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Abstract

This study aimed to assess the factor structure and validity of the Composite Scale of Morningness (CSM) in Japanese samples. A sample of 348 Japanese university students (196 men, 152 women) and 170 adults from the community (50 men, 120 women) completed a questionnaire including the CSM, the Diurnal Type Scale (DTS) and questions regarding sleeping and waking times. Four measurement models were compared, and a two-factor measurement model with Morningness/ Time of day preference ($\alpha = 0.78$) and Morning Affect/Alertness ($\alpha = 0.80$) factors yielded the closest fit. Both Morningness/Time of day preference and Morning Affect/Alertness were positively correlated with DTS score. Morningness/Ttime of day preference was negatively correlated with the midpoint of sleep on weekdays and free days. The measurement model was invariant across the university and community groups. The community group, which was older, was characterized by greater morningness. The results provide

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evidence of the validity of the Japanese CSM, thus opening up the possibility of including Japanese samples in cross-cultural research on morningness.

Keyword: Psychology

1. Introduction

Circadian rhythm is the important indicator to regulate life style influencing physical and mental health. Individuals who are characterized by a more extreme position toward morningness are usually early risers, perform mentally and physically at their best in the morning hours, and go to bed early in the evening. People who show a more extreme eveningness stay up late at night, rise at a later time in the morning, and perform best mentally and physically in the late afternoon or evening (Randler, 2008). A growing body of research examines how chronotype (morningness-eveningness) can be conceptualized and measured adequately in different cultures and under different circumstances (Di Milia and Randler, 2013; Levandovski et al., 2013). Although the terms 'morning-types' or 'larks' and 'evening-types' or 'owls' are frequently used in studies and questionnaires, morningness-eveningness is better treated as a continuum, with most people falling somewhere between the two extremes (Adan et al., 2012; Natale and Cicogna, 2002).

Morningness-eveningness is determined by genetic/biological and environmental factors: about 50% of variance is explained by genetic factors, 3% by age and the remaining nearly 47% by non-shared environmental factors (Koskenvuo et al., 2007). Because of the remarkable impact of environmental − including sociocultural − factors, it is important to examine how chronotype questionnaires are employable in different regions of the word (Masal et al., 2015).

Individual characteristics, such as age and gender, influence morningness-eveningness as well. The two main shifts observed in chronotype occur in adolescents (shift to eveningness) and in the elderly (shift to morningness), and are determined by complex interactions between neural, hormonal and environmental factors (Monk and Kupfer, 2007; Roenneberg et al., 2007). There is a lack of consensus about gender differences in morningness; some studies have found that women show greater morningness than men (Achari and Pati, 2007; Adan and Natale, 2002; Randler, 2007; Roenneberg et al., 2007), whilst others have not observed any gender differences (Cavallera and Giudici, 2008; Levandovski et al., 2013).

Chronotype can be measured in terms of physiological parameters, primarily body temperature, but also sympathetic-parasympathetic reactivity and levels or diurnal fluctuations in hormones, including melatonin and stress hormones (Duffy et al., 2001; Mongrain et al., 2004; Sugawara et al., 2001), but in large population-based studies it is more common to rely on self-report questionnaires. Self-report measures,

however, have been validated by physiological parameters (Mongrain et al., 2004; Natale and Alzani, 2001). One group of questionnaires (including the Composite Scale of Morningness, CSM; Smith et al., 1989) attempts to measure phase preferences relating to daytime behaviour, whereas others measure the position of the sleep phase. Several reviews have compared the different scales and their psychometric properties, strengths, weaknesses and usability (Caci et al., 2009; Di Milia et al., 2013; Levandovski et al., 2013; Smith et al., 1989; Tonetti et al., 2015) and noted some methodological problems with the use of such scales. The groups identified by the various scales do not always correspond and most scales fail to take into account gender, age, culture, social roles, work schedules and mealtimes. It is important to determine which questionnaires are most appropriate in specific cultures and circumstances.

The CSM (Smith et al., 1989) is one of the most popular self-report chronotype questionnaires. The 13-item CSM was based on the best items of the MEQ (Horne and Ostberg, 1976), Diurnal Type Scale (DTS; Torsvall and Akerstedt, 1980) and Circadian Type Questionnaire (CTQ; Folkard et al., 1979), selected using factor analysis. The CSM has been translated into a number of languages, including Italian (Natale and Alzani, 2001), Spanish (Adan et al., 2005), French (Caci et al., 1999), Thai (Pornpitakpan, 1998), Hindi (Bhatia et al., 2013), Arabic (Mansour et al., 2015), Polish (Jankowski, 2015), Hungarian (Haraszti et al., 2014), Persian (Rahimi and Ebrahimi, 2017), Peruvian (Díaz-Morales and Sánchez-López, 2005) and Argentinian Spanish (Gil et al., 2008), and has been validated on large samples. Most of these studies concluded that CSM is a highly reliable instrument (Adan et al., 2005; Bhatia et al., 2013; Caci et al., 2000; Di Milia et al., 2013), but its factor structure is debated. Most researchers treat the CSM as a one-dimensional questionnaire (Caci et al., 1999; Di Milia et al., 2013; Díaz-Morales et al., 2015), but two- and three-factor models have also been fitted to CSM data (Adan et al., 2005; Bhatia et al., 2013; Caci et al., 2009; Di Milia et al., 2013; Gil et al., 2008; Díaz-Morales and Sánchez-López, 2004; Pornpitakpan, 1998; Rahimi and Ebrahimi, 2017; Smith et al., 1989). Age, gender, residency bias and occupational and cultural differences are considered the main reasons for the non-replicability of its factor structure (Di Milia et al., 2013; Díaz-Morales and Sánchez-López, 2004; Randler and Díaz-Morales, 2007). There is no consensus on the content, items and names of the factors underlying the CSM (Adan et al., 2005; Caci et al., 2009).

