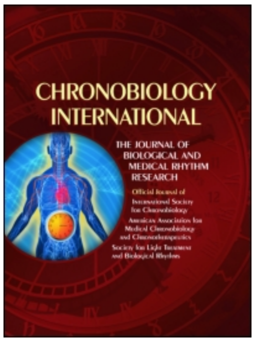
Morning affect or sleep inertia? Comparing the constructs and their measurement



Chronobiology International

The Journal of Biological and Medical Rhythm Research

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/icbi20

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To cite this article: Richard Carciofo (2023): Morning affect or sleep inertia? Comparing the constructs and their measurement, Chronobiology International, DOI: 10.1080/07420528.2023.2187211

To link to this article: https://doi.org/10.1080/07420528.2023.2187211

CHRONOBIOLOGY INTERNATIONAL
https://doi.org/10.1080/07420528.2023.2187211

ORIGINAL ARTICLE

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Morning affect or sleep inertia? Comparing the constructs and their measurement

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ABSTRACT

The construct of Morning Affect (MA; alertness upon awakening/time required to feel fully awake) emerged from exploratory factor analysis of morningness-eveningness questionnaires, and while it has been equated with morningness-eveningness preference it has much conceptual overlap with sleep inertia (SI; the transitional state between sleep and being fully awake). The current study compared questionnaire measures of these constructs to help clarify their inter-relationships. A volunteer sample of 453 students at an English-medium university in China completed an online survey including the Sleep Inertia Questionnaire (SIQ), the Morningness-Eveningness-Stability-Scale-improved (MESSi), with subscales for MA, Eveningness, and Distinctness (amplitude of diurnal variation), and the reduced Morningness-Eveningness Questionnaire (rMEQ). Measures of depression, sleep quality, mindfulness, and personality were also included. Exploratory factor analysis of the SIQ, MESSi, and rMEQ items revealed seven factors: Cognitive, Emotional, and Physiological SI, Responses to SI (including one MA item), and Duration of SI (one SIQ item, 3/5 MA items, and one rMEQ item); Morningness-Eveningness (MESSi Eveningness items, plus 3/5 rMEQ items); Distinctness (3/5 MESSi items). These results suggest that Morning Affect may be better characterised as a general measure of sleep inertia, and may contribute to ongoing development/refinement of questionnaire measures of circadian functioning.

ARTICLE HISTORY
Received 19 December 2022
Revised 31 January 2023
Accepted 28 February 2023

KEYWORDS
Morningness-eveningness; chronotype; morning affect; sleep inertia; depression; sleep quality

Introduction

Individual differences include preferences for rising/sleeping relatively earlier or later in the day, which have some correspondence with the times of being more alert, energetic, and active: morning-types being oriented towards earlier times, evening-types oriented towards later times, and intermediate types (the majority of people) between these extremes (Adan et al. 2012). Morning-types reach their body temperature acrophase approximately 1.5–3 hours earlier than evening-types, and the evening onset of melatonin release is about three hours earlier (Horne and Östberg 1976; Lack et al. 2009).

Although objective measures may be impractical for research involving large samples, self-report scales of chronotype/morningness-eveningness preference have shown good psychometric properties (Di Milia et al. 2013), with validity being supported by their consistency with circadian sleep/wake patterns as assessed by actigraphy (Thun et al. 2012). The 19-item Morningness-Eveningness Questionnaire (MEQ; Horne and Östberg 1976) has been the most widely used, being regarded as the gold standard questionnaire scale (Di Milia et al. 2013; Levandovski et al. 2013). It was developed with a focus on morningness-eveningness preferences (phase differences); more morningness (higher MEQ score) was associated with earlier peak body temperature, and earlier rising and bedtimes (Horne and Östberg 1976).

MEQ items are typically summed to produce a score on the morningness-eveningness continuum, or to classify respondents into chronotype categories using score cut-off points. However, the MEQ items are heterogenous, including preferences for the timing of physical and mental activities (peak performance), rise and retiring time preferences, alertness in the morning, and self-classification of chronotype. Factor analysis has shown various structures for the MEQ. For example, Smith et al. (1989) identified morning-type and evening-type factors, while Adan and Almirall (1991) identified factors for morningness-eveningness, rigidity-flexibility, and subjective alertness/fatigue. More recently, Panjeh et al. (2021) identified factors corresponding to dissipation of homeostatic sleep pressure and sensitivity to

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Supplemental data for this article can be accessed online at https://doi.org/10.1080/07420528.2023.2187211.

build-up of homeostatic sleep pressure. A 5-item reduced version of the MEQ (rMEQ; Adan and Almirall 1991) was also developed, focused on morningness.

Other scales assessing morningness-eveningness /chronotype include the Diurnal Type Scale (DTS; Torsvall and Åkerstedt 1980), Early/Late Preferences Scale (PS; Bohle et al. 2001; Smith et al. 2002), Children's ChronoType Questionnaire (CCTQ; Werner et al. 2009), the Caen Chronotype Questionnaire (CCQ; Dosseville et al. 2013), and the Munich Chronotype Questionnaire (MCTQ; Roenneberg et al. 2003). In addition to phase of circadian functioning, recent research has identified Distinctness, i.e., amplitude of diurnal variation (in mood, motivation, and cognitive functioning) as an additional individual difference, and developed questionnaire measures of this construct (Di Milia et al. 2011; Dosseville et al. 2013; Ogińska 2011; Ogińska et al. 2017; Randler et al. 2016). A scale assessing diurnal variation in energetic feeling has also been developed (the Circadian Energy Scale/CIRENS; Ottoni et al. 2011).

Another widely used scale, the Composite Scale of Morningness (CSM; Smith et al. 1989), is comprised of items from the MEQ and the DTS, with various factor structures having been reported (see Di Milia and Bohle 2009; Díaz-Morales and Parra-Robledo 2018, for discussions of CSM factor solutions, and Randler et al. 2016, Appendix Table A1 for a summary of different solutions). However, a notable finding has been a factor that Smith et al. (1989) identified as "Morning Affect," which in their study was comprised (with some slight changes of wording) of MEQ items 4, 5, and 7 (CSM items 3, 4, 5), plus item 6 of the DTS (CSM item 12), respectively: *Assuming normal circumstance, how easy do you find getting up in the morning? How alert do you feel during the first half-hour after having awakened in the morning? During the first half-hour after having awakened in the morning, how tired do you feel? How long a time does it usually take before you "recover your senses" in the morning after rising from a night's sleep?* As can be seen, these items refer to ease of getting up, alertness/tiredness upon awakening, and the time taken to feel fully awake.

