Journal of Personality and Social Psychology
2017, Vol. 112, No. 3, 491–509

0022-3514/17/$12.00 http://dx.doi.org/10.1037/pspp0000099

How Distinctive Are Morningness and Eveningness From the Big Five Factors of Personality? A Meta-Analytic Investigation

Anastasiya A. Lipnevich
Queens College and The Graduate Center, The City University of New York

Marcus Credè
Iowa State University

Elisabeth Hahn and Frank M. Spinath
Universitaet des Saarlandes

Richard D. Roberts
Professional Examination Service, New York, New York

Franzis Preckel
University of Trier

This study explores relations between measures of individuals' circadian preferences and the Big Five. To this end, we compared a model of circadian preferences that acknowledges morningness (M) and eveningness (E) as separate dimensions to that of a model that places M and E on a single continuum (M-E). Analyses of 620 correlations from 44 independent samples (N = 16,647) revealed weak to modest relations between both dimensions of circadian preferences and the Big Five personality traits. The strongest observed relation was found between Conscientiousness and M (ρ = .37). In the next step, regression analyses revealed that personality traits accounted for between 10.9% and 16.4% of the variance in circadian preferences. Of all the Big Five dimensions, Conscientiousness exhibited the strongest unique relation with M (β = .32), E (β = −.26), and M-E (β = .32). Extraversion and Openness exhibited moderate unique relations with E (β = .23 and β = .17, respectively), whereas relations with M (β = .00 and β = .04), and M-E (β = −.05 and β = −.06) were relatively weak. Neuroticism exhibited a modest unique and negative relation with M (β = −.16), and Agreeableness was largely unrelated to all circadian preference variables. To determine whether these findings translated into anything of applied significance, we explored relations between circadian preference and academic performance. M and E incremented slightly over the Big Five factors in predicting grade-point average. Theoretical and practical implications of these findings are discussed.

Keywords: Big Five factor model of personality, circadian preferences, morningness, eveningness, meta-analysis

Supplemental materials: http://dx.doi.org/10.1037/pspp0000099.supp

The search for new constructs to supplement the practitioners' toolkit, advance theory, and impact policy is an important undertaking in the social and behavioral sciences, inclusive of psychology, sociology, education, and economics. Often, however, the question remains as to whether, and to what degree, any proposed new construct is distinct from existing ones. The Cattell-Horn-Carroll model of human cognitive abilities (e.g., Carroll, 1993) and the Big Five factor model of personality (e.g., De Raad, 2000; John, Angleitner, & Ostendorf, 1988), in particular, and with rare exceptions (e.g., Danthiir, Pallier, Roberts, & Stankov, 2001), have a tendency to subsume "new" constructs under them. Clearly, frequent commentary invoking the jingle-jangle fallacy and/or critiques pointing to this or that construct representing an old wine in a new bottle, often inside the context of large multivariate studies, are telling. The purpose of the present research is to examine one such individual differences construct—circadian preferences—and the nature of its relation to the factors encapsulated by modern conceptualization of personality. This goal is particularly important for circadian preferences due to a lacking consensus on the structure of this construct. Hence, our investigation will employ both a one- (morningness [M]–eveningness [E]) and two-dimensional conceptualization (M and E, each as independent con-

This article was published Online First December 15, 2016.

Anastasiya A. Lipnevich, Department of Elementary and Early Childhood Education, Queens College, and Department of Educational Psychology, The Graduate Center, The City University of New York; Marcus Credè, Department of Psychology, Iowa State University; Elisabeth Hahn and Frank M. Spinath, Department of Psychology, Universitaet des Saarlandes; Richard D. Roberts, Professional Examination Service, New York, New York; Franzis Preckel, Department of Psychology, University of Trier.

The views expressed here are those of the authors and do not reflect on The City University of New York, Iowa State University, University of Trier, Universitaet des Saarlandes, or Professional Examination Service.

Correspondence concerning this article should be addressed to Anastasiya A. Lipnevich, Department of Elementary and Early Childhood Education, Queens College and The Graduate Center, The City University of New York, PH 056O, 65-30 Kissena Boulevard, Flushing, NY. E-mail: a.lipnevich@gmail.com

structs) of circadian preferences and will examine its relation to the Big Five personality factors.

In the passages that follow, we first define circadian preferences, before moving to a relatively recent model that has begun to gain traction in the literature. Next we consider some of the outcome space that has been explored with individual differences in circadian preferences, noting at several points overlap with what the Big Five personality constructs predict, adding support to the importance of the current study. Then we consider extant studies examining relations between circadian preferences and personality factors broadly writ, in the process setting up the rationale for the meta-analyses that follow.

Conceptualization and Measurement of Circadian Preference

The term *circadian* denotes "the near 24-hour physiological rhythm that has been observed under free-running conditions, at every system level in nearly all plants and mammals, under near constant environmental conditions" (Brown, 1982, p. 9). These rhythms produce changes in variables such as body temperature, various hormone levels, and the sleep–wake cycle. Circadian rhythmicity in humans is controlled by endogenous factors such as a self-sustaining oscillator mechanism (Crowley, Acebo, & Carskadon, 2007; Dijk & von Schantz, 2005), as well as exogenous factors such as light and temperature, food intake, physical activity, and social factors (Ehlert, 2003). Without environmental cues, the endogenous free-running time of the human circadian cycle is, on average, about 25 hr (Edery, 2000; Ehlert, 2003; Roenneberg et al., 2004; Roenneberg, Wirz-Justice, & Merrow, 2003). Although apparently endogenous, circadian rhythms in humans show large interindividual variation (Song & Stough, 2000), with this variation being in part attributable to M and E preferences. Twin studies reveal that up to 50% of variability in circadian preference can be attributed to genetic influences (Hur, 2007; Vink, Groot, Kerkhof, & Boomsma, 2001).

In the psychological literature, the terms circadian preference and chronotype are often used interchangeably. However, these two constructs are not identical. Circadian preference is one manifestation of chronotype in humans that refers to behavioral and biological patterns of circadian rhythm. That is, circadian preference, typically measured with self-report questionnaires,[1] can be used as a proxy (albeit an imperfect one) for chronotype. To avoid further conceptual confusion we would like to acknowledge that although preferences for M and E represent an acceptable proxy for chronotype, circadian preference better denotes the individual difference construct that is reflected in individual variations in timing of activity and sleep–wake preference. A person with a morning preference is someone who prefers morning activities, gets up easily, and is more alert in the morning than in the evening, whereas a person with an evening preference prefers afternoon-evening activity, is more alert at night, and is able to sleep late into the morning. This pattern of activities in the morning or evening is associated with biological signs at the respective time of day.

Most studies have operationalized circadian preference as a one-dimensional construct. Within this framework, circadian preference is assumed to vary along a single continuum bounded by a morningness preference on the high end, and an eveningness preference on the low end (i.e., M-E). This assumption is reflected in the conceptualization of almost all circadian preference measures including the Morningness Eveningness Questionnaire (MEQ; Horne & Östberg, 1976), the Diurnal Type Scale (Torsvall & Akerstedt, 1980), the Composite Scale of Morningness (CSM; Smith, Reilly, & Midkiff, 1989), and the Composite Circadian Scale (Smith, Reilly, & Midkiff, 1989).

However, the unidimensionality of the M-E construct has recently been challenged (e.g., Preckel, Lipnevich, Schneider, & Roberts, 2011; Putilov, 1993). Factor analytic studies consistently reveal two separate dimensions of M and E—even for measurements explicitly developed to capture the construct as a single dimension. For example, Neubauer (1992) found two factors in the MEQ (arguably the most prominent circadian preference measure) representing morning and evening types of activities, as well as preferred times for performance. Monk and Kupfer (2007) found three factors with this same measure, morningness ("circadian phase/morning functioning"), eveningness ("eveningness sleepiness"), and flexibility of sleep behavior ("morning alertness/inability to sleep late"; see also Caci, Deschaux, Adan, & Natale, 2009 and Caci et al., 2005, for factor analyses of the CSM). For the Composite Circadian Scale, which is based on nine MEQ items and four additional items from the Diurnal Type Scale, factor analysis indicated two factors—a general morningness factor and a factor dominated by a single item relating to evening activities (Roberts & Kyllonen, 1999). Thus, it can be assumed that correlations of these measures with personality dimensions mainly represent relations with shared variance of M and E or a general circadian preference factor. Currently, there are only two questionnaires explicitly designed to assess circadian preference as a two-dimensional construct with separate scales for M and E: the Lark-Owl Chronotype Indicator (LOCI; Roberts, 1998) and the Sleep–Wake Pattern Assessment Questionnaire (Putilov, 1990, 1993). To reach conceptual clarity, in a series of meta-analyses, we will compare and contrast results for both types of questionnaires—that is, studies that use a single-dimensional conceptualization (M-E) and the ones that rely on a two-dimensional conceptualization (M or E) separately.

Individual Differences and Circadian Preference

Similarly to most personality characteristics, individuals with an extreme morning and/or extreme evening preference are relatively rare with about 10% to 15% of the general population being clear morning or evening types. Studies reveal that although individuals have a proclivity toward one of the two dimensions, the majority (70–80%) tends to exhibit characteristics of both M and E, but to varying degree (see, e.g., Achari & Pati, 2007; Cavallera & Giudici, 2008; Gaina et al., 2006; Natale & Cicogna, 2002).

The inclination toward M and E may vary throughout life. The distribution of circadian preference within age groups is very similar to that of the general population (i.e., across age groups).

