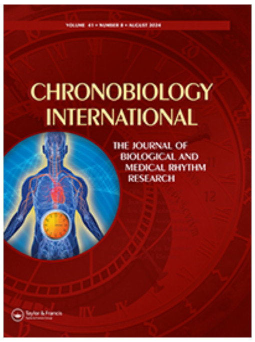
Validation of the English-language version of the Morningness-Eveningness-Stability-Scale-improved (MESSi), and comparison with a measure of sleep inertia



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ORIGINAL ARTICLE

Validation of the English-language version of the Morningness-Eveningness-Stability-Scale-improved (MESSi), and comparison with a measure of sleep inertia

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ABSTRACT

The Morningness-Eveningness-Stability-Scale-improved (MESSi) assesses three components of circadian functioning: Morning Affect (time to fully awaken), Eveningness (orientation/preference for evening activity), and Distinctness (amplitude of diurnal variations in functioning). Following the original German version, translations of the MESSi (including Spanish, Turkish, and Chinese) have been validated, but validity evidence for the English-language version has been lacking. The current study tested the factor structure, internal consistency, and predicted correlations of the English-language MESSi. A sample of 600 adults from an online recruitment platform (aged 18–78, mean = 41.31, *SD* = 13.149) completed an online survey including the MESSi, reduced Morningness-Eveningness Questionnaire (rMEQ), Sleep Inertia Questionnaire (SIQ), and measures of personality and depressive symptoms. Exploratory factor analysis exactly reproduced the three-component structure of Morning Affect (MA), Eveningness, and Distinctness, with all items loading strongly on their respective component. Confirmatory factor analysis of this structure showed acceptable fit. The three subscales showed good internal consistency and replicated previously reported correlations with depressive symptoms, sleep inertia, sleep quality, and personality. Further factor analysis combining the items of the MESSi, rMEQ, and SIQ replicated a previously found seven-factor structure: Cognitive, Emotional, and Physiological sleep inertia (SI), Responses to SI (including one MA item); Duration of SI (one SIQ item, 3/5 MA items); Morningness-Eveningness (MESSi Eveningness items, plus 3/5 rMEQ items); Distinctness (5/5 MESSi items). In conclusion, the English-language MESSi shows sound psychometric properties, but Morning Affect may be more suitably characterised as a measure of sleep inertia duration, rather than morningness preference.

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Morningness-Eveningness; chronotype; Morningness-Eveningness-Stability-Scale-improved (MESSi); morning affect; sleep inertia; depressive symptoms; personality

Introduction

Self-report questionnaire scales assess morningness-eveningness preference (related to times of rising/sleeping, activity, etc.) on a continuum, or chronotype classifications (morning-type/evening-type/intermediate), and are useful research tools for investigating population characteristics and correlates of morningness-eveningness (Adan et al. 2012; Díaz-Morales et al. 2017; Duarte et al. 2014). The Morningness-Eveningness Questionnaire (MEQ; Horne and Östberg 1976) has been the most widely used scale, being considered the gold standard self-report measure of morningness-eveningness (Di Milia et al. 2013; Levandovski et al. 2013), but other scales were subsequently developed, including the Diurnal Type Scale (DTS; Torsvall and Åkerstedt 1980), the Composite Scale of Morningness (CSM; Smith et al. 1989), and the Early/Late Preferences Scale (PS; Bohle et al. 2001; Smith et al. 2002). These scales have demonstrated sound psychometric properties (Di Milia et al. 2013), and consistency with objective measures such as actigraphy assessment of sleep/wake patterns (Thun et al. 2012), and the timing of daily peak body temperature, which is earlier in morning-types (Horne and Östberg 1976).

However, concerns have been raised about the scales assessing morningness-eveningness. For instance, there has been debate about the validity of using clock times in questions or using items in which the respondent compares themselves with others (Adan et al. 2012; Randler et al. 2016; Tonetti et al. 2024). There are also concerns about the structure of widely used scales. Factor analysis of the MEQ has produced a variety of results in the number and character of the factors, these ranging from morning-type and evening-type factors (Smith et al. 1989), morningness-eveningness, rigidity-flexibility, and subjective alertness/fatigue factors (Adan and Almirall 1991), and dissipation of homeostatic sleep pressure and sensitivity to build-up of homeostatic sleep

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Table 1. Pattern matrix for the MESSi subscales.

MESSi item	Morning Affect	Distinctness	Eveningness
1	**0.799**	−0.040	−0.026
2	**0.884**	0.055	0.052
3	**0.912**	0.094	0.148
4	**0.786**	−0.038	−0.097
5	0.201	0.015	**0.722**
6	**0.801**	−0.090	0.046
7	−0.130	0.040	**0.720**
8	0.024	**0.721**	0.061
9	−0.159	**0.683**	−0.153
10	0.081	**0.832**	−0.040
11	−0.050	**0.722**	0.031
12	0.080	**0.806**	0.067
13	−0.244	−0.045	**0.733**
14	−0.264	0.029	**0.725**
15	0.274	−0.039	**0.811**

Principal Components Analysis with Promax rotation (with Kaiser Normalization). $N = 300$.
MESSi = Morningness-Eveningness-Stability-Scale improved. Component loadings ≥ .400 are in bold.
Reverse-scored items were reversed prior to conducting the PCA.

pressure factors (Panjeh et al. 2021). A variety of factor structures have also been identified for the CSM (Randler et al. 2016, Appendix Table 1; for discussion, see Carciofo 2023).

