free running intrinsic circadian rhythm (*tau*) (Emens et al., 2009) generated by the biological clock – anatomical structure located in the suprachiasmatic nuclei (Dijk & Lockley, 2002); the same location of biological clock and relationships between *tau* and chronotype are also observed in animals (Sládek, Polidarová, Nováková, Parkanová, & Sumová, 2012). In people with longer free running *tau* (exceeding typical value of 24.2 hr) activity and sleep tend to drift toward later hours, particularly when they are released from social obligations (e.g., on free days). Among other biological determinants of morningness-eveningness, the role of age is well proven; during adolescence a shift toward eveningness is observed, and then a shift back to morningness from early adulthood to old age appears (Jankowski, 2015).

Chronotype is also influenced by environmental factors, with light being the best documented agent both in human beings (Jankowski, Vollmer, Linke, & Randler, 2014; Roenneberg, Kantermann, Juda, Vetter, & Allebrandt, 2013) and animals (Vivanco et al., 2010). Apart from ongoing influences of light on circadian functioning, some effects of postnatal light exposure have been reported (Tonetti, Fabbri, Martoni, & Natale, 2011). Also, social activity has been recognized as an important synchronizer, even in animals (Favreau, Richard-Yris, Bertin, Houdelier, & Lumineau, 2009), but recently it was argued that the action of social *Zeitgeber* is actually mediated by light exposure (Roenneberg et al., 2013), for example, people forced to go to work early in the morning are exposed to early sunlight, what shortens their *tau* to 24 hr. Overall, morningness-eveningness meets requirements to be considered a temperamental trait (Strelau, 2008), that is, has well-established biological background, exists in animal world, though it can be partly influenced by environmental factors.

Morningness has been related to a number of individual characteristics, such as a better school performance

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(Escribano, Díaz-Morales, Delgado, & Collado, 2012), a more stable sleep schedule (Sukegawa et al., 2009), shorter ideal sleep length, lower sleep deficit (Oginska et al., 2010), and lower sleepiness during the first half of the day (Di Milia, Folkard, & Walker, 2011). With particular consistency, morning oriented people have shown inclinations to more advantageous mood. Evening subjects, as compared to morning oriented individuals, have exhibited more depressive symptoms, in healthy individuals (Haraszti et al., 2014; Hidalgo et al., 2009) and in clinical conditions, such as bipolar I disorder (Ahn, Chang, Joo, Kim, & Lee, 2008), major depression (Hasler, Buysse, Hupfer, & Germain, 2010; Selvi et al., 2010), and seasonal affective disorder (Johansson et al., 2003). A more nuanced description of affective experience could be inferred from studies considering basal mood dimensions. A three-dimensional conceptualization of mood, namely the framework developed by Matthews, Jones, and Chamberlain (1990), showed three separate dimensions of mood: energetic arousal (EA; energetic-tired), tense arousal (TA; nervous-relaxed), and hedonic tone (HT; pleasant-unpleasant), all of them related to morningness in such a way that evening subjects, as compared to morning individuals, exhibited lower EA and HT and higher TA (Jankowski, 2014) – a depression-like profile of mood (Gozdzik-Zelazny, Borecki, & Pokorski, 2011). However, more detailed studies, using a time-of-day paradigm, revealed that eveningness was related to the above mood profile in the morning, but during the evening hours morning chronotypes were losing their affective advantage over evening chronotypes (Adan & Guardia, 1993; Jankowski & Ciarkowska, 2008). It is, however, surprising that evening chronotypes did not display a better mood in their preferred evening hours, as compared to the morning chronotypes (Jankowski & Ciarkowska, 2008). This raises the question of whether there exist other individual characteristics affecting the mood experienced during later hours of the day.

