Circadian functioning and time perspectives: associations with eveningness, morning affect, and amplitude distinctness

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Abstract

Well-established correlates of morningness-eveningness include those of morningness with more future Time Perspective (TP), and eveningness with more present TP. However, research into these relationships has used unidimensional measures of morningness-eveningness. So, the current study aimed to further understanding by assessing associations between TP and the separate components of Morning Affect (MA: alertness/sleep inertia after awakening) and Distinctness (DI; amplitude of diurnal variations of functioning), in addition to Eveningness (EV; time-of-day preference). Chinese university students ($N=299$, aged 18–25, 94 males, 205 females) completed an online survey with questionnaire measures of TP, MA, DI, EV, and other measures including mind wandering, conscientiousness, life satisfaction, positive and negative affect, and sleep quality. Previously demonstrated correlations were replicated, including positive correlations between Future TP, conscientiousness, and life satisfaction, and Past-negative TP and more negative affect. MA positively correlated with Future TP, and negatively correlated with Past-negative TP and Deviation from Balanced Time Perspective (DBTP); DI positively correlated with Past-negative TP, and with DBTP, and negatively correlated with Future TP; EV positively correlated with Present-hedonic TP, and negatively correlated with Future TP. The EV-Future TP association was mediated by MA. Path models were consistent with the view that the relationship between EV and less Future TP may involve impaired functioning and reduced self-control/self-regulation associated with experiencing lower Morning Affect. This research shows relationships between time perspectives and specific components of circadian functioning, indicating the value of component-level analysis and the limitations of research utilising unidimensional measures of morningness-eveningness.

Keywords Morningness-eveningness · Morning affect · Sleep Inertia · Time Perspective · Mind wandering · Conscientiousness

Introduction

Humans vary in their morningness-eveningness preference or chronotype: morning-types prefer an earlier phase for sleeping and rising, and are more energetic and active earlier in the day, evening-types prefer a later phase for sleep/

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rising and activity, and intermediate-types are between these extremes (Adan et al., 2012).

Research utilising self-report measures of chronotype has revealed many psychological and behavioural correlates. Being more morning-oriented is associated with better emotional and social wellbeing (Howell et al., 2008), more life satisfaction (Randler, 2008), and being more physically active (Suh et al., 2017). Morningness is also associated with positive affect (Biss & Hasher, 2012), while eveningness has been associated with negative emotionality, including depression (Au & Reece, 2017), and also with poor sleep quality and more mind wandering (Carciofo et al., 2014; Bakotic et al., 2017). Eveningness is also linked with the use of substances such as alcohol and nicotine (Bakotic et al., 2017; Suh et al., 2017; Wittmann et al., 2006), and increased risk of poor physical health, including hypertension and

diabetes (Partonen, 2015). Potential mechanisms linking eveningness and poor wellbeing include aspects of sleep, social jetlag (in which the social and biological clocks are misaligned; Wittmann et al., 2006), genetics, night-time light exposure, and maladaptive emotional regulation (Taylor & Hasler, 2018; Watts & Norbury, 2017). For example, poor sleep quality may mediate between eveningness and substance use, and eveningness and negative emotionality (Bakotic et al., 2017; Taylor & Hasler, 2018).

Eveningness has been associated with creativity (Giampietro & Cavallera, 2007), imaginative and creative thinking, and innovation-seeking (Díaz-Morales, 2007). However, despite these findings, eveningness is associated with poorer academic achievement, while more morningness is positively correlated with better academic achievement (Randler & Frech, 2006; Gomes et al., 2011; Preckel et al., 2011; Önder et al., 2014). Potential mechanisms may again include sleep-related factors: sleep duration, sleep quality, mood, and daytime functioning may mediate between morningness-eveningness and academic achievement (Warner et al., 2008). Furthermore, while conscientiousness is positively correlated with morningness, eveningness is associated with less conscientiousness (Lipnevich et al., 2017), and being more conscientious has also been found to mediate the relationship between morningness and better academic achievement (Eberspach et al., 2016).

A further correlate of morningness-eveningness is time perspective. Human cognitive functioning includes the ability to focus attention onto the past, present, and future, and consideration of these different time perspectives influences emotion, cognition, and behaviour in the present, and planning for the future; individual differences in these processes possibly extend to trait-like biases towards over-reliance on particular perspective/s, which may largely operate at an unconscious level (Stolarski et al., 2020; Zimbardo & Boyd, 1999).

Much research on correlates of time perspective has employed the Zimbardo Time Perspective Inventory (ZTPI; Zimbardo & Boyd, 1999), which has five dimensions: Past-negative (such as focusing on negative past experiences), Present-hedonistic (impulsiveness, focusing on present pleasure, disregarding consequences, etc.), Future (focusing on future plans, goals, etc.), Past-positive (positive views of the past, nostalgia, etc.), and Present-fatalistic (perceiving a lack of control over the present, and future). The ideal of having a 'balanced time perspective' (BTP) involves having the ability to make flexible use of the different perspectives, to more effectively deal with varying situational demands (Zimbardo & Boyd, 1999).

Notable associations with time perspective (TP) include positive correlations between depression and Past-negative and Present-fatalistic TPs; more Future and Past-positive TPs being associated with less depression; higher Present-hedonistic TP being associated with more sensation-seeking and risk-taking; and positive correlations between Future TP, conscientiousness, impulse control, and academic achievement/GPA (Stolarski et al., 2018; Zimbardo & Boyd, 1999). In addition, correlates of more BTP include better academic achievement, more self-control, life satisfaction, mindfulness, and conscientiousness, while having more Deviation from Balanced Time Perspective (DBTP) is associated with neuroticism, and indices of poor wellbeing including depression (Stolarski et al., 2016, 2020). Poor sleep quality has been associated with Past-negative and Present-fatalistic TPs, and with DBTP (Borisenkov et al., 2019).