Thus, although it is common practice to sum all scores on the MEQ or CSM to produce an overall unidimensional measure of morningness-eveningness, the multi-factor structure of these scales means it may not be clear what exactly is being represented by a "general" morningness-eveningness score. For instance, while the total CSM score is often used in research, a "Morning Affect" factor, comprised of items assessing alertness after awakening, ease of getting up, and time required to feel fully awake, has been consistently identified (e.g. Adan et al. 2005; Caci et al. 2005; Di Milia and Bohle 2009; Hasan et al. 2022; Jankowski 2015; Kato et al. 2019; Kolomeichuk et al. 2015; Pordanjani and Ebrahimi 2017; Randler 2008; Smith et al. 1989). Also, although unidimensional/composite measures of morningness-eveningness have found that eveningness is associated with depressive symptoms (e.g. Antypa et al. 2016; Merikanto et al. 2013), when Morning Affect and morningness-eveningness preference have been assessed separately, Morning Affect has been found to be a stronger correlate (Jankowski 2016; Konttinen et al. 2014). Furthermore, Distinctness (i.e. diurnal variations in energy, motivation, mood, cognitive functioning, etc.) has received increasing theoretical attention, and this construct has been assessed with recently developed questionnaire scales (Di Milia et al. 2011; Dosseville et al. 2013; Ogińska 2011; Ogińska et al. 2017; Ottoni et al. 2011; Randler et al. 2016).

To address some of these research developments, in addition to concerns raised about existing scales (such as the long length of some scales and possible problems from using clock times in items), Randler et al. (2016) developed the German-language Morningness-Eveningness-Stability-Scale improved (MESSi), utilising (revised) items from the Composite Scale of Morningness (CSM; Smith et al. 1989), the Caen Chronotype Questionnaire (CCQ; Dosseville et al. 2013), and the Circadian Energy Scale (CIRENS; Ottoni et al. 2011). The MESSi has three subscales: Morning Affect, assessing morning alertness and energy; Eveningness, assessing evening energy, affect and preferences; and Distinctness, assessing the amplitude of diurnal variations in functioning.

Validated translations of the MESSi include Spanish (Díaz-Morales and Randler 2017), Farsi (Rahafar et al. 2017), Portuguese (Rodrigues et al. 2018), Slovenian (Tomažič and Randler 2020), Turkish (Demirhan et al. 2019), Chinese (Carciofo and Song 2019), and Polish (Gorgol et al. 2023). The three-factor structure has been consistently replicated, and each subscale has shown good internal consistency, test–retest reliability, and consistent correlations with other variables; for instance, Morning Affect (MA) negatively correlates with Eveningness (EV) and Distinctness (DI); MA positively correlates with morningness, while EV and DI negatively correlate; MA positively correlates with conscientiousness, and negatively correlates with sleep inertia, depressive symptoms, and poor sleep quality; EV positively correlates with sleep inertia, and negatively correlates with conscientiousness; DI positively correlates with neuroticism, sleep inertia, depressive symptoms, and poor sleep quality, and negatively correlates with conscientiousness (Carciofo 2020, 2023; Carciofo and Song 2019; Demirhan et al. 2019; Díaz-Morales and Randler 2017; Díaz-Morales et al. 2017; Gorgol et al. 2023; Öğütlü et al. 2021; Randler et al. 2016; Rodrigues et al. 2018).

The MESSi has been used in research with adolescents (Öğütlü et al. 2021), and younger and older adults (e.g. Díaz-Morales and Randler 2017; Díaz-Morales et al. 2017; Gorgol et al. 2023; Rahafar et al. 2017; Rodrigues et al. 2018; Vagos et al. 2019). While there has been limited research to establish cut-off points for low/high Morning Affect, Eveningness, and Distinctness, Díaz-Morales et al. (2017) and Gorgol et al. (2023) provided data for the 10th–90th percentiles for males and females.

However, although Randler et al. (2016) published an English language version of the MESSi and items were drawn from existing scales, there is a lack of evidence for the validity of the English-language MESSi. So, the current study aimed to address this by testing the factor structure through both exploratory and confirmatory factor analysis, assessing the reliability of the subscales, testing convergent validity by comparison with a measure of morningness-eveningness, and assessing construct validity by testing whether previously reported correlations (as noted above) would be replicated. Previously reported mediation effects were also re-tested: MA as a mediator between eveningness and negative emotionality (Carciofo 2020), and as a mediator between eveningness and conscientiousness (Carciofo 2022). Associations with age and gender were also explored.

Furthermore, although MA has been seen as interchangeable with morningness preference (e.g. Di Milia and Bohle 2009; Di Milia et al. 2013; Randler et al. 2016; Rodrigues et al. 2018; Vagos et al. 2019; Weidenauer et al. 2019), the items in the MESSi subscale only refer to ease of getting up, alertness/tiredness upon awakening, and time required to feel fully awake, and so conceptually resemble sleep inertia, i.e. the period of transitioning from sleep to wakefulness during which functioning may be impaired (Trotti 2017). Although the strongest effects of sleep inertia (SI) may typically dissipate within 30 min of waking, some effects may last for several hours (Jewett et al. 1999; Lundholm et al. 2021; Occhionero et al. 2021). SI has been associated with depressive symptoms and shorter sleep duration (Kanady and Harvey 2015) and has also been associated with eveningness (Carciofo 2023; Ritchie et al. 2017; Roenneberg et al. 2003). A factor analysis of the items from Chinese-language versions of the MESSi, the reduced Morningness-Eveningness Questionnaire (Adan and Almirall 1991), and the Sleep Inertia Questionnaire (SIQ; Kanady and Harvey 2015) found that Morning Affect was distinguishable from morningness-eveningness preference and was more clearly characterised as a measure of sleep inertia duration (Carciofo 2023). So, the second aim of the current study was to test whether this finding would be replicated in factor analysis of English-language versions of the MESSi, rMEQ, and SIQ.

