Why do Larks Perform Better at School than Owls? The Mediating Effect of Conscientiousness

Lars Eberspach[1], Georg Fenske[1], Sarah Christina Groten[1], Laura Elena Neufeldt[1], Vsevolod Scherrer[1] and Franzis Preckel[1]

[1]University of Trier, Department of Psychology, 54286 Trier, Germany

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ABSTRACT

Circadian preference refers to individuals' preference for morning or evening activities. Its two dimensions (i.e., morningness and eveningness) are related to a number of academic outcomes. While morningness shows positive relations with academic achievement, eveningness shows negative relations. Further, morningness and eveningness show the same correlational pattern with conscientiousness (i.e., positive relations for morningness, negative relations for eveningness), which – in turn – predicts academic achievement. Therefore, the main aim of the present study was to investigate if the relation between circadian preference and academic achievement was mediated by conscientiousness. The sample comprised 422 students attending the 11th grade at a grammar school in Germany. Circadian preference (morningness and eveningness) and conscientiousness were assessed by self-report questionnaires; academic achievement was operationalized by school grades. Using confirmatory analyses and structural equation modelling, the results supported the assumption that conscientiousness mediates the relation between circadian preference and academic achievement. Implications for research into circadian preference and for education are discussed.

Introduction

> "The early bird catches the worm"
> "Early to bed and early to rise, makes a man healthy, wealthy, and wise."

Proverbs like the ones above are part of our daily lives. They show specific assumptions about people getting up early in the morning. The proverbs imply that people who get up early and who are active in the morning – so-called "early birds" – are in general more successful than people who have problems getting up early. Are these assumptions justified? Considering that the improvement of performance and the discovery of variables related to success are of great interest in our modern achievement-oriented society, studies in educational science engaged in the investigation of circadian preference, the preference of individuals for morning or evening activities, as a non-cognitive predictor of academic achievement (e.g., Preckel et al., 2013). Numerous studies reveal a significant relation between circadian preference and academic achievement (e.g., Randler & Frech, 2006). As implied in the above mentioned proverbs, there is accumulating empirical evidence for a positive relation between an early circadian preference (i.e., morningness) and academic achievement and for no or a negative relation between a late circadian preference (i.e., eveningness) and academic achievement (e.g., for meta-analysis, see, Preckel, Lipnevich, Schneider, & Roberts, 2011; Lipnevich, et al., in press; Kirby & Kirby, 2006).

[1] Corresponding author's address: Franzis Preckel, University of Trier, Department of Psychology, 54286 Trier, Germany
Telephone: +49 651 201 4520
Fax: +49 651 201 4578
e-mail: preckel@uni-trier.de

But how can this relation be explained? Recent studies offer first evidence that the personality trait of conscientiousness is an important mediator for the relationship between circadian preference and academic achievement (Arbabi, Vollmer, Dörfler, & Randler, 2015; Rahafar, Maghsudloo, Farhangnia, Vollmer, & Randler, 2015). These studies assessed circadian preference as a one-dimensional continuum from morning-orientation to evening-orientation. However, the one-dimensional approach of morningness-eveningness has been challenged by findings supporting morningness and eveningness to be two only weakly correlated dimensions (Preckel et al., 2011; Lipnevich et al., in press; Scherrer, Roberts, & Preckel, 2016; Putilov, Donskaya, & Verevkin, 2015). Thus, a two-dimensional approach might be a more appropriate conception of circadian preference than a one-dimensional one. Therefore, the present study examined the mediating role of conscientiousness while using a two-dimensional conception of circadian preference. To the best of our knowledge, this has not been done before.

Definition of Circadian Preference

People differ in many characteristics and preferences. The individual tendency and preference for morning or evening activities is referred to as the circadian preference of a person. Circadian preference is related to physiological and psychological functioning (Díaz-Morales, 2007; Dijk & von Schantz, 2005), personality traits (Lipnevich et al., in press; Tsaousis, 2010), habits (Cavallera & Giudici, 2008), or sleeping and eating behavior (Korczak, Martynhak, Pedrazzoli, Brito, & Louzada, 2008). Morning-oriented persons are fit, well rested, and attentive in the morning. Getting up early is no problem for them and they are already hungry in the morning. In comparison to people considered to be evening-oriented, morning-oriented people get tired earlier (especially if there are variations in sleeping hours) and, therefore, go to bed early in the evening (e.g., Randler, 2008). They generally prefer morning activities (e.g., Preckel et al., 2013). Opposed to that, evening-oriented people tend to get up late, and their appetite is low during the morning hours. Furthermore, evening-oriented persons prefer afternoon-evening activities and are more alert at night. They are able to sleep late into the morning and it takes them more time to fall asleep (Hahn, Preckel, & Spinath, 2011; Giannotti, Cortesi, Sebastiani, & Ottaviano, 2002; Zimmermann, 2016). Overall, they have a later sleep-wake time (Rahafar et al., 2015). Due to these behavioral differences, researchers coined the terms "larks" for morning-oriented people and "owls" for evening-oriented people. In general, sleeping habits of "larks" follow more continuous rules than sleeping habits of "owls" which are more irregular (Tankova, Adan, & Buela-Casa, 1994).