Furthermore, studies have shown that dimensions of time perspective are related to chronotype. Díaz-Morales et al. (2008) found that morningness was associated with more Future TP, and with less Present-fatalistic TP. Stolarski et al. (2013) also found that morningness positively correlated with Future TP, while greater eveningness was associated with more Present-hedonistic TP. In addition, small correlations were found showing more morningness was associated with more Past-positive TP, and with less Past-negative and Present-fatalistic TPs. Nowack and Van der Meer (2013), with a more age-diverse sample, found that morningness was associated with more Future TP, and eveningness was associated with more Present TP; Ponzi et al. (2015) reported that morningness was associated with more Future TP, and eveningness was associated with more Present-fatalistic TP. McGowan et al. (2017) assessed time-of-day preference (measured with the Morningness-Eveningness Questionnaire/MEQ; Horne & Östberg, 1976), and circadian phase (sleep mid-point, assessed with the Munich Chronotype Questionnaire/MCTQ; Roenneberg et al., 2003) finding that more eveningness and later phase were associated with more Present TP, and more morningness and earlier phase were associated with more Future TP. Meng et al. (2021) reported that morningness positively correlated with Future TP, and negatively with Past-negative and Present-fatalistic TPs. Morningness has been associated with more balanced TP, and eveningness associated with more DBTP (McGowan et al., 2017; Guenther & Stolarski, 2021; Meng et al., 2021; Milfont & Schwarzenthal, 2014; Rönnlund at al., 2021; Stolarski et al., 2013; Stolarski et al., 2020).

Stolarski et al. (2013) argued that associations between morningness-eveningness and TP may be related to effortful impulse control, whereby morningness is associated with having greater impulse control (ability to inhibit behaviours), and ability to delay gratification, these being reflected in having more Future TP, while eveningness has the opposite associations, as reflected in the association with greater Present-hedonistic TP. The respective correlations with conscientiousness (positive with morningness and Future

TP, and negative with eveningness and Present-hedonistic TP), in addition to the reported association between morningness and more self-control (Digdon & Howell, 2008), are also consistent with this conceptualisation, as are the associations between eveningness and impulsivity (Caci et al., 2005), and eveningness and sensation-seeking (Tonetti et al., 2010). Supporting Stolarski et al.'s (2013) proposal, Milfont and Schwarzenthal (2014) found that the positive correlation between morningness and Future TP was mediated by self-control.

However, while research on associations between morningness-eveningness and time perspective has shown relatively consistent findings, a limitation is that studies have used unidimensional assessments of morningness-eveningness from scales such as the MEQ or the Composite Scale of Morningness (Smith et al., 1989). In addition to chronotype/morningness-eveningness/time-of-day preference, recent research on circadian rhythms has also identified another, separate individual difference in circadian functioning in the component of Distinctness, i.e., the amplitude of diurnal variations in cognition, affect, and motivation (Ogińska, 2011; Randler et al., 2016). More Distinctness has been associated with poor sleep quality, more neuroticism, less conscientiousness, more spontaneous mind wandering, and negative emotionality (e.g.Carciofo & Song, 2019; Carciofo, 2022a; Demirhan et al., 2019; Díaz-Morales et al., 2017; Díaz-Morales & Randler, 2017).

Furthermore, Morning Affect (MA), i.e., how alert someone feels after awakening/time required to achieve full wakefulness (sleep inertia), has also been identified as a separate aspect of circadian functioning (Carciofo, 2023; Randler et al., 2016; Smith et al., 1989). Evening-types are more likely to experience low Morning Affect/more sleep inertia due to social jetlag such that they must awaken at a time when the circadian core body temperature rhythm is closer to its nadir, when sleep inertia is more likely (Scheer et al., 2008). However, sleep inertia can occur without having had sleep restriction (Jewett et al., 1999), and has been found to be unrelated to chronotype on free days (Roenneberg et al., 2003), so is distinguishable from morningness-eveningness preference. Higher Morning Affect (less sleep inertia) is associated with more morningness, conscientiousness, positive affect, and life satisfaction, while less Morning Affect (more sleep inertia) is associated with neuroticism, poor sleep quality, negative emotionality, and spontaneous mind wandering (Carciofo & Song, 2019; Carciofo, 2020, 2022a; Demirhan et al., 2019; Randler et al., 2016). Depression correlates more strongly with Morning Affect (negatively) than with eveningness, as do aspects of poor sleep quality (Carciofo, 2020, 2022a; Demirhan et al., 2019; Jankowski, 2016). Morning Affect also mediates the relationship between eveningness and negative emotionality (Carciofo, 2020). Furthermore, while more eveningness is associated with less conscientiousness, more Morning Affect shows a stronger, positive correlation, and the association between eveningness and conscientiousness is attenuated when controlling for Morning Affect which may act as a mediator of the relationship (Carciofo, 2022b). Morning Affect also mediates the association between eveningness and spontaneous mind wandering (Carciofo, 2022a).

Thus, as previous research on the relationship between time perspective and morningness-eveningness has used unidimensional measures of morningness-eveningness, the primary aim of the current research was to test the associations between time perspectives and separate components of circadian functioning, specifically: Eveningness (time-of-day preference), Morning Affect (sleep inertia), and Distinctness (amplitude of diurnal variations). Morning Affect (MA) is moderately/strongly correlated with morningness, and both show, for example, positive correlations with conscientiousness, life satisfaction, and positive affect. So, it may be hypothesised that MA may show the same associations with TP as have been found for morningness, in particular, more MA associated with more Future TP, and with less Deviation from Balanced Time Perspective. Associations with Eveningness may be expected to replicate the previously reported findings: more eveningness associated with less Future TP and with more Present TP (Present-hedonistic and Present-fatalistic). Also, as correlations with eveningness have been attenuated when controlling for MA, exploratory analysis investigated whether controlling for MA would influence correlations between eveningness and time perspective, and whether MA may be a mediator (as has been found for the relationships between eveningness and negative emotionality, eveningness and conscientiousness, and eveningness and spontaneous mind wandering). Given that more Distinctness is correlated with more neuroticism and negative emotionality, and with less conscientiousness, it may be hypothesised to be positively correlated with more Past-negative TP, more Present-fatalistic TP, and more deviation from balanced TP, and also associated with less Future TP. As a secondary aim of the current study, correlations between components of circadian functioning, time perspectives, and a network of other variables (conscientiousness, sleep-related factors, life satisfaction, positive and negative affect, spontaneous and deliberate mind wandering, GPA and attendance) were investigated to test if previously reported associations were replicated. Previously reported mediation effects (MA mediating between eveningness and negative emotionality, eveningness and conscientiousness, and eveningness and spontaneous mind wandering) were also re-tested. Potential relationships between variables were further explored in path models,

building on the model proposed by Carciofo (2022a) by also including time perspective.