Method

Sample

A sample of 600 participants was recruited from Prolific (www.Prolific.com) for remuneration (mean age = 41.31, $SD = 13.149$; range = 18–78; skewness = 0.413; kurtosis = −0.501); 287 male (mean age = 41.23, $SD = 13.476$); 309 female (mean age = 41.43, $SD = 12.898$); 4 "other" (mean age = 37.50, $SD = 10.408$); male-female age comparison, $t = -0.189$, $p = 0.851$.

The online briefing included that participation was voluntary, de-identified, and could be withdrawn at any time. The survey was presented after electronic informed consent was obtained. Approval for the research protocol was provided by the University of Reading School of Psychology and Clinical Language Sciences Research Ethics Committee (research number: 2024–008-RC).

Materials

The Morningness-Eveningness-Stability-Scale improved (MESSi; Randler et al. 2016) was developed by adapting items from the CSM, CCQ, and CIRENS. The MESSi has three subscales: 1) Morning Affect (MA; items 1–4, 6, e.g. *How long a time does it usually take before you "recover your senses" in the morning after rising from a night's sleep?*) assessing alertness/tiredness/energy in the morning; 2) Eveningness (EV; items 5, 7, 13–15, 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, items 8–12; e.g. *There are moments during the day when it is harder for me to think*), assessing the amplitude of diurnal variations in functioning. There are five items for each subscale, each scored on a scale from 1 to 5, with some items reverse-scored. Scores are summed for each subscale; higher scores indicate more MA/EV/DI. The English-language MESSi is reproduced in the Supplementary materials.

The Sleep Inertia Questionnaire (SIQ; Kanady and Harvey 2015) assesses four aspects of sleep inertia (SI), with items scored from 1 (not at all) to 5 (all the time): Cognitive (items 16, 17, 18, 19, 21, e.g. *Find that you think more slowly*), Physiological (items 4, 5, 7, 8, 9, 10, 11, 12, e.g. *Notice that you feel tense*), Emotional (items 13, 14, 20, e.g. *Dread starting your day*), and Responses to SI (items 1, 2, 3, 6, 15, e.g. *Wish you could sleep more*). Scores are summed for each subscale. An additional item inquires how many minutes it takes to "come to" in the morning; options in the current study were 0–5, 5–15, 15–30, 30–60, 60/more. A final SIQ item asks how many days per week this happens (1–7). The SIQ has shown good internal consistency and construct validity (Kanady and Harvey 2015).

The reduced Morningness-Eveningness Questionnaire (rMEQ; Adan and Almirall 1991) is comprised of five items from the MEQ: *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?* Items have four or five response options, which are summed so that higher total scores indicate more morningness. The rMEQ correlates strongly with other measures of morningness-eveningness and with actigraphic assessment of sleep/activity (Thun et al. 2012).

The Big Five Inventory, 10-item (BFI-10; Rammstedt and John 2007) has two items for each big five personality dimension (extraversion, agreeableness, conscientiousness, neuroticism, openness) and has shown good test–retest reliability and consistency with longer personality scales. Items are scored on a 1–5 scale (one reversed-scored item for each dimension). Scores are summed so that higher scores indicate more extraversion, agreeableness, conscientiousness, neuroticism, and openness.

The Depression Anxiety Stress Scales (DASS; Lovibond and Lovibond 1995). Only the 7-item depression subscale was used. Items are scored on a 0–3 scale for the past week; item scores are summed so that higher scores indicate more depressive symptoms. The DASS-21 subscales have shown good internal consistency, convergent and discriminant validity (Henry and Crawford 2005).

Sleep quality. A single item was used to assess subjective, 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 indicating poorer sleep quality).

Sleep duration. A single item inquired: *How many hours do you usually sleep every night?* Response options were 4 or less, 5, 6, 7, 8, 9 or more.

Data analysis

Complete data was obtained from all 600 participants. To test the factor structure of the English language MESSi, the total data set ($N = 600$) was sorted into a random sequence, and then split into two groups of $n = 300$. Exploratory factor analysis (EFA) was conducted on the first group. Following Randler et al. (2016) principal components, analysis with Promax (oblique) rotation was undertaken. In deciding how many factors to retain, reference was made to the scree plot, the Kaiser rule (initial eigenvalues > 1), and consideration of alternate solutions (Costello and Osborne 2005), referring to expectations based on theory and previous research findings. The criteria for retaining items were to have a loading of ≥ .400 on a single factor and no cross-loadings ≥ .400. Confirmatory Factor Analysis (CFA; maximum likelihood, with co-varied factors, using IBM Amos, version 29) was then undertaken on the second group of $n = 300$ cases to test the structure identified by the EFA. Guidelines for ranges of acceptable values for fit indices include: RMSEA (root-mean-square error of approximation) < .08; SRMR (standardized root mean square residual) < .08; CFI (Comparative Fit Index) and TLI (Tucker-Lewis Index) both > .90; relative/normed Chi-square (Chi-squared statistic/degrees of freedom) at least < 5.0 (Brown 2006; Hair et al. 2014; Hooper et al. 2008).