Endogenous factors such as a self-sustaining oscillator mechanism as well as exogenous factors such as light, temperature, and society affect the circadian preference in humans (e.g., Crowley, Acebo, & Carskadon, 2007; Korczak et al., 2008). The term chronotype is often used interchangeably to circadian preference; however, these two constructs are not identical. The term chronotype describes a specific daytime rhythmicity resulting from an underlying endogenous biological clock while circadian preference, which is usually assessed with self-report questionnaires, constitutes a proxy for chronotype (Lipnevich et al., in press).

Circadian preference is understood as a trait or as an individual preference that is robust over time and already observable during early childhood (Arbabi et al., 2015; Randler, 2008; Zimmermann, 2016). However, there is a certain variation in circadian preference over the lifetime. Whereas children have early wake-up times, adolescents tend to be more evening-oriented (Randler, 2008). This shift begins approximately around the age of thirteen and peaks at about the age of twenty (Roenneberg et al., 2004). For adults, differences in their sleep-wake pattern can be caused by their occupation. Employees tend to be morning-types, while students mostly belong to the evening-type (Kerkhof, 1985). People around the age of 50 experience a shift in their rhythm toward a morning-orientation (Hahn, Preckel, & Spinath, 2011). In spite of these general developmental changes, the inter-individual differences in circadian preference are quite robust over lifetime (ibid).

Measurement of Circadian Preference

Researchers often use self-report questionnaires to gauge the individual's circadian preference (e.g., Hidalgo et al., 2009; Escribano & Díaz-Morales, 2016) whereas assessments by other persons like parents are used more rarely (Scherrer et al., 2016; Zimmermann, 2016). Most of these questionnaires are based on a one-dimensional instead of a two-dimensional conceptualization of circadian preference. Using a one-

dimensional conceptualization, the concept of circadian preference is considered as one continuum from (extreme) morningness to (extreme) eveningness. One of the first and mostly utilized questionnaires in studies using this conceptualization is the "Morningness-Eveningness-Questionnaire" (MEQ; Horne & Östberg, 1976).

An increasing number of findings challenges the one-dimensionality of the circadian preference construct (e.g., Preckel et al., 2013; Neubauer, 1992; Putilov & Onischenko, 2005; Randler & Vollmer, 2012; Roberts & Kyllonen, 1999). These studies also revealed that most of the existing scales predominantly measure morningness. Some recent studies used circadian preference measures, which were based on a two-dimensional conceptualization and accordingly assessed morningness and eveningness as two relatively independent dimensions (Lipnevich et al., in press; Scherrer et al., 2016; Putilov et al., 2015; Randler, Díaz-Morales, Rahafar, & Vollmer, 2016). Using confirmatory factor analyses, Scherrer et al. (2016) and Randler et al. (2016) demonstrated a good fit of models with morningness and eveningness as two separate dimensions of circadian preference. The two-dimensional conceptualization of circadian preference represents correlations with academic achievement in a more differentiated way as it allows to investigate the relation of morningness and eveningness with academic achievement, separately (e.g., Preckel et al., 2011). Examples for self-report questionnaires that measure morningness and eveningness as two separate dimensions are the "Lark-Owl Chronotype Indicator" (LOCI; Roberts, 1998) and the "morningness-eveningness-stability-scale improved" (MESSi; Randler et al., 2016).

Several studies support the validity of self-report questionnaires for the assessment of circadian preference. Those studies controlled the congruence of questionnaire results with findings of other measurements like biological dimensions (e.g., Natale & Alzani, 2001; Bailey & Heitkemper, 2001), sleep diaries (e.g., Neubauer, 1992), or the assessment of one's circadian preference by another person (e.g., parents ratings; Preckel et al., 2013).

Circadian Preference, Academic Achievement and Cognitive Abilities

Morningness is positively related to academic achievement and eveningness reveals no or negative relations with academic achievement. These relations were found for elementary school students (e.g., Scherrer et al., 2016), secondary school students (Preckel et al., 2013), and university students (Randler & Frech, 2006). A recent meta-analytic review (Preckel et al., 2011) reported significant and homogenous correlations between morningness and academic achievement (ρ = .16; 13 correlations) as well as eveningness and academic achievement (ρ = -.14; 6 correlations). Therefore, morning-oriented students seem to achieve better academic results than evening-oriented students. In contrast, however, some findings suggest that eveningness is more strongly related to cognitive abilities than morningness (e.g., Roberts & Kyllonen, 1999). These relations were supported in the meta-analysis by Preckel et al. (2011). Morningness and cognitive abilities showed negative relations (ρ = -.04, $p < .05$; 11 correlations), whereas eveningness and cognitive abilities showed positive relations (ρ = .08, $p < .05$; 7 correlations). Furthermore, the positive relation of eveningness and cognitive abilities was recently replicated for elementary school-aged children by Scherrer et al. (2016), whereas no significant relation of morningness and cognitive abilities was found in this study. Of note, the relations reported by Preckel et al. (2011) and by Scherrer et al. (2016) were very small. Further, Arbabi et al. (2015) found slightly higher cognitive abilities for morning-oriented students than for evening-oriented students. However, Arbabi et al. (2015) did not differentiate between morningness and eveningness, which might explain these discrepant findings.