Method

Sample

An invitation, including the link to the Chinese-language online survey, was emailed to approximately 8700 students at a university in Suzhou, China. The survey was active for three weeks during the spring semester. The survey began with a briefing about the study, with stated inclusion criteria of being a Chinese student at the university aged 18 years/older. Participation was voluntary, unpaid, anonymous, and could be withdrawn at any time. Clicking an icon at the end of the briefing provided informed consent and began presentation of the survey questions; 576 began the survey, with 299 providing complete responses for analysis. The mean age = 20.46 (SD = 1.130; range = 18–25; skewness = 0.741; kurtosis = 1.024); there were 94 males (mean age = 20.56, SD = 1.223), and 205 females (mean age = 20.42, SD = 1.084), t = 1.026 (df = 297), p = .306 (Hedges' g = 0.127). The research protocol was approved by the Research Ethics Committee at Xi'an Jiaotong-Liverpool University, Suzhou, China (research proposal number: 20-03-17).

Materials

The Morningness-Eveningness-Stability-Scale improved (MESSi; Randler et al., 2016; Chinese version: Carciofo & Song, 2019) includes subscales for: *Morning Affect* (MA) assessing alertness/energy in the morning (e.g., *I feel drowsy for a long time after awakening*), comparable to a measure of general sleep inertia duration (Carciofo, 2023), with higher scores indicating shorter lasting sleep inertia; *Eveningness* (EV; time-of-day preference for activity/time of optimal functioning, e.g., *I am more an evening than a morning active person*); *Distinctness* (DI; amplitude of diurnal variations in functioning, *e.g., There are moments during the day when it is harder for me to think*). There are five items for each subscale, each scored 1–5, higher total scores indicating more MA/EV/DI.

The Zimbardo Time Perspective Inventory (ZTPI; Zimbardo & Boyd, 1999) has 56 items each scored from 1 (*very uncharacteristic*) to 5 (*very characteristic*). Wang et al.'s (2015) 20-item Chinese version assesses the five dimensions of Past-negative (e.g., *Painful past experiences keep being replayed in my mind*), Present-hedonistic (e.g., *I take risks to put excitement in my life*), Future (e.g., *I am able to resist temptations when I know that there is work*

to be done), Past-positive (e.g., *Familiar childhood sights, sounds, smells, often bring back a flood of wonderful memories*), Present-fatalistic (e.g., *Since whatever will be will be, it doesn't really matter what I do*).

The Big Five Inventory, 44-item (BFI-44; John & Srivastava, 1999; Chinese version: John & Srivastava, 2003; Carciofo et al., 2016). Only the nine-item conscientiousness subscale was included; items are scored on a 1–5 Likert scale so that higher scores indicate more conscientiousness.

The Mind Wandering-Deliberate and Mind Wandering-Spontaneous scales (Carriere et al., 2013; Chinese versions: Carciofo & Jiang, 2021). There are four items for each scale, each assessed on a 7-point Likert scale, so that higher scores indicate more trait-level deliberate/spontaneous mind wandering.

The Positive and Negative Affect Schedule (Watson et al., 1988; Chinese version: Huang et al., 2003), assesses positive affect (10 items) and negative affect (10 items) for the preceding 3–4 weeks; all items are scored 1–5, so higher values indicate more positive/negative affect.

*The Students' Life Satisfaction Scale (*Huebner, 1991*)*. Jiang et al.'s (2018) Chinese version has 5-items, each scored 1–6; higher scores indicate more general life satisfaction. A reference to 'kids' in one item was replaced with 'people'.

Sleep. A single item provided a subjective assessment of overall sleep quality: *How often do you have problems with your sleeping, for example insomnia or frequently waking during the night?* Response options were (1) never, (2) occasionally, (3) at least once a month, (4) at least once a week, (5) every day; higher scores indicated poorer sleep quality. A single item assessed sleep duration: *How many hours do you usually sleep every night?* Response options were 4 or less, 5, 6, 7, 8, 9 or more.

Academic study. One item enquired *Your class attendance during this academic year*, with response options of (1) Less than 20%, (2) 20-50%, (3) 50-80%, (4) 80-100%. One item enquired *Your Grade Point Average (GPA) during this academic year*, with response options of (1) Very bad, (2) Below average, (3) Average, (4) Good, (5) Excellent.

Data analysis

Descriptive statistics included the mean, standard deviation, range, skewness, kurtosis, and Cronbach's alpha (internal consistency). Associations with age, and gender differences, were also tested. Deviation from Balanced Time Perspective (DBTP) was calculated according to the formula in Stolarski et al. (2020); for comparison, the Deviation from Balanced Time Perspective-revisited (DBTP-r) was also calculated, according to the formula in Jankowski et al. (2020). To make comparisons with previous research which has used

unidimensional measures of morningness-eveningness, the scores for Eveningness were reversed and then added to the scores for Morning Affect, to produce a composite scale with higher scores indicating more morningness (for this procedure see also Vagos et al., 2019).

Correlations between variables were assessed with Pearson's product-moment correlation; coefficients of 0.10, 0.30, and 0.50 may respectively indicate small, medium, and large effect sizes (Cohen, 1992). To establish small/medium ($r = .2$) correlations with 80% power at $p = .05$, $N = 194$ (https://sample-size.net/correlation-sample-size/). Partial correlations between Eveningness and ZTPI dimensions were calculated, controlling for Morning Affect. Partial correlations were also calculated to identify unique associations between ZTPI dimensions and deliberate and spontaneous mind wandering when controlling for the other form of mind wandering (for this procedure see Carciofo & Jiang, 2021; Seli et al., 2019).

Mediation analysis was undertaken using PROCESS (Hayes, 2022); unstandardised indirect effects and their 95% percentile bootstrap confidence intervals (established from 5000 bootstrap samples) are reported, whereby significant effects are shown when confidence intervals exclude zero. Path models were developed with IBM Amos (v.28). Acceptability of model fit was assessed utilising the following guidelines: Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI) > 0.90; root mean square error of approximation (RMSEA) < 0.08; standardized root mean square residual (SRMR) < 0.08 (Brown, 2006).

Results

Descriptive statistics

Table 1 shows descriptive statistics for all scales/subscales. Scores generally spanned the possible scale ranges, and distributions approximated normality (absolute values of skewness and kurtosis all < 1); values of Cronbach's alpha were mostly > 0.7, although lower for some of the 4-item ZTPI subscales.