Most of the psychometric analyses (both two- and three-factor solutions) have revealed a factor composed of items connected to morning mood characteristics (items 3; 4; 5; 12; sometimes one of these items is missing) (Bhatia et al., 2013; Di Milia and Bohle, 2009; Díaz-Morales and Sánchez-López, 2004; Randler and Díaz-Morales, 2007). This factor has been termed Morning Affect (Di Milia and Bohle, 2009) or Alertness/Morning Alertness or Sensitivity (Bhatia et al., 2013; Díaz-Morales and Sánchez-López, 2004; Randler and Díaz-Morales, 2007). Some authors have suggested using only

the CSM items associated with the Morning Affect factor, because scores on such a scale are strongly correlated with total CSM score and this subset of items has better psychometric properties and is less dependent on age and more appropriate for intercultural comparisons than the full CSM (Di Milia et al., 2013; Di Milia and Bohle, 2009; Di Milia and Muller, 2012). Others have agreed that the Morning Affect factor shows stronger invariance across age groups and cultures than other aspects of diurnal activity (Di Milia et al., 2013; Díaz-Morales and Sánchez-López, 2004). Using bifactor-exploratory structural equation modeling, Morin and his colleagues also confirmed the significance of this Morning Affect specific factor beside a general diurnal preference factor (Morin et al., 2016). Bifactor-CFA models (B-CFA) provide an alternative to higher order CFA, and directly test the presence of a general construct underlying all indicators (G-factor) and whether this general construct co-exists with meaningful specificities (S-factors) (Morin et al., 2016).

The CSM has good convergent validity; the correlation between CSM, MEQ and reduced MEQ scores is around 0.9 in both male and female samples (Caci et al., 2000, 2009; Di Milia et al., 2013). The construct validity of the scale has also been demonstrated; scores are moderately correlated with rising time, bedtime and times of peak physical and mental performance (Caci et al., 1999; Smith et al., 2002) as well as with other self-report indicators of sleeping behavior, such as midpoint of sleep on free days (Jankowski, 2015). Furthermore, chronotype groups based on the CSM overlap substantially with chronotype groups based on body temperature and subjective alertness (Natale and Alzani, 2001).

The two aims of our study were (1) to determine the psychometric properties of a Japanese version of the CSM, including a comparison of different measurement models and (2) to investigate the convergent validity of a Japanese version of the CSM. The present research is the initial validation study of the Japanese version of the CSM; furthermore several alternative measurement models were also tested.

2. Materials and methods

2.1. Participants and procedure

A convenience sample split into two groups was analyzed in this cross-sectional study. The first group comprised Japanese students attending the Faculty of Human Development (Kobe University) ($n = 348$, 196 men, 152 women; mean age $= 19.54$ years, $SD = 1.92$). No incentives were offered for participation. They completed the CSM and a subsample also completed the DTS ($n = 234$, 158 men, 76 women; mean age $= 19.73$ years, $SD = 1.86$) before or after class. The second group was drawn from residents attending a community public health center for their annual health check ($n = 170$, 50 men, 120 women; mean age $= 52.19$ years, $SD = 12.23$). They have completed only the CSM. The health center and the university were

located in the same district in Japan in order to control for unknown confounding variables relating to geographic area. The response rate was 70.5%. This study was carried out in 2016.

Ethical approval was obtained from Kobe University (No 207) and Osaka Prefecture University (No 2016-308). This study was performed according to the ethical principles of the Declaration of Helsinki. Participants were informed of the aims of this study. Participation was voluntary and anonymous. All data were analyzed statistically and personal information remained strictly confidential.

2.2. Measurements

2.2.1. Composite Scale of Morningness (CSM)

The original version of the CSM (Smith et al., 1989) was translated into Japanese by three bilingual Japanese psychologists and then back-translated by a bilingual English psychologist. Total score ranges from 13 (minimum score: extreme eveningness) to 55. Higher scores indicate greater morningness.