To conclude, when operationalizing morningness and eveningness as two separate dimensions of circadian preference, eveningness seems to be related to higher cognitive abilities but to lower academic achievement while the opposite pattern of relations holds for morningness. Overall, these are unintuitive relations, considering that multiple studies have shown cognitive ability to be the best single predictor for academic attainment (e.g., Deary, Strand, Smith, & Fernandes, 2007; Mayes, Calhoun, Bixler, & Zimmerman, 2009).

Conscientiousness as a Mediator between Circadian Preference and Academic Achievement

Conscientiousness is one factor of the Big Five personality-model by Goldberg (1993) and can be described as the tendency to be organized, achievement-focused, disciplined, and industrious. A positive

relationship between conscientiousness and academic achievement has been found in several studies (e.g., Preckel, Holling, & Vock, 2006; Furnham & Monsen, 2009). A recent meta-analysis by Poropat (2009) revealed conscientiousness as the strongest predictor for academic achievement regarding the Big Five personality traits (ρ = .22).

The relation between conscientiousness and circadian preference is also very well investigated. A meta-analysis by Tsaousis (2010) found significant and positive relations between conscientiousness and morningness (ρ = .29; 20 correlations). The correlation between conscientiousness and morningness was higher than any other correlation regarding circadian preference and the factors of the Big Five model. A recent meta-analytic investigation by Lipnevich et al. (in press) confirmed the positive relation between morningness and conscientiousness (ρ = .37; 19 correlations) and additionally revealed a negative relation between eveningness and conscientiousness (ρ = -.19; 19 correlations). These findings suggest conscientiousness as a possible mediator of the relations between circadian preference and academic achievement. Further, this mediation could explain the unintuitive findings regarding the correlations between circadian preference, cognitive abilities, and academic performance. Note that circadian preference was a predictor of school achievement even after controlling for cognitive abilities in recent research (Preckel et al., 2013; Scherrer et al., 2016). Up to now only two studies investigated conscientiousness as a mediator of circadian preference on school achievement (for primary-school students: Arbabi et al., 2015; for high-school students: Rahafar et al., 2015). Both studies found that the relation between circadian preference and academic achievement was (partly) mediated by conscientiousness. However, both studies did not assess circadian preference as a two-dimensional construct but rather used measures that predominantly assessed morningness.

Research Aims and Hypotheses

The main aim of this study was to investigate whether the relationship between circadian preference and academic achievement is mediated by conscientiousness. It is certainly unintuitive that eveningness is associated with lower academic achievement but at the same time with higher cognitive abilities. Furthermore, circadian preference was found to be incrementally related with academic achievement beyond cognitive abilities (Preckel et al., 2013; Scherrer et al., 2016). These findings suggest that additional variables are involved in the relation of circadian preference and academic achievement. According to the available findings of the relations between conscientiousness, circadian preference, and academic achievement and according to the findings of Arbabi et al. (2015) and Rahafar et al. (2015), it can be assumed that conscientiousness mediates the relationship between circadian preference and academic achievement.

This study focused on the mediation assumption and measured circadian preference as a two-dimensional construct (i.e., morningness and eveningness). Careful synthesis of existing literature led us to the formulation of the following six research hypotheses:

H1: Morningness is positively related to academic achievement.
H2: Eveningness is negatively related to academic achievement.
H3: Morningness is positively related to conscientiousness.
H4: Eveningness is negatively related to conscientiousness.
H5: Conscientiousness is positively related to academic achievement.
H6: The relationship between morningness or eveningness and academic achievement is (partially) mediated by conscientiousness.

Method

Participants and Procedure

Data of four cohorts of 11th graders at one German grammar school were collected from 2011 to 2014 (overall *N* = 422; 2011: *n* = 141; 2012: *n* = 92; 2013: *n* = 95; 2014: *n* = 94). The total sample consisted of 292 females and 130 males. Students were not assigned to particular classes but individually chose major and minor courses out of eighteen school subjects (German as native language, English, French, Latin, Spanish, Russian, math, physics, chemistry, biology, civics, history, geography, social studies, religion, music, art, and drama classes). The average age was 16.57 years (*SD* = .65, range = 14-19 years). Students were assessed in groups in their courses during one testing session. Trained experimenters conducted each assessment. The

participation was voluntary, anonymous, and approved by students' parents. The study was approved by the data protection commissioner of the school district.