Deviation from Balanced Time Perspective (DBTP; mean = 2.669, SD = 0.859) and Deviation from Balanced Time Perspective-revisited (DBTP-r; mean = 3.873, SD = 0.919) were very strongly correlated ($r = .969$). Age showed small/small to medium significant correlations with DBTP-r ($r = .117$, $p = .043$), poor sleep quality, $r = .138$ ($p = .017$), attendance, $r = -.117$ ($p = .044$), and life satisfaction, $r = -.182$ ($p = .002$). There were significant gender differences, with small effect sizes, for Present-hedonistic TP (male mean = 14.36, SD = 2.910; female mean = 13.30, SD = 2.732, $t = 3.063$, df = 297, $p = .002$, Hedges' $g = 0.381$), and for Future TP (male mean = 13.87, SD = 2.428; female mean = 13.17, SD = 2.881, $t = 2.184$, df = 211.581, $p = .030$, Hedges' $g = 0.255$).

Correlational analysis

Table 2 shows correlations between time perspectives and components of circadian functioning (primary research aim), and also between time perspectives and the other

Table 1 Descriptive statistics

	Range (possible)	Mean	Standard deviation	Skewness	Kurtosis	Cronbach's Alpha
Zimbardo Time Perspective Inventory						
Past-positive	4–20 (4–20)	13.96	2.992	−0.601	0.526	0.678
Past-negative	4–20 (4–20)	13.12	3.498	−0.129	−0.471	0.782
Present-hedonistic	7–20 (4–20)	13.63	2.828	−0.054	−0.494	0.620
Present-fatalistic	4–20 (4–20)	10.77	2.775	0.165	0.014	0.644
Future	5–20 (4–20)	13.39	2.762	−0.197	−0.140	0.726
Morning Affect	5–25 (5–25)	16.78	3.830	−0.597	0.153	0.804
Eveningness	5–25 (5–25)	17.67	4.091	−0.211	−0.257	0.796
Distinctness	6–25 (5–25)	19.50	3.659	−0.770	0.834	0.729
Positive Affect	11–48 (10–50)	30.10	5.882	−0.021	−0.160	0.803
Negative Affect	11–50 (10–50)	26.35	7.813	0.399	−0.239	0.857
Conscientiousness	9–44 (9–45)	29.19	5.730	−0.279	0.316	0.795
Mind wandering-deliberate	4–28 (4–28)	17.32	6.233	−0.061	−0.895	0.828
Mind wandering-spontaneous	4–28 (4–28)	18.31	5.974	−0.195	−0.664	0.845
Life satisfaction	5–30 (5–30)	19.80	5.512	−0.434	−0.392	0.887
Grade Point Average (GPA)	1–5 (1–5)	3.40	1.052	−0.407	−0.311	-
Attendance	1–4 (1–4)	3.33	0.802	−0.936	0.014	-
Poor sleep quality	1–5 (1–5)	2.60	1.155	0.671	−0.645	-
Sleep duration	1–6 (1–6)	4.19	1.005	−0.377	0.222	-

$N = 299$; standard error of skewness = 0.141; standard error of kurtosis = 0.281

Table 2 Correlations with Time Perspectives

	Past-positive	Past-negative	Present-hedonistic	Present-fatalistic	Future	DBTP	DBTP-r
Morningness-eveningness	0.021	−0.125*	−0.077	−0.067	0.271***	−0.165**	−0.208***
Morning Affect	0.073	−0.185**	0.065	−0.105	0.302***	−0.252***	−0.277***
Eveningness	0.036	0.017	0.178**	0.004	−0.129*	0.015	0.057
Eveningness, controlling for Morning Affect	*0.054*	*−0.026*	*0.199****	*−0.021*	*−0.064*	*−0.046*	*−0.008*
Distinctness	0.004	0.208***	−0.005	0.103	−0.227***	0.202***	0.237***
Positive Affect	0.302***	−0.275***	0.395***	−0.296***	0.376***	−0.491***	−0.472***
Negative Affect	−0.015	0.531***	−0.037	0.332***	−0.146*	0.444***	0.475***
Conscientiousness	0.057	−0.243***	0.030	−0.345***	0.609***	−0.376***	−0.458***
Mind wandering-deliberate	−0.104	0.114*	0.107	0.191***	−0.181**	0.196***	0.229***
MW-deliberate, controlling for MW-spontaneous	*−0.085*	*−0.009*	*0.085*	*0.105*	*−0.030*	*0.072*	*0.077*
Mind wandering-spontaneous	−0.066	0.293***	0.072	0.236***	−0.373***	0.322***	0.395***
MW-spontaneous, controlling for MW- deliberate	*−0.025*	*0.271****	*0.030*	*0.175***	*−0.333****	*0.269****	*0.338****
Life satisfaction	0.215***	−0.477***	0.266***	−0.259***	0.305***	−0.528***	−0.538***
Grade Point Average (GPA)	0.022	−0.305***	0.066	−0.200***	0.389***	−0.337***	−0.379***
Attendance	0.242***	−0.150**	0.024	−0.077	0.333***	−0.288***	−0.310***
Poor sleep quality	−0.016	0.381***	−0.082	0.135*	−0.115*	0.309***	0.324***
Sleep duration	−0.002	−0.063	0.121*	−0.072	−0.043	−0.090	−0.058

$N=299$. *$p \leq .05$; **$p \leq .01$; ***$p \leq .001$. MW = mind wandering. DBTP = Deviation from Balanced Time Perspective. DBTP-r = Deviation from Balanced Time Perspective-revisited.