Among the above three mood dimensions, the most robust differences between chronotypes appeared in EA, which was also the only affective dimension showing a time shift between chronotypes (i.e., earlier peak in morning chronotypes than in evening types; Jankowski & Ciarkowska, 2008). This particular importance of EA for differentiation between chronotypes entails further question: whether cognitive performance and particularly attention varies between chronotypes in a manner similar to that observed for EA. Namely, EA, among the components of affect, seems to be of particular relevance for performance and its effect seems specifically related to the attentional demands of the task, that is, high EA is considered as a marker of attentional resources (Matthews & Davies, 2001). Furthermore, sleepiness, fatigue, and alertness – the core compounds of EA – are considered by some researchers as subjectively perceived aspects of of attention or, at least, ever-present background (Schmidt, Collette, Cajochen, & Peigneux, 2007). Indeed, some studies showed that subjective alertness/sleepiness varies in parallel with objectively measured attention and core body temperature (CBT; the indicator of circadian arousal driven by biological clock), but the conclusion that individuals who feel less sleepy have also better performance has been questioned (see Schmidt et al., 2007). In general, simple cognitive processes, like sustained or selective attention, follow the circadian rhythm of CBT, which in young adults has a peak in the evening and a nadir in the morning (these are shifted by two and a half hours between morning vs. evening chronotypes; Lack, Bailey, Lovato, & Wright, 2009). The above dependencies suggest that both morning and evening chronotypes should perform better in the evening hours than in the morning hours in tasks measuring sustained and selective attention, however, studies directly testing this hypothesis are scarce. Considering sustained attention, studies showed either better performance in subjectively preferred time of day (Lara, Madrid, & Correa, 2014) or a lack of difference between chronotypes (Mongrain, Noujaim, Blais, & Dumont, 2008). As for selective attention, one study reported an effect of chronotype similar to that observed for EA, however, it seems small and was noticed after removing participants representing the middle of morningness-eveningness dimension (Natale, Alzani, & Cicogna, 2003). These results impose further questions, that is, whether the role of chronotype in time-of-day effects on performance in simple attention tasks is similar to those observed for EA and whether or not there are other temperamental traits predicting performance in different times of day.

Sleep-wake behavior in human beings is regulated by two processes – a circadian process and a homeostatic process (Borbély, 1982) – and morningness-eveningness by definition regulates mostly the circadian one: namely, circadian phase position (Roenneberg et al., 2013). The homeostatic process, on the other hand, refers to increasing fatigue during hours of ongoing wakefulness, subjectively perceived as decreasing energy and increasing fatigue. In fact, differential psychology offers a trait related to individual differences in vulnerability to fatigue. Endurance, also termed hardiness, in the Regulative Theory of Temperament by Strelau (2008) refers to the capacity to react adequately in situations demanding long-lasting or exhausting behaviors and to work effectively in demanding external conditions. Endurance applies to formal characteristic of behavior, which may manifest in every behavior or situation, and proved to have an impact on either shift work tolerance (Natvik et al., 2011) or burnout symptoms resulting from other demanding work conditions (prison security) (Cieslak, Korczynska, Strelau, & Kaczmarek, 2008). What is more, endurance was the temperamental trait most strongly related to morningness, and accounted for the relationships between morningness-eveningness and EA, TA, and HT, however, exclusive of possible time-of-day effects (Jankowski, 2014). Thus, it is not known whether endurance has an overall effect on mood regardless of time of day, or, alternatively, if it has a more profound effect on mood the more time individuals are wakeful, as could be inferred from the definition of endurance and the two-factor model of sleep-wake regulation.

Given that individual differences in time-of-day effects on affect and cognitive performance have been mainly described in terms of chronotype, the present study aimed to test whether endurance has an added explanatory value over morningness-eveningness itself. Consequently, this study aimed to test effects of morningness and endurance on different dimensions of affect and objectively measured attention during morning and evening hours. As morningness in previous studies differentiated mood states in the morning but not in the evening, we expected that during morning hours morning oriented individuals exhibit more advantageous profile of affect and greater attention than evening oriented individuals, whereas during evening hours chronotype effects deteriorate. As for endurance, we hypothesized that it has an effect opposite to that of chronotype regarding time of day alterations. Specifically, we expected that during the evening hours individuals with greater endurance exhibit more advantageous profile of affect and greater attention compared to subjects with lower endurance, whereas in the morning hours effects of endurance will be negligible.

Materials and Methods

Questionnaires

Endurance was measured using the Formal Characteristics of Behaviour-Temperament Inventory (FCB-TI; Zawadzki & Stralau, 1997). The inventory has 120 statements in a yes-no response format divided into six dimensions consisting of 20 items each. Thus, the endurance dimension has 20 items and higher scores indicate a greater level of this temperament trait. The FCB-TI average reliability coefficient was .86 and its psychometric characteristics were investigated in several studies in different cultures (Strelau, 2008). Cronbach's alpha in the present sample for endurance was .85, showing high internal consistency.