Studies identifying two or more CSM factors have consistently found the Morning Affect/alertness factor, although there has been some variation in its constituent items (see, for example, Adan et al. 2005; Caci et al. 2005,2009; Di Milia and Bohle 2009; Di Milia et al. 2013; Hasan et al. 2022; Jankowski 2015; Kato et al. 2019; Kolomeichuk et al. 2015; Pordanjani and Ebrahimi 2017; Randler 2008; Wong et al. 2017; see also Randler et al. 2016, Appendix Table A1). The Morning Affect (MA) factor has shown much consistency across sex, age group, and country/culture (Caci et al. 2005; Di Milia and Randler 2013; Díaz-Morales and Parra-Robledo 2018; Díaz-Morales and Sánchez-López 2004; Randler and Díaz-Morales 2007; Smith et al. 2002). A short form version of the CSM also identified a separate MA component (Randler 2009), and it has also been identified in the MEQ (e.g., Caci et al. 2009; MEQ items 4, 5, 7, corresponding to CSM items 3, 4, 5), and in a 6-item, two-factor version of the rMEQ (Konttinen et al. 2014; MEQ items 4 and 7, labelled "morning alertness"). Furthermore, in addition to subscales for Eveningness and Distinctness, the recently developed Morningness-Eveningness-Stability-Scale improved (MESSi; Randler et al. 2016) includes a Morning Affect subscale comprised of CSM items 3, 4, and 12, plus the "morningness energy" item from the CIRENS (*In general, how is your energy level in the morning?*), and an item from the CCQ (*I feel drowsy for a long time after awakening*). The three-factor structure of the MESSi has been replicated in several countries/languages (e.g., Demirhan et al. 2019; Díaz-Morales and Randler 2017; Rahafar et al. 2017; Rodrigues et al. 2018).

Thus, the construct of Morning Affect has become well-established in morningness-eveningness/chronotype research as a distinct component of circadian functioning. According to Jankowski (2016, 48) "[m]orning affect refers to the ease of waking up, freshness afterwards, or more generally, to the ease of transition from sleep to an awake state. Circadian preference relates to preferences to undertake activities and sleep at given times of day, as well as to self-recognition as being morning or evening oriented compared to other people." Similarly, in discussing the two factors identified in a Japanese version of the CSM, Kato et al. (2019, 15) stated that both " … reflect essential, but different components of chronotype; the Morning Affect/ Alertness factor primarily represents the 'subjective consequences' of physiological features, whereas the more cognitive Morningness/Time of Day Preference factor integrates sociocultural aspects of chronotype."

However, despite being distinguishable, Morning Affect and morningness/circadian preference have been seen as interchangeable. For instance, Di Milia and Randler (2013, 298–299) stated that (as represented in CSM items 3, 4, 5, 12) morning affect " … may be considered a 'pure' measure of morning preference" and that " … it is a pure measure of morning activity … " (Di Milia and Randler 2013, 300), while Di Milia et al. (2013, 1265) stated that " … [s]imilar to the rMEQ, the MA is a pure measure of morning behavior … ," and Di Milia and Bohle (2009) argued that the MA subscale could be used as a proxy/substitute for the total CSM scale. Also more recently, "Morning Affect" has been used interchangeably with "morningness" or morningness preference (e.g., Randler et al. 2016; Rodrigues et al. 2018; Vagos et al. 2019; Weidenauer et al. 2019). The lack of reference to time of day in the typical MA items has been seen as advantageous for cross-cultural research on morningness-eveningness (e.g., Di Milia and Bohle 2009; Di Milia and Randler 2013; Di Milia et al. 2013).

However, the "core" CSM Morning Affect items (3, 4, 5, 12), and the MESSi Morning Affect items, have no references to preferred/scheduled timings for rising, sleeping, activities, etc. Also, studies identifying separate Morning Affect and morningness-eveningness/activity/preference factors, have found moderate to strong, rather than very strong inter-correlations, with, for example, *rs* of .65 (Konttinen et al. 2014), .40 (Jankowski 2015), .54 (Jankowski 2016), .55 (Kato et al. 2019), .488 (Pordanjani and Ebrahimi 2017). For the MESSi, the Morning Affect and Eveningness factors have correlated, for example, −.60 (Díaz-Morales and Randler 2017), −.526 (Demirhan et al. 2019), −.412 (Tomažič and Randler 2020), −.410 (Carciofo and Song 2019). Thus, R^2/shared variance may be around 16%-42%.

Furthermore, recent findings have shown that measures of morningness-eveningness and Morning Affect may be differentially related with other variables. For example, while studies utilising unidimensional/composite measures of morningness-eveningness have found an association between eveningness and depression (e.g., Antypa et al. 2016; Merikanto et al. 2013 for a review see Au and Reece 2017), Konttinen et al. (2014) found that depression was more strongly associated (negatively) with the Morning Alertness factor of their 6-item rMEQ than with the Circadian Preference factor (as was emotional eating), and Jankowski (2016) found that the Morning Affect CSM factor was more strongly associated with depression than was the circadian preference factor; also, the MESSi Morning Affect subscale has been more strongly associated with depression/psychological distress than has Eveningness (Carciofo 2020; Díaz-Morales et al. 2017). Likewise, while research with unidimensional measures of morningness-eveningness has shown that eveningness may be associated with poorer sleep quality (e.g., Bakotic et al. 2017; Carciofo et al. 2014a), research with the MESSi has shown that the associations are stronger with MA (negatively) than with Eveningness (Carciofo 2020; Carciofo and Song 2019; Demirhan et al. 2019).

So, given such findings, failing to clearly distinguish Morning Affect from morningness/eveningness preference and using them interchangeably (or summed together in a total score) may lead to inaccurate assessments of relationships with other variables. Further clarification of these constructs may be informative, and in this regard it is notable that the core features of Morning Affect, i.e., ease of getting up, degree of alertness/tiredness upon awakening, and the time required to feel fully awake, have a strong resemblance to sleep inertia, i.e., " … the transitional state between sleep and wake, marked by impaired performance, reduced vigilance, and a desire to return to sleep" (Trotti 2017, 76). Sleep inertia (SI) represents a paradox of "waking up tired" and may be seen as a brief process in addition to the homeostatic drive for sleep (Process S) which is dissipated by sleep, and the circadian rhythm of arousal (Process C) which promotes daytime wakefulness (Borbély 1982; Hilditch and McHill 2019).

Many factors influence the occurrence and intensity of sleep inertia (for reviews, see Hilditch and McHill 2019; Tassi and Muzet 2000; Trotti 2017). For example, sleep inertia (SI) is more severe when woken during the biological night, when closer to the nadir of the circadian core body temperature rhythm (Scheer et al. 2008), and also when chronically sleep deprived (McHill et al. 2019). However, SI also occurs in healthy individuals who have not experienced sleep restriction (Hilditch and McHill 2019; Jewett et al. 1999), and even extreme/severe SI (confusional arousals) are relatively common (Ohayon et al. 2000). There are stable individual differences in vulnerability to SI (Lundholm et al. 2021), but SI/extreme SI become less likely with increasing age (Ma et al. 2022; Ohayon et al. 2000), mirroring the increase in morningness, and Morning Affect, with increasing age (e.g., Carciofo et al. 2012; Vagos et al. 2019).