2.2.2. Diurnal type scale (DTS)

The validated Japanese version of the DTS (Shibata et al., 2011) was used to assess the convergent validity of the Japanese CSM. The original version of DTS (Torsvall and Akerstedt, 1980) was adapted to Japanese (Harada, 1998), and improved upon (Shibata et al., 2011). Shibata et al. (2011) reported low waking basal body temperature related to eveningness. DTS consists of seven items. Total score ranges from 7 (minimum score: extreme eveningness) to 28 (maximum score: extreme morningness). The internal consistency of the scale in this sample was relatively low (Cronbach's $\alpha = 0.57$).

2.2.3. Sleep-wake variables

Participants were asked what time they woke up and fell asleep on working and free days. Sleep duration and the midpoint of the period between falling asleep and waking on weekday (MSW) and free days (MSF) were calculated. Sleep duration was calculated as the difference between time of wake up and time of asleep [Sleep duration = time of wake up − time of asleep] in minutes. Midpoint of sleep was calculated from sleep duration. The half of sleep duration was added to the time of asleep.

2.3. Statistical analyses

Descriptive statistics (mean, SD and range) were calculated and the Kolmogorov-Smirnov test was used to assess normality of distribution. The reliability of the scores was estimated with Cronbach's α coefficient.

Confirmatory factor analysis (CFA) was implemented in Mplus 8.0 (Muthén and Muthén, 1998) to estimate the degree of fit between previously published factor models and the Japanese data. We tested four measurement models for the CSM: one-factor, two-factor, three-factor models, and finally a bifactor model. The latest is a higher order factor model, operating with general and specific factors, while the former models work with coequal factors at the same level. The one-factor model reflects the general use of CSM score as an index of morningness. Further models were developed with exploratory factor analytic approaches. The two-factor model we tested (Bhatia et al., 2013) comprised Morningness (items 1; 2; 7; 9; 10; 11) and Sensitivity (items 3; 4; 5; 12) factors. We, like others, call this second factor Morning Affect/Alertness because we believe that this name reflects its content better. We named the Morningness factor to Morningness/Time of Day Preference factor for two reasons: (1) it is easier to differentiate it from the total score of the chronotype questionnaires ("general morningness"), and (2) the contents of the items of this factor refer to time-structuring preference. We also tested an extended version of the two-factor model in which items 8 and 13 were added to the Morningness/Time of Day Preference factor due to their content, and a three-factor model (Adan et al., 2005) comprising the factors Morning Affect (items 3; 4; 5; 6; 10; 11; 12), Retiring Time (items 2; 7), and Activity Planning (items 8; 9; 13). Finally, we tested a currently published bifactor model proposing one general diurnal preference factor and three specific factors, namely Morning Affect (items 3, 4, 5, 12), Time of Rising (items 1, 6, 8, 10, 11) and Activity Planning (item 2, 7, 9, 13). Where model fit was close to adequate, we screened for large modification indices to detect local misfit and also estimated the error covariance when the content of items made it meaningful to do so. Separate analyses were run for the university student group, the community group and the total sample.

After determining the best-fitting model we also performed a measurement invariance test to compare its performance in the university and community groups. We assessed configural, metric and scalar invariance in three nested models with increasing constraints. In one model factor loadings and intercepts were freely estimated (configural invariance), in the second model the factor loadings were set to be equal and in the final model factor loadings and intercepts were set as equal in all groups (metric and scalar invariance).

Finally, we performed CFA with covariates in order to test the group difference between student and resident samples and also the convergent validity with diurnal type scale and sleep-wake variables.

All CFAs were performed using maximum likelihood parameter estimates with standard errors and chi-squared test statistics that were robust to deviation from normal distribution. We estimated the absolute degree of fit in term of χ^2 test value. However, the χ^2 test increases in a nonmonotonic way as the sample size increases. For

example, Iacobucci (2010) demonstrated with Monte Carlo simulation that there is a large increase in χ^2 test value when the sample size becomes larger than 200. We therefore suspect that the χ^2 test value is inflated and thus the use of less conservative measures of degree of fit is necessary. Several fit indices were used to determine the best-fitting model. Satisfactory fit requires the Comparative Fit Index (CFI) and the Tucker−Lewis index (TLI) to be higher than or close to 0.95 and models should be rejected if the values of these indices are less than 0.90 (Brown, 2015). The criteria for the root mean square error of approximation (RMSEA) are as follows: below 0.05 indicates excellent fit, a value around 0.08 indicates adequate fit and a value above 0.10 indicates poor fit. Closeness of model fit using RMSEA (CFit of RMSEA) is a statistical test (Brown, 2015) which evaluates the statistical deviation of RMSEA from 0.05, non-significant probability values ($p > 0.05$) indicate good model fit (Brown, 2015).

3. Results

3.1. Descriptive statistics

The descriptive statistics for the two samples are provided in Table 1. The range of CSM scores was 18−51. The community group displayed higher morningness than the student group. Although the university students spent less time sleeping on working days than the community group, they slept more on free days.