Measures

Circadian preference. We used the German version of the Lark-Owl Chronotype Indicator (LOCI; Roberts, 1998). This inventory consists of 38 items and measures morningness and eveningness with 13 items, each (e.g., *I find it easy to get up in the morning* or *I am a 'morning' person* for morningness; *I go to bed after 10 pm* or *I feel alive, ready to go in the evening* for eveningness). Relations with behavioral data and other ratings support the criterion-related validity of the LOCI (Preckel et al., 2013); further, confirmatory analyses supported its two-dimensional structure (Scherrer et al., 2016). Students rated the extent to which they agreed with the different statements on a 6-point Likert scale from *never* (1) to *always* (6). Sample internal consistency of the morningness scale was good (α = .86). The eveningness scale showed an acceptable internal consistency (α = .79).

Conscientiousness. Conscientiousness was assessed with the short version of the Big Five Inventory (BFI-K; Rammstedt & John, 2005). The whole questionnaire consists of 21 items, four of them assessing conscientiousness (e.g., *I get things done thoroughly*). Students rated the extent to which they agreed with the different statements on a scale from *inapplicable* (1) to *very applicable* (5). Results by Rammstedt and John (2005) suggest satisfactory psychometric values for the scale and items. In this study, the internal consistency of the conscientiousness scale was α = .69.

Academic achievement. Academic achievement was operationalized by self-reported grades in the final record for eighteen school subjects (German as native language, English, French, Latin, Spanish, Russian, math, physics, chemistry, biology, civics, history, geography, social studies, religion, music, art, and drama classes). These grades reflect accumulated educational achievements of a whole school term and not only single test results. Following suggestions from recent research, self-reported school grades do not seem to be systematically biased and can, therefore, be assumed to be valid (Dickhäuser & Plenter, 2005). Grades were reported on a scale from *very good* (1) to *insufficient* (6). To interpret results in a more intuitive manner, students' grades were inverted, so that higher numbers indicate higher levels of performance. Not every student attended all of the reported subjects. Therefore, four different grand point averages (GPAs) were calculated across groups of subjects. This allowed us to calculate at least one value for a single person in each category. We conducted a GPA for languages ('LANG': German (native language), English, French, Latin, Spanish, and Russian), natural sciences ('MINT': math, physics, chemistry, and biology), social sciences ('SOCIAL': civics, history, geography, social studies, and religion), and fine arts ('ART': music, art, and drama classes).

Data Analysis

SPSS (IBM, Version 22) and Mplus (Version 7.4; Muthen & Muthen, 1988-2015) were used for statistical calculation. Scale distribution (i.e., Kolmogorov–Smirnov tests) and internal consistency (i.e., Cronbachs Alpha) were analyzed in SPSS. The four GPAs (i.e., MINT, LANG, SOCIAL, and ART) were used as indicator variables for a latent factor academic achievement. Besides academic achievement, morningness, eveningness, and conscientiousness were also modelled as latent factors using the self-report items as indicators. The fit of the measurement model for each factor was tested via confirmatory factor analysis (CFA). Subsequently, to investigate the association between morningness, eveningness, conscientiousness, and academic achievement, structural equation modeling (SEM) was used. First, we investigated the relationship of morningness or eveningness with academic achievement mediated by conscientiousness, separately (Models 1 and 2). Second, we included all variables in one model (Model 3). Finally, we calculated a model with academic achievement being regressed on the correlated factors of morningness and eveningness (without the inclusion of conscientiousness as a mediator; Model 4). This was done to estimate the difference in explained variance of academic achievement between Model 3 and 4. Model fit of the CFAs and the SEMs was evaluated according to the criteria proposed by Schermelleh-Engel, Moosbrugger, and Müller (2003). For a good fit, the CFI value should be at least .95, whereas the RMSEA and the SRMR values should be .05 or lower. Missings on variables was handled with the Full-Information-Maximum-Likelihood-Estimator (FIML) in all SEM models. Of note, 14 participants (3.30 %) had missings on morningness items, 14 participants (3.30 %) had missings on eveningness items, and 13 participants (3.10 %) had missings on conscientiousness items. Furthermore, 19 participants (4.50 %) had no LANG data, 16 participants (3.80 %)

had no MINT data, 23 participants (5.50 %) had no SOCIAL data, and 27 participants (6.40 %) had no ART data.

Results

Before conducting the CFAs for morningness and eveningness, two items of the original LOCI morningness scale (10, 35; e.g., *I like to see the sun rise*) and three items of the original LOCI eveningness scale (5, 7, 12; e.g., *I enjoy working unusual hours*) were excluded from further analysis because they were inconclusive and therefore could be interpreted in different ways. Regarding the CFA for morningness, the residuals of three item pairs (28 and 32, 4 and 33, 24 and 38; e.g., *Even when I go to bed late, I wake up at my usual time the next morning* and *I wake up before the alarm*) were allowed to correlate because of similarities in item wording and content (i.e., correlated uniqueness; Little, Preacher, Selig, & Card, 2007). Regarding the CFA for eveningness, the residuals of two item pairs (3 and 15, 3 and 34) were allowed to correlate because their content was confounded (e.g., *I fall asleep before 11 pm* and *I study after midnight*). Likewise, the residuals of two further item pairs (36 and 37, 26 and 27) were allowed to correlate because of similarities in item wording and content. Model fit results for the CFAs for morningness, eveningness, conscientiousness, and academic achievement are shown in Table 1.