study variables (secondary research aim). Past-positive TP did not significantly correlate with components of circadian functioning, but had small to medium positive correlations with positive affect, life satisfaction, and class attendance. Past-negative TP had a strong positive correlation with negative affect, and small to medium positive correlations with Distinctness, deliberate and spontaneous mind wandering (MW), and poor sleep quality; it also had a strong negative correlation with life satisfaction, and small to medium negative correlations with morningness (MA+reversed EV composite), Morning Affect, positive affect, conscientiousness, GPA, and attendance. Present-hedonistic TP had small/medium positive correlations with Evening-ness, positive affect, life satisfaction, and sleep duration. Present-fatalistic TP had small/medium negative correlations with positive affect, conscientiousness, life satisfaction, and GPA, and small/medium positive correlations with deliberate and spontaneous MW, negative affect, and poor sleep quality. Future TP had a strong positive correlation with conscientiousness, and medium positive correlations with morningness, Morning Affect, positive affect, life satisfaction, GPA, and attendance; it also had small/medium negative correlations with Eveningness, Distinctness, negative affect, deliberate and spontaneous MW, and poor sleep quality. Correlations with DBTP and DBTP-r were generally very similar, although mostly stronger for DBTP-r, and

included negative correlations with morningness and Morning Affect, conscientiousness, positive affect, life satisfaction, GPA, and attendance, and positive correlations with Distinctness, negative affect, MW, and poor sleep quality. Correlations between ZTPI dimensions (see Supplementary materials Table S1) ranged from −0.254 (Future and Present-fatalistic TPs) to 0.314 (Past-negative and Present-fatalistic TPs); correlations between study variables excluding ZTPI dimensions (secondary research aim), replicated previously reported associations (see Supplementary materials Table S2).

Partial correlations between TP and Eveningness controlling for Morning Affect (Table 2), showed the small/medium positive correlation between Eveningness and Present-hedonistic TP became slightly stronger, while the small negative correlation between Eveningness and Future TP became attenuated, weak, and no longer significant. When controlling for spontaneous MW, the correlations between TP and deliberate MW were all attenuated, becoming weak and no longer statistically significant. When controlling for deliberate MW, correlations between TP and spontaneous MW showed some attenuation but remained small/medium, with no change in statistical significance at $p \leq .05$.

Mediation analysis

The partial correlation between EV and Present-hedonistic TP, controlling for MA, showed a slightly stronger positive coefficient. A test of the indirect/mediation effect through MA showed that this was not significant (B = − 0.018; 95% CI = − 0.042 /0.003). However, the negative correlation between EV and Future TP was attenuated and no longer significant in the partial correlation controlling for MA, and the indirect/mediation effect from EV to Future TP through MA was significant (B = − 0.045; 95% CI = − 0.075 / − 0.019). Previously reported mediation effects of MA were also replicated in the current sample: MA mediated between EV and negative emotionality (here indexed by negative affect; B = 0.069; 95% CI = 0.011 / 0.146; compare Carciofo, 2020); MA mediated between EV and spontaneous MW (B = 0.073; 95% CI = 0.026 / 0.130; compare Carciofo, 2022a); and MA mediated between EV and conscientiousness (B = − 0.073; 95% CI = − 0.133 / − 0.026; compare Carciofo, 2022b). In addition, given that Milfont and Schwarzenthal (2014) found that the association between morningness (assessed unidimensionally using the MEQ) and Future TP was mediated by self-control, further exploratory analysis tested whether there was an indirect effect from MA to Future TP through conscientiousness (as a proxy for self-control), and this was significant (B = 0.092; 95% CI = 0.041 / 0.145).

Exploratory path analysis

A path model was previously developed (Carciofo, 2022a) from Eveningness (EV) through to negative affect (NA) with the following paths: EV to MA (Morning Affect); MA to subject sleep quality (SSQ), conscientiousness, spontaneous MW (MW-S), and NA; SSQ to NA; conscientiousness to MW-S; and MW-S to NA. Given the observed significant correlations between these variables and Future TP in the current study, in addition to the observed indirect effects of EV on Future TP through MA, and MA on Future TP through conscientiousness, it was explored whether Future TP could be added to the previously developed model. First the model developed in Carciofo (2022a) was re-tested. Future TP was then added to the model as a second final outcome variable, and the model was developed with consideration of modification indices and the significance of paths. Full details are included in the Supplementary materials; final models are presented here.

The model developed in Carciofo (2022a) again showed acceptable/good model fit (see Supplementary materials Figure S1), but the path from MA to NA was not significant; removing this path showed mostly slight improvement in the model fit (chi-square = 14.468; df = 8; p = .070; CFI = 0.960,

TLI = 0.925, SRMR = 0.0443, RMSEA = 0.052, 90% CI = 0.000 / 0.094), and all paths were significant (ps < 0.05); see Supplementary materials Figure S2.

Future TP was then added as a second outcome variable, and paths were added to Future TP from EV, MA, SSQ, MW-S, and conscientiousness. This model showed acceptable fit (see Supplementary materials), but the paths from EV to Future TP, and SSQ to Future TP were not significant; removing these paths mostly produced slightly improved model fit (chi-square = 17.140, df = 11, p = .104; CFI = 0.981, TLI = 0.963; SRMR = 0.0414, RMSEA = 0.043, 90% CI = 0.000 / 0.081), and all paths were significant (all ps < 0.05); see Fig. 1. Paths were then added from NA to Future TP, and, in a separate model, from Future TP to NA, but in both cases the paths were not significant, and model fit was mostly slightly inferior (see Supplementary materials).

Another model was explored in which negative affect in the original model from Carciofo (2022a) was replaced with life satisfaction (LS), as an alternative measure of wellbeing which has been previously researched in relation to TP. As for the first model, Future TP was added as a second final outcome variable, and paths were added to Future TP from EV, MA, SSQ, MW-S, and conscientiousness, but this model showed mostly poor fit (see Supplementary materials). After removing paths from EV to Future TP, SSQ to Future TP, and MW-S to LS, and adding a path from Future TP to LS, acceptable/good model fit was shown (chi-square = 21.903, df = 11, p = .025; CFI = 0.966, TLI = 0.935. SRMR = 0.0459, RMSEA = 0.058, 90% CI = 0.020 / 0.093), and all paths were significant (all ps < 0.05); see Fig. 2.

Discussion

Previous research has consistently shown associations between morningness-eveningness and time perspective (TP), but a limitation has been the utilisation of unidimensional measures of morningness-eveningness (time-of-day preference), so the current survey research investigated associations between TPs and specific, distinguishable components of circadian functioning: Eveningness (time-of-day preference), Morning Affect (sleep inertia), and Distinctness (amplitude of diurnal variations in functioning). Additional measures included mind wandering (spontaneous and deliberate), conscientiousness, positive and negative affect, sleep quality, GPA, and life satisfaction.