A Kolmogorov-Smirnov test confirmed that morningness as measured by CSM score was normally distributed ($z = 1.12$, $p = .161$). Inspection of the cumulative

Table 1. Descriptive statistics for the two groups.

	University students $n = 348$	Residents $n = 170$	t/χ^2	Cohen's d
Female gender: number (%)	152 (43.7)	120 (70.6)	33.20***	
Age: Mean (SD)	19.54 (1.92)	52.19 (12.23)	34.60***	3.73
Morningness (CSM score): Mean (SD)	33.5 (5.94)	40.6 (5.25)	13.26***	1.27
Weekday sleep duration in minutes: Mean (SD)	359 (58)	395 (61)	6.35***	0.60
Free day sleep duration in minutes: Mean (SD)	480 (101)	446 (70)	4.00***	0.39
Weekday midpoint of sleep: Mean (SD) h:min (min)	3:38 (55 min)	2:47 (55 min)	9.96***	0.94
Free day midpoint of sleep: Mean (SD) h:min (min)	4:44 (78 min)	3:22 (62 min)	12.87***	1.16
Morningness (DTS score): Mean (SD)	13.9 (3.37)[#]	N/A	N/A	N/A

Notes. ***: p < .001. #: n = 234.

percentile distribution indicated that the cut-off scores for eveningness and morningness were 27 (10% lowest score), 28 (20% lowest score), 39 (20% highest score) and 45 (10% highest score) respectively. Cronbach's α for the CSM was 0.77 in the student group, 0.76 in the community group and 0.82 in the total sample.

3.2. Measurement models for Composite Scale of Morningness

We tested four measurement models: one-factor, two-factor, three-factor models, and finally a bifactor model. The fit indices are presented in Table 2. The χ^2 test was significant in all models, but this test may be oversensitive in sample sizes larger than 200.

The two-factor model used by Bhatia et al. (2013) yielded a closer fit to the data than the one- and three-factor models, but still did not provide an adequate fit. Because specification searches based on modification indices are more likely to be successful when the model contains only minor misspecifications (Brown, 2015), only the two-factor model was explored further. Based on the modification indices and the content of the items, we estimated the error covariance between items 1 (free choice of time to get up) and 10 (free choice of time to rise during workdays), and between items 2 (free choice of time to go to bed) and 7 (time of feeling tiredness during evening). Freeing these error covariances increased the model fit to an acceptable level. We also tested a second version of two factor model in which an additional three items (item 6; 8; 13) loaded on the Morningness/Time of Day Preference factor. Inspection of factor scores showed that item 6 did not load significantly on the target factor so it was removed from the model. Since both items 9 and 13 refer to self-defined chronotype we estimated the error covariance between them. The final model and the factor loadings are presented in Fig. 1. This model was an acceptable fit to the data from the total sample and the university and community groups. Detailed analysis of the extended two-factor model demonstrated that all standardized factor loadings for items associated with the Morningness/Time of Day Preference factor were between 0.39 and 0.68 and standardized loadings for the items associated with the Morning Affect/Alertness factor ranged between 0.65 and 0.80. The correlation between the two factors was 0.70. The factor determinacy values are acceptable (0.88 and 0.91 respectively) which indicates that the items included represent the latent variables well. Cronbach's α value for the Morningness/Time of Day Preference and Morning Affect/Alertness factors and for the total score were also acceptable (0.78, 0.80 and 0.84 respectively). The ranges of item-total correlations were as follows: Morningness/Time of Day Preference: 0.34−0.62, Morning Affect/Alertness: 0.57−0.67 and model score: 0.34−0.62.

The bifactor model also yielded a close fit to the data. The degree of fit of the bifactor and the extended two-factor models cannot be compared directly due to non-nestedness. The bifactor model yielded a larger Akaike Information Criteria index

Table 2. Fit indices for the various measurement models and measurement invariance of the Composite Scale of Morningness.