[1] The validity of these self-report questionnaires for the assessment of circadian preference has been well documented. Studies examined relationships of questionnaire results with biological measures (e.g., body temperature: Horne & Östberg, 1976, or Natale & Alzani, 2001; hormone profiles: Bailey & Heitkemper, 2001), sleep diaries (e.g., Neubauer, 1992; Torsvall & Akerstedt, 1980), and actigraph measures or sleep labor research (e.g., Ishihara, Miyasita, Inugami, Fukuda, & Miyata, 1987) and found consistent patterns of relationships.

However, the majority of children are morning-oriented. During adolescence a delay of phase preference can be observed (e.g., Carskadon, Wolfson, Acebo, Tzischinsky, & Seifer, 1998; Crowley et al., 2007) reaching a maximum eveningness level at approximately age 20 years. After the age of 50 years, there is an increase in morningness (e.g., Baehr et al., 2000; Diaz-Morales & Gutiérrez Sorroche, 2008; Gau et al., 2004; Giannotti, Cortesi, Sebastiani, & Ottaviano, 2002; Monk & Kupfer, 2007; Roenneberg et al., 2007). With respect to gender, a meta-analysis by Randler (2007) revealed a weak, but significant, effect of gender on morningness with females being more morning-oriented than males.

Research has also demonstrated that morning-oriented individuals were less pessimistic (Levy, 1985) and more satisfied with their lives (Randler, 2008a, 2008b). They also reported experiencing less stress, depression, and anxiety, compared to their evening-oriented counterparts (Buschkens, Graham, & Cottrell, 2010; Mecacci & Rocchetti, 1998). Evening-oriented individuals reported higher incidence of sleep and mood problems (Taillard, Philip, Chastang, Diefenbach, & Bioulac, 2001), had irregular sleep/wake habits, and reported greater caffeine consumption than morning-oriented individuals (Preckel et al., 2013; Taillard, Philip, & Bioulac, 1999). It must be noted that these effects, however, are generally small in magnitude.

An increasing number of studies has investigated the links between morningness, eveningness, achievement, and cognitive ability. Single studies, as well as meta-analytic research, show that morning-oriented individuals do better in school, whereas evening-oriented individuals are of higher intelligence (e.g., Diaz-Morales & Escribano, 2013; Kanazawa & Perina, 2009; Roberts & Kyllonen, 1999). Preckel et al. (2011) conducted a series of four meta-analyses that examined relations between morningness and cognitive ability, eveningness and cognitive ability, morningness and academic achievement, and eveningness and academic achievement. These studies revealed that eveningness was positively related to individuals' cognitive ability, yet negatively related to indicators of academic achievement. Conversely, morningness was unrelated to cognitive ability but positively related to academic success. We would like to note that in these meta-analyses data captured through one-dimensional questionnaires (single M-E scales) and two-dimensional questionnaires (separate M or E scales) were collapsed into one group (i.e., M-E and M) and interpreted as morningness. That is, the meta-analytic findings for morningness reported in Preckel et al. (2011) partly rely on shared variance of M and E. Another study by Preckel et al. (2013) in which M and E were exclusively assessed as separate dimensions demonstrated that eveningness was a significant negative predictor of overall grade-point average (GPA), math/science GPA, and language GPA, even after cognitive ability, conscientiousness, need for cognition, achievement motivation, daytime sleepiness, and gender were held constant (for similar findings see Diaz-Morales & Escribano, 2013). Again, however, it should be noted that the reported effect sizes tend to be rather modest.

Another extant area of research that has gained considerable attention concerns the link between circadian preference and personality characteristics, the focus of the current study. In an attempt to aggregate findings from a large number of studies that deal with circadian preference and key personality dimensions, we conducted a series of meta-analyses to examine linkages between M and E, assessed as a one- and a two-dimensional construct, and the Big Five personality dimensions. Literature reviews that examined links between circadian preference and personality are available (e.g., Cavallera & Giudici, 2008) but to date only one meta-analysis (Tsaousis, 2010) has been conducted. Our meta-analytic investigation is different from that of Tsaousis (2010) in several important ways. Tsaousis (2010) did not include studies using a two-dimensional conceptualization of circadian preference and therefore was unable to differentiate between M and E as two separate dimensions. Further, Tsaousis included personality dimensions based on various personality conceptualizations (Big Three, Big Five, 16PF, Cloninger's Temperament Inventory)—an approach that may be problematic due to a variety of reasons (see discussion below). With respect to the Big Five framework, the study only included seven studies. In the series of meta-analyses reported herein, we differentiated between morningness as a separate dimension, eveningness as separate dimension, as well as M-E as a single dimension, and focused on personality traits within the Big Five factor model. Therefore, we accounted for conceptual and methodological issues associated with previous studies and aim to present clearly interpretable meta-analytic findings on the relations between M and E and key personality dimensions.

Circadian Preference and Personality

For decades, researchers have been examining issues related to personality and circadian preference. For example, Eysenck (1967) speculated that extraverts may differ from introverts in their daily patterns of arousal. This hypothesis instigated a number of inquiries that examined extraverts' and introverts' patterns of activity in relation to their circadian rhythms (e.g., Anderson & Revelle, 1994; Eysenck & Folkard, 1980; Neubauer, 1992; Wilson, 1990; Zuber & Ekehammar, 1988). Most of these investigations have used Eysenck's three-factor personality model (i.e., extraversion, neuroticism, and psychoticism) to circumscribe personality characteristics. The majority of the studies reported low negative correlations between morningness and extraversion (e.g., Adams, Folkard, & Young, 1986; Adan & Almirall, 1990; Horne & Östberg, 1977; Larsen, 1985; Monk, Leng, Folkard, & Weitzman, 1983; Neubauer, 1992) and morningness and neuroticism (e.g., Adan & Almirall, 1991; Hess, Sherman, & Goodman, 2000), and moderate negative correlations between morningness and psychoticism (Matthews, 1988; Mecacci & Rocchetti, 1998; Mecacci, Zani, Rocchetti, & Lucioli, 1986). However, there were also reports of low positive correlations between morningness and extraversion (Kaliterna, 1989; Mecacci, Righi, & Rocchetti, 2004; Mecacci, & Rocchetti, 1998) and morningness and neuroticism (Langford & Glendon, 2002; Wilson, 1990).

In recent decades, however, the five-factor model (or the Big Five model; e.g., Costa & McCrae, 1992a, 1992b; Tupes & Christal, 1992) became the most commonly accepted conceptualization of personality, and scientists began to examine links between the five factors and individuals' proclivity toward M and E. The Big Five model comprises (a) Openness to Experience, defined as the tendency to be open to new feelings, thoughts, and values; (b) Conscientiousness, the tendency to be organized, achievement-focused, disciplined, and industrious; (c) Extraversion, defined as the tendency to be friendly, cheerful, assertive, social, and energetic; (d) Agreeableness, the tendency to be sympathetic, kind, trusting, and cooperative; (e) Emotional Stability,

the positive pole of neuroticism, as the tendency to be resilient to negative emotions such as anxiety and depression. The Big Five model of personality has been shown to be remarkably robust. The same five factors have been identified in both self- and peer ratings (McCrae & Costa, 1987), in both children and adults (Digman, 1997), and across various cultures (McCrae & Costa, 1997). Before reporting the findings for relations between circadian preference and the Big Five, we would like to note that most of these studies used a one-dimensional assessment of circadian preference; hence, eveningness simply represented the opposite pole of morningness.

Circadian Preference and Openness

The Openness dimension is perhaps the least well-understood personality dimension within the Big Five model (see, e.g., McCrae, 1996). However, it is recognized that the open individual is generally "more willing to entertain novel ideas and unconventional values, while [the individual] low in openness tends to be conventional in behavior and conservative in outlook" (Costa & McCrae, 1992a, p. 654). Overall, findings for the relation between circadian preference and openness are inconsistent. Some of the studies reported small negative correlations with morningness (Cavallera & Giampietro, 2007; Díaz-Morales, 2007; Dresch et al., 2005; Hogben, Ellis, Archer, & von Schantz, 2007; Russo, Leone, Penolazzi, & Natale, 2012; Tsaousis, 2010), whereas others reported moderate positive relations (Randler, 2008b; Zelenski et al., 2003) or no significant relation (DeYoung, Hasher, Djikic, Criger, & Peterson, 2007; Tonetti, Fabbri, & Natale, 2009). In sum, research findings do not reveal systematic relations between circadian preference and openness.

Circadian Preference and Conscientiousness

Out of all the Big Five personality dimensions, the relation between Conscientiousness and circadian preference is the most well established (Tonetti et al., 2009). Studies have consistently revealed small to medium positive correlations between Conscientiousness and morningness (e.g., Clark, 2007; DeYoung et al., 2007; Díaz-Morales, 2007; Kollia & Kothali, 2009; Russo et al., 2012). Similarly, Tsaousis' (2010) meta-analysis demonstrated that the average relation of morningness with Conscientiousness was $r = .29$. Preckel et al. (2013) found a significant positive correlation of .27 between Conscientiousness and morningness and a significant negative correlation of $-.17$ between Conscientiousness and eveningness (assessed as two dimensions with the LOCI; Roberts, 1998).