Correlational analysis replicated and extended previously reported findings, producing a network of consistent inter-relationships. More Future TP was associated with more conscientiousness, better academic achievement/GPA, and better sleep quality (Borisenkov et al., 2019; Stolarski et al.,
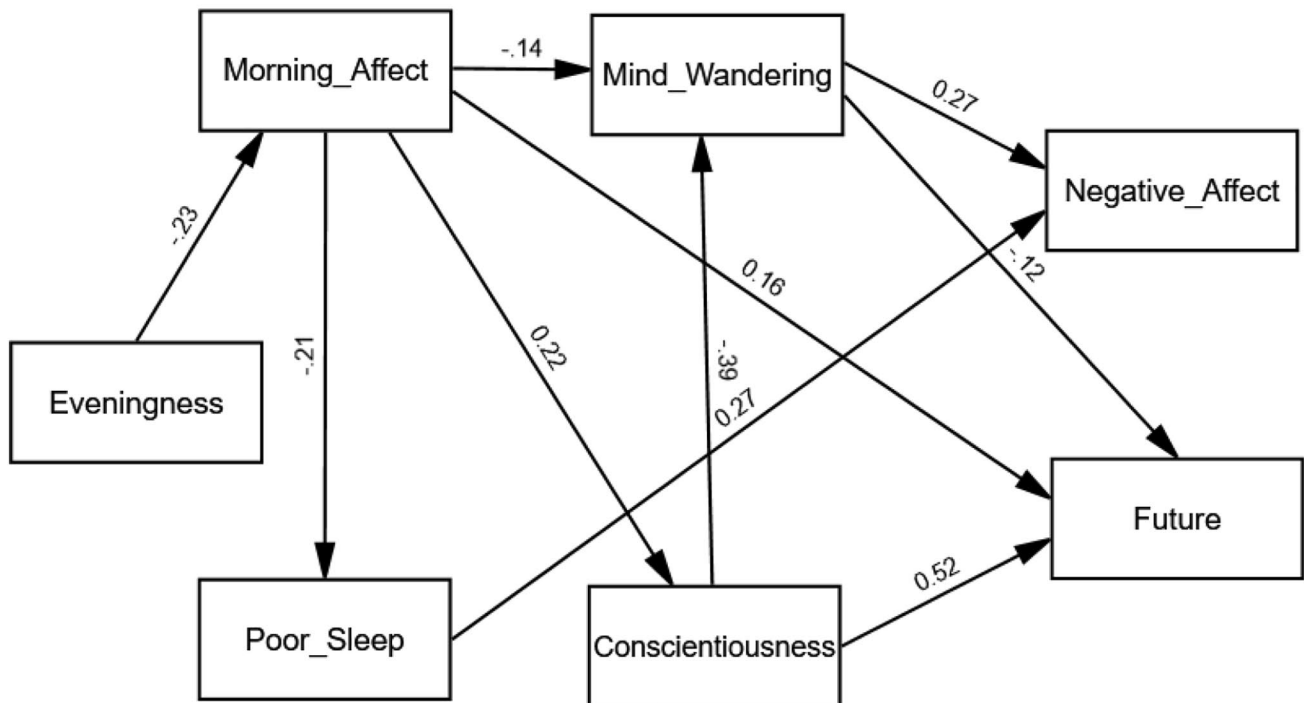
Fig. 1 Path model 1, including standardised path coefficients
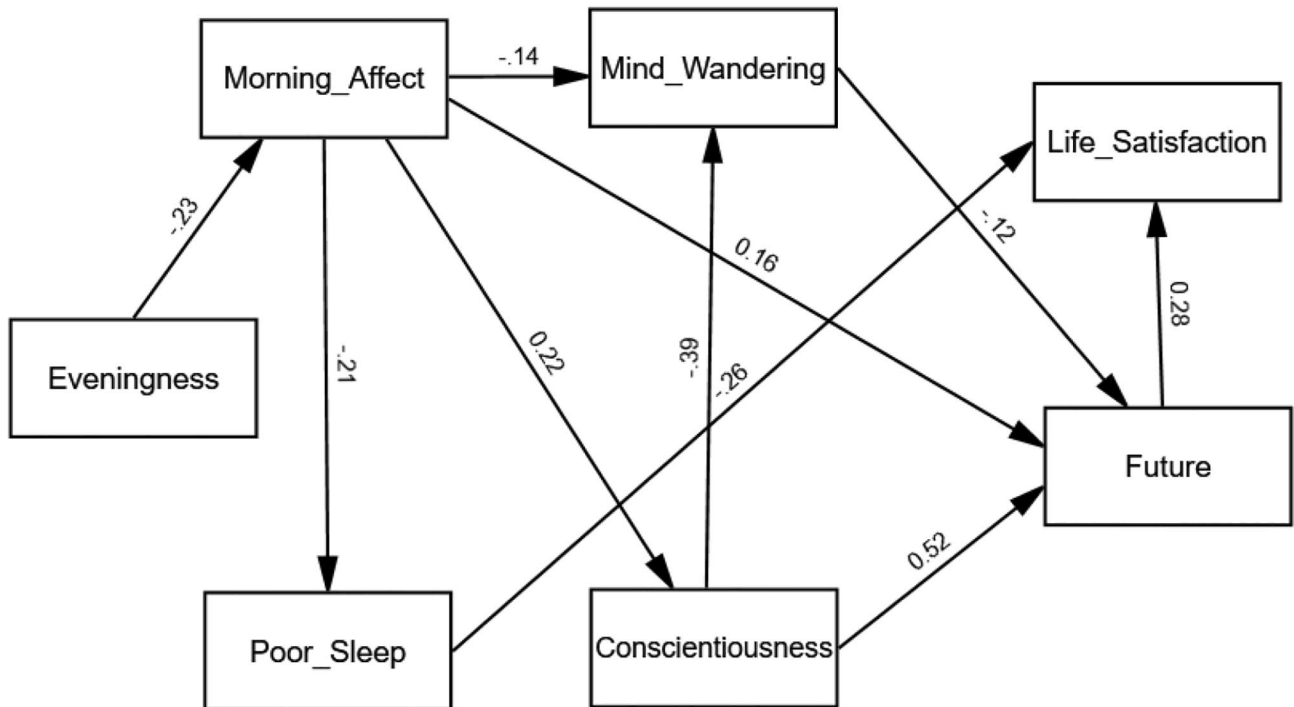