	χ^2	df	CFI	TLI	RMSEA	Cfit of RMSEA	SRMR
Combined sample (N = 518)							
One-factor model	520.0*	65	0.725	0.670	0.116	<0.001	0.074
Two-factor model (Bhatia et al., 2013)	154.2*	34	0.902	0.870	0.083	<0.001	0.050
Two-factor model# (Bhatia et al., 2013)	62.9*	32	0.975	0.965	0.043	0.748	0.029
Extended two-factor model[a]	101.7*	50	0.968	0.958	0.045	0.747	0.031
Three-factor model (Adan et al., 2005)	288.6*	62	0.863	0.828	0.084	<0.001	0.069
Three-factor model# (Adan et al., 2005)	187.6*	60	0.923	0.900	0.064	0.013	0.054
Bifactor CFA model (Morin et al., 2016)	132.7*	52	0.951	0.927	0.055	0.238	0.039
Japanese university students (N = 348)							
One-factor model	400.0*	65	0.615	0.538	0.122	<0.001	0.086
Two-factor model (Bhatia et al., 2013)	111.6*	34	0.872	0.831	0.081	0.001	0.058
Two-factor model# (Bhatia et al., 2013)	52.8*	32	0.966	0.952	0.043	0.686	0.038
Extended two-factor model	88.0*	50	0.956	0.942	0.047	0.613	0.041
Three-factor model (Adan et al., 2005)	220.5*	62	0.818	0.771	0.086	<0.001	0.079
Three-factor model# (Adan et al., 2005)	157.4*	60	0.888	0.771	0.086	<0.001	0.065
Bifactor CFA model (Morin et al., 2016)	105.0*	52	0.939	0.909	0.054	0.309	0.045
Japanese community (N = 170)							
One-factor model	235.7*	65	0.570	0.484	0.124	<0.001	0.094
Two-factor model (Bhatia et al., 2013)	93.0*	34	0.792	0.723	0.101	<0.001	0.075
Two-factor model# (Bhatia et al., 2013)	51.6*	32	0.930	0.902	0.060	0.272	0.054
Extended two-factor model[a]	84.9*	50	0.907	0.878	0.064	0.157	0.060
Three-factor model (Adan et al., 2005)	156.8*	62	0.761	0.700	0.095	<0.001	0.089
Three-factor model# (Adan et al., 2005)	121.1*	60	0.846	0.800	0.077	0.014	0.076
Bifactor CFA model (Morin et al., 2016)	94.0*	52	0.894	0.842	0.069	0.083	0.062
Measurement invariance testing of the extended two-factor model							
Configural	172.9*	100	0.941	0.922	0.053	0.339	0.048
Metric invariance (equal loadings)	192.8*	110	0.933	0.919	0.054	0.293	0.062
Metric against configural Δ	19.8*	10	0.008	0.003	0.001		0.014
Scalar invariance (equal loading and equal intercepts)	226.3*	120	0.914	0.905	0.058	0.114	0.071
Scalar against metric Δ	33.6*	10	0.019	0.014	0.004		0.009

Notes. #: error covariance between items 1 and 10, between items 2 and 7, and between items 9 and 13 was unconstrained.
[a] Presented in Fig. 1. *: $p < 0.05$.

(bifactor model AIC: 15932.8 versus extended two-factor model AIC:14549.9) which may imply a lower degree of fit compared to the extended two-factor model. The factor loadings of this model are presented in Table 3. Omega and omega hierarchical values indicated a strong General Diurnal Preference factor and a meaningful Morning Affect factor. However, the Time of Rising and Activity Planning
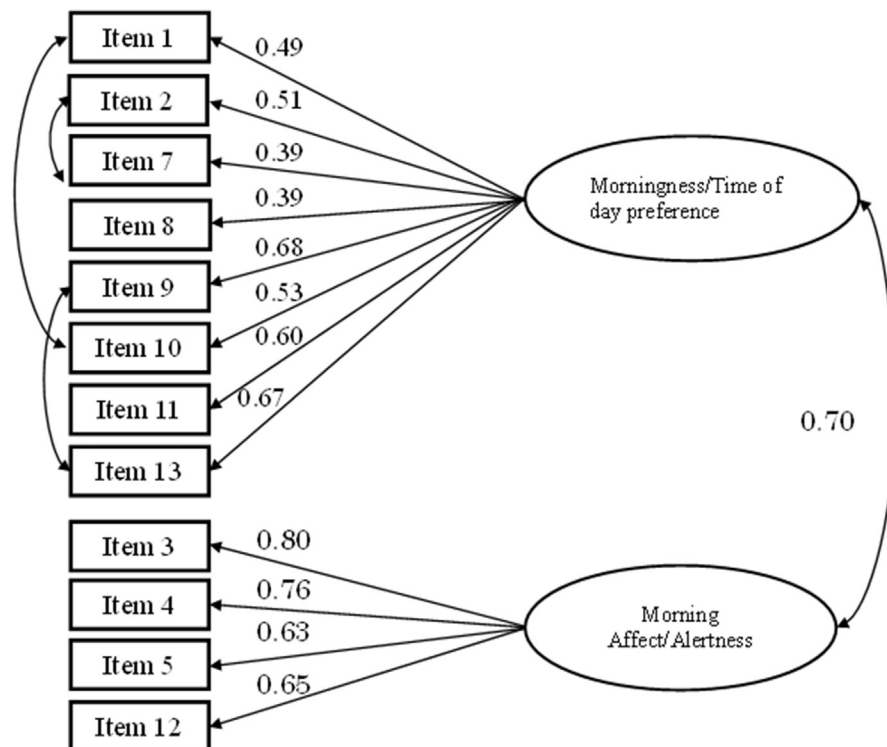
Fig. 1. Extended two-factor measurement model of Japanese version of the Composite Scale of Morningness.

specific factors made a minimal or almost zero contribution to explained variance according to omega hierarchical values.