To provide descriptive statistics for each scale/subscale, the mean, standard deviation, range, skewness, kurtosis, and Cronbach's alpha were calculated. Predicted correlations between MESSi subscales and other study variables were assessed with Pearson correlations. As a guideline, correlations of .10, .30, and .50 indicate small, medium, and large effect sizes, respectively; a sample size of $N = 85$ is suggested to establish medium effect sizes with 80% power at $p = 0.05$ (Cohen 1992). The study sample size of $N = 600$ was based on this being sufficient to establish small correlations of around 0.115 with 80% power at the 5% significance level (https://homepage.univie.ac.at/robin.ristl/samplesize.php?test=correlation). The predicted correlations were expected to be of at least this magnitude, or larger. In addition, with consideration of published guidelines, the sample was reasonable for undertaking the planned EFA and CFA (Field 2009; Wolf et al. 2013). The second aim of the current study was assessed by undertaking EFA of the MESSi, rMEQ, and SIQ items for the complete data set ($N = 600$). For comparison with the analysis in Carciofo (2023), Maximum Likelihood EFA with Direct Oblimin (oblique) rotation was undertaken. Mediation effects were tested using PROCESS (Hayes 2022).

Results

Exploratory factor analysis of the MESSi

After sorting the total data set into a random sequence, principal component analysis was undertaken on the first group of 300 cases. The Kaiser–Meyer–Olkin measure of sampling adequacy = 0.862, and Bartlett's test of sphericity was significant (approximate Chi-square = 2168.369, df = 105, $p < 0.001$), indicating suitability for analysis (Field 2009). Communalities ranged 0.439 (item 5) to 0.765 (item 14), with a mean of 0.632. The scree plot indicated three components, and three eigenvalues were > .1, explaining 63.229% of the variance.

The Pattern matrix after Promax (oblique) rotation (with Kaiser Normalization) is shown in Table 1. All of the Morning Affect items (1–4, 6) loaded strongly (>.7) on component 1; the largest cross-loading was 0.148. All of the Distinctness items (8–12) loaded strongly (>.6) on component 2; the largest cross-loading was −0.159. All of the Eveningness items (5, 7, 13–15) loaded strongly (>.7) on component 3; the largest cross-loading was 0.274. Thus, the EFA showed very clear results: the 3-component structure exactly reproduced the structure of the original MESSi, with items strongly loading on their respective components, combined with weak cross-loadings.

Confirmatory factor analysis

CFA (maximum likelihood, with co-varied factors) was undertaken on the remaining 300 cases to further test the identified structure. The results mostly indicated an acceptable model fit. While the chi-square test was significant (263.903, df = 87, $p < 0.001$), the relative/normed chi-square was acceptable (3.033), as were values of TLI (.903) and CFI (.920); RMSEA was borderline (.082, 90% CI = .071–.094), but there was an acceptable value of SRMR (.0781). Standardised loadings ranged from .520 (item 15) to .937 (item 14). Correlating the errors for items 14 and 15 (Eveningness subscale), produced a slight improvement in model fit: Chi-square = 239.694, df = 86, $p < 0.001$; relative/normed Chi-square = 2.787; TLI = .915, CFI = .930; RMSEA = .077 (90% CI = .066–.089); SRMR = .0781.

Descriptive statistics

The MESSi subscales and the other study scales/subscales showed wide ranges of scores (Table 2); distributions generally approximated normality (absolute values of skewness and kurtosis nearly all < 1), and internal consistency was acceptable/good (Cronbach's alpha > .7, except for the rMEQ and most of the 2-item BFI-10 subscales).

Correlations

Correlations between Morning Affect (MA), Eveningness (EV), Distinctness (DI) and the other study variables are shown in Table 3. MA had a strong positive correlation with morningness (rMEQ), small/moderate positive correlations with extraversion, agreeableness, conscientiousness, and sleep hours, and moderate/strong negative correlations with sleep inertia (SI), depressive symptoms, neuroticism, and poor sleep quality. EV had a strong negative correlation with morningness, a small negative correlation with conscientiousness, and small/moderate positive correlations with sleep inertia and openness. DI had small/moderate negative correlations with morningness, extraversion, agreeableness, conscientiousness, and sleep hours, and moderate/strong positive correlations with sleep inertia, depressive symptoms, neuroticism, and poor sleep quality. When controlling for age and male/female gender ($n = 596$), and comparing with the corresponding zero-order correlations, the largest difference in coefficients was .050.

Previously reported mediation effects were replicated: MA mediated between EV and depressive symptoms, and between EV and conscientiousness (see Supplementary materials Table S1). Correlations

Table 2. Descriptive statistics.

	Range (possible)	Mean	Standard deviation	Skewness	Kurtosis	Cronbach's Alpha
Morning Affect	5–25 (5–25)	15.50	4.656	−0.148	−0.704	.882
Eveningness	5–25 (5–25)	15.83	4.560	0.010	−0.858	.834
Distinctness	5–25 (5–25)	16.25	4.272	−0.192	−0.602	.813
Reduced Morningness-Eveningness Questionnaire	4–23 (4–25)	13.93	3.861	−0.165	−0.343	.699
Sleep Inertia Scale total (21 items)	21–102 (21–105)	47.59	17.303	0.632	−0.209	.951
Physiological Sleep Inertia	*8–38 (8–40)*	*16.51*	*6.719*	*0.864*	*0.263*	*.901*
Emotional Sleep Inertia	*3–15 (3–15)*	*6.14*	*2.898*	*0.892*	*0.125*	*.812*
Responses to Sleep Inertia	*5–25 (5–25)*	*14.07*	*5.022*	*0.229*	*−0.754*	*.825*
Cognitive Sleep Inertia	*5–25 (5–25)*	*10.86*	*4.948*	*0.729*	*−0.237*	*.937*
Depressive symptoms	0–21 (0–21)	5.51	5.485	0.935	−0.046	.941
Extraversion	2–10 (2–10)	5.23	2.102	0.312	−0.520	.696
Agreeableness	2–10 (2–10)	7.19	1.758	−0.421	−0.223	.435
Conscientiousness	2–10 (2–10)	7.49	1.831	−0.391	−0.607	.607
Neuroticism	2–10 (2–10)	5.92	2.271	0.028	−0.935	.706
Openness	2–10 (2–10)	7.00	1.887	−0.344	−0.367	.423
Sleep quality	1–5 (1–5)	3.19	1.229	−0.031	−1.278	–
Sleep hours	1–6 (1–6)	3.72	1.070	−0.266	0.112	–

N = 600; standard error of skewness = .100; standard error of kurtosis = .199.