On awakening, the effects of SI on task performance may be comparable to those seen after sleep deprivation, and while the most severe effects of SI may dissipate within around 30 minutes, up to four hours may be necessary for all effects to dissipate, depending on the type of task and how SI is measured (Jewett et al. 1999; Lundholm et al. 2021). For example, Occhionero et al. (2021) found that SI may influence the speed of semantic memory recall for around 30 minutes after awakening, but not influence episodic or procedural memory. Regarding alertness, in participants who were not sleep-deprived, and sleeping on their habitual schedule, Jewett et al. (1999) found that subjective alertness ratings improved rapidly and substantially over the first hour after waking, then levelled off after about two hours; Occhionero et al. (2021) found that alertness ratings (assessed every 10 minutes) increased linearly after awakening, but at 70 minutes they were still significantly below the ratings for a control (wakeful) condition.

Although much research on SI has involved experimental designs, including brain imaging techniques and behavioural measures in forced desynchrony and nap protocols, Kanady and Harvey (2015) developed the self-report Sleep Inertia Questionnaire (SIQ) which includes subscales for Physiological, Cognitive, and Emotional SI, and Responses to SI, plus questions about the duration and frequency of SI. More severe SI was associated with more depression (in both clinical and non-clinical sub-samples), and with shorter sleep duration (Kanady and Harvey 2015).

Kanady and Harvey (2015) also found that SI was not correlated with morningness-eveningness (CSM total score). However, Roenneberg et al. (2003) found that being more evening-type (assessed by sleep mid-point) was associated with requiring a longer time to feel fully awake on workdays (but not on free days), with a later sleep onset being associated with shorter sleep duration and subsequently a longer time to feel fully awake. Also, in an experimental study Ritchie et al. (2017) found that, even when sleeping on their habitual schedule, the effects of SI on responses in a visual search task and reaction time were generally longer lasting for evening-types than for morning-types (assessed by mid-point of sleep, and by dim-light melatonin onset/DLMO). So, the increased likelihood for SI, and longer-lasting SI, in evening-types may be due to habitually/frequently waking at a point closer to the nadir of the core body temperature rhythm, and this effect may be stronger on work/school days when evening-types must rise even earlier than preferred (Ritchie et al. 2017).

However, it is notable that there have been few explicit considerations of sleep inertia in the development of scales to assess chronotype/morningness-eveningness. In developing the CCTQ, Werner et al. (2009) assessed SI (defined as the difference between the time of awakening and that of achieving full alertness), finding that it was shorter on free days than on scheduled days (means of 14 minutes and 22 minutes, respectively), and that evening-types had longer sleep inertia on scheduled (e.g., school) days. Also, although Adan and Natale (2002) used the term "sleep inertia" as a factor label, few discussions of Morning Affect have referred to SI in explicating this construct (for exceptions, see Caci et al. 2009; Jankowski 2016). Likewise, Trotti's (2017) review of research on SI included a range of search terms (in addition to "sleep inertia"), but did not include "morning affect."

So, the current research aimed to help clarify the construct of Morning Affect and its relationships with sleep inertia and chronotype/morningness-eveningness. This was undertaken by including questionnaire scales for Morning Affect (MESSi), sleep inertia (SIQ), and chronotype/morningness-eveningness (MESSi Eveningness subscale; rMEQ), together in exploratory factor analysis; Distinctness (MESSi) was also included. In addition, depression, sleep quality, mindfulness, and personality were assessed, to test for previously reported associations and explore associations with SI. It was expected that MA (MESSi) would positively correlate with morningness (rMEQ), and both would positively correlate with mindfulness and conscientiousness, and negatively correlate with poor sleep quality and depression; Eveningness (MESSi) would negatively correlate with MA, morningness, mindfulness, and conscientiousness; Distinctness would negatively correlate with MA, morningness, and conscientiousness, and positively correlate with depression, poor sleep quality, and neuroticism (Carciofo 2020; Carciofo and Song 2019; Carciofo et al. 2014a,2014b; Demirhan et al. 2019; Díaz-Morales and Randler 2017; Díaz-Morales et al. 2017; Randler et al. 2016; Rodrigues et al. 2018). In addition, more severe sleep inertia (SIQ) was expected to show positive correlations with depression and Eveningness (MESSi), and negative correlations with morningness and sleep duration (Kanady and Harvey 2015; Ritchie et al. 2017; Roenneberg et al. 2003; Werner et al. 2009); a negative correlation with Morning Affect was expected, as MA items are scored oppositely to SI items (low MA associated with high SI). SIQ associations with Distinctness, mindfulness, and personality were also explored. A Chinese translation of the Sleep Inertia Questionnaire was produced for this research, and its psychometric properties were assessed.

Methodology

Sample

An email invitation, with the link to the online survey, was sent to 11 254 students at an English-medium university in Suzhou, China. The online briefing included that participation was voluntary, anonymous, and could be withdrawn at any time; stated inclusion criteria were being a Chinese student of the university aged 18 years/older. After clicking an icon at the end of the briefing to give informed consent participants proceeded to the survey; 799 began the survey, 454 provided complete responses, but one did not meet the inclusion criteria, leaving 453 (mean age = 19.64, $SD = 1.330$; range = 18–25; skewness = 1.043; kurtosis = 1.152); 147 male (mean age = 19.78, $SD = 1.451$); 306 female (mean age = 19.57, $SD = 1.265$), $t = 1.540$, $p = .124$. Approval for the research protocol was provided by the Research Ethics

Committee at Xi'an Jiaotong-Liverpool University, Suzhou, China (research proposal number: 19-01-26).

Materials

The Sleep Inertia Questionnaire (SIQ; Kanady and Harvey 2015) has 21 items assessing sleep inertia (SI), with each item scored on a scale of 1 (*not at all*) to 5 (*all the time*). Four factors/subscales were identified by Kanady and Harvey (2015): Physiological SI (e.g., *Bump into and drop things*), Cognitive SI (e.g., *Find that you think more slowly*), Emotional SI (e.g., *Dread starting your day*), and Responses to SI (e.g., *Wish you could sleep more*). In addition, there are two open questions, one asking how long it takes to "come to" in the morning, in minutes (item 22), and one asking how many days per week this happens (item 22b). The SIQ was translated into Chinese by a native Chinese-speaker, independently back-translated by another native Chinese-speaker, and then checked by a native English-speaker; for clarity in the translation, some minor changes of wording were made in consultation with another native Chinese-speaker.

The Morningness-Eveningness-Stability-Scale improved (MESSi; Randler et al. 2016; Chinese version: Carciofo and Song 2019). This adapted items from the CSM, CCQ, and CIRENS into three subscales: 1) Morning Affect (MA) assessing alertness/tiredness/energy in the morning; it is comprised of CSM items 3, 4, and 12, plus the "morningness energy" item from the CIRENS, and an item from the CCQ; 2) Eveningness (EV; e.g., *I am more an evening than a morning active person*), assessing evening preferences, affect, and energy in the evening, and 3) Distinctness (DI; e.g., *There are moments during the day when it is harder for me to think*), assessing the amplitude of diurnal variations in functioning. Each subscale has five items, each scored on a 1–5 scale (one reversed scored for MA, and three for DI), so that higher scores indicate more MA/EV/DI.