Table 1. Model Fit Results of the CFAs for the Four Factors and of the SEMs for the Separate Mediation Analyses and the Whole Model

Model	χ^2	df	p	CFI	RMSEA	SRMR
CFAs						
Morningness (M)	93.887*	41	.000	.954	.056	.040
Eveningness (E)	52.253*	31	.010	.977	.041	.038
Conscientiousness (C)	5.808*	2	.055	.981	.068	.022
Academic achievement (AACH)	1.290*	2	.525	1.000	.000	.009
SEMs (mediation models)						
Model 1: M → C → AACH	225.436*	146	.000	.960	.036	.045
Model 2: E → C → AACH	188.763*	128	.000	.966	.034	.048
Model 3: M and E → C → AACH	640.552*	364	.000	.915	.042	.059
Model 4: M and E → AACH	480.190*	265	.000	.926	.044	.059

Note. * = the chi-square value is not comparable to other models through the use of the MLR.

All models showed a good fit. RMSEA values did not fulfill the criterion of ≤ .05 completely. However, RMSEA values of .06 are often evaluated as sufficient (Hu & Bentler, 1999; MacCallum, Browne, & Sugawara, 1996). Table 2 shows the manifest means (*M*), standard deviations (*SD*), and latent factor loadings of all indicators (i.e., items or GPAs). Factor loadings ranged from .23 (LOCI25, eveningness-factor) to .82 (LOCI2, morningness-factor).

Table 2. Means (*M*), Standard Deviations (*SD*), and Factor Loadings for all Indicators

Scale	Indicator	M	SD	Factor loading
Morningness	LOCI1	2.84	0.85	0.67
	LOCI2	2.63	0.50	0.82
	LOCI4	2.12	0.65	0.75
	LOCI8	2.76	0.87	0.56
	LOCI14	2.50	1.27	0.66
	LOCI19	3.53	0.71	0.65
	LOCI24	2.44	0.91	0.59
	LOCI28	3.47	0.99	0.40
	LOCI32	2.49	1.05	0.39
	LOCI33	2.49	0.97	0.53
	LOCI38	4.21	0.97	0.37
Eveningness	LOCI3	3.54	1.05	0.33
	LOCI9	4.40	0.71	0.74
	LOCI15	4.53	0.97	0.35
	LOCI17	2.30	1.01	0.32
	LOCI25	3.07	1.13	0.23
	LOCI26	4.44	0.71	0.80
	LOCI27	4.44	0.71	0.76
	LOCI34	2.08	1.05	0.33
	LOCI36	2.69	1.05	0.38
	LOCI37	3.40	0.65	0.74
Conscientiousness	1 CON	3.63	0.91	0.79
	2 CON	2.65	1.07	0.54
	3 CON	3.20	1.27	0.65
	4 CON	3.77	1.27	0.48
Academic achievement	LANG	4.14	0.64	0.78
	MINT	3.72	0.80	0.68
	SOCIAL	4.27	0.68	0.75
	ART	4.48	0.82	0.62

The correlation matrix of the latent factor scores is shown in Table 3. All factors were significantly correlated. In line with our hypotheses, morningness was positively related to academic achievement (H1) and conscientiousness (H3) while eveningness was negatively related to academic achievement (H2) and conscientiousness (H4). Further, conscientiousness was positively related to academic achievement (H5).

Table 3. Correlations Between the Latent Factors

Variable	Morningness	Eveningness	Conscientiousness
Eveningness	-.375**		
Conscientiousness	.360**	-.277**	
Academic achievement	.171**	-.251**	.408**

*Note. *p* < .05; **p* < .01. Correlations of morningness, eveningness, and conscientiousness factors with the four GPA indicators were: Morningness and LANG (*r* = .127, *p* < .05), MINT (*r* = .138, *p* < .05), SOCIAL (*r* = .142, *p* < .01), and ART (*r* = .060, *p* = .382); Eveningness and LANG (*r* = -.190, *p* < .001), MINT (*r* = -.235, *p* < .001), SOCIAL (*r* = -.134, *p* < .05), and ART (*r* = -.168, *p* < .01); Conscientiousness and LANG (*r* = .319, *p* < .001), MINT (*r* = .331, *p* < .001), SOCIAL (*r* = .265, *p* < .001), and ART (*r* = .240, *p* < .001).*

For testing our mediation hypothesis (H6) assuming that the relationship between morningness and eveningness and academic achievement is (partially) mediated by conscientiousness, we first calculated separate mediation models for morningness and eveningness. Both models showed a good fit to the data (see Table 1: Model 1 and Model 2). Morningness was positively related to conscientiousness (β = .359, *p* < .001) and academic achievement (β = .173, *p* = .004; total effect). Eveningness was negatively related to conscientiousness (β = -.274, *p* < .001) and academic achievement (β = -.254, *p* < .001; total effect). The regression of academic achievement on conscientiousness was also significant (β = .408, *p* = .001). This positive relation revealed the highest beta value.