Circadian Preference and Extraversion

Studies that examined relations between circadian preference and Extraversion reported no significant correlations (DeYoung et al., 2007; Russo et al., 2012; Tonetti et al., 2009) or weak correlations between morningness and Extraversion as assessed by Big Five measures. Some of these correlations were negative (Cavallera & Giampietro, 2007; Díaz-Morales, 2007; Mitchell & Redman, 1993; Neubauer, 1992) and others were positive (Clark, 2007; Randler, 2008b). Overall, findings point to no systematic relations between circadian preference and Extraversion.

Circadian Preference and Agreeableness

A significant positive relation of $r = .13$ between morningness and Agreeableness has been found in Tsaousis' (2010) meta-analysis. However, findings from single studies that used Big-Five-based assessments reported either no relation (e.g., Cavallera & Giampietro, 2007; Tonetti et al., 2009; Russo et al., 2012) or small positive correlations with morningness (e.g., DeYoung et al., 2007; Hogben et al., 2007; Randler, 2008b). Overall, findings are inconsistent.

Circadian Preference and Neuroticism

Studies reported variable results on the relation between circadian preference and Neuroticism. Some investigations showed no significant relations between morningness and Neuroticism (e.g., DeYoung et al., 2007; Russo et al., 2012). Other investigations showed low correlations between the two constructs, some of which were negative (Tsaousis, 2010; Randler, 2008b) and others were positive (Cavallera & Giampietro, 2007; Díaz-Morales, 2007; Kollia & Kothali, 2009). Tonetti et al. (2009) found lower levels of Neuroticism in eveningness-oriented types.

It is obvious that although plentiful, the existing studies that have investigated links between circadian preference and personality reveal inconsistent and sometimes contradictory results. Such inconsistencies may, in part, be due to a variety of conceptualizations used to describe supposedly analogous personality factors in these studies (e.g., Cloninger's model of the seven dimensions of personality, Adan, Lachica, Caci, & Natale, 2010; Eysenck's three-factor model, PEN, which includes Psychoticism, Extraversion, and Neuroticism factors, Hess, Sherman, & Goodman, 2000; HEXACO, which includes honesty-humility (H), Emotionality (E), Extraversion (X), Agreeableness (A), Conscientiousness (C), and Openness to Experience (O) factors, Ashton et al., 2004; the Big Five in a first-order factor model, Russo et al., 2012, or as metatraits, DeYoung et al., 2007). Thus, aggregating findings across different models may be far less informative than it seems. Studies comparing the Eysenck three-factor model and the Costa and McCrae five-factor model (Angleitner & Ostendorf, 1994; McCrae & Costa, 1985) showed that although Extraversion and Neuroticism were convergent with the corresponding trait measures in both models, other factors did not align as clearly. So, for example, McCrae and Costa (1985) revealed that Eysenck's factor of psychoticism was related to Agreeableness and Conscientiousness factors in their Big Five model, and Angleitner and Ostendorf (1993) found relations among Eysenck's psychoticism and Agreeableness, Conscientiousness, and Openness in the Big Five, with the strongest correlation between psychoticism and Openness. A recent study by Dunlop et al. (2012) presented additional evidence showing that there may not be a clear conceptual overlap among putatively analogous factors that are part of different models. So, the researchers compared Eysenck's PEN with the HEXACO model—the latter including the factor of honesty-humility in addition to the Big Five factors. The investigation revealed that psychoticism captured elements of both emotionality (Big Five Neuroticism) and Conscientiousness. Further, Ashton demonstrated that Agreeableness and Neuroticism in HEXACO were not equivalent to the same factors in the Big Five model. The researchers showed that Agreeableness and Neuroticism (emotionality) from the HEXACO model represent rotated variants of their Big

Five counterparts. For example, characteristics related to a quick temper are associated with Neuroticism in the Big Five framework, but with low Agreeableness in the HEXACO framework. Hence, although there appears to be a certain degree of overlap among personality theories, comparing results of studies that are based on different approaches may not be a fruitful exercise. In our meta-analytic investigation, we examined studies that were based on a single conceptualization of personality, namely, the Big Five factor model (Costa & McCrae, 1992a, 1992b).

Aims of the Present Study

The main aim of the present study was to synthesize findings from a large number of investigations examining relations between circadian preference and personality. By employing the tool of meta-analysis we intended to derive aggregated effects of these relations, while also examining potential moderators of these relations (e.g., features of the sample: gender and age composition, nationality; features of the study: publication status, year of publication, design; Rosenthal & Rubin, 1978). We approached this task with seemingly stringent constraints.

First, unlike all prior reviews, we investigated relations of personality with circadian preference assessed as both separate dimensions and as a one-dimensional construct of circadian preference. We based our decision on empirical evidence attesting to the multidimensionality of circadian preference (Caci et al., 2005, 2009; Monk & Kupfer, 2007; Neubauer, 1992; Preckel et al., 2011, 2013; Putilov, 2010; Putilov, Donskaya, & Verevkin, 2015; Roberts & Kyllonen, 1999). The investigation of eveningness assessed with a separate scale and personality might be of particular interest not only for basic but also for applied research because eveningness seems to be a factor contributing to (lower) academic attainment (see meta-analysis by Preckel et al., 2011) and (lower) psychosocial adjustment (e.g., Schneider et al., 2011).

Second, we focused exclusively on studies that employed the Big Five assessments, and omitted those that used dimensions that came from Eysenck's or other personality models. The latter decision stemmed from the fact that conceptualizations of personality factors vary across models (Angleitner & Ostendorf, 1994; Dunlop et al., 2012; McCrae & Costa, 1985). Additionally, Tsaousis (2010) found that different personality questionnaires (Big Five vs. other) significantly moderated relations of circadian preference and personality. Aggregating across measures that differ in construct validity may bring more confusion rather than clarity to the field.

Finally, we used the Hunter and Schmidt (2004) meta-analytic approach that has a number of important advantages over alternative methods. For example, it provides an estimate of the amount of variation in the observed effect sizes that remains after accounting for the amount of variation that is to be expected as a function of known study artifacts and allows for computation of credibility intervals around the population estimates (further advantages are presented in the Analytical Strategy section).

Method

Study Collection and Coding of Study Characteristics

Studies were identified through a literature search in PsycINFO, PsycARTICLES, MedLINE, PubMed, Science Direct, Wiley Interscience, and PSYNDEX (all databases updated last time in December 2015), as well as Dissertation Abstracts International. The keywords were *chronotype [OR] circadian [OR] morningness [OR] eveningness [AND] personality*; *chronotype [OR] circadian [OR] morningness [OR] eveningness [AND] big five*; *chronotype [OR] circadian [OR] morningness [OR] eveningness[AND] openness*; *chronotype [OR] circadian [OR] morningness [OR] eveningness [AND] conscientiousness*; *chronotype [OR] circadian [OR] morningness [OR] eveningness [AND] extraversion/introversion*; *chronotype [OR] circadian [OR] morningness [OR] eveningness [AND] agreeableness*; as well as *chronotype [OR] circadian [OR] morningness [OR] eveningness [AND] neuroticism/emotional stability*. In addition, the journals *Chronobiology International*, *Sleep*, *Journal of Sleep Research*, and *Personality and Individual Differences* were systematically scanned. The references in every research report obtained were examined to identify other relevant studies. In addition, unpublished studies from cooperation projects of the authors were taken into account. Moreover, we contacted the authors in the field directly per email asking for further unpublished studies.

Inclusion criteria for studies were where (a) nonclinical samples were investigated, (b) the study used standardized scales that had previously been shown to produce scores characterized by high reliability for the assessment of Big Five personality factors and circadian preference, and (c) the study reported all the correlations (or other effect sizes that could be transformed into correlations) between Big Five personality and circadian preference. We excluded studies if they reported no empirical data or only reported previously published data. No time of publication, geographical location, or cultural location limitations were used to select or exclude studies. In five papers, correlations were not reported in the original study but obtained by contacting the authors (i.e., Cavallera, Gatto, & Boari, 2014; Ponzi, Wilson, & Maestripier, 2014; Randler, 2009; Tonetti, Fabbri, & Natale, 2009; Zelenski, Rusting, & Larson, 2003). We excluded one study, because it did not report the relevant correlations that could also not be obtained otherwise (Randler, 2008b). Another study (Jackson & Gerard, 1996) was excluded because of inconsistent information (which could not be clarified by contacting the authors) and because of a plausible methodological limitation not otherwise found in other studies (i.e., participants were allowed to complete protocols, at home, under nonstandardized conditions) as well as statistical anomalies (i.e., over one third of the participants were excluded from the analyses). Table A1 in the Appendix provides further information on study characteristics and the reliabilities of scores on scales.

For each study, the following information was coded: authors, publication status (published = 1, unpublished = 0), year of data publication (if published) or data collection (if unpublished), correlations between circadian preference and Big Five personality dimensions, correlations between eveningness and morningess, correlations among Big Five personality dimensions, sample size, gender composition of sample (percentage male), mean age of sample, country of data collection (U.S = 1, non-U.S.= 0); study design (longitudinal = 1, concurrent = 0), the assessment tool for both circadian preference and Big Five personality, and reliabilities reported for scores of both Big Five personality traits and circadian preference. The quality of studies was not coded because study quality was judged to be largely invariant. Data were coded independently by two of the authors who were highly familiar with the literature using detailed coding instructions. Intercoder agree-

ment was 100%. The coding protocol (list of the analyzed samples with their coded characteristics) is available from the authors.