Table 3. Correlations with the MESSi subscales.

	Morning Affect	Eveningness	Distinctness
Reduced Morningness-Eveningness Questionnaire	.585***	−.709***	−.210***
Sleep Inertia Scale total	*−.689****	*.199****	*.571****
Physiological Sleep Inertia	*−.574****	*.100**	*.525****
Emotional Sleep Inertia	*−.534****	*.150****	*.500****
Responses to Sleep Inertia	*−.710****	*.327****	*.446****
Cognitive Sleep Inertia	*−.597****	*.139****	*.537****
Depressive symptoms	−.404***	0.079	.446***
Extraversion	.163***	−0.046	−.239***
Agreeableness	.217***	0.033	−.213***
Conscientiousness	.279***	−.133**	−.319***
Neuroticism	−.300***	−0.039	.470***
Openness	−0.021	.152***	−0.015
Sleep quality	−.251***	−0.014	.249***
Sleep hours	.108**	0.022	−.106**
Morning Affect	–	−.431***	−.474***
Eveningness		–	.062

N = 600. **p* ≤ 0.05; ***p* ≤ 0.01; ****p* ≤ 0.001.

between morningness-eveningness (rMEQ), sleep inertia, depressive symptoms, personality, and sleep quality showed consistency with previous findings, including morningness negatively correlated with depressive symptoms and sleep inertia, and positively correlated with conscientiousness; depressive symptoms negatively correlated with conscientiousness, and positively correlated with neuroticism, poor sleep quality, and sleep inertia (see Supplementary materials Table S2).

Age and gender

Correlations with age were .168 (MA), −.099 (EV), and − .195 (DI), all *ps* < .05. Further ANOVA analysis considered differences between males/females ($n = 596$) across four age groups: (1) 18–30 ($n = 148$; 78 males, 70 females); (2) 31–40 ($n = 151$; 69 males, 82 females); (3) 41–50 ($n = 152$; 67 males, 85 females); (4) 51–78 ($n = 145$; 73 males, 72 females). Means and standard deviations for each age group and gender for MA/EV/DI are shown in the Supplementary materials Tables S3-S5.

For MA, there was a main effect of age, $F(3, 588) = 6.349$, $p < 0.001$, but no main effect of gender, and the age group by gender interaction was also not significant (*ps* > .05). Means increased from group 1 (14.51, $SD = 4.496$) to group 2 (15.50, $SD = 4.622$), reduced in group 3 (15.30; SD = 4.778), and were highest in group 4 (16.79, $SD = 4.472$). Tukey post-hoc tests showed significant differences between groups 1 and 4 ($p < 0.001$), and between groups 3 and 4 ($p = 0.027$).

For EV, there was a main effect of gender $F(1, 588) = 16.593$, $p < 0.001$. Males scored higher than females for all age groups (see Supplementary materials Table S4); there were significant differences within group 2 ($t = 3.220$, $p = 0.002$; Hedges' $g = 0.523$), and group 3 ($t = 3.039$, $p = 0.003$; Hedges' $g = 0.494$). Means decreased from the youngest to the oldest age groups, but the main effect of age, and the age group by gender interaction, were not significant (*ps* > .05).

For DI, there was a main effect of age $F(3, 588) = 7.493$, $p < 0.001$, with means decreasing with age: group 1, 17.18 ($SD = 3.988$), group 2, 16.47 ($SD = 4.107$), group 3, 16.34 ($SD = 4.222$), and group 4, 14.97 ($SD = 4.506$). Tukey post-hoc tests showed significant differences between groups 1 and 4 ($p < 0.001$), groups 2 and 4 ($p = 0.010$), and groups 3 and 4 ($p = 0.023$). There was also a main effect of gender $F(1, 588) = 25.878$, $p < 0.001$, with females scoring higher than males in all age groups (see Supplementary materials Table S5), with significant differences within groups 1 ($t = -3.339$, $p < 0.01$; Hedges' $g = -0.547$), and 2 ($t = -4.213$, $p < 0.001$; Hedges' $g = -0.685$). The age group by gender interaction was not significant ($p > 0.05$).

Percentile scores for the total sample, and separately for males and females, are shown in the Supplementary materials, Table S6.

Exploratory factor analysis: SIQ, MESSi, and rMEQ

To test the second aim of the current study, Maximum Likelihood EFA with Direct Oblimin (oblique) rotation was conducted on all MESSi, SIQ, and rMEQ items. For the SIQ, the 21 main items plus the item for sleep inertia duration *(How long does it take you to "come to" in the morning?)* were included, with the scoring for this item (item 22) reversed (higher scores = less time) so as to be consistent with the scoring of MESSi Morning Affect items. The Kaiser–Meyer–Olkin measure of sampling adequacy = 0.951, and Bartlett's test of sphericity was significant (approximate Chi-square = 17310.754, df = 861, $p < 0.001$), indicating suitability for analysis. The scree plot showed two clear factors but then was not clearly interpretable. There were seven initial

Table 4. Pattern matrix for the sleep inertia questionnaire, the MESSi morning affect, eveningness, and Distinctness subscales, and the reduced morningness-eveningness questionnaire.