The morningness-eveningness dimension was measured with the Horne and Östberg (1976) Morningness-Eveningness Questionnaire (MEQ) adapted for Polish speakers by Ciarkowska (Jankowski & Ciarkowska, 2008). The Polish version has good psychometric proprieties: for example, test-retest reliability at a 3-month interval was .84 and Cronbach's alpha was .84. Higher scores indicate greater morningness, whereas lower scores indicate greater eveningness.

Mood was assessed with the UWIST Mood Adjective Checklist (UMACL) of Matthews et al. (1990) in the Polish adaptation provided by Goryńska (2005). The scale has 29 items divided into three subscales measuring: EA (with poles: energetic-tired, 10 items); TA (nervous-relaxed, 9 items); and HT (pleasant-unpleasant, 10 items). Internal consistency for each subscale as indicated by Cronbach's alpha was high, ranging from .71 to .90. Higher scores indicate greater levels of each mood domain.

Visual Search Task

The task used in the study measured selective attention and was a modification of a visual search task designed by Neisser (1964). The task was computerized and consisted of 44 trials. In each trial, participants were presented for 5,000 ms with an array of letters on the computer screen and had to decide whether there appeared a letter "Z" in the array or not (by pressing the appropriate button out of the two buttons corresponding to "appeared" and "did not appear"). The array had 24 lines, with six letters in each line. The stimuli included an equal number of round (O, S, Q) and angular letters (K, E, L) randomly distributed on the screen. The target letter "Z" was present in half of the trials and was displayed in lines 3, 6, 9, 12, 15, 18, 21, or 24 to control for searching strategy (starting from the top or bottom). The experimental session immediately followed a short practice session. There were two performance indicators: (a) reaction time – averaged across all trials for correct and incorrect reactions (missing reactions were not taken into account), reflecting overall impulsivity; and (b) accuracy – the sum of correct responses (maximum 44).

Participants and Procedure

The participants were 80 university students (55 female) aged between 19 and 47 years ($M = 24.88$, $SD = 6.38$) from Warsaw who were studying psychology. Males and females did not differ in age ($M = 24.64$, $SD = 5.73$; $M = 24.98$, $SD = 6.70$, respectively; $t = .22$, $p = .826$) or morningness ($M = 52.04$, $SD = 10.71$; $M = 51.75$, $SD = 9.83$, respectively; $t = .12$, $p = .904$). According to the Polish MEQ cutoff scores (Jankowski, 2013), the sample consisted of 21% morning types, 33% neither types, and 46% evening types. Males and females also did not differ in average baseline daily levels of EA ($M = 29.24$, $SD = 5.10$; $M = 30.60$, $SD = 4.35$, respectively; $t = 1.23$, $p = .224$), TA ($M = 14.36$, $SD = 3.23$; $M = 15.57$, $SD = 3.83$, respectively; $t = 1.38$, $p = .173$), and HT ($M = 31.58$, $SD = 4.40$; $M = 32.01$, $SD = 4.00$, respectively; $t = .431$, $p = .668$).

Participants were asked to come to a laboratory at the University of Warsaw twice a day during morning (8:00–10:00) and evening hours (19:00–21:00). Participants were randomly assigned to begin the study either in the morning or in the evening; thus, they completed the two sessions within 1 day (morning, evening sequence) or in 2 days (evening, morning sequence). The two testing sessions consisted of filling in the UMACL scale and completing the computerized cognitive task. Moreover, participants filled in the MEQ and FCB-TI upon arrival for the first time in the laboratory.

Statistical Analyses

At first, four Student's t tests supplemented with Cohen's d were run to find out whether there were significant time-of-day differences in mood and cognitive performance. Next, contributions of morningness and endurance to mood levels and cognitive performance were tested. Thus, hierarchical regression analyses were run with morningness entered in the first block and endurance in the second as predictors

Table 1. Mean (*SD*) mood and performance levels for morning and evening sessions compared with Student's *t* tests

	Morning session	Evening session	*t*	*d*	*p*
Mood					
Energetic arousal	29.6 (6.2)	30.8 (5.2)	1.68	.24	.10
Tense arousal	15.1 (4.3)	15.3 (4.2)	0.36	.02	.72
Hedonic tone	32.0 (4.7)	31.8 (4.8)	0.41	.05	.68
Visual search					
Reaction time	3,310.8 (298.8)	3,170.3 (309.9)	**4.09**	**.44**	**< .001**
Accuracy	29.2 (5.9)	33.1 (5.1)	**5.41**	**.70**	**< .001**

Note. Statistically significant effects are bolded.