Morningness and eveningness questionnaires used by the studies in the meta-analyses were the LOCI (Roberts, 1998), the CSM (Smith et al., 1989), a seven-item short form of the CSM (Randler, 2009), Horne and Östberg's (1976) MEQ, an Italian five-item short version of the MEQ (Natale, 1999), the Chronotype Questionnaire (Ogińska, 2011), and an adjusted version of the Pittsburgh Sleep Quality Index (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989) modified by Clark (2007). These various questionnaires conceptualize circadian preference in one of two ways: either as comprising separate M and E dimension or as a single-continuum (M-E). We therefore report separate meta-analytic estimates of the relation between personality and circadian preference for each conceptualization of the construct.

Big Five personality questionnaires for the studies in the meta-analyses were the Trait Self-Description Inventory (Tupes & Christal, 1992); the International Personality Item Pool (Goldberg et al., 2006); the Openness, Conscientiousness, Extraversion, Agreeableness, Neuroticism Index Condensed (Schulze & Roberts, 2006); the Big Five Inventory (John & Srivastava, 1999); the NEO-Five Factor Inventory (Costa & McCrae, 1992a), the Inventar Minimal Redundanter Skalen (Ostendorf, 1990); the NEO-Personality Inventory–Revised (Costa & McCrae, 1992b); the short version of the Big Five Inventory (Rammstedt & John, 2007); the Big Five Questionnaire (Caprara, Barbaranelli, & Borgogni, 1993); the Big Five Observer (Caprara, Barbaranelli, & Borgogni, 1994); the questionnaire Come Mi Vedo (Dogana, 2002); the Adjective-Based Personality Test (Bacanlı, İlhan, & Aslan, 2009); and the Traits Personality Questionnaire–5 (Tsaousis & Kerpelis, 2004).

Final Database

The final database comprised 620 correlations from 44 independent samples representing data from 16,647 individuals. Three hundred nine of these correlations described the relation of morningness, eveningness, and M-E with the Big Five personality traits.

Analytical Strategy

SPSS syntax provided by Field and Gillett (2010) and based on the Hunter and Schmidt (2004) meta-analytic methodology was used to quantitatively synthesize effect sizes across studies. Similar to most other meta-analytic methods, the Hunter and Schmidt approach allows computation of a sample size weighted estimate of the size of the population correlation between two variables (i.e., ρ) by correcting for study artifacts such as range restriction and unreliability in the measurement of both variables. The Hunter and Schmidt approach, however, also has a number of advantages over alternative meta-analytic methods. Primary among these is that it is based upon a random-effects model, which does not assume that the studies being included in the meta-analysis are homogenous at the level of the population effect size—an assumption made by fixed effects meta-analytic approaches such as the Hedges and Olkin (1985) approach. That is, the approach allows for the possibility that variations in estimated effect sizes across studies are not purely a function of study artifacts such as sampling error, range restriction, and unreliability in the measurement of variables but may reflect substantive differences across studies (i.e., study moderators). As such, the Hunter and Schmidt methodology provides an estimate of the amount of variation in the observed effect sizes that remains after accounting for the amount of variation that is to be expected as a function of known study artifacts. This value (SD_ρ) can be used as an indicator of effect size heterogeneity as well as of the presence and size of possible unexamined study moderators. SD_ρ values are also used to compute credibility intervals around the population estimate. These credibility intervals represent the range of plausible values for the true score correlation across situations such that wide credibility intervals (based on large SD_ρ values) indicate the likely presence of unexamined moderators. For the purposes of this study, we report 80% credibility intervals.

A second reason why the Hunter and Schmidt approach is preferable to alternative methods is that it allows the inclusion of studies that do not report full information on study artifacts (e.g., no data is reported on the reliability of scores). Rather than excluding such studies from the meta-analysis the Schmidt and Hunter approach as represented by the syntax provided by Field and Gillett (2010) imputes the mean observed reliability estimate for the few studies that did not report local reliability estimates. We did not make corrections for range restriction in our data because data for the population standard deviation was not available.

In addition to ρ, SD_ρ, and the 80% credibility intervals, we also report six additional pieces of information for each meta-analysis. The total number of independent samples included in each meta-analysis is represented by k, N is the total sample size of the k independent samples, r_{obs} is the sample size weighted mean observed correlation, SD_{obs} is the sample size weighted mean observed standard deviation in correlations, and % Var is the proportion of the variation in observed effect sizes that can be explained by variations in study artifacts (sampling error and unreliability in the measurement of both variables). As for credibility intervals, this value reflects the likelihood that the data may be characterized by unexamined moderators. Hunter and Schmidt (2004) argued that moderators are unlikely to be present if the values of % Var are greater than 75% because meta-analyses typically cannot correct for all study artifacts. That is, some unexplained variation is almost certainly caused by study artifacts that could not be corrected for due to incomplete information. Finally, we also present 95% confidence intervals for the computed values of ρ using the formula presented by Hunter and Schmidt (2004, p. 207).

To explore the possibility that our meta-analytic review is characterized by availability bias we present funnel plots of all relations involving the circadian preference variables as well as a test of funnel plot asymmetry as described by Egger, Smith, Schneider, and Minder (1997). For this test, the standard normal deviate of the effect size estimate reported in each study is regressed against the precision of the estimate. The intercept of the regression line provides information as to the presence of availability bias; significant negative intercepts indicating that studies with small sample sizes and low relations may be missing from the review. Funnel plots are presented in the supplemental materials.

We further explored the unique relation of each Big Five trait with morningness, eveningness, and M-E. Moreover, we investigated the ability of M and E (assessed by separate scales) to

explain unique variance in an external criterion (i.e., academic performance) by constructing a meta-analytic correlation matrix of the relation among Big Five traits, morningness, eveningness, and academic performance in secondary school and college. The data from the same set of studies used for the primary analysis (i.e., relations between circadian preference and Big Five) was used to calculate meta-analytic estimates of the relations among all Big Five traits (10 meta-analyses) and among M and E (one meta-analysis). We then imported the meta-analytic estimates of the relations of Big Five traits and M and E with academic performance from recently published meta-analyses (McAbee & Oswald, 2013; Preckel et al., 2011). Based on this matrix, we performed three multiple regression analysis. First we regressed morningness, eveningness, and M-E separately onto the Big Five traits to explore the unique relations of each Big Five trait with M and E. Second, we repeated this analysis for morningness while controlling for eveningness, and vice versa. Third, we regressed academic performance onto the Big Five traits, M and E. Of note, this analysis could not be done for M-E because no existing meta-analytic estimates of the relation between academic performance and M-E have been published to our knowledge. The harmonic mean of sample sizes associated with each correlation was used as the sample size for these regression analyses. It should be noted that this approach—based purely on correlations—is somewhat limited by the fact that information about the full covariance structure of variables is not available. Becker (1992) has shown that multivariate meta-analytic procedures can be slightly more accurate, although the gains in accuracy are typically small (e.g., Card, 2012).

The meta-analytic results of the relation between Big Five traits and circadian preference suggested the presence of some unexamined moderators. Thus, we explored whether or not any of the coded study characteristics might explain the variation in observed effect sizes across studies. These results are presented as supplemental materials.

Results

Relations Between Circadian Preferences and Big Five Personality Factors

Meta-analytic results regarding the relation between circadian preference and Big Five personality traits are presented in Table 1. Overall, the weakest (nonzero; see correlation between M-E and openness) relations were observed between M-E and Extraversion ($\rho = .03$) and between eveningness and Neuroticism ($\rho = -.04$), respectively, while the strongest relation was observed between Conscientiousness and morningness ($\rho = .37$) and between Conscientiousness and M-E ($\rho = .32$). The meta-analytic results also suggested the presence of relatively large undetected moderators (see the supplemental materials for moderator analyses). SD_ρ values (and hence, credibility intervals) were relatively large for both the morningness-Openness relation ($SD_\rho = .12$) and for the morningness-Neuroticism relation ($SD_\rho = .13$), as well as for the M-E–Conscientiousness relation ($SD_\rho = .13$) and the M-E–Neuroticism relation ($SD_\rho = .13$), indicating that the size of these relations varied relatively widely across studies.

Our meta-analytic strategy was to compute separate correlations between morningness and Big Five traits, eveningness and Big Five traits, and M-E and Big Five traits. This approach is justified if M and E exhibit unique relations with the Big Five personality traits. To explore this issue we also computed two widely used indexes of profile similarity, the simple Pearson correlation and the double-entry intraclass correlation (Furr, 2010; McCrae, 2008) for the relations of both M and E with Big Five traits. The moderate size of both of these relations ($r = .34$, ICC $= -.40$) supported the M-E distinction in so far as it suggests that the two constructs exhibit relatively distinct relations with Big Five traits. This distinction was also supported by the meta-analytic estimate of the relation between morningness and eveningness (see Table 2), which was found to be negative in direction, and characterized by

Table 1
Meta-Analytic Estimates of Relations Between Morningness/Eveningness and Big Five Personality Traits