Item	Factor 1 Physiological Sleep Inertia	Factor 2 Morningness-Eveningness	Factor 3 Duration of Sleep Inertia	Factor 4 Cognitive Sleep Inertia	Factor 5 Distinctness	Factor 6 Emotional Sleep Inertia	Factor 7 Responses to Sleep Inertia
SIQ1	0.155	−0.034	−0.202	−0.038	0.077	−0.083	**−0.517**
SIQ2	0.010	−0.025	0.062	−0.085	−0.022	−0.032	**−0.614**
SIQ3	0.128	−0.066	0.030	0.024	−0.030	−0.084	**−0.585**
SIQ4	**0.516**	0.019	−0.005	−0.097	0.083	0.010	−0.110
SIQ5	**0.534**	0.036	−0.076	−0.291	0.044	0.107	−0.092
SIQ6	0.381	0.008	−0.183	−0.025	0.132	−0.099	−0.297
SIQ7	**0.477**	0.052	−0.086	−0.029	0.118	−0.089	−0.136
SIQ8	**0.654**	−0.023	−0.079	−0.067	−0.001	−0.079	−0.050
SIQ9	0.330	0.005	−0.198	−0.255	0.144	−0.120	−0.075
SIQ10	**0.536**	−0.050	−0.018	−0.062	0.003	−0.177	0.052
SIQ11	**0.714**	−0.002	0.060	−0.152	−0.016	0.027	−0.012
SIQ12	0.374	0.077	−0.032	−0.079	0.108	**−0.422**	−0.027
SIQ13	0.057	0.023	−0.019	−0.096	0.103	**−0.729**	−0.033
SIQ14	0.019	0.022	−0.071	−0.206	0.078	**−0.573**	−0.159
SIQ15	0.093	−0.046	−0.047	−0.174	0.096	−0.141	**−0.404**
SIQ16	0.050	0.034	−0.107	**−0.555**	0.133	−0.178	−0.083
SIQ17	0.010	0.004	−0.045	**−0.880**	0.085	0.008	−0.012
SIQ18	0.153	−0.041	−0.021	**−0.800**	0.018	−0.008	0.022
SIQ19	0.161	0.028	−0.054	**−0.581**	0.067	−0.135	−0.019
SIQ20	0.160	−0.079	−0.047	−0.322	−0.017	−0.216	−0.138
SIQ21	0.207	−0.025	−0.139	**−0.435**	0.078	−0.203	−0.008
SIQ22	0.051	0.021	**0.832**	0.099	−0.004	0.035	−0.083
MA1	0.017	0.094	0.269	0.062	−0.094	−0.017	**0.592**
MA2	0.072	−0.016	**0.559**	0.102	−0.044	−0.064	0.347
MA3	−0.029	0.054	**0.887**	0.010	0.027	0.034	−0.114
MA4	−0.048	0.170	0.384	0.012	−0.133	−0.026	0.356
MA5	−0.172	0.087	**0.513**	0.026	−0.054	0.061	0.166
EV1	−0.054	**−0.629**	0.007	−0.018	−0.140	−0.089	0.073
EV2	0.090	**−0.726**	−0.050	0.000	0.053	0.015	0.018
EV3	0.114	**−0.819**	0.020	−0.025	0.056	0.107	−0.094
EV4	0.115	**−0.837**	−0.085	0.046	0.136	0.064	0.050
EV5	−0.008	**−0.571**	0.056	0.043	−0.081	0.056	0.048
DI1	0.086	0.006	−0.006	0.132	**0.579**	−0.202	0.006
DI2	−0.018	0.032	−0.045	−0.079	**0.657**	0.038	−0.025
DI3	−0.120	0.035	0.057	0.007	**0.806**	0.005	−0.024
DI4	0.100	−0.052	−0.016	−0.066	**0.602**	0.006	0.035
DI5	0.035	−0.040	−0.018	−0.117	**0.657**	0.023	0.077
rMEQ1	0.123	0.355	0.071	−0.026	−0.060	0.113	0.262
rMEQ2	−0.150	0.014	0.375	−0.042	−0.108	−0.041	0.316
rMEQ3	0.132	**0.503**	−0.048	0.079	0.011	0.091	0.058
rMEQ4	−0.002	**0.493**	0.129	−0.024	−0.026	0.003	0.015
rMEQ5	0.022	**0.699**	0.043	0.038	−0.064	−0.046	0.197

N = 600.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; EV = Eveningness items; DI = Distinctness items; rMEQ = reduced Morningness-Eveningness Questionnaire items.

eigenvalues > 1, and the seven extracted factors (Table 4) were clearly interpretable and consistent with the results of Carciofo (2023): Morningness-Eveningness (all MESSi EV items plus 3 rMEQ items), Distinctness (all MESSi items), the four SIQ subscales (Cognitive, Physiological, and Emotional sleep inertia (SI), and Responses to SI), plus a factor for Duration of SI comprised of items regarding time required to achieve full wakefulness/alertness (SIQ item 22, plus 3 MA items). The Responses to SI factor included MA item 1 (*Assuming normal circumstance, how easy do you find getting up in the morning?*), as found by Carciofo (2023).

SIQ items 6, 9, and 20, MA item 4, and rMEQ items 1 and 2 did not load ≥.400 on any factor. SIQ item 9 had its strongest loading (0.330) on the expected factor (Physiological SI), but item 6 loaded most strongly (0.381) on Physiological SI rather than Responses to SI and item 20 most strongly (−0.322) on Cognitive SI rather than Emotional SI. Morning Affect item 4 (*In general, how is your energy level in the morning?*) and rMEQ item 2 (*During the first half-hour after having woken in the morning, how tired do you feel?*) loaded most strongly (0.384 and 0.375, respectively) on the Duration of SI factor, while rMEQ item 1 (*Considering only your own feeling best rhythm, at what time would you get up if you were entirely free to plan your day?*) loaded most strongly (0.355) on the Morningness-Eveningness factor.