Table 2. Results of hierarchical regression analyses (β, ΔR^2, p) with morningness and endurance as predictors

	Energetic arousal	Tense arousal	Hedonic tone	Accuracy	Reaction time
			Morning hours		
Morningness	**.44, .23, < .001**	**−.25, .07, .016**	**.34, .13, .001**	−.03, .00, .83	−.06, .00, .68
Endurance	.16, 03, .12	−.08, .01, .49	.09, .01, .42	.00, .00, .97	.06, .00, .59
			Evening hours		
Morningness	−.02, .00, .72	−.12, .02, .19	.07, .01, .32	−.01, .00, .88	−.03, .00, .82
Endurance	**.30, .09, .008**	−.13, .02, .24	.21, .04, .07	−.05, .00, .69	−.03, .00, .75
			Change scores (Evening hours–Morning hours)		
Morningness	**−.43, .17, < .001**	.14, .02, .26	**−.26, .05, .04**	.02, .00, .94	.08, .00, .61
Endurance	.09, .01, .41	−.06, .00, .63	.12, .01, .28	−.04, .00, .73	−.11, .01, .37

Notes. Statistically significant effects are bolded; p values are for ΔR^2.

and EA, TA, HT, and cognitive performance (reaction time and accuracy) as dependent variables. These regressions were run separately for morning and evening sessions. Also, effects of morningness and endurance on time-of-day alterations were tested with the same approach – here, the dependent variables were change scores (evening minus morning) for mood dimension and cognitive performance. The above regression analyses were conducted in order to take advantage of the continuous character of the studied variables and prevent variability reduction in case of categorization. Analyses were conducted using SPSS 21 with $p < .05$ two-tailed considered statistically significant.

The above analyses were supplemented with visualizations in the form of graphs presenting mean mood levels in the morning and evening sessions: (a) corrected for endurance levels and presented in three chronotype groups (created according to the cutoff scores indicated in the Participants and Procedure section); and (b) corrected for morningness levels and presented in three endurance groups (created according to the score distribution in the sample – lower quartile, middle 50%, upper quartile).

Results

Student's *t* tests revealed that in the whole sample significant differences between the morning and evening sessions appeared only in selective attention, but not in mood (Table 1). Subjects were more accurate and faster in the visual search in the evening as compared to the morning session.

However, regression analyses showed (Table 2) that HT change scores (evening-morning session) differed significantly according to morningness – the more evening oriented subjects were, the greater increase of HT from morning to evening session they experienced, whereas for more morning individuals a decrease of HT was observed (Figure 1A). Moreover, during the morning session morningness mostly affected HT levels – the more morning oriented subjects were, the greater HT they had, whereas in the evening hours neither morningness nor endurance differentiated HT.

As for TA, regression analyses revealed (Table 2) that neither morningness nor endurance affected diurnal alterations (evening-morning session) of this mood dimension. Nevertheless, during morning hours morningness was related to TA – the more morning oriented subjects were, the less tension they experienced. In the evening no individual characteristic was related to TA (Figure 1B).

As for EA, regression analyses showed (Table 2) that EA change scores (evening minus morning session) differed significantly according to morningness – the more evening oriented subjects were, the greater increase of EA from the morning to the evening session they experienced, whereas for more morning individuals a decrease of EA was observed (Figure 1C). Moreover, during the morning session morningness mostly affected EA levels – the more morning oriented subjects were, the greater EA they exhibited – whereas in the evening hours it was endurance that impacted EA – more durable individuals showed greater EA (Figure 1D).

Visual search was affected neither by morningness nor by endurance (Table 2); thus, it could be concluded that