The reduced Morningness-Eveningness Questionnaire (rMEQ; Adan and Almirall 1991; Chinese version: Carciofo et al. 2012) is comprised of five items from the Morningness-Eveningness Questionnaire (MEQ; Horne and Östberg 1976), with higher scores indicating more morningness: *1) Considering only your own "feeling best" rhythm, at what time would you get up if you were entirely free to plan your day? 2) During the first half-hour after having woken in the morning, how tired do you feel? 3) At what time in the evening do you feel tired and as a result in need of sleep? 4) At what time of the day do you think that you reach your "feeling best" peak? 5) One hears about "morning" and "evening" types of people. Which ONE of these types do you consider yourself to be?*

The Big Five Inventory, 10-item (BFI-10; Rammstedt and John 2007; Chinese version: Carciofo et al. 2016). This has two items for each of the big five personality dimensions (extraversion, agreeableness, conscientiousness, neuroticism, openness), scored on a 1–5 scale, with one reversed-scored item for each dimension.

The Mindful Attention Awareness Scale-lapses only (MAAS-LO; Brown and Ryan 2003; Carriere et al. 2008; Chinese version: Carciofo et al. 2014b). This has 12 items, each scored on a 1–6 scale; higher scores indicate more mindfulness.

The Depression Anxiety Stress Scales (DASS; Lovibond and Lovibond 1995). Only the 6-item Chinese version (Wang et al. 2016) of the depression subscale was used, with items scored on a 0–3 scale for the past week; higher scores indicate more depression.

The Pittsburgh Sleep Quality Index (PSQI; Buysse et al. 1989; Chinese version: Liu et al. 1996) includes items assessing seven components of sleep for the preceding month: subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbances, use of medication, and daytime dysfunction. Higher scores indicate poorer sleep quality.

Data analysis

Firstly, the factor structure of the Chinese translation of the Sleep Inertia Questionnaire was tested with exploratory factor analysis (EFA), which is a suitable approach for translated scales allowing identification of structural differences caused by translation issues or culture differences (Orçan 2018). Following Kanady and Harvey (2015), maximum likelihood EFA was conducted with an oblique factor rotation method. The number of factors to retain was decided with reference to the scree plot, the Kaiser rule (initial eigenvalues>1), and by comparing different solutions (Costello and Osborne 2005; Field 2009), with reference to the theoretical expectations based on Kanady and Harvey's (2015) development of the SI. Items with a loading of ≥.400 on a factor, with no cross-loadings ≥ .400, were retained. Internal consistency of the identified factors was assessed with Cronbach's alpha, and construct validity was assessed by testing the expected correlations with depression, sleep duration, and eveningness. Further EFAs added MESSi subscales and the rMEQ.

Descriptive statistics for each scale include the mean, standard deviation, range, skewness, kurtosis, and Cronbach's alpha. Pearson correlations were calculated, with coefficients of .10, .30, and .50 respectively indicating small, medium, and large effect sizes; for medium effect sizes to be established with 80% power at $p = .05$, a sample size of $N = 85$ is suggested, and for small effect sizes $N = 783$ (Cohen 1992).

Results

Sleep Inertia Scale (SIQ)

Maximum Likelihood EFA, with Direct Oblimin (oblique) rotation, was used to assess the structure of the SIQ. Following Kanady and Harvey (2015) items 22 and 22b (regarding time required to fully awaken, and how often SI occurs) were excluded from the analysis. The scree plot indicated two clear factors with a break around the third factor, while there were four initial eigenvalues>1. So, two, three, and four-factor solutions were compared; see the Supplementary materials for details. The four-factor solution was most clearly interpretable, with "clean" loadings and much correspondence with Kanady and Harvey's (2015) four-factor SIQ, except that item 6 (*Notice that you feel sleepy?*) loaded on Physiological SI rather than Responses to SI, and item 20 (*Can't imagine being able to wake up?*) did not load ≥.400 on any factor, so was removed: items 4 to 12 loaded >.4 on factor 1 (Physiological SI), items 13 and 14 loaded >.4 on factor 2 (Emotional SI), items 1, 2, 3, and 15 loaded >.4 on factor 3 (Responses to SI), and items 16, 17, 18, 19, 21 loaded >.4 on factor 4 (Cognitive SI); cross-loadings were all <.3 (see the Supplementary materials Table S1). Age was not correlated with SIQ total or any of the subscales, all $rs < .1$, all $ps > .05$, and there were no significant gender differences (all $ps > .1$).

Descriptive statistics

Each scale/subscale (Table 1) had a wide range of scores, with distributions generally approximating normality (absolute values of skewness and kurtosis<1, except for Depression, and some of the PSQI components). PSQI component 6 (sleep medication) was highly skewed, with 414/453 reporting no medication use over the last month. Internal consistency was good/very good with Cronbach's alpha values all >.7, except for the Pittsburgh Sleep Quality Index, and most of the 2-item BFI-10 subscales.

Correlations

Correlations with the SIQ are shown in Table 2. Morning Affect had medium/strong negative correlations with the SIQ total score (less MA, more SI), and with each component; the rMEQ also had negative correlations (more SI associated with more eveningness), although the coefficients were not as strong. Eveningness and Distinctness had small/medium positive correlations with SIQ and all components (except for weak/non-significant correlations with Emotional SI, and Responses to SI, respectively). SIQ total/SIQ components positively correlated with depression, neuroticism, and poor sleep quality, and negatively correlated with mindfulness and conscientiousness.

Table 1. Descriptive statistics.