Table 5. Chronotype X sleep inertia duration.

Sleep Inertia Duration (minutes)	Chronotype			Total
	Evening-type	Intermediate	Morning-type	
0-5	7 (10.90%)	70 (14.60%)	16 (28.10%)	93 (15.50%)
5-15	14 (21.90%)	**195 (40.70%)**	**28 (49.10%)**	237 (39.50%)
15-30	**19 (29.70%)**	139 (29.00%)	10 (17.50%)	168 (28.00%)
30-60	16 (25.00%)	58 (12.10%)	2 (3.50%)	76 (12.70%)
60+	8 (12.50%)	17 (3.50%)	1 (1.80%)	26 (4.30%)
Total	64 (100%)	479 (100%)	57 (100)%	600 (100%)

N = 600. Modal frequency for each chronotype shown in bold.

After removing these items that did not load ≥ .400 on any factor, and repeating the EFA, all remaining items retained their > .400 loadings on the same factors, except for SIQ item 15 (as found by Carciofo 2023); after removing this item, a further EFA showed all remaining items retained their >.400 loadings on their respective factors with no cross-loadings ≥.400 (details in the Supplementary materials). Scales for these final factors were constructed: Morningness-Eveningness (the 3 rMEQ items plus the 5 MESSi EV items reverse-scored); Sleep Inertia Duration (SIQ item 22, plus MA items 2, 3, and 5, with scoring reversed as appropriate so that higher scores = longer SI duration); Responses to SI (SIQ items 1, 2, 3 plus MA item 1, reverse-scored); Physiological SI (SIQ items 4, 5, 7, 8, 10, 11), Emotional SI (SIQ items 12, 13, 14), and Cognitive SI (SIQ items 16, 17, 18, 19, 21); the DI subscale was unchanged. Internal consistency for these scales was good (all > .8), and correlations were as expected (see Supplementary materials Table S11); more morningness correlated − .416 with Duration of Sleep Inertia.

Finally, the scores for the Morningness-Eveningness scale identified in the factor analysis (Table 4) were split into evening-types (at/below the approximate 10th percentile; $n = 64$), morning-types (at/above the approximate 90th percentile; $n = 57$), and intermediate-types ($n = 479$), and then cross-tabulated with the responses for SIQ item 22 for the duration of sleep inertia (Table 5). The modal response for morning-types (and intermediate) was 5–15 min, and for evening-types it was 15–30 min. While 37.5% of evening-types reported 30–60/60+ min compared with 5.3% of morning-types, nearly a third (32.8%) of evening-types reported sleep duration of up to 15 min (compared with 77.2% of morning-types).

An alternative analysis was undertaken categorising evening-type as at/below the approximate 20th percentile ($n = 115$) and morning-types as at/above the approximate 80th percentile ($n = 122$); the modal frequencies were again 15–30 min for evening-types and 5–15 min for intermediate and morning-types (Supplementary materials Table S12).

Discussion

The current study tested the psychometric properties of the English-language version of the Morningness-Eveningness-Stability-Scale improved (MESSi; Randler et al. 2016). Exploratory Factor Analysis produced a clear solution which exactly reproduced the original MESSi structure, with subscales for Morning Affect (MA), Eveningness (EV), and Distinctness (DI). Confirmatory Factor Analysis showed acceptable results for this structure. Each subscale showed good internal consistency, and convergent validity was supported by strong correlations with a general measure of morningness-eveningness (the rMEQ), these being positive for MA and negative for EV.

Furthermore, MA positively correlated with extraversion, agreeableness, conscientiousness, and sleep hours, and negatively correlated with sleep inertia (SI), depressive symptoms, neuroticism, and poor sleep quality; EV negatively correlated with conscientiousness, and positively correlated with sleep inertia and openness; DI negatively correlated with extraversion, agreeableness, conscientiousness, and sleep hours, and positively correlated with sleep inertia, depressive symptoms, neuroticism, and poor sleep quality. These results replicate those of previous studies conducted in several countries, including Germany, Portugal, Spain, Turkey, China, and Poland (Carciofo 2023; Carciofo and Song 2019; Demirhan et al. 2019; Díaz-Morales and Randler 2017; Díaz-Morales et al. 2017; Gorgol et al. 2023; Öğütlü et al. 2021; Randler et al. 2016; Rodrigues et al. 2018), although the EV-openness correlation was stronger in the current study. Previously reported mediation effects were also replicated: MA mediating between EV and negative emotionality (Carciofo 2020) and between EV and conscientiousness (Carciofo 2022).

It is notable that Distinctness has consistently shown moderate/strong correlations with depressive symptoms, poor sleep quality, more neuroticism, and less conscientiousness. However, this construct still remains to be fully elucidated (Ogińska et al. 2017). In the current study, moderate/strong correlations were observed with all

Sleep Inertia Questionnaire components, MA, and the Duration of Sleep Inertia factor from the SIQ/MESSi/rMEQ factor analysis. These results suggest that sleep inertia may be one factor that contributes to the subjective assessment of having greater diurnal variations in functioning; other factors await further study.