Table 4 shows the results for the total, direct, and indirect effects of the mediation analyses for morningness (Model 1) or eveningness (Model 2), respectively.

Table 4. Results for Total, Direct and Indirect Effects in the Mediation Analyses

Predictors	$\hat{\beta}$	*SE*	*p*
Model 1: Separate model for Morningness (M)			
M (total)	.173	0.061	.004
M (indirect)	.143	0.040	.000
M (direct)	.030	0.069	.667
Model 2: Separate model for Eveningness (E)			
E (total)	-.254	0.056	.000
E (indirect)	-.099	0.033	.002
E (direct)	-.156	0.063	.014
Model 3: Combined model for Morningness (M) and Eveningness (E)			
M (total)	.089	0.068	.190
M (indirect)	.111	0.036	.002
M (direct)	-.022	0.073	.761
E (total)	-.218	0.065	.001
E (indirect)	-.061	0.028	.031
E (direct)	-.156	0.069	.023

There was a full mediation of the relationship between morningness and academic achievement and a partial mediation of the relationship between eveningness and academic achievement by conscientiousness. The combined model for testing the mediation hypothesis is shown in Figure 1. The fit of the combined model was acceptable (see Table 1, Model 3). Regression weights are displayed in Figure 2.
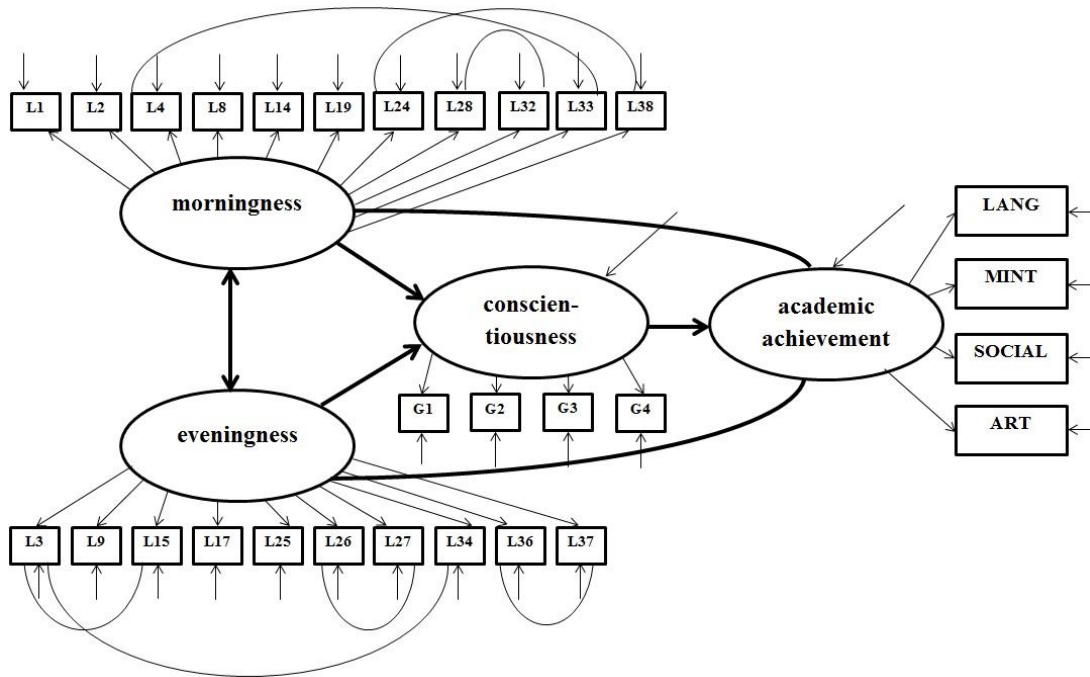
Figure 1. Structural equation model of the constructs (elipses) and their measurement (squares).
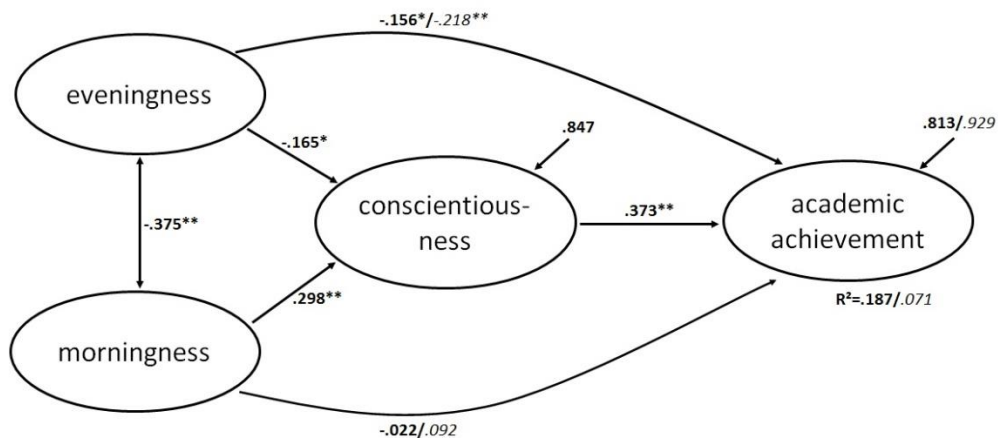
Figure 2. Results of the structural equation model of the relationship of the constructs including conscientiousness as mediator (bold numbers; Model 3) and excluding conscientiousness as mediator (numbers behind the slash in italics; Model 4).