Fig. 2 Path model 2, including standardised path coefficients

2018; Wang et al., 2015; Zimbardo & Boyd, 1999), and also with more positive affect, life satisfaction, and attendance, and also associated with less negative affect and less mind wandering. Also, consistent with the findings of Borisenkov

et al. (2019), Wang et al. (2015), and Zimbardo and Boyd (1999), Present-fatalistic and Past-negative TPs were both associated with poor sleep quality and less conscientiousness, and with less positive affect, life satisfaction, and

GPA; furthermore, both TPs positively correlated with more mind wandering (spontaneous and deliberate). Also consistent with previous research (Borisenkov et al., 2019; Orkibi, 2015; Stolarski et al., 2018, 2020), life satisfaction was associated with more Past-positive TP and with less Past-negative TP, positive affect was associated with more Present-hedonic TP, negative affect had positive correlations with Past-negative and Present-fatalistic TPs, and more Deviation from Balanced Time Perspective (DBTP) was associated with negative affect and poor sleep quality (and also with more mind wandering), and less DBTP was associated with better academic achievement (GPA), more conscientiousness, and more life satisfaction. Correlations with the values obtained from the DBTP-revisited (DBTP-r) formula were mostly slightly stronger than those for the original DBTP, similar to results reported by Jankowski et al. (2020). Mind wandering (particularly spontaneous mind wandering) was associated with poor sleep quality, more Distinctness, and more negative emotionality, and with less Morning Affect, conscientiousness, and life satisfaction, and lower academic achievement (Carciofo & Jiang, 2021; Carciofo, 2022a; Seli et al., 2019; Wammes et al., 2016). Other inter-correlations between study variables, (e.g., more Morning Affect associated with more conscientiousness and more life satisfaction, and with better sleep quality; see Supplementary materials) replicated previously reported results (e.g., Carciofo & Song, 2019; Carciofo, 2020; Demirhan et al., 2019; Randler et al., 2016).

Associations between TP and components of circadian functioning also replicated and extended previous findings. Firstly, associations between TP and Distinctness (amplitude of diurnal variations in functioning) were consistent with expectations derived from previously established mutual correlates: Distinctness was associated with more Past-negative TP and with more DBTP, and associated with less Future TP. These associations between TPs and Distinctness are consistent with their mutual associations with more negative emotionality, poor sleep quality, less conscientiousness, and more mind wandering (see, e.g., Borisenkov et al., 2019; Carciofo, 2020, 2022a, b; Demirhan et al., 2019; Díaz-Morales & Randler, 2017; Randler et al., 2016; Stolarski et al., 2018, 2020; Zimbardo & Boyd, 1999).

Secondly, a composite measure of morningness-eveningness (Morning Affect plus reversed Eveningness scores) replicated associations between more morningness and more Future TP, and more morningness and less DBTP (more eveningness, more DBTP), which have been consistently reported in studies utilising unidimensional/composite measures of morningness-eveningness such as the MEQ or CSM (Díaz-Morales et al., 2008; Guenther & Stolarski, 2021; McGowan et al., 2017; Meng et al., 2021; Milfont & Schwarzenthal, 2014; Nowack & Van der Meer, 2013;

Ponzi et al., 2015; Rönnlund at al., 2021; Stolarski et al., 2013, 2020). More morningness was also associated with less Past-negative TP, as was found by Meng et al. (2021) and Stolarski et al. (2013).

However, results for the separate Morning Affect (MA) and Eveningness (EV) components showed some divergence. Past-negative TP was associated with less MA (small/medium negative correlation) but was not correlated with EV, while Present-hedonic TP was associated with more EV (small/medium positive correlation) but was not correlated with MA. Also, DBTP/DBTP-r were both associated with less MA (small/medium negative correlations) but only had weak, non-significant correlations with EV, indicating that the association between more eveningness (less morningness) and more DBTP, consistently found in studies utilising unidimensional measures of morningness-eveningness, may need reconsideration. It appears that eveningness per se may not be associated with more DBTP; rather DBTP is more associated with experiencing less Morning Affect (i.e., more sleep inertia; Carciofo, 2023). Similarly, while unidimensional measures of morningness-eveningness have shown associations between eveningness and negative emotionality (Au & Reece, 2017), and eveningness and poor sleep quality (Bakotic et al., 2017; Carciofo et al., 2014), MA has been found to be a stronger correlate (Carciofo, 2020, 2022a; Demirhan et al., 2019; Jankowski, 2016).

Furthermore, although Future TP was associated with less EV (small negative correlation), in addition to more MA (medium positive correlation), when controlling for MA the correlation between EV and Future TP became weak and non-significant, with MA found to mediate the relationship. The path model developed by Carciofo (2022a) was replicated, and then extended to include Future TP. Two models with acceptable/good fit indices were established: (1) a model with paths from Eveningness to MA; MA to subjective sleep quality (SSQ), conscientiousness, spontaneous MW (MW-S), and Future TP; SSQ to negative affect (NA); conscientiousness to MW-S; conscientiousness to Future TP; MW-S to NA; and MW-S to Future TP. (2) A model with paths from Eveningness to MA; MA to subjective sleep quality (SSQ), conscientiousness, MW-S, and Future TP; SSQ to Life Satisfaction; conscientiousness to MW-S; conscientiousness to Future TP; MW-S to Future TP; and Future TP to Life Satisfaction.

While the two path models developed in the current research slightly varied when including either negative affect or life satisfaction, the paths between Eveningness, Morning Affect, sleep quality, conscientiousness, spontaneous mind wandering, and Future TP were consistent. Stolarski et al. (2013) argued that the correlation between morningness and Future TP may be related to morningness being associated with having greater effortful impulse