Interestingly, two seemingly different measurement models are very similar to each other. The G-factor of the bifactor model is very similar to the Morningness/Time of Day Preference factor in the extended two-factor model. The Morning Affect factor of the bifactor model is identical to the Morning Affect/Alertness factor in the two-factor model. The Time of Rising specific factor was represented in the error covariance between item 1 and item 10 in the extended two-factor model. The Activity Planning specific factor of the bifactor model is represented as correlated uniqueness between item 9 and 13 in the two-factor model. However, the latter two specific factors explain just a small proportion of the variance. Therefore, we accepted the extended two-factor model of the Japanese CSM in further analyses.

The measurement invariance (equal latent form, equal factor loadings, equal indicator intercepts) of the Japanese CSM was tested in university students and the community group using multiple-group CFA. Three nested models with increasing constraints were estimated. The fit indices are reported in Table 2. Configural invariance was tested when the measurement model was estimated freely in the total sample. This unconstrained solution fitted the data satisfactorily. To test the metric invariance the factor loadings were constrained to equality, which yielded a

Table 3. Bifactor CFA model of the Composite Scale of Morningness in the total sample.

	G-factor	Specific factors		
		Morning affect	Time of rising	Activity planning
CSM3	**0.52**	**0.56**		
CSM4	**0.42**	**0.59**		
CSM5	**0.31**	**0.43**		
CSM12	**0.40**	**0.51**		
CSM1	**0.39**		**0.45**	
CSM6	0.01		0.04	
CSM8	**0.34**		**0.12**	
CSM10	**0.43**		**0.66**	
CSM11	**0.52**		**0.16**	
CSM2	**0.43**			**−0.32**
CSM7	**0.34**			**−0.32**
CSM9	**0.71**			**0.20**
CSM13	**0.74**			**0.30**
Total variance	0.241	0.085	0.052	0.026
Omega	0.822	0.764	0.577	0.681
Omega hierarchical	0.680	0.471	0.241	0.003

Note: Standardized factor loadings. Boldfaced values are significant at least at p < .05. [#]Omega refers to the proportion of explained variance in the scale score attributed to the G- and specific factors. [##]: Omega hierarchical refers to the proportion of explained variance of the scale score attributed to the specific factor.

significant change in the χ^2 value of absolute fit. The traditional χ^2 difference test for comparing two nested models is sensitive to model complexity and sample size, so we followed the recommendations of Cheung and Rensvold (2002) and Chen (2007) for comparing two nested models, using the following criteria for invariance: ΔCFI < 0.01 and ΔRMSEA < 0.015. Setting equal factor loadings yielded ΔCFI $= 0.008$ and ΔRMSEA $= 0.001$, providing support for the metric invariance of the modified two-factor model (Chen, 2007; Cheung and Rensvold, 2002). To test for scalar invariance we ensured that the intercepts were equal and a χ^2 difference test demonstrated that this produced a significant decrease in model fit, with ΔCFI $= 0.019$ and ΔRMSEA $= 0.004$. We therefore concluded that the model did not demonstrate scalar invariance.

3.3. Concurrent validity: CFA with covariates

To assess the concurrent validity of the Japanese CSM we estimated a CFA with covariates model. This type of model has two parts: a measurement and a structural model. Our measurement model had Morningness/Time of Day Preference and

Morning Affect/Alertness as latent variables and the structural part contained the co-variates, including a group code (students; residents), age, gender, sleep duration on weekdays, sleep duration on free days, MSW, MSF and Japanese DTS score. Due to the strong correlations between MSW and MSF in both samples (r = 0.52 and r = 0.76, respectively), only MSF was used in the further analyses. The standardized regression coefficients are presented in Table 4. In the total sample the significant group difference is indicated in Morningness/Time of Day Preference, with the community group tending to have higher Morningness/Time of Day Preference when variance in age, gender and sleep-wake variables was controlled. MSF was inversely associated with Morningness/Time of Day Preference and Morning Affect/Alertness. Age was positively associated with Morning Affect/Alertness. We also reported the CFA with covariates analyses separately in university and community samples. Although gender was weakly associated with the Morningness/Time of Day Preference but not associated with Morning Affect/Alertness aspect of chronotype in the total sample, women scored lower on Morningness/Time of Day Preference and higher on Morning Affect/Alertness factor only in the community sample.

Surprisingly while longer sleep duration was associated with better Morning mood/Alertness on weekdays, the relationship was inverse on free days in the community sample. However the correlation between weekday sleep duration and target

Table 4. Covariates of the two factors of the Composite Scale of Morningness: Confirmatory factor analysis with covariates.