Morningness (M) or eveningness (E)	Big Five variable	k	N	r_{obs}	SD_{obs}	ρ	SD_ρ	10% CR	90% CR	% Var.	2.5% CI	97.5% CI	Egger's test$_a$	p
M	Openness	19	6,577	.10	.12	.12	.12	−.04	.28	21	.10	.14	−1.71	.25
M	Conscientiousness	19	6,577	.32	.07	.37	.06	.30	.44	51	.35	.39	−.66	.48
M	Extraversion	19	6,577	.11	.09	.13	.09	.01	.25	33	.11	.15	.72	.57
M	Agreeableness	19	6,577	.17	.09	.19	.10	.07	.32	30	.17	.21	.50	.68
M	Neuroticism	19	6,577	−.20	.12	−.23	.13	−.39	−.07	18	−.25	−.21	.48	.77
E	Openness	19	6,577	.14	.09	.17	.08	.06	.27	37	.17	.19	.19	.87
E	Conscientiousness	19	6,577	−.16	.05	−.19	.02	−.21	−.16	89	−.21	−.17	−.12	.87
E	Extraversion	19	6,577	.16	.05	.20	.00	.20	.20	100	.18	.22	−.68	.24
E	Agreeableness	19	6,577	−.05	.11	−.06	.11	−.20	.08	25	−.08	−.04	−2.80	.04
E	Neuroticism	19	6,577	−.04	.10	−.04	.11	−.18	.10	26	−.06	−.02	−1.33	.32
M	Eveningness	19	7,034	−.33	.11	−.40	.12	−.55	−.24	18	−.42	−.38	−1.16	.34
M-E cont.	Openness	23	8,659	.00	.01	.00	.10	−.13	.13	27	−.02	.02	−.30	.77
M-E cont.	Conscientiousness	25	10,070	.27	.11	.32	.13	.16	.49	16	.30	.34	−1.49	.15
M-E cont.	Extraversion	23	8,659	.02	.08	.03	.07	−.06	.12	42	.01	.05	−.19	.85
M-E cont.	Agreeableness	24	8,954	.12	.08	.14	.08	.05	.24	40	.12	.16	−.66	.52
M-E cont.	Neuroticism	24	8,954	−.07	.12	−.09	.13	−.26	.08	18	−.11	−.07	.77	.45

Note. M-E cont. = Morningness–eveningness as a unidimensional variable; k = number of studies; N = number of subjects; r_{obs} = sample size weighted mean observed correlation; SD_{obs} = standard deviation of observed correlations; ρ = true score correlation; SD_ρ = standard deviation of true score correlation; CR = credibility interval; % Var = proportion of the variation in observed effect sizes that can be explained by variations in study artifacts (sampling error and unreliability in the measurement of both variables), CI = confidence interval; Egger test$_a$ = intercept from Egger's test for funnel plot asymmetry, p = p-value associated with test of null hypothesis that intercept is not significantly different from zero.

Table 2
Meta-Analytic Estimates of Relations Among Big Five Personality Traits

Relation	*k*	*N*	r_{obs}	SD_{obs}	ρ	SD_{ρ}	10% CR	90% CR	% Var.	2.5% CI	97.5% CI
Conscientiousness–Agreeableness	28	10,113	.32	.19	.39	.23	.10	.68	6	.37	.41
Conscientiousness–Extroversion	27	9,818	.21	.12	.25	.14	.08	.42	18	.23	.27
Conscientiousness–Neuroticism	28	10,111	−.17	.25	−.20	.29	−.57	.17	4	−.18	.22
Conscientiousness–Openness	27	9,816	.16	.23	.19	.27	−.16	.54	5	.17	.21
Agreeableness–Extroversion	27	9,821	.20	.20	.26	.25	−.06	.57	6	.24	.28
Agreeableness–Neuroticism	28	10,114	−.11	.27	−.14	.31	−.54	.27	4	−.16	−.12
Agreeableness–Openness	27	9,819	.21	.19	.26	.22	−.01	.54	7	.24	.28
Extroversion–Neuroticism	27	9,819	−.16	.25	−.19	.31	−.58	.20	4	−.21	.17
Extroversion–Openness	27	9,819	.22	.14	.27	.16	.06	.48	13	.25	.29
Neuroticism–Openness	27	9,818	−.07	.17	−.09	.19	−.33	.14	10	−.11	−.07

Note. *k* = number of studies; *N* = number of subject; r_{obs} = sample size weighted mean observed correlation; SD_{obs} = standard deviation of observed correlations; ρ = true score correlation; SD_{ρ} = standard deviation of true score correlation; CR = credibility interval; % Var = percentage of overall variance accounted for by examined study artifacts; CI = confidence interval.

a moderate level of moderation ($k = 19$, $N = 7{,}034$, $\rho = -.40$, $SD_{\rho} = .12$).

Regression Analysis

Table 2 also reports results for the 11 meta-analyses on the relations among Big Five traits. Relations among Big Five traits were characterized by substantial variability across studies.

Table 3 through to Table 6 present results from the regression analyses based on the meta-analytic correlation matrix for the relations among Big Five traits, morningness, eveningness, M-E, and academic performance. Big Five traits accounted for 16.4% of the variance in morningness, 13% of the variance in eveningness, and 10.9% of the variance in M-E. We found that all Big Five traits accounted for some unique variance in the three dependent variables but the relative importance of Big Five traits varied widely. Of all the Big Five traits, Conscientiousness exhibited the strongest unique relation with morningness (β = .32), eveningness (β = −.26), and M-E (β = .32). Both, Extraversion and Openness exhibited modest unique relations with eveningness (β = .23 and β = .17, respectively) but not with morningness (β = .00 and β = .04, respectively) or M-E (β = −.05 and β = −.06, respectively). Neuroticism exhibited a modest relation with morningness (β = −.16); it did not, however, show a unique relation with either eveningness (β = −.04) or M-E (β = −.04). Agreeableness was only weakly related to the three circadian preference variables.

The pattern of relations between Big Five variables and M and E was largely retained when first controlling for the other dimension. That is, when controlling for eveningness, morningness was modestly positively related to Conscientiousness (β = .21) and modestly negatively related to Neuroticism (β = −.18). When controlling for morningness, eveningness was modestly related to Extraversion (β = .23) and Openness (β = .19).

Incremental validity of circadian preference variables over Big Five factors was evaluated using hierarchical regression. As shown in Table 6, M and E explained small amounts of unique variance in college academic performance ($\Delta R = .014$, $\Delta R^2 = .008$, both $p < .01$), after controlling for Big Five traits.

Discussion

In the current meta-analyses we quantitatively synthesized existing relations among the Big Five personality dimensions and circadian preferences. Although ours is not the first meta-analysis looking at these links, it is notably different from previous ones (e.g., Tsaousis, 2010). In our study we explored circadian preference assessed as a one-dimensional construct (i.e., M-E) or two-dimensional construct (i.e., M and E) and focused on studies that

Table 3
Results for Regression of Morningness and Eveningness Onto Big Five Personality Traits

	Dependent Variables											
	Morningness						Eveningness					
Independent variables	β	*t*-ratio	*p*	$r^2_{Y(A.B)}$	2.5% CI	97.5% CI	β	*t*-ratio	*p*	$r^2_{Y(A.B)}$	2.5% CI	97.5% CI
Openness	.04	3.29	<.01	.001	−.020	.022	.17	15.36	<.01	.026	.007	.045
Conscientiousness	.32	27.66	<.01	.081	.062	.100	−.26	−22.34	<.01	.055	.037	.073
Extroversion	.00	.17	.86	.000	−.021	.021	.23	20.07	<.01	.045	.027	.063
Agreeableness	.03	2.95	<.01	.000	−.021	−.021	−.07	−5.76	<.01	.004	−.016	.024
Neuroticism	−.16	−14.84	<.01	.023	.002	.044	−.04	−3.96	<.01	.002	−.018	.022
Adjusted R^2				.164						.130		
Adjusted *R*				.405						.361		

Note. Harmonic sample size used for analysis = 7,859. $r^2_{Y(A.B)}$ = squared semipartial correlation; CI = confidence interval. Standardized regression coefficients, *t*-values, and squared semipartial correlations are for all variables entered jointly.

Table 4
Results for Regression of Morningness–Eveningness Onto Big Five Personality Traits

Independent variables	Morningness–Eveningness					
	β	*t*-ratio	*p*	$r^2_{Y(A.B)}$	2.5% CI	97.5% CI
Openness	−.06	−5.92	<.01	.003	−.014	.020
Conscientiousness	.32	30.02	<.01	.084	.071	.097
Extroversion	−.05	−4.88	<.01	.002	−.015	.019
Agreeableness	.04	3.55	<.01	.001	−.016	.018
Neuroticism	−.04	−3.55	<.01	.001	−.016	.018
Adjusted R^2				.109*		
Adjusted *R*				.330*		

Note. Harmonic sample size used for analysis = 9,595. $r^2_{Y(A.B)}$ = squared semipartial correlation; CI = confidence interval.
* $p < .01$.

conceptualized personality exclusively within the Big Five model. We also used a meta-analytic approach that has a number of important advantages over alternative methods (Hunter & Schmidt, 2004). Further, we investigated whether M and E incremented over the Big Five personality dimensions in explaining academic performance.

General Findings and the One- or Two-Dimensional Assessment of Circadian Preference

The current study revealed small to moderate relations between circadian preference and personality. The strongest observed relations were between Conscientiousness and circadian preference (morningness ρ = .37; eveningness ρ = −.19; M-E ρ = .32). Agreeableness and circadian preference were also related, although the link was much weaker (morningness ρ = .19; eveningness ρ = −.06; M-E ρ = .14). These finding are well aligned with those reported by Tsaousis (2010). However, while Conscientiousness and Agreeableness showed similar relations with M-E and with morningness, the relations of both personality factors with M-E or with eveningness differed (e.g., eveningness showed a moderate negative relation with Conscientiousness while M-E showed a moderate positive relation). These findings suggest that unidimensional assessments of circadian preference (i.e., M-E) may reflect variability in circadian preference primarily attributable to morningness preferences.