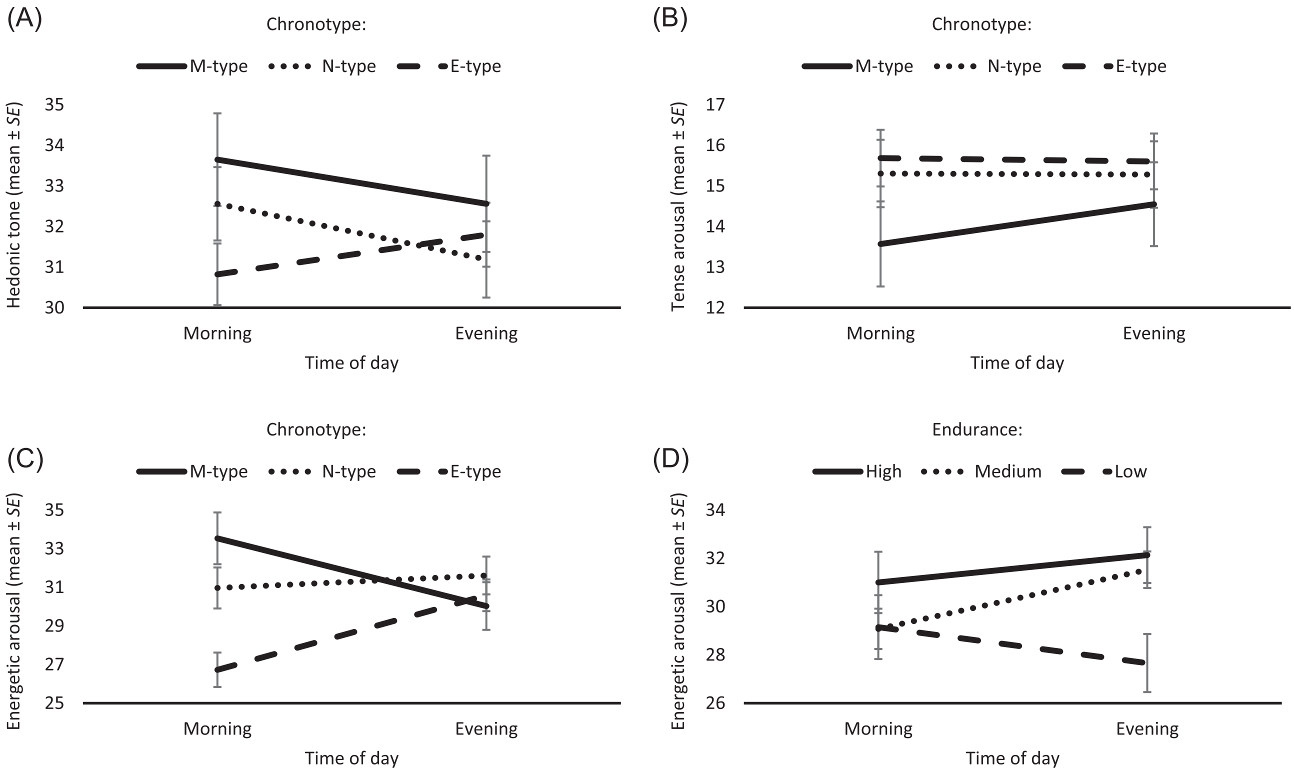

Figure 1. Mood levels (corrected for endurance) during morning and evening hours in three chronotype groups; and energetic arousal levels (corrected for morningness) during morning and evening hours in three endurance groups.

only mood levels are impacted by morningness and endurance: morningness fostered better mood in the morning, while in the evening only endurance promoted greater EA.

Discussion

The present study aimed to test the effects of morningness and endurance on affect and selective attention during morning and evening hours. When morningness and endurance were not considered, overall time-of-day effects appeared in the selective attention but not in affect. On the other hand, morningness and endurance were related to mood levels, but not to the performance in visual search task.

During the evening, as compared to the morning hours, performance in selective attention was higher; this effect was observed both in the accuracy in the visual search task (75% vs. 66%, respectively) and in reaction time in this task which was faster in the evening (by 141 ms). Thus, an evening increase in accuracy was accompanied by faster reaction times. Previous studies on time-of-day effects on visual search generally did not analyze accuracy, but rather reaction time due to ceiling effects in accuracy resulting from the easiness of the tasks they used (e.g., McDougall, Tyrer, & Folkard, 2006; Pomplun et al., 2012). One study, where accuracy in visual search was analyzed, revealed that in very easy task (92.5% or more correct responses) no time-of-day effect appeared (Natale et al., 2003). The present results show that for relatively difficult visual search tasks evening hours, compared to morning ones, are more advantageous both in terms of accuracy and speed, confirming the general rule stating that performance in attention is better when CBT is higher (Schmidt et al., 2007). Considering practical aspect, this result could likely be generalized to such activities as proofreading and typewriting, as the task we used consisted of visually searching for a specified letter among other letters. Nevertheless, morningness and endurance were related neither to this time-of-day variability nor to performance levels during morning/evening hours.