All paths were significant with the exception of the direct path from morningness to academic achievement. The results for the total, direct, and indirect effects of the mediation analyses for morningness or eveningness, respectively, are shown in Table 4. Conscientiousness mediated the relationship of morningness with academic achievement, as well as the relationship of eveningness with academic achievement (significant indirect effects). Note that the relationship of eveningness and academic achievement was only partially mediated by conscientiousness as the direct effect for eveningness remained significant. While we found significant total effects for the mediation of the relation between circadian preference and academic achievement via conscientiousness in separate models for morningness and eveningness, no significant total effect of morningness on academic achievement could be observed in the combined model. This means that morningness was not incrementally related to academic achievement beyond eveningness. Nevertheless, morningness was significantly related to conscientiousness and the indirect relation with academic achievement was significant.

Finally, a model with morningness and eveningness explaining academic achievement (i.e., the combined model without conscientiousness as the mediating variable) was analyzed (Model 4). This was

necessary to assess the impact of conscientiousness as a mediator on the explained variance in academic achievement. The fit of this model was acceptable (see Table 1, Model 4). The results of the model are displayed in Figure 2 (numbers behind the slash in italics). The inclusion of conscientiousness as mediator increased the explained variance in academic achievement by 12% (R^2 = .187 instead of R^2 = .071).

Discussion

One strand in current research on circadian preference is to examine the relationship between its dimensions (i.e., morningness and eveningness) themselves and their relations with other central constructs like cognitive abilities, personality, or academic achievement. However, the mechanisms underlying these relations are still mainly unexplored. While replicating the findings of previous studies regarding the relations of circadian preference, conscientiousness, and academic achievement, this study investigated how these constructs were related by hypothesizing that conscientiousness mediates the relation between circadian preference and academic achievement.

Our study was based on a two-dimensional conceptualization of circadian preference with morningness and eveningness as relatively independent dimensions. Results supported our hypotheses: Morningness was positively related to conscientiousness and academic performance, while eveningness was negatively related to these two constructs. A positive correlation between conscientiousness and academic achievement was also found. Merging those relations into a SEM (Figure 1) provided the basis for analyzing the mediating role of conscientiousness in the relationship between circadian preference and academic achievement. The results of this analysis revealed a full mediation for the relation of morningness and academic achievement and a partial mediation for the relation of eveningness and academic achievement by conscientiousness.

Not only do these results support current findings on the relations of circadian preference, conscientiousness, and academic achievement (e.g., conscientiousness and academic achievement; Poropat, 2009; circadian preference and academic achievement; Preckel et al., 2011, 2013; circadian preference and conscientiousness; Lipnevich et al., in press), furthermore, our findings broadened those provided by Arbabi et al. (2015) of how these three constructs interact. Firstly, we used a two-dimensional assessment of circadian preference. Secondly, we investigated students in late adolescence (instead of elementary school-aged children) whose achievement might be influenced more strongly by circadian preference than that of younger students, since the relation between circadian preference and academic achievement is moderated by age (Preckel et al., 2011). Before discussing these findings, however, we would like to point to some limitations of our study.