	Total sample (N = 518)		University subsample (N = 234)		Community subsample (N = 170)	
	Morning-ness/time of day preference	Morning affect/ alertness	Morning-ness/time of day preference	Morning affect/ alertness	Morning-ness/time of day preference	Morning affect/ alertness
Group	**0.19****	0.13				
Age	−0.01	**0.27***	0.03	0.02	−0.01	**0.24***
Gender	**−0.09***	0.01	0.03	−0.05	**−0.25***	**0.22***
Weekday sleep duration	0.01	0.06	−0.04	−0.05	0.13	**0.37****
Free day sleep duration	−0.03	−0.03	0.03	−0.06	0.12	**−0.12****
Free day midpoint of sleep	**−0.73****	**−0.29****	**−0.50****	−0.04	**−0.88****	−0.17
Morningness (DTS score)			**0.53****	**0.53****		
R^2	72.0%	37.0%	78.9%	34.1%	84.1%	34.6%

Notes. Data are standardized regression coefficients. Group: 0 = university students; 1 = residents. Gender: 0 = male; 1 = female. *: $p < .05$; **: $p < .01$; ***: $p < .001$.

Table 5. Estimated correlations of the variables included in CFA with covariates analyses (Table 4).

	Morningness/time of day preference	Morning affect/alertness	Age	Gender	SDWD	SDFD	MWD	MFD
University sample (N = 234)								
Morning affect/alertness	**0.55**							
Age	−0.07	−0.02						
Gender	−0.06	−0.09	−0.07					
Weekday sleep duration (SDWD)	−0.02	−0.10	0.11	−0.03				
Free day sleep duration (SDFD)	**−0.35**	**−0.23**	0.08	**−0.14**	**0.20**			
Weekday midpoint of sleep (MSW)	**−0.56**	**−0.14**	**0.13**	**0.14**	0.02	**0.24**		
Free day midpoint of sleep (MSF)	**−0.77**	**−0.36**	0.11	0.08	−0.10	**0.45**	**0.52**	
Morningness (DTS score)	**0.80**	**0.58**	−0.07	−0.09	−0.09	**−0.28**	**−0.36**	**−0.57**
Community sample (N = 170)								
Morning affect/alertness	**0.55**							
Age	0.11	**0.33**						
Gender	−0.04	**0.32**	**0.15**					
Weekday sleep duration (SDWD)	**0.42**	**0.39**	0.12	0.10				
Free day sleep duration (SDFD)	0.10	0.11	0.04	0.13	**0.57**			
Weekday midpoint of sleep (MSW)	**−0.89**	**−0.48**	**−0.17**	−0.05	**−0.27**	−0.08		
Free day midpoint of sleep (MSF)	**−0.86**	**−0.37**	**−0.15**	**−0.20**	**−0.28**	0.07	**0.76**	

Note: Boldfaced correlations are significant at p < 0.05.

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variables (Morningness/Time of Day Preference and Morning Affect/Alertness) are positive (Table 5), and the same correlations between free day sleep duration and target variables are not significant, therefore we may suspect that the negative coefficient in the regression model is due to the negative suppressor effect (Paulhus et al., 2004) as a result of a relatively high correlation between weekday and free day sleep duration (r = 0.57) in the community sample. Interestingly, the same correlation between weekday and free day sleep duration is significant but small in the university sample (r = 0.20).

Weekday and free day midpoints of sleep correlate negatively with Morningness/ Time of Day Preference and Morning Affect/Alertness. The effect size of the correlation is medium or high with Morningness/Time of Day Preference (weekday midpoint of sleep r = −0.56 and r = −0.89; free day midpoint of sleep r = −0.77 and −0.86, respectively in the two groups), and small or moderate with Morning Affect/Alertness (weekday midpoint of sleep r = −0.14 and r = −0.48; free day midpoint of sleep r = −0.36 and −0.37, respectively in the two groups). In the multivariate analysis only the free day midpoint of sleep was used in order to avoid multicollinearity problem. In the multivariate analyses, the free day midpoint of sleep was negatively associated with Morningness/Time of Day Preference and Morning Affect/Alertness in total sample, and only with Morningness/Time of Day Preference in the two separate samples.

Finally, DTS score was strongly correlated with both latent variables in the university student sample (r = 0.80 and 0.58 respectively), and these associations are represented in the multivariate model as well.

4. Discussion

The aim of this study was to explore the factor structure of a Japanese version of the CSM and assess its psychometric properties in Japanese samples (university sample, community group and the total sample).

The distribution of CSM scores in our samples was normal, as in other studies (Adan et al., 2005; Caci et al., 1999, 2000), which supports the dimensional nature of chronotype (Adan et al., 2012; Natale and Cicogna, 2002). The mean CSM score in our university student group (33.5) was close to published means for other university samples (Caci et al., 2009; Zickar et al., 2002).