Although overall mood levels did not differ between morning and evening hours, they did when morningness was considered. Namely, the more morning oriented subjects were, the greater the decrease of EA and HT that occurred from morning to evening hours, and the more evening oriented subjects were, the greater the increase of EA and HT that appeared from the morning to the evening session. The above pattern in EA is similar to those observed in previous research (Adan & Guardia, 1993; Jankowski & Ciarkowska, 2008). The results regarding HT, however, replicate findings of Adan and Guardia (1993), but not that reported by Jankowski and Ciarkowska (2008), who hypothesized that HT follows EA when activity is not restricted by external factors (e.g., study design as in

Jankowski & Ciarkowska, 2008). TA diurnal variability was not influenced by morningness levels. Moreover, as hypothesized, in the morning hours more morning oriented individuals showed greater EA and HT and lower TA, whereas in the evening hours morningness-eveningness was unrelated to the three mood dimensions. However, taking endurance into consideration shed new light on the studied relationships.

It was previously shown (Jankowski, 2014) that when endurance was considered together with morningness in mood predictions, endurance could explain all the variability in mood ascribed to morningness. In the present study we tested these effects during morning or evening hours. We exhibited that in the morning it is only morningness, but not endurance that is related to mood, whereas during evening hours morningness is not related to mood, but endurance is linked to one of the mood dimensions (EA). Adding this result to those previously reported (Jankowski, 2014b), it could be hypothesized that morningness and endurance impact mood differently throughout the day, with a decreasing role of morningness and an increasing role of endurance as the day progresses. In the morning hours it is morningness that fosters better mood while endurance has less importance, but later in the day both morningness and endurance differentiate mood, simultaneously sharing the same mood variability – this effect of mood variance shared between morningness and endurance was previously shown in a study sampling most of the individuals between morning and evening hours (Jankowski, 2014). In the later, evening hours chronotype has less effect on mood, but the role of endurance increases, and in these late hours of the day it is endurance that fosters better mood, most profoundly EA. Such a result is concordant with the role of endurance postulated in the Regulative Theory of Temperament (Strelau, 2008), indicating endurance indeed is a trait modulating an impact of demanding external conditions on psychological outcomes – here in the context of circadian functioning.

The above observations seem to have serious implications for further chronobiology research, which up to date has considered morningness-eveningness as the most pronounced individual characteristic differentiating human functioning according to a 24-hr cycle. Here, we indicate endurance as another individual trait that has a noticeable effect on functioning during the day, but by definition and based upon the results presented here, particularly during the later hours of the day, as endurance seems to refer to the homeostatic process of sleep-wake regulation (Borbély, 1982). Thus, endurance could be considered an individual characteristic differentiating people in growth rate of homeostatic sleep pressure and preventing negative outcomes of activity during late hours of the day or prolonged wakefulness, and not only, therefore, a predictor of shift work tolerance (Natvik et al., 2011).

The present study has some limitations and further extensive research should be conducted to test the proposed hypothesis and allow for greater generalization of the results. Firstly, sample size was limited, though quite large for a repeated-measures study in a time-of-day paradigm (e.g., Pomplun et al., 2012). Secondly, multiple analyses were conducted increasing the likelihood of a type I error. This risk particularly applies to the relationships where p values were not very low, for example, to the effects of morningness on time-of-day changes in HT or effects of morningness on TA during morning hours. On the other hand, statistical inference in these cases is strengthened due to the fact that observed effects replicate previous findings of Adan and Guardia (1993) and Jankowski and Ciarkowska (2008), respectively. Contrary, some of the other effects (e.g., daily changes in attention, morningness effects on EA) have very low p values (e.g., below .001) and they would remain statistically significant even if conservative Bonferroni correction were applied for as many as 50 (hypothetical) independent comparisons. Thirdly, in the present study testing sessions covered only limited time intervals of a 24-hour day; thus, further research would add much if dependent variables were sampled more frequently during the day and for longer time periods. Given the ascribed role of endurance as representing the protective factor against negative outcomes of homeostatic sleep pressure, studies in extended wakefulness or sleep deprivation paradigms would allow for more extensive tests of the role of endurance. Moreover, we showed the effects of morningness and endurance on mood but not on selective attention, so future studies should test a greater number of psychological and cognitive outcomes to allow for greater generalization of the common/unique effects of endurance and morningness.

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