	Range (possible)	Mean	Standard deviation	Skewness	Kurtosis	Cronbach's Alpha
Sleep Inertia Scale total (20 items)	21–100 (20–100)	55.56	16.923	.261	−.675	.926
Physiological Sleep Inertia	9–45 (9–45)	22.58	8.329	.491	−.563	.895
Emotional Sleep Inertia	2–10 (2–10)	5.07	2.607	.481	−.917	.862
Responses to Sleep Inertia	4–20 (4–20)	14.41	4.264	−.561	−.619	.777
Cognitive Sleep Inertia	5–25 (5–25)	13.51	5.833	.372	−.882	.925
Morning Affect	5–25 (5–25)	15.66	4.107	−.314	−.302	.812
Eveningness	5–25 (5–25)	18.58	4.550	−.550	−.334	.832
Distinctness	5–25 (5–25)	19.63	3.860	−.838	.753	.717
Reduced Morningness-Eveningness Questionnaire	4–24 (4–25)	11.81	3.641	.259	−.154	.752
Depression	0–18 (0–18)	4.82	4.395	1.158	.979	.886
Mindfulness	12–72 (12–72)	44.43	8.965	−.284	.675	.824
Extraversion	2–10 (2–10)	6.30	2.142	−.143	−.750	.722
Agreeableness	2–10 (2–10)	6.86	1.664	−.254	−.270	.211
Conscientiousness	2–10 (2–10)	5.45	1.679	.234	.013	.434
Neuroticism	2–10 (2–10)	6.51	1.984	−.088	−.600	.538
Openness	2–10 (2–10)	7.85	1.746	−.679	−.075	.379
Pittsburgh Sleep Quality Index (PSQI)	0–18 (0–21)	6.55	3.162	.635	.398	.696
PSQI 1: subjective sleep quality	0–3 (0–3)	1.31	.813	.222	−.411	-
PSQI 2: sleep latency	0–3 (0–3)	1.28	1.044	.320	−1.074	-
PSQI 3: sleep duration	0–3 (0–3)	.40	.649	1.542	1.689	-
PSQI 4: sleep efficiency	0–3 (0–3)	.30	.662	2.570	6.578	-
PSQI 5: sleep disturbances	0–3 (0–3)	1.06	.530	.424	1.700	-
PSQI 6: sleep medication	0–3 (0–3)	.18	.620	3.608	12.091	-
PSQI 7: daytime dysfunction	0–3 (0–3)	2.03	.872	−.442	−.745	-

N = 453; standard error of skewness = .115; standard error of kurtosis = .229.

Table 2. Correlations with the Sleep Inertia Questionnaire.

	Sleep Inertia Scale total	Physiological Sleep Inertia	Emotional Sleep Inertia	Responses to Sleep Inertia	Cognitive Sleep Inertia
Morning Affect	−.705***	−.614***	−.397***	−.553***	−.585***
Eveningness	.225***	.173***	.063	.243***	.201***
Distinctness	.358***	.330***	.279***	.091	.375***
Reduced Morningness-Eveningness Questionnaire	−.450***	−.373***	−.249***	−.429***	−.347***
Depression	.458***	.372***	.584***	.094*	.469***
Mindfulness	−.423***	−.371***	−.404***	−.138**	−.415***
Extraversion	−.114*	−.103*	−.232***	.001	−.079
Agreeableness	.000	−.018	−.102*	.097*	.001
Conscientiousness	−.316***	−.289***	−.205***	−.128**	−.318***
Neuroticism	.299***	.267***	.412***	.061	.257***
Openness	−.019	.032	−.040	−.005	−.078
Pittsburgh Sleep Quality Index (PSQI)	.525***	.505***	.476***	.148**	.481***
PSQI subjective sleep quality	.425***	.398***	.392***	.115*	.405***
PSQI sleep latency	.287***	.272***	.267***	.119*	.238***
PSQI sleep duration	.247***	.251***	.231***	.028	.236***
PSQI sleep efficiency	.133**	.122**	.155***	.055	.104*
PSQI sleep disturbances	.298***	.333***	.270***	.001	.267***
PSQI sleep medication	.198***	.169***	.205***	.057	.198***
PSQI daytime dysfunction	.557***	.533***	.442***	.183***	.523***

N = 453. *$p \leq .05$; **$p \leq .01$; ***$p \leq .001$.

Inter-correlations between morningness-eveningness, components of circadian functioning, depression, personality, mindfulness, and sleep quality were consistent with previous research (see Supplementary Materials Table S2).

Sleep inertia and morning affect exploratory factor analysis

To test how Morning Affect (MA) may be related to Sleep Inertia (SI), EFA (maximum likelihood with Direct Oblimin rotation) was done for the SIQ items plus the items of the MA scale. SIQ item 22 *(How long does it take you to "come to" in the morning?. . . minutes)* was included in the EFA, given its similarity to some MA items (especially item 3: *How long a time does it usually take before you "recover your senses" in the morning after rising from a night's sleep?*). The open responses to SIQ item 22 were coded into five groups; also, for consistency with the SIQ scoring, MA items were reversed (see Supplementary materials for details). As there were six unusable responses for SIQ item 22, *N* = 447 for this EFA.

The scree plot indicated two clear factors, possibly up to six, while there were five initial eigenvalues>1. Given that the four-factor SIQ had previously been established, four-factor, five-factor, and six-factor solutions were compared (see Supplementary materials). The five-factor solution was the most clearly interpretable: the four previously established SIQ factors were exactly replicated, and with MA item 1 loading on the Responses to SI factor. MA items 2, 3, and 5 each loaded >.4 on the fifth factor, as did SIQ item 22 (SIQ item 20 and MA item 4 did not load ≥.4 on any factor). This presented a coherent grouping of the SIQ and MA items: for the Responses to SI factor items all refer to some kind of reaction related to SI: *Have problems getting out of bed? Need an alarm to wake up? Hit the snooze button on the alarm? Wish you could sleep more?* Likewise for MA item 1: *Assuming normal circumstance, how easy do you find getting up in the morning?* In contrast the items on the fifth factor, named *Duration of Sleep Inertia*, all refer to time to achieve full wakefulness/alertness: MA item 2 (*How alert do you feel during the first half hour after having awakened in the morning?*), item 3 (*How long a time does it usually take before you "recover your senses" in the morning after rising from a night's sleep?*), and item 5 (*I feel drowsy for a long time after awakening*); likewise SIQ item 22: *How long does it take you to "come to" in the morning?* Each item loaded >.400 on one factor, with no cross-loadings ≥ .300 (Table 3).

Further exploratory analysis was undertaken with the SIQ, the three MESSi subscales (Morning Affect/MA, Eveningness/EV, and Distinctness/DI), and the rMEQ. Full details are included in the Supplementary materials. The seven-factor solution was most clearly interpretable: the four SIQ factors were replicated (except that SIQ item 15 did not load ≥.400 on any factor); the Duration of SI factor was replicated, but also included rMEQ item 2 (*During the first half-hour after having woken in the morning, how tired do you feel?*); there was a separate Distinctness factor (the three reverse-scored Distinctness items; the other two did not load ≥.400 on any factor); and a separate Morningness-Eveningness factor, comprised of all MESSi Eveningness items, plus rMEQ items 3 (time of

Table 3. Pattern matrix for the Sleep Inertia Questionnaire with the Morning Affect scale.