control. The current results suggest that higher levels of Morning Affect (less sleep inertia) may be a mechanism for this association rather than morningness preference per se. Evening-types are more likely to experience the social jetlag of their biological clock being misaligned with the social clock, having to rise earlier than preferred due to social obligations (Wittmann et al., 2006), and so rising at a time closer to the nadir of the core body temperature rhythm which may result in more severe sleep inertia (Scheer et al., 2008). In addition to reduced alertness, sleep inertia impairs cognitive functioning and task performance, and the effects may last for several hours (Jewett et al., 1999; Lundholm et al., 2021; Occhionero et al., 2021). Furthermore, experiencing these effects could lead to the inference being made that sleep quality had been poor (Barclay et al., 2010). Less effective cognitive functioning may also increase the frequency of mind wandering, perhaps through an increased likelihood of executive control failures (McVay & Kane, 2010). Such effects of more severe and/or longer-lasting sleep inertia (less Morning Affect) may reduce the ability and/or motivation for self-regulation. This is consistent with the finding that less social jetlag may partially mediate the positive association between morningness and self-control (Wang & Hu, 2016), given that more social jetlag would increase the likelihood of experiencing severe sleep inertia. Also, 'self-regulatory fatigue' following a task requiring more self-regulatory effort may weaken the influence of conscientiousness on task engagement/persistence (Nes et al., 2011), so reduced ability for self-regulation due to sleep inertia may have similar effects on conscientiousness. In addition, future-focused thought requires more cognitive resources, with a reduction in prospective thinking under greater working memory demands (Smallwood et al., 2009), so a reduction in the availability of cognitive resources due to sleep inertia may reduce future-oriented thought. Consistently, an association between more social jetlag and less Future time perspective (and also more social jetlag and more DBTP) has been reported (McGowan et al., 2017). Thus, the paths between Eveningness, Morning Affect, subjective sleep quality, conscientiousness, spontaneous mind wandering, and Future TP in the models developed in the current research are consistent with existing theory and research evidence, and indicate how these relationships may impact wellbeing, as assessed by negative affect or life satisfaction.

Consistent with previous research, the current study also found that eveningness was associated with more Present-Hedonistic TP. As argued by Stolarski et al. (2013), this may relate to eveningness being associated with less self-control, more impulsivity, less conscientiousness, etc. The possible role of MA (sleep inertia) in the EV-Present-hedonistic relationship (as for the EV-Future TP relationship) is suggested

by the finding that MA may mediate between eveningness and conscientiousness (Carciofo, 2022b). However, in the current study MA and conscientiousness were only weakly correlated with Present-hedonistic TP, and the association between EV and Present-hedonistic TP was retained (and slightly strengthened) after controlling for MA. So, other mechanism/s may be considered for the association between EV and Present-hedonistic TP. For instance, having more Present-hedonistic TP may increase the likelihood of more (impulsive) participation in evening social activities which then delay bedtime, influencing sleep schedules and leading to the self-perception of being more evening-oriented.

Limitations and Future research

The current study involved a limited, gender-imbalanced sample of young, adult students. Previous research has shown age-related changes in chronotype, including more morningness in older age (Adan et al., 2012). Present-hedonistic and Past-negative TPs may decline with age (Laureiro-Martinez et al., 2017), while some evidence indicates more DBTP in older people (Stolarski et al., 2020); furthermore, the associations between chronotype and TP may vary with age, and there may be age-gender interactions (Nowack & Van der Meer, 2013). So, further research should include larger and more demographically diverse samples to test the generalisability of the current findings, and investigate possible age/gender effects and interactions. The current research is also limited by the cross-sectional design, so future longitudinal research may test for causal relationships in the mediation and path models proposed in the current study. Furthermore, sleep variables were only assessed with single-items; more thorough assessment of associations with aspects of sleep could be undertaken using a comprehensive, validated scale such as the Pittsburgh Sleep Quality Index (PSQI; Buysse et al., 1989). Also, experience-sampling via smart phones while participants are engaged in their daily routines (e.g., Killingsworth & Gilbert, 2010) would reduce reliance on memory for retrospective assessments, and may be useful for testing inter-relationships between, for example, sleep inertia, spontaneous mind wandering, and the temporal orientation of thinking. This would also allow research to address state aspects of moment-to-moment temporal focus, which is not possible with the trait-like view of TP inherent in the ZTPI (Stolarski et al., 2018). Also, objective measures, such as grade transcripts and recorded attendance data, may be included to supplement the evidence from self-report questionnaires.

Further research may include a measure of social jetlag to establish if this accounts for the relationship between more eveningness and lower Morning Affect (more sleep inertia), or whether other factors may also be involved. Further

research may also investigate associations with other TPs that have been proposed (see Stolarski et al., 2018, for a discussion of recently proposed TPs), such as Future-positive and Future-negative TPs, which were distinguished by Carelli et al. (2011). Guenther and Stolarski (2021) found (using a unidimensional assessment of morningness-eveningness) that morningness was positively correlated with Future-positive, and eveningness was associated with Future-negative, so it may be informative to test how these TPs are related to the components of Morning Affect, Eveningness, and Distinctness as operationalised in the MESSi.

Further research may also re-test other reported findings from research using unidimensional measures of morningness-eveningness, to establish if associations differ for the separate components. For example, Pruszczak et al. (2018) reported that morning-types have more positive perceptions of/attitudes towards time, while evening-types show more negative/hostile perceptions/attitudes, and they identified possible mechanisms for these associations: (1) as evening-types have more experience of negative emotionality, this may be 'projected' on to perceptions of/attitudes about time; (2) being required to rise earlier than desired (experiencing social jetlag) is unpleasant as the person is still sleepy, so this may influence perceptions of/attitudes about time as like an 'enemy' forcing the person to do things they do not want to, and being the cause of unpleasant experiences. Sleep inertia (Morning Affect) may be involved in both of these mechanisms: the latter (early-rising) explanation involves a direct influence of sleep inertia, which is more pronounced when rising closer to the nadir of the core body temperature rhythm (Scheer et al., 2008); for the former (negative emotionality) explanation, sleep inertia/Morning Affect has been found to mediate the relationship between eveningness and negative emotionality (Carciofo, 2020).

Conclusion

Associations between morningness-eveningness and time perspective have been consistently demonstrated with unidimensional measures of morningness-eveningness, but the current research found that associations vary for different components of circadian functioning: more Morning Affect (less sleep inertia) was associated with more Future TP, less Past-negative TP, and less deviation from balanced time perspective, while more Distinctness (amplitude of diurnal variations) showed the opposite associations. Eveningness (time-of-day preference) was associated with more Present-hedonistic and less Future TPs, but the latter relationship was mediated by Morning Affect. Path models developed in the current study are consistent with the view that the relationship between Eveningness and less Future TP

may involve impaired functioning and a reduction in self-control/self-regulation related to experiencing more sleep inertia (having less Morning Affect). Further research may more fully investigate this, test state-level relationships, and include other dimensions of time perspective.

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