Our findings further revealed unique relations of eveningness with Openness (ρ = .17) and Extraversion (ρ = .20) and of morningess with Neuroticism (ρ = −.23), which did not show up when assessing circadian preference as M-E (values of ρ between −.09 and .03). These results echo findings presented in Tsaousis (2010), who reported very weak relations between M-E and Openness (−.02), Extraversion (.02), and Neuroticism (−.05) when only Big Five questionnaires were considered in his moderator analysis.

Our meta-analyses further demonstrated a moderate link between M and E (ρ = −.40) indicating that both circadian preferences are neither opposite to one another, nor are they mutually exclusive. Further, our findings reported above and the findings of our regression analyses show that M and E display independent (i.e., specific) relations with the Big Five personality traits. Hence, our results support the suitability and usefulness of a two-dimensional assessment of circadian preferences. Specifically, circadian preference appears to be a two-dimensional construct and should be interpreted in a manner akin to the bivariate attitude plane outlined by Cacioppo and colleagues (Cacioppo & Berntson, 1994; Cacioppo, Gardner, & Berntson, 1999). That is, we should describe individuals in terms of their joint position on M and E because all combinations (high-low) of these two constructs appear plausible, although some are more or less common than others. To that end, Putilov et al. (2015) attempted to validate a four type (two-dimensional) classification of individuals' morning/evening preference. The authors supported the two-dimensional classification and proposed that M and E should be considered singly and in terms of the ways they might interact. Thus, in addition to the traditionally understood morning and evening types, an individual could be described as high M and E (e.g., being energetic in morning *and* evening hours) or, conversely, as low M and E (e.g., being not energetic in morning or evening hours but possibly during midday).

Table 5
Results for Regression of Morningness and Eveningness Onto the Other Circadian Preference Dimension and the Big Five Personality Traits

Step	Independent variables	Dependent variable: Morningness						Dependent variable: Eveningness					
		β	*t*-ratio	*p*	$r^2_{Y(A.B)}$	2.5% CI	97.5% CI	β	*t*-ratio	*p*	$r^2_{Y(A.B)}$	2.5% CI	97.5% CI
1	Morningness							−.42	−40.00	<.01	.147	.125	.169
	Eveningness	−.40	−40.00	<.01	.142	.119	.165						
2	Openness	.11	10.38	<.01	.010	−.014	.034	.19	18.32	<.01	.031	.007	.055
	Conscientiousness	.21	19.65	<.01	.034	.010	.058	−.13	−11.48	<.01	.012	−.012	.036
	Extroversion	.09	9.02	<.01	.007	−.017	.031	.23	22.09	<.01	.045	.022	.068
	Agreeableness	.01	.63	.53	.000	−.024	.024	−.05	−4.99	<.01	.002	−.022	.026
	Neuroticism	−.18	−18.05	<.01	.029	.005	.053	−.11	−10.88	<.01	.011	−.013	.035
1	Adj. R^2 and Adj. *R*				.160* and .400*						.160* and .400*		
2	Adj. R^2 and Adj. *R*				.306* and .553*						.277* and .526*		
	ΔR, ΔR^2				.146* and .153*						.117* and .126*		

Note. CI = confidence interval; $r^2_{Y(A.B)}$ = squared semipartial correlation; Adj. = adjusted. Harmonic sample size used for analysis = 7,859.
* $p < .01$.

Table 6
Results for Hierarchical Regression of College Academic Performance Onto Big Five Personality Traits, Morningness, and Eveningness

Independent variables	β	*t*-ratio	*p*	$r^2_{Y(A.B)}$	2.5% CI	97.5% CI
Openness	.07	5.41	<.001	.004	−.015	.023
Conscientiousness	.26	17.91	<.001	.058	.041	.075
Extraversion	−.09	−6.73	<.001	.006	−.013	.025
Agreeableness	−.03	−2.47	.014	.000	−.019	.019
Neuroticism	.05	3.68	<.001	.001	−.018	.020
Total adjusted *R*	.286*					
Total adjusted R^2	.082*					
Morningness	.06	4.15	<.001	.002	−.017	.021
Eveningness	−.06	−4.21	<.001	.002	−.017	.021
Total adjusted *R*	.300*					
Total adjusted R^2	.090*					
ΔR, ΔR^2	.014*, .008*					

Note. $r^2_{Y(A.B)}$ = squared semipartial correlation; CI = confidence interval. Harmonic sample size used for analysis = 6,073. Standardized regression coefficients, *t*-values, and squared semipartial correlations are for all variables entered jointly.
* $p < .05$.

When discussing the two-dimensional structure of circadian preference, an important point should be articulated. Circadian preference can be and has been used by researchers as a proxy for chronotype because of the established relation between self-reported circadian preference and biological correlates. At the same time, chronotype, conceptualized as the endogenous phase of the circadian rhythm, does not appear to involve largely independent peaks in the morning or evening activity. That is, while there is evidence that circadian preference is two-dimensional, no such evidence exists for chronotype and related endogenous processes. This view is supported by examining underlying sources of M and E from a behavioral genetic perspective. Using information on twin similarities, behavioral genetics studies investigate the genetic and environmental origins of individual differences by partitioning the observed variation into genetic as well as environmental variance components (Plomin, DeFries, Knopik, & Neiderhiser, 2013). To explore the etiology of circadian preference, eveningness and morningness were assessed by separate scales in a sample of adult twins (ChronoS twin study; Hahn, Preckel, & Spinath, 2011; for a description see Hahn, Gottschling, & Spinath, 2013). Initial results showed substantial genetic influences on both M and E. Further, the relation between morningess and eveningness was investigated using bivariate genetic modeling (Loehlin, 1996). This approach allows for exploring genetic and environmental influences on common and specific aspects of M and E. Results, on the one hand, indicated that the moderate relation between M and E was largely explained by shared genetic influences. The larger proportion of specific variance in M and E, on the other hand, was explained mainly by environmental factors. This pattern of findings is in line with the assumption that general effects exist at the genetic level that influence a global tendency for the individual to exhibit a particular circadian preference. However, the specifics that describe M and E and also contribute to their dimensionality appear to reflect to a larger degree cultural forces including schedules for work, peer groups and socialization, both within and outside the family.

In sum, we propose that the idea of a M-E continuum impedes the identification of relations such as those found here with Extraversion, Openness, and Neuroticism. The meta-analytic findings herein reported provide empirical evidence and suggest the need for viewing circadian preference as a two-dimensional construct. We feel that a multidimensional view of circadian preference will allow future research to uncover more nuanced and meaningful relations among circadian preference and related concepts.

Circadian Preference and Its Distinctiveness From the Big Five Personality Factors

To estimate the unique contributions made by each Big Five trait in explaining variance in morningness, eveningness, or M-E, we conducted regression analyses. The analyses revealed that the Big Five traits accounted for 16.4% of the variance in morningness, for 13% of the variance in eveningness, and for 10.9% of the variance in M-E. Of all the Big Five traits, Conscientiousness exhibited the strongest unique relation with circadian preference (morningness β = .32; eveningness β = −.26; M-E β = .32), a finding consistent with results of the previous meta-analysis (Tsaousis, 2010) and individual studies (e.g., Cavallera & Giampietro, 2007; DeYoung et al., 2007). Both Extraversion and Openness showed unique relations with eveningness (β = .23 and β = .17, respectively) and Neuroticism showed unique relations with morningness (β = −.16). Agreeableness revealed weak but significant relations with morningness (β = .03) and eveningness (β = −.07). Again, these results are in line with earlier findings that have also failed to reveal significant relations between these personality variables and chronotype dimensions (e.g., Tsaousis, 2010). For M and E findings were stable, when controlling for the other circadian preference, respectively.

Circadian Preference, Conscientiousness, and Academic Achievement

The strongest relations that were revealed in our analyses were between Conscientiousness and circadian preference. We found a positive relation between Conscientiousness and morningness and M-E and a negative relation between Conscientiousness and eveningness. The former finding is consistent with that of Tsaousis (2010). The relation between eveningness and Conscientiousness, however, has been masked in previous studies, where only a morningness factor or a general factor of M-E has been typically explored (e.g., DeYoung et al., 2007; Díaz-Morales, 2007; Kollia & Kothali, 2009).

The consistent relation between Conscientiousness and morningness, eveningness as well as the combination score of M-E may in part reflect a common genetic source, that is, the same set of genes influencing the tendency to be conscientious and more oriented toward morning activities. The findings on the heritability of both personality (for a review, see Johnson et al., 2008) and chronotype (Hur, Bouchard, & Lykken, 1998; Hur, 2007; Vink, Groot, Kerkhof, & Boomsma, 2001; Hahn et al., 2011), as well as on the phenotypic correlation among them may indicate a common genetic background—a hypothesis that might be investigated in future inquiries. In addition, this moderate association between circadian preference and personality was in part also attributable to environmental sources that propagated behavior more common in

conscientious individuals with a morningness orientation. Further genetically informed research is needed to disentangle the etiological underpinnings of the development of Conscientiousness and morningness over the life course, especially as they relate to the field of academic achievement.