Item	Factor 1 Cognitive Sleep Inertia	Factor 2 Responses to Sleep Inertia	Factor 3 Emotional Sleep Inertia	Factor 4 Physiological Sleep Inertia	Factor 5 Duration of Sleep Inertia
SIQ1	−0.056	**0.688**	0.014	0.218	−0.112
SIQ2	0.017	**0.697**	−0.052	−0.072	−0.031
SIQ3	0.058	**0.723**	−0.001	−0.117	0.001
SIQ4	−0.015	0.059	−0.057	**0.449**	−0.038
SIQ5	0.180	0.020	−0.044	**0.539**	−0.109
SIQ6	0.170	0.145	−0.009	**0.509**	−0.076
SIQ7	0.029	0.093	0.084	**0.600**	0.092
SIQ8	0.029	0.005	−0.016	**0.789**	−0.027
SIQ9	0.034	−0.060	−0.004	**0.796**	−0.103
SIQ10	0.103	0.063	0.076	**0.572**	0.013
SIQ11	0.007	−0.074	0.077	**0.647**	0.034
SIQ12	0.023	−0.047	0.134	**0.593**	−0.047
SIQ13	0.021	0.039	**0.822**	0.069	0.017
SIQ14	0.031	−0.030	**0.855**	−0.038	−0.075
SIQ15	0.069	**0.489**	0.093	0.180	0.061
SIQ16	**0.675**	0.079	0.210	0.024	0.011
SIQ17	**1.025**	0.060	−0.044	−0.066	0.041
SIQ18	**0.900**	−0.011	−0.057	0.051	−0.023
SIQ19	**0.664**	−0.049	0.074	0.105	−0.061
SIQ21	**0.494**	−0.075	0.132	0.162	−0.162
SIQ22	−0.015	0.193	0.094	−0.122	**−0.752**
MA1	−0.072	**0.681**	0.034	0.154	−0.196
MA2	0.060	0.064	−0.043	0.168	**−0.572**
MA3	0.006	−0.055	0.034	0.002	**−0.867**
MA5	0.206	0.016	0.021	0.224	**−0.447**

N = 447. Extraction Method: Maximum Likelihood, with Direct Oblimin rotation (with Kaiser Normalization).
Item loadings ≥ .400 are shown in bold. SIQ = Sleep Inertia Questionnaire items; MA = Morning Affect items (scoring reversed).

feeling tired in the evening), 4 (time of the "feeling best" peak), and 5 (self-categorised chronotype); rMEQ item 1 (preferred time of rising) did not load ≥.400 on any factor. The final pattern matrix is shown in Table 4.

Cronbach's alpha for the subscales corresponding to the factors in Table 4 were: Responses to SIQ, .827; Morningness-Eveningness (rMEQ + EV items reverse-scored), .876; Distinctness, .757; Sleep Inertia Duration (rMEQ item 2 reverse-scored), .849 (SIQ Cognitive, Emotional, and Physiological factors were unchanged, and so as reported in Table 1). SIQ factors negatively correlated with Morningness-Eveningness (more SI, less morningness), and positively correlated with Distinctness (see Supplementary materials Table S5). To further explore the relationship between Morningness-Eveningness and Duration of Sleep Inertia, SI duration scores were split into three groups: short, moderate, and long (using the approximate 33rd and 66th percentiles); Morningness-Eveningness scores were split into chronotypes: evening-types as those at/below the approximate 10th percentile, and morning-types at/above the approximate 90th percentile. While the cross-tabulation (Table 5) showed modal frequencies of short/moderate duration for morning-types, and long duration for evening-types, 6/46 morning-types (13.00%) had long SI duration, and 16/56 evening-types (28.60%) had short SI duration.

Discussion

The current study aimed to help clarify the construct of Morning Affect and its relationships with sleep inertia and chronotype/morningness-eveningness. The Chinese translation of the Sleep Inertia Questionnaire (SIQ; Kanady and Harvey 2015) made for this study replicated the four-factor structure of the original English-language version: Cognitive SI, Physiological SI, Responses to SI, and Emotional SI. One item (*Can't imagine being able to wake up?*) was removed for not loading ≥.400 on any factor, but all other items loaded ≥.400 on their respective factors, with no cross-loadings ≥ .300; one item (*Notice that you feel sleepy?*) loaded on the Physiological factor rather than Responses to SI. The subscales showed good internal consistency and, as expected, SI total score (and most subscales) correlated positively with depression and negatively with sleep duration, comparable with the findings of Kanady and Harvey (2015).

In addition, SI had negative correlations with mindfulness and conscientiousness, and positive correlations with Distinctness and neuroticism. These personality correlates are consistent with those found with poor sleep quality (Duggan et al. 2014), and with depression (Kotov et al. 2010), with Distinctness also positively correlating with depression (Carciofo 2020), while mindfulness is associated with well-being (Howell et al. 2008). SI total score (and most subscales) showed positive correlations with most components of poor

Table 4. Pattern matrix for the Sleep Inertia Questionnaire with the Morning Affect, Eveningness, and Distinctness scales, and the reduced Morningness-Eveningness Questionnaire.

Item	Factor 1 Cognitive Sleep Inertia	Factor 2 Morningness-Eveningness	Factor 3 Responses to Sleep Inertia	Factor 4 Emotional Sleep Inertia	Factor 5 Distinctness	Factor 6 Physiological Sleep Inertia	Factor 7 Duration of Sleep Inertia
SIQ1	−0.035	0.094	**0.653**	0.006	−0.038	0.269	−0.109
SIQ2	0.021	0.064	**0.666**	−0.051	−0.041	−0.015	−0.036
SIQ3	0.067	−0.009	**0.701**	−0.016	0.003	−0.046	−0.011
SIQ4	−0.015	0.003	0.074	−0.036	0.026	**0.431**	−0.028
SIQ5	0.184	0.024	0.028	−0.033	0.062	**0.508**	−0.097
SIQ6	0.183	−0.052	0.141	−0.029	0.068	**0.505**	−0.098
SIQ7	0.042	−0.011	0.091	0.053	0.077	**0.611**	0.092
SIQ8	0.047	0.009	0.000	−0.021	0.021	**0.773**	−0.028
SIQ9	0.054	−0.023	−0.060	−0.018	0.050	**0.772**	−0.108
SIQ10	0.119	0.032	0.062	0.082	−0.010	**0.578**	0.022
SIQ11	0.035	0.030	−0.082	0.099	−0.063	**0.636**	0.037
SIQ12	0.058	−0.032	−0.036	0.139	−0.064	**0.604**	−0.047
SIQ13	0.071	0.075	−0.026	**0.738**	0.006	0.161	−0.021
SIQ14	0.070	0.072	−0.082	**0.816**	−0.020	0.052	−0.107
SIQ16	**0.655**	0.038	0.070	0.182	0.082	0.071	0.007
SIQ17	**0.979**	0.038	0.062	−0.045	0.036	−0.028	0.036
SIQ18	**0.878**	−0.035	0.004	−0.050	0.002	0.070	−0.037
SIQ19	**0.652**	0.009	−0.047	0.074	0.009	0.122	−0.068
SIQ21	**0.500**	0.049	−0.088	0.137	−0.018	0.160	−0.171
SIQ22	0.020	−0.017	0.200	0.096	−0.021	−0.126	**−0.744**
MA1	−0.043	0.120	**0.617**	0.030	−0.080	0.199	−0.209
MA2	0.051	0.025	0.051	−0.053	0.072	0.134	**−0.604**
MA3	0.034	−0.031	−0.029	0.041	−0.001	−0.046	**−0.871**
MA5	0.207	0.088	−0.016	0.016	0.012	0.197	**−0.470**
EV1	0.130	**0.651**	0.119	−0.088	−0.051	−0.040	0.063
EV2	0.016	**0.795**	0.006	0.104	0.055	−0.069	0.007
EV3	0.057	**0.881**	−0.050	0.006	0.002	0.032	0.001
EV4	−0.030	**0.893**	−0.064	0.034	0.031	−0.003	0.019
EV5	−0.024	**0.413**	−0.155	−0.229	−0.135	0.054	−0.051
DI1	−0.058	−0.021	−0.045	−0.028	**0.586**	0.065	0.024
DI2	0.121	0.041	−0.035	0.027	**0.748**	−0.038	−0.055
DI3	0.039	0.080	−0.006	−0.015	**0.831**	−0.045	−0.020
rMEQ2	0.064	−0.079	−0.046	0.012	−0.183	−0.321	**0.403**
rMEQ3	0.038	**−0.467**	−0.114	−0.011	−0.058	−0.018	0.090
rMEQ4	0.026	**−0.676**	−0.094	−0.112	−0.083	0.011	−0.020
rMEQ5	−0.009	**−0.720**	−0.087	−0.066	−0.037	−0.031	0.021