MA increased with age from group 1 (aged 18–30) to group 2 (aged 31–40), slightly decreasing in group 3 (aged 41–50), but highest in group 4 (aged 51–78), with significant differences between groups 1 and 4, and 3 and 4. There were no significant gender differences in any age group, and no age by gender interaction. For EV, in all age groups, males scored higher than females, with significant differences in groups 2 and 3. EV decreased with age, although differences between the groups were not significant, and there was no age group by gender interaction. DI showed decreasing means across the four age groups (significant differences between groups 1 and 4, 2 and 4, and 3 and 4). Also, females scored higher than males in all age groups (differences significant within groups 1 and 2), but there was no age group by gender interaction. While variation in the composition of samples between studies makes comparison difficult, the current results have some correspondence with other findings from research utilising the MESSi with younger and older adults: higher DI in females; higher EV in males; MA positively correlated with age; EV and DI negatively correlated with age (Díaz-Morales and Randler 2017; Díaz-Morales et al. 2017; Gorgol et al. 2023; Rahafar et al. 2017; Rodrigues et al. 2018; Vagos et al. 2019).

Overall, the current results add to those which have established the validity and reliability of the MESSi in Spanish (Díaz-Morales and Randler 2017), Farsi (Rahafar et al. 2017), Portuguese (Rodrigues et al. 2018), Slovenian (Tomažič and Randler 2020), Turkish (Demirhan et al. 2019; Öğütlü et al. 2021), Chinese (Carciofo and Song 2019), and Polish (Gorgol et al. 2023), in addition to German (Randler et al. 2016). Having been validated in these languages, the MESSi has been established as a valuable research tool, available to researchers in many countries, which may promote further international survey research, such as for the investigation of population characteristics, cross-cultural differences, and psychological and behavioural correlates of MA/EV/DI.

However, the findings of the second aim of the current study support previous results indicating that the characterisation of the MA subscale may be reconsidered. A factor analysis of all items of the MESSi, the Sleep Inertia Questionnaire (SIQ; Kanady and Harvey 2015), and the reduced Morningness-Eveningness Questionnaire (rMEQ; Adan and Almirall 1991) identified seven factors: Morning-Eveningness, Distinctness, the four SIQ components identified by Kanady and Harvey (2015; i.e., Cognitive, Physiological, Emotional, and Responses to Sleep Inertia), plus a separate factor for Duration of Sleep Inertia. Items loaded strongly on their respective factors, with weak cross-loadings. Also, the pattern of item loadings was substantially consistent with that found by Carciofo (2023) using Chinese-language versions of the MESSi, SIQ, and rMEQ. In particular, the Morningness-Eveningness factor was comprised of the five EV items of the MESSi plus items 3, 4, and 5 of the rMEQ. None of the MA subscale items loaded on the Morningness-Eveningness factor, but instead three MA items, plus one SIQ item, formed a separate Duration of Sleep Inertia factor.

Thus, while Morning Affect has been considered interchangeable with "morningness" or morningness preference (e.g. Di Milia et al. 2013; Randler et al. 2016; Rodrigues et al. 2018; Vagos et al. 2019; Weidenauer et al. 2019), the utility of this may be questioned. Although sleep inertia (SI) is associated with eveningness (Carciofo 2023; Ritchie et al. 2017; Roenneberg et al. 2003), SI is commonly experienced (Jewett et al. 1999), and may be unrelated to chronotype on free days (Roenneberg et al. 2003). The cross-tabulation results in the current study and Carciofo (2023) indicate that approximately a third of evening-types may report short SI duration (up to 15 min). Furthermore, morningness-eveningness preference and Morning Affect/sleep inertia differentially correlate with other variables, including sleep quality, personality, and depressive symptoms (e.g. Carciofo 2020; Demirhan et al. 2019; Díaz-Morales et al. 2017; Jankowski 2016; Konttinen et al. 2014).

Using measures of general morningness-eveningness, such as the MEQ and CSM scale total scores, will produce less specific results with other variables, failing to identify which aspect of circadian functioning (morningness-eveningness preference, sleep inertia, Distinctness, etc.) may be the strongest component involved in the identified associations. While it is not proposed that the results of the factor analysis of the MESSi, SIQ, and rMEQ be used as a new scale (which would be impractically long for brief questionnaire survey studies), further clarification of constructs in questionnaire measures of components of circadian functioning may inform the development of new scales, help establish more standardised use of nomenclature, and facilitate communication across different but related research fields.

Limitations and future research

While the current study benefitted from having participants of a wide range of ages and with a relatively equal balance of males and females, studies of larger samples are required to establish reliable findings for relationships between MA/EV/DI, age, and gender, and whether there are any interactions between age and gender. Reliable normative data also needs to be established, and demographic correlates (e.g. educational level and marital status) may be investigated. Also, while the MA/EV/DI subscales showed good internal consistency, test–retest reliability was not assessed in the current study, so this remains for future research. In addition, very brief measures of personality and sleep were used in the current study, so these associations may be further tested with more thorough scales, such as the BFI-44 (John and Srivastava 1999) and Pittsburgh Sleep Quality Index (Buysse et al. 1989). Testing of other variables previously assessed in the nomological network of MA/EV/DI (e.g. life satisfaction and positive affect) may also be undertaken. Also, the current study was limited to online data collection, so objective measures of behavioural and biological correlates of the aspects of circadian functioning that have been operationalised in subjectively assessed questionnaires also need to be obtained (Putilov 2017).

Conclusions

The English-language version of the MESSi has sound psychometric properties, exactly reproducing the Morning Affect, Eveningness, and Distinctness subscales identified in the original German-language MESSi and in subsequent translations. Evidence supports re-characterising the Morning Affect subscale as a measure of sleep inertia duration, and highlights that further developments may be made in questionnaire measures of circadian functioning.

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