Limitations

Longitudinal studies that investigated the relations of circadian preference and psychological constructs are very rare, although they are highly needed if one wants to address the functional mechanisms underlying these relations. The present cross-sectional study of 11th grade German high school students is no exception in this regard. While the theoretical assumptions presented earlier in this article suggest causal relationships between circadian preference, conscientiousness, and academic achievement, the present study cannot draw any conclusions in terms of the causality (see below: Implications). Another important point to note is the operationalization of academic achievement. As not all students had the same combination of school subjects, the subjects were clustered into four groups, which – in turn – operated as indicators of academic achievement. This method deviates from the frequently used GPA to measure academic achievement, which makes comparisons with other studies more complicated. Furthermore, a replication of our findings in other groups and cultures is desirable, as climate, language, and culture can affect circadian preference (Randler, 2008). Another important limitation is that this study did not include cognitive ability, although we argued, that the models investigated in the present study could help to explain the unintuitive findings regarding the relations between circadian preference, cognitive ability, and academic performance. Unfortunaely, we had no cognitive abilities measure in our study. However, we trust that our findings still inform about unintuitive findings regarding the relations between circadian preference, cognitive ability, and academic performance because there is evidence that circadian preference remains a significant predictor for academic performance even after controlling for cognitive abilities (Preckel et al., 2013; Scherrer et al., 2016). We would also like to point out, that the total effect of the relationship of morningness and

academic achievement did not reach significance in the mediation model including both dimensions of circadian preference. One might argue that this indicates that the relationship of morningness and academic achievement cannot be mediated by conscientiousness simply because there is no such relationship. Yet, it is more likely to assume, that morningness is not incrementally related to academic achievement *beyond* eveningness. This assumption is supported by the fact (a) that we did find a total mediation for the relationship of morningness and academic achievement via conscientiousness in a model without eveningness and (b) that the indirect effect of this relationship remained significant even after including eveningness.

Implications

The results of this study show the importance of considering the construct of conscientiousness when investigating the relationship between circadian preference and academic achievement. Main parts of the relations of circadian preference with academic achievement could be explained by conscientiousness. This, again, stresses the importance of conscientious behavior in academic contexts (implying that teaching students conscientious behavior could positively influence their academic achievement; see, e.g., Lipnevich, Preckel, & Roberts, 2016). The relation between circadian preference and conscientiousness may in part reflect a common genetic source such that the same set of genes influences the tendency to be conscientious and more oriented toward morning or evening activities. Another, rather speculative explanation might involve a causal relationship between circadian preference and conscientiousness. Assuming circadian preference predates conscientious behavior, one could argue that the time schedule imposed to students by their schools encourages morning-oriented people to show conscientious behavior, since they are already at the peak of their functional level. On the other hand, evening-oriented people are below their maximum functional capacities at early hours making it more difficult to show conscientious behavior. For example, they might be less motivated and less concentrated than morning-oriented students might be. Over time, those differences in behavior might express themselves in the actual personality trait. Future longitudinal studies starting at an early age might be able to investigate the causality of the relationship between circadian preference and conscientiousness, and thus, be able to shed more light on its explanation. In addition, there seem to be environmental influences that strengthen behavior more common in conscientious individuals with a morningness orientation (for a further discussion of this point, see, Lipnevich et al., in press).

A small but significantly negative relationship between eveningness and academic achievement remained in our study, even after controlling for the mediating influence of conscientiousness. This implies that other factors beyond conscientiousness affect the relationship of eveningness and academic achievement. One possible explanation for this residual relationship is the time schedule that is provided by the German school system. It forces students with high eveningness orientation to get up early in the morning against their circadian preference and to perform in academic contexts at a suboptimal time of day. Especially during adolescence, this might become problematic because at this age there is a general shift towards eveningness (Roenneberg et al., 2004). Although the most obvious solution to this problem – starting school at later hours (Arbabi et al., 2015) – might be hard to implement in the German school system due to a variety of reasons like conflicts with the time schedule of parents, there are a number of measures that could be taken to reduce the impact of disadvantages for eveningness-oriented students. For example, tests could be performed at later hours (Arbabi et al., 2015). Another important point includes educating students, parents, and teachers about the interindividual differences in circadian preference and chronotype. On the one hand, this could counteract stigmatization for eveningness-oriented students, who might be prejudiced as lazy. On the other hand, it could provide teachers with a better understanding of optimal daytimes of their students. As a result, teachers might put an emphasis on planning important school tasks accordingly. Other methods focus on enabling eveningness-oriented people to perform better at earlier times of the day. These include physical activity in the morning like physical education at the first time slots in school, walking/riding the bike to school etc., the necessity of a healthy breakfast before going to school, or daylight lamps (Randler, 2008).

Summary and Conclusion

The present study followed up on recent research regarding the association of circadian preference, conscientiousness, and academic achievement. While replicating main findings, we extended the research base by using a two-dimensional approach to circadian preference (i.e., morningness and eveningness) and by integrating all three constructs into one mediation model. The results suggested a (partially) mediating effect of conscientiousness on the relationship between circadian preference and academic achievement. In separate mediation models, our findings suggested a full mediation of the relation of morningness with academic achievement by conscientiousness and a partial mediation of the relation of eveningness with academic achievement by conscientiousness. The mediation analyses including both dimensions of circadian preference showed that morningness seems not to be incrementally related to academic achievement beyond eveningness (and conscientiousness). These findings stress the importance of a two-dimensional measurement approach to circadian preference since instruments, that measure circadian preference one-dimensionally tend to measure morningness primarily, and thus, the relation of circadian preference with academic achievement might be underestimated – especially for adolescents.

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