The relation of circadian preference and Conscientiousness is of great importance, especially in the educational context. Conscientiousness has consistently been found to predict academic achievement from preschool (Abe, 2005) through high school (Noftle & Robins, 2007), the postsecondary level (O'Connor & Paunonen, 2007) and adulthood (Ackerman & Heggestad, 1997; De Fruyt & Mervielde, 1996; Shiner et al., 2003). Conscientiousness measured in schoolchildren was found to predict academic achievement at age 20 and eventual academic attainment at age 30 (Shiner & Masten, 2002). Conscientiousness also explained college grades even after controlling for high school grades and SAT scores (Conard, 2006; Noftle & Robins, 2007), suggesting that it may compensate for lower cognitive ability (Chamorro-Premuzic & Furnham, 2003a). M and E inversely relate to academic performance with morningness showing positive and eveningness showing negative relations (Preckel et al., 2011).

In the current study, we also estimated whether M and E explained variance in academic performance above and beyond the variance explained by Big Five personality traits. Interestingly, after controlling for Big Five traits, M and E explained unique variance in academic performance ($\Delta R = .014$, $\Delta R^2 = .008$). We must note that the amount of incremental variance explained was small. However, even small increments in explained variance can be very useful in applied settings. For example, future studies may investigate whether M and E may provide significant incremental validity over Big Five traits in the prediction of other important outcomes from other important domains, such as job performance, subjective well-being, or marital success.

Future Research Directions

Personality is a relatively dynamic entity, changing in meaningful and periodical ways across time (Luhmann, Orth, Specht, Kandler, & Lucas, 2014). Here, an important distinction between traits and behavioral manifestation of traits has to be made. A trait represents individuals' general tendency to react and behave in a particular way. It can change over time, but is likely to remain relatively stable over months or years. The degree to which a trait manifests in behavior, however, fluctuates much more widely over the course of an hour or a day or a week. Time of day then, can be seen to be important not just in changing the manifestation of personality, but in defining it. For example, Extraversion might be partially defined by a periodical function, which modulates it to into being a slightly different thing at different times of day. As it happens, this is precisely the finding reported by Brown and Moskowitz (1998) in their study of the Big Five factors of personality across daily and weekly cycles. Time of day is a factor that is very often left out of our descriptions of people, yet it is basic to the way we function. The importance of cyclical functions of time for traits and behavior is too great to be overlooked, and the role that circadian rhythms research can play in this is important as well. Future research should aim to link cyclicity in personality traits with circadian preference factors and look at their combined predictive power for behavior at different times of day. In a similar vein, it would be interesting to conduct longitudinal investigation on how circadian preference develops from chronotype. Genetically informed study designs could be used to identify the role of specific environmental sources such as social norms while controlling for underlying genetic effects. Finally, studying M and E within research designs focusing also on neurological, physiological, and developmental perspectives, may both validate and expand upon the model that has been proposed, including issues of dimensionality.

Further, circadian preference may be particularly important as a predictor of success in certain jobs, for example jobs requiring high alertness or energy in early morning or late in evening. This is something that future inquiries may consider. Also, from a methodological perspective it may be advisable to use polynomial regression and response surface methods to explore the joint relation of M and E with important criteria.

Future studies might also investigate the structure of circadian preferences assessed as one- and two-dimensional construct in a single sample. A confirmatory factor analysis would be in order as it will help us to better understand the construct validity of existent circadian preference questionnaires.

Additionally, Russo et al. (2012) examined the effects of broad (i.e., Conscientiousness) and narrow (i.e., orderliness or sensation seeking) personality traits on individuals' circadian preferences. The researchers found no direct effects of the Big Five traits after the effects of narrower traits were taken into account. Future studies could further examine these contingencies and analyze relations of narrow personality traits, M and E.

Our findings as well as those of previous investigations consistently reveal medium to strong correlations between Conscientiousness and circadian preferences. Considering such strong links between the two constructs, one may wonder whether circadian preference (i.e., its morningness dimension) could be categorized as a facet of Conscientiousness. Our results reveal that links between circadian preference and Conscientiousness, albeit substantial, may not be strong enough to arrive at this conclusion. For example, Roberts, Chernyshenko, Stark, and Goldberg (2005) showed that the facets of Conscientiousness were correlated at .44 to .64 with overall Conscientiousness. Of note is that correlations in Roberts' et al. (2005) study were not corrected for unreliability; hence, the corrected correlations could be even higher. Other studies reveal lower correlations between facets of Conscientiousness and the overall factor (MacCann, Duckworth, & Roberts, 2009). Correlations between circadian preferences and Conscientiousness in our study were lower (e.g., $\rho = .37$ for Conscientiousness and M). However, the question of whether circadian preference (or one of its dimensions) could constitute a facet of Conscientiousness may be an interesting question to be addressed by future research.

Limitations

This study is not without limitations. The number of correlations for some of the analyses was small. Schmidt et al. (1985) addressed this issue directly. The researchers noted that it was appropriate to cumulate results based on relatively few studies due to the fact that although meta-analyses based on small numbers of studies may increase the variability in the effect sizes, they do not affect the mean estimates. Thus, estimates that are distinguishable from zero based on a small number of studies will very likely continue to be distinguishable from zero as evidence accumulates. Further, researchers have noted that even small meta-analyses

were superior to the subjectivity and imprecision involved in interpreting primary study results (Judge & Bono, 2001). Finally, this study reported meta-analyses of correlations between individuals' circadian preference and personality dimensions. Due to the fact that correlations assume a linear relation, all relations in this manuscript are assumed to be linear. It is possible that some of the relations among variables under study may be nonlinear, but could not be adequately tested in the current investigation given the linear constraints of aggregating correlation coefficients.

Conclusion

The current series of meta-analyses aggregated research findings available to date on the relation of circadian preference and the Big Five personality factors. We also examined the unique contribution of the Big Five factors in explaining variance in morningness, eveningness, and M-E assessed on a continuum, and investigated whether the two dimensions of circadian preference incremented over personality factors in explaining students' academic performance. Conscientiousness exhibited the strongest relation with and explained the largest amount of variance in circadian preferences. We also found that M and E incrementally explained variance in academic performance over and above the Big Five personality factors. The results suggested the importance of treating circadian preference as separable from the Big Five and opened new and promising avenues for future research.

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Appendix

Study Characteristics, Reliabilities, and Correlations of Morningness, Eveningness, and Big Five of Studies Included in the Meta-Analyses

Study/Project	*N* (% male)	Mean age	Big Five measure		Chronotype measure		Correlations				
			Name	Reliability	Name	Reliability	O × M/E	C × M/E	Ex × M/E	A × M/E	N × M/E
1. Hahn, Preckel, & Spinath (2011)	887 (27%)	44.10	NEO-PI-R	O: .87 C: .89 Ex: .88 A: .85 N: .92	LOCI	M: .87 E: .88	M: −.04 E: .19	M: .27 E: −.09	M: .04 E: .18	M: .12 E: −.09	M: −.21 E: −.05
2. Krause & Roberts (2006)	84 (8%)	20.87	TSDI	O: .93 C: .92 Ex: .52 A: .86 N: .93	LOCI	M: .84 E: .82	M: .12 E: .06	M: .44 E: −.30	M: .09 E: .09	M: .18 E: −.29	M: −.26 E: .05
3. Lipnevich, Preckel, & Krumm (2014)	203 (76%)	19.46	BFI	O: .68 C: .78 Ex: .82 A: .65 N: .75	LOCI	M: .78 E: .71	M: .13 E: .21	M: .33 E: −.17	M: .15 E: .13	M: .21 E: −.21	M: −.26 E: −.18
4. Mikolajski (2002)	255 (19%)	20.48	OCEANIC	Not reported	LOCI	Not reported	M: .08 E: .20	M: .40 E: −.22	M: .24 E: .18	M: .29 E: −.05	M: −.35 E: .01
5. Pallier et al. (2002)	520 (85%)	20.03	TSDI	O: .92 C: .93 Ex: .50 A: .84 N: .93	LOCI	M: .88 E: .83	M: .21 E: .18	M: .41 E: −.09	M: .12 E: .18	M: .26 E: −.05	M: −.36 E: −.10
6. Preckel et al. (2013)	273 (52%)	15.59	MRS	O: .71 C: .75 Ex: .50 A: .58 N: .68	LOCI	M: .81 E: .75	M: .13 E: .09	M: .28 E: −.18	M: −.02 E: .14	M: .20 E: −.14	M: −.10 E: −.25
7. Preckel, F. (2005)	124 (15%)	21.50	NEO-FFI	O: .65 C: .82 Ex: .83 A: .88 N: .77	LOCI	M: .88 E: .88	M: −.06 E: .06	M: .15 E: −.19	M: −.06 E: .12	M: .22 E: −.32	M: −.04 E: −.11
8. Lipnevich, Preckel, & Krumm (2014)	216 (29%)	22.56	BFI	O: .78 C: .84 Ex: .87 A: .75 N: .85	LOCI	M: .87 E: .88	M: .02 E: .29	M: .31 E: −.17	M: .15 E: .21	M: .16 E: −.16	M: −.02 E: −.17
9. Roberts & Heggestad, (1998)	700 (83%)	20.44	TSDI	O: .91 C: .93 Ex: .57 A: .83 N: .94	LOCI	M: .84 E: .74	M: .17 E: .09	M: .39 E: −.14	M: .20 E: .12	M: .28 E: −.02	M: −.40 E: .04

(*Appendix continues*)

Appendix (*continued*)