N = 447. Extraction Method: Maximum Likelihood, with Direct Oblimin rotation (with Kaiser Normalization). Item loadings ≥ .400 are shown in bold. SIQ = Sleep Inertia Questionnaire items; MA = Morning Affect items (scoring reversed); EV = Eveningness items; DI = Distinctness items; rMEQ = reduced Morningness-Eveningness Questionnaire items.

Table 5. Chronotype X sleep inertia duration.

	Chronotype			
Sleep Inertia Duration	Evening-type	Intermediate	Morning-type	Total
Short	16 (28.60%)	101 (29.30%)	**20 (43.50%)**	137 (30.60%)
Moderate	13 (23.20%)	**145 (42.00%)**	**20 (43.50%)**	178 (39.80%)
Long	**27 (48.20%)**	99 (28.70%)	6 (13.00%)	132 (29.50%)
Total	56 (100%)	345 (100%)	46 (100%)	447 (100%)

N = 447. Modal frequency for each chronotype shown in bold.

sleep quality, consistent with the findings of Ma et al. (2022), and negative correlations with morningness/positive correlations with eveningness, consistent with findings reported by Roenneberg et al. (2003), Werner et al. (2009), Ritchie et al. (2017), and Ma et al. (2022). In contrast, Kanady and Harvey (2015) unexpectedly found that SI was not associated with sleep quality or eveningness, perhaps indicating important moderating factors on these relationships which may be investigated in future research.

Intercorrelations between morningness-eveningness, Morning Affect, Eveningness, Distinctness, depression, sleep quality, mindfulness, and personality were consistent with previous research (Carciofo 2020; Carciofo and Song 2019; Carciofo et al. 2014a,2014b; Demirhan et al. 2019; Díaz-Morales and Randler 2017; Díaz-Morales et al. 2017; Randler et al. 2016; Rodrigues et al. 2018).

Sleep inertia, morning affect, morningness-eveningness, and distinctness

The strongest correlate of SI total score, and most SI factors, was Morning Affect ($r = -.705$ for SI total), and when MA was included in exploratory factor analysis (EFA) with the SIQ items, MA item 4 (*In general, how is your energy level in the morning?*) did not load ≥.4 on any factor, while MA item 1 (*Assuming normal circumstance, how easy do you find getting up in the morning?*) loaded with the Responses to SI factor. Additionally, the other three MA items, together with SIQ item 22, formed a separate factor named *Duration of Sleep Inertia*, as all items relate to time taken to achieve full wakefulness/alertness: MA item 2 (*How alert do you feel during the first half hour after having awakened in the morning?*), item 3 (*How long a time does it usually take before you "recover your senses" in the morning after rising from a night's sleep?*), item 5 (*I feel drowsy for a long time after awakening*); SIQ item 22: *How long does it take you to "come to" in the morning?*

Further EFA including the MESSi Eveningness and Distinctness subscales, plus the rMEQ, identified separate factors for Morningness-Eveningness (all MESSi Eveningness items, plus three rMEQ items), and Distinctness (only the three reverse-scored MESSi items); rMEQ item 2 (*During the first half-hour after having woken in the morning, how tired do you feel?*) loaded on Duration of Sleep Inertia. Although these resulting subscales showed good internal consistency, it is not proposed that they be combined as a new scale; the aim of the current research was rather to contribute towards clarification of constructs as represented in widely used scales, which may help inform future developments.

Implications

There is much similarity in the constructs of Morning Affect and sleep inertia. The different nomenclature may result from independent research fields and methods: the construct of Morning Affect was not hypothesised as a component of circadian functioning in the development of morningness-eveningness questionnaires but emerged ("bottom-up") from exploratory factor analysis in developing the CSM (Smith et al. 1989), was subsequently replicated in many studies using the CSM, and was established as a subscale of the MESSi. In contrast, much research on sleep inertia has been laboratory based (Hilditch and McHill 2019; Tassi and Muzet 2000; Trotti 2017), but the Sleep Inertia Questionnaire (Kanady and Harvey 2015) was recently developed in a "top-down" approach, guided by empirical findings on SI.

Morning Affect has been suggested as an index of morningness-eveningness preference (e.g., Di Milia and Randler 2013; Di Milia et al. 2013; Randler et al. 2016; Rodrigues et al. 2018; Vagos et al. 2019; Weidenauer et al. 2019). However, although MA and morningness may be strongly associated, the appropriateness of equating MA with morningness-eveningness/circadian preference may be questioned: (1) Evening-types may be more at risk from long-lasting SI (low MA) due to awakening closer to the nadir of the circadian core body temperature rhythm, when SI is more likely (Jankowski 2016; Scheer et al. 2008). Added to this, experiencing frequent and/or severe SI may influence self-reports of chronotype; as noted by Kato et al. (2019, 15) "[o]f course, the two 'components' - preference and mood – cannot be separated easily, because the way one feels in the morning influences preference/planning." However, although evening-types may experience more frequent/severe SI, and although SI may influence self-assessment of chronotype (and also assessment of Distinctness/amplitude of diurnal variations in functioning), morningness-eveningness preference and MA (SI) have consistently been identified as separate/distinguishable in factor analysis. Furthermore, SI is widely experienced even without having sleep restriction (Jewett et al. 1999), and following afternoon naps, so may not necessarily be associated with circadian preference. Roenneberg et al. (2003) found that SI was unrelated to chronotype (or sleep duration) on free days. Also, cross-tabulation analysis in the current research showed that while evening-types were more likely to have long SI duration (consistent with the findings of Ritchie et al. 2017), 28.60% of evening-types had short SI duration, and 13.00% of morning-types had long SI duration. This disconnect between circadian preference and sleep inertia is comparable with previous research showing that good sleep quality is reported by some evening-types (Tavernier and Willoughby 2014). (2) MA and morningness-eveningness factors differentially correlate with other variables (Jankowski 2016; Konttinen et al. 2014). (3) None of the MESSi Morning Affect items (adapted from the CSM, CCQ, and CIRENS) refer to preferred timing for sleep/rising or activities (or to positive or negative affect states/moods); instead, 4/5 items refer only to ease or time required for fully awakening, showing much conceptual overlap with sleep inertia (the fifth item, referring to energy levels in the morning, did not load on any of the factors identified in the current research, so may require further clarification).

Consideration of these issues, in addition to the current findings, support re-characterising questionnaire items/scales for Morning Affect as items/scales for sleep inertia. This may help conceptual clarification and standardisation of nomenclature, and facilitate more integration with the wider research on sleep inertia. Alternatively, if it is argued that Morning Affect is distinguishable from sleep inertia, then the differences between these constructs need to be clearly explicated and appropriately operationalised in corresponding measures.

The current results may also contribute to ongoing discussions about whether to assess a single morningness-eveningness dimension, or to assess specific components (e.g., Díaz-Morales and Parra-Robledo 2018; Putilov 2017; Randler et al. 2016). It is still common practice to utilise MEQ and CSM total scores in research, and this use of unidimensional measures of morningness-eveningness may be supported by biological markers, such as the sinusoidal core body temperature rhythm with a single nadir (Randler et al. 2016), which may possibly be related to assessment of a "general" morningness-eveningness construct. Some research may support this; for instance, Díaz-Morales and Parra-Robledo's (2018) analysis of the CSM indicated a bi-factor model with a general morningness-eveningness factor, plus specific factors of morningness, morning affect, and time of retiring (but see also Kato et al. 2019). In addition, the MEQ and CSM are well-validated as unidimensional scales, and, as argued by Smith et al. (1989, 733) for the CSM, the high value of internal consistency " . . . indicates that the 13 items can be used to calculate a single scale score, even though the items were derived from an item pool that is multidimensional . . . "

In contrast, Di Milia et al. (2013, 1262) argue "[i]t may be obvious to state, but a single scale score should only be calculated if all the items load onto a single factor." Given that there are identifiable subcomponents of circadian functioning, using CSM or MEQ total ("general") scores, rather than separate subscale scores, will give less precise indications of relationships with other variables. It may be argued that this is adequate for some research aims; in addition, although the multi-factorial structures of the MEQ and CSM have been demonstrated in many studies, the lack of consistency in the identified factors may have contributed to a preference for using the total scale scores. Nevertheless, this continued practice may hinder development of questionnaire measures of circadian functioning which are conceptually unambiguous, and which may progress research by establishing greater specificity in relationships with other variables.

The value of focusing more on distinct components is reflected in recently developed scales incorporating this approach (CCQ, MESSi), and in the demonstration that morningness-eveningness, Morning Affect, and Distinctness have differential associations with variables including depression, sleep quality, and personality (Carciofo 2020; Díaz-Morales et al. 2017; Jankowski 2016; Konttinen et al. 2014). In addition, Ojeda et al. (2013) found genetic associations with components of the CSM (morningness, activity planning, and morning alertness), but no associations with the CSM total score. The current research suggests that the MESSi Morning Affect scale may be a useful general measure of sleep inertia (particularly SI duration), but if researchers seek to more fully understand specific aspects of functioning upon awakening, then the SIQ subfactors may be more appropriate.

Limitations and future research

Limitations of the current research include the low response rate to the survey invitation, and relatively low completion rate, perhaps due to the length of the survey (with typical completion time estimated at around 10–15 minutes). However, for the obtained sample the scales showed good internal consistency, and results replicated previously established findings, although, as the age range was limited, further research is required to establish if the four-factor structure of the SIQ identified in the current study is replicated with more diverse samples; factor structures may vary with age, as has been found for the CSM (Di Milia and Randler 2013). Furthermore, the SIQ subfactors are imbalanced: the Physiological factor had nine items, while the Emotional SI factor had two items in the current study (eight and three items, respectively, in Kanady and Harvey's 2015 SIQ). Also, there was some evidence that the Physiological SI factor may involve subgroups (see Supplementary materials). So, revisions/refinements may potentially be made to the SIQ.

Further research may also establish if the *Duration of Sleep Inertia* factor (and its constituent items) is consistently replicated. While the current results found that 3/5 MA items plus SIQ item 22 and rMEQ item 2 formed a coherent *Duration of Sleep Inertia* factor (all items relating to time taken to fully awaken), Kanady and Harvey (2015) excluded SIQ item 22 from their EFA, as they considered it a general question independent of any particular component of SI. The current results are consistent with this view of independence from the other SI components, but also suggest that a separate Duration of Sleep Inertia factor may be identified when combined with additional items. Although it may be questioned whether a separate multi-item factor is required, rather than a single-item measure of SI duration as used by Kanady and Harvey (2015), multi-item measurement has advantages psychometrically for reducing measurement error and establishing reliability (Credé et al. 2012), which may benefit the investigation of correlates of sleep inertia duration.

The causal relationships between eveningness, sleep inertia (Morning Affect), and depression may also be more fully investigated. If the experience of severe SI may itself be a cause of depression, then this may explain the increased vulnerability of evening-types who wake closer to the biological night, which increases the likelihood of SI (Jankowski 2016; Scheer et al. 2008). Consistent with this, Morning Affect mediates the association between eveningness and negative emotionality (Carciofo 2020). However, it may also be that difficulty with waking is (partly) due to a lack of motivation caused by depression (Trotti 2017). Better understanding of these mechanisms may inform effective treatments (Kanady and Harvey 2015). Furthermore, developing preventative strategies and reactive countermeasures to mitigate the effects of SI has important practical applications where SI may have consequences for health and safety, such as when making decisions or operating machinery (Hilditch and McHill 2019; Scheer et al. 2008; Trotti 2017).

Finally, the current research was limited by the reliance on subjective, self-report measures. More research is required on the biological correlates of the components of circadian functioning identified in self-rating measures (Putilov 2017). Likewise, the SIQ requires more validation with objective criteria (Kanady and Harvey 2015). Objective and subjective measures of the effects of SI may be inconsistent (Hilditch and McHill 2019), and chronotype defined by sleep mid-point may differ from that defined by DLMO (Ritchie et al. 2017). So, it may be preferable to use multiple measures of constructs whenever possible.

Conclusions

The current results suggest that the construct of Morning Affect that has emerged from factor analysis of morningness-eveningness questionnaires may be better characterised as a measure of sleep inertia. While many scales are available to assess morningness-eveningness and related constructs, and the choice of scale depends on the specific research aims (Di Milia et al. 2013), the current study joins other calls (e.g., Konttinen et al. 2014; Putilov 2017; Randler et al. 2016) for further clarification and refinement of questionnaire measures of components of circadian functioning.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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