Study/Project	*N* (% male)	Mean age	Big Five measure		Chronotype measure		Correlations				
			Name	Reliability	Name	Reliability	O × M/E	C × M/E	Ex × M/E	A × M/E	N × M/E
10. Roberts & Karlov (2002)	100 (21%)	19.57	OCEANIC	not available	LOCI	M: .83 E: .82	M: .09 E: .32	M: .15 E: −.03	M: .01 E: .28	M: .14 E: .04	M: −.25 E: −.08
11. Roberts (2001)	91 (43%)	19.75	NEO-FFI	O: .75 C: .80 Ex: .83 A: .75 N: .90	LOCI	M:.88 E: .85	M: −.03 E: .13	M: .29 E: −.07	M: .42 E: .07	M: .16 E: .03	M: −.26 E: −.12
12. Roberts & Garcia (1999)	100 (44%)	30.35	BFI-44	O: .64 C: .74 Ex: .80 A: .49 N: .79	LOCI	M: .82 E: .85	M: −.18 E: .27	M: .35 E: −.19	M: −.07 E: .09	M: .32 E: −.22	M: −.23 E: −.04
13. Roberts (2002)	256 (14%)	22.07	OCEANIC	O: .85 C: .87 Ex: .48 A: .69 N: .87	LOCI	M: .93 E: .89	M: .17 E: .10	M: .24 E: −.17	M: .15 E: .24	M: .17 E: .05	M: −.16 E: .02
14. Wagener (2003)	199 (6%)	21.26	NEO-PI-R	Not reported	LOCI	M: .87 E: .83	M: .27 E: −.02	M: .36 E: −.10	M: .15 E: .13	M: .20 E: −.28	M: −.30 E: .06
15. Roberts (2005)	431 (37%)	22.09	IPIP-100	not available	LOCI	M: .86 E: .81	M: .01 E: .19	M: .20 E: −.13	M: .08 E: .12	M: .07 E: .13	M: −.12 E: −.01
16. Roberts & Schulze (2005)	824 (37%)	21.96	IPIP-100	not available	LOCI	M: .87 E: .81	M: .04 E: .21	M: .29 E: −.19	M: .08 E: .13	M: .01 E: .08	M: −.08 E: −.10
17. Roberts (2006)	814 (49%)	12.00	IPIP-100	not available	LOCI	M: .76 E: .79	M: .29 E: −.02	M: .32 E: −.23	M: .04 E: .23	M: .23 E: −.04	M: −.04 E: .17
18. DeYoung, Hasher, Djikic, Criger, & Peterson (2007)	297 (29%)	18.80	BFI	O: .71 C: .76 Ex: .85 A: .76 N: .80	MEQ	.67	.00	.11	.04	.21	−.09
19. Hogben, Ellis, Archer, & von Schantz (2007)	617 (33%)	25.20	NEO-FFI	O: .70 C: .83 Ex: .78 A: .78 N: .85	MEQ	Not reported	−.14	.33	.05	.18	−.03
20. Kollia & Kothali (2009)	151 (?)		TEXAP5	not available	MEQ	not available	.12	.26	−.02	.18	.10
21. Roberts & Kyllonen (1999)	420 (83%)	20.22	TSDI	O: .90 C: .94 Ex: .50 A: .87 N: .94	MEQ	.72	.10	.32	−.01	.22	−.26
22. Tonetti, Fabbri, & Natale (2009)	503 (44%)	25.50	BFO	O: .67 C: .68 Ex: .74 A: .60 N: .54	MEQ	Not reported	−.06	.38	.00	.06	.18
23. Zelenski, Rusting, & Larsen (2003)	80 (25%)	20.46	NEO-FFI	O: .72 C: .89 Ex: .82 A: .76 N: .82	MEQ	.85	.15	.36	.01	.01	.09
24. Randler (2008a)	1231 (56%)	15.76	Short BFI	Not reported	CSM	.86	.02	.34	.01	.13	−.07
25. Hahn & Spinath (2011)	182 (33%)	23.20	NEO-FFI	O: .76 C: .86 Ex: .80 A: .77 N: .88	LOCI	M: .87 E: .86	M:−.02 E: .10	M: .34 E: −.20	M: .23 E: .02	M: .09 E: −.18	M: −.19 E: −.07
26. Cavallera & Giampietro (2007)	120 (50%)	24.30	Come mi vedo	O: .76 C: .85 Ex: .84 A: .84 N: .81	rMEQ	.71	−.31	.32	−.17	.02	.00
27. Randler (2009)	206 (17%)	23.91	Short BFI	Not reported	rCSM	.82	−.02	.27	.01	.12	−.01
28. Clark (2007; from Tsaousis, 2010)	80 (70%)	?	NEO-PI-R	O: .87 C: .90 Ex: .89	PSQI modified by author	.69	.10	.30	.03	.31	−.11

(*Appendix continues*)

Appendix (*continued*)

Study/Project	*N* (% male)	Mean age	Big Five measure		Chronotype measure		Correlations				
			Name	Reliability	Name	Reliability	O × M/E	C × M/E	Ex × M/E	A × M/E	N × M/E
29. Duggan, Friedman, McDevitt, & Mednick (2014)	436 (50%)	19.88	BFI	A:.86 N: .92 O: .84[a] C: .84[a] Ex: .84[a] A: .84[a] N: .84[a]	MEQ	.86 (no sample reliabilities, but taken from MEQ manual)	.15	.35	.07	.15	−.18
30. Ogińska & Ogińska-Bruchal (2014)	101 (44%)	26.4	Neo-FFI	Not reported	ChQ	.82 − .84	.16	−.11	.01	−.13	.11
31. Randler, Stadler, Vollmer, & Diaz-Morales (2012)	277 (0%)	22.25	Short BFI	O: .74[b] C: .77[b] Ex: .83[b] A: .68[b] N: .74[b]	CSM	.89	−.00	.28	.28	.12	.13
32. Randler, Baumann, & Horzum (2014)	291 (22%)	22.14	Short BFI	O: .74[b] C: .77[b] Ex: .83[b] A: .68[b] N: .74[b]	CSM	.87	−.17	.41	.03	.10	−.01
33. Önder, Beşoluk, Iskender, Masal, & Demirhan (2014)	1343 (37%)	21.01	ABPT	.71 - .87[c]	MEQ	.81	.07	.19	Not reported	.13	−.07
34. Russo, Leone, Penolazzi, & Natale (2012)	390 (46%)	26.70	BFQ	Not reported	rMEQ	Not reported	−.15	.15	−.05	−.03	.08
35. Cavallera, Gatto, & Boari (2014)	184 (58.7%)	40	BFQ	.60 - .90[c]	rMEQ	.71	.11	.09	−.05	.07	−.04
36. Arbabi, Vollmer, Doerfler, & Randler (2015)	1116 (51.9%)	10.22	FFPI-C	C: .73	CSM	.78		.36			
37. Ponzi, Wilson, & Maestripieri (2014)	172 (50%)	28.8	BFI	Not reported	rMEQ	Not reported	.00	−.09	−.08	−.02	.04
38. Ponzi et al. (2015)	107 (100%)	22.44	BFI	O: .75 C: .82 Ex: .87 A: .76 N: .82	rMEQ	.68	.03	.22	.15	.21	−.09
39. Qu et al. (2015)	310 (50.2%)	37.34	BFI	C: .73 A: .73 N: .78	rMEQ	Not reported		.37		.31	−.37
40. Randler, Horzum, & Vollmer (2014)	616 (27.9%)	20.81	Big-5	Not reported	CSM	.80	.10	.07	.06	.03	−.09
41. Ruffing, Hahn, Spinath, Brünken, & Karbach (2015)	318 (29.2%)	22.6	NEO-FFI	O: .78 C: .85 Ex: .78 A: .81 N: .89	LOCI	M: .89 E: .85	M: .06 E: .09	M: .38 E: −.21	M: .28 E: .14	M: .08 E: −.05	M: −.25 E: −.06
42. Walker, Kribs, Christopher, Shewach, & Wieth (2014)	491 (52%)	32.45	NEO-PI-R	O: .91 C: .93 Ex: .92 A: .90 N: .93	MEQ	.83	−.11	.31	−.10	.14	−.22
43. Walker, Christopher, Wieth, & Buchanan (2015)	279 (54.1%)	34.08	NEO-FFI-3	O: .83 C: .90 Ex: .88 A: .83 N: .92	MEQ	.82	−.04	.23	.23	.15	−.28
44. Werner, Geisler, & Randler (2015)	267 (16.1%)	22.76	BFI-10	Not reported	CSM	.88	−.09	.42	−.07	.04	−.09

Note. M = morningness; E = eveningness; O = Openness; C = Conscientiousness; Ex = Extraversion; A = Agreeableness; N = Neuroticism; NEO-PI-R = NEO-Personality Inventory, Revised; TSDI = Trait Self-Description Inventory; BFI = Big Five Inventory; OCEANIC = Openness, Conscientiousness, Extraversion, Agreeableness, Neuroticism Index Condensed; MRS = Inventar Minimal Redundanter Skalen; NEO-FFI = NEO-Five Factor Inventory; IPIP-100 = International Personality Item Pool; TEXAP5 = Traits Personality Questionnaire 5; BFO = Big Five Observer; ABPT = Adjective-Based Personality Test; BFQ = Big Five Questionnaire; FFPI-C = Five Factor Personality - Children; Big-5 = Big Five factor model; LOCI = Lark-Owl Chronotype Indicator; MEQ = Morningness-Eveningness Questionnaire; CSM = Composite Scale of Morningness; PSQI = Pittsburgh Sleep Quality Index; ChQ = Chronotype Questionnaire.

Received July 15, 2015
Revision received March 1, 2016
Accepted March 7, 2016 ■