Our study provided evidence for the validity of a two-factor model containing Morningness/Time of Day Preference and Morning Affect/Alertness factors. The Morningness/Time of Day Preference factor integrates items connected to preferred time for various activities (getting up, going to bed, performing mentally exhausting tasks) and self-identified position on the morningness-eveningness continuum. In

our total sample the Morningness/Time of Day Preference factor was strongly correlated with the sleep midpoints variables during free and working days, which confirms that time-structuring or preferred time for different activities are essential parts of this factor. The Morning Affect/Alertness factor comprises items referring to mood, alertness and tiredness after waking, thus it reflects the respondent's subjective perception of how difficult it is to reach alertness upon waking and become ready to function. Item 6, the willingness to perform physical exercise in the morning did not load significantly on either factor. The factor loadings of item 6 have also been relatively low in other Asian-language versions of the CSM (Thai (Pornpitakpan, 1998); Hindi (Bhatia et al., 2013); Persian (Rahimi and Ebrahimi, 2017)), and further research is needed to determine whether this is due to cultural, climate or other factors. Some earlier studies emphasized the significance of the Morning Affect/Alertness factor (or items connecting to morning activity) owing to its good psychometric properties, and high stability (Adan et al., 2005; Di Milia and Bohle, 2009; Zickar et al., 2002). Researchers suggest that morning activity preference is predominantly responsible for the aforementioned stability, but we propose that the affective/mood component can be as important, because all of the items in our Morning Affect/Alertness factor refer to the way one feels during the morning and morning activities. Of course, the two 'components' —preference and mood — cannot be separated easily, because the way one feels in the morning influences preference/planning. It is well-documented that there are differences between evening and morning people in mood, morning mood and diurnal mood fluctuation (Biss and Hasher, 2012; Jankowski and Ciarkowska, 2008; Jeong et al., 2015). These differences have been attributed to emotion-regulation difficulties connected to inadequate sleep (Díaz-Morales et al., 2015; Killgore et al., 2008) and affective temperament (Park et al., 2015).

Based on our factor analysis of the Japanese CSM, we suggest that both the Morningness/Time of Day Preference and Morning Affect/Alertness factors 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.

Our community group reported greater morningness (higher CSM scores) than our student group, which is in line with earlier studies (Di Milia and Muller, 2012; Zickar et al., 2002). Age is one possible explanation for this result, as it is well-documented that individuals reach their 'eveningness peak' at the age of around 20, and thereafter morningness increases (Roenneberg et al., 2007). However, as this group effect remained after controlling for age, it is probable that both age and flexibility of daily routine (lower in the community sample because of work and social responsibilities) were responsible for the difference (Roenneberg et al., 2007). It is important to emphasize that in our two-factor model the groups only

differed with respect to the Morningness/Time of Day Preference factor, and not the Morning Affect/Alertness factor, which implies that the group effect was driven by differences in activity timing preferences rather than differences in morning mood, tiredness and morning alertness.

Our results regarding age are in accordance with previous research. Age did not co-vary with morningness-eveningness in the university sample, probably due to the narrow age range of that sample. In the total sample and in the community subsample, however, age was positively associated with morning affect and alertness in the morning. Monk and Kupfer (2007) explored which characteristics of chronotype change with age and concluded that although all aspects of morningness increased with age, the factors containing items referring to morning alertness, inability to sleep late and morning functioning were more affected by age than the factor containing items referring to evening sleepiness. Morin and his colleagues also reported that older females tend to present more positive morning mood than younger females (Morin et al., 2016). Others have suggested — in line with our results — that the age-related increase in early morning awakening (and the related reduction in difficulties with morning functioning) may result from an inability to remain asleep in a particular circadian phase in older age and can contribute to psychiatric vulnerability (Duffy and Czeisler, 2002).

Gender did not affect either the Morningness/Time of Day Preference or Morning Affect/Alertness aspect of chronotype in the university subsample, but was related to both factors of CSM in the community sample. Males tended to "prefer" more morning activities, while females reported better affect/alertness in the morning. It seems that adult responsibilities (work-schedule, family life) might be accountable for these differences. These results are not surprising, because the literature regarding gender differences/effects is highly inconsistent (Achari and Pati, 2007; Adan and Natale, 2002; Cavallera and Giudici, 2008; Levandovski et al., 2013; Randler, 2007; Roenneberg et al., 2007; Russo et al., 2007). Methodological differences between studies (for example in item or scale sensitivity to gender differences, age range characteristics) and sociocultural factors may account for these inconsistencies (Randler, 2007). Better mood in the morning among women in the community subsample requires replication and further research.

We assessed the construct validity of the CSM through comparison with the DTS and sleep-wake variables. Both the Morningness/Time of Day Preference and Morning Affect/Alertness factors of the CSM were positively associated with DTS score. Sleep duration did not affect CSM score, but CSM Time of Day Preference was quite strongly negatively affected by MSF in total sample. Furthermore, in this study the CSM had a higher and more stable Cronbach's α than the DTS. The internal consistency of the DTS is limited in this university sample (Cronbach's α = 0.57). The

reasons for low consistency should be investigated further in future research and determine which scale provides the best measure of chronotype in Japanese culture. Table A.1. showed Japanese language version of the CSM for further details.

The main limitation of this study is that we used a convenience sample; this makes it difficult to apply our findings to the Japanese population as a whole. The second limitation is that we were unable to confirm the validity of the CSM by examining the relationship between CSM scores and the other variables. In prior study biological variables such as temperature (Natale and Alzani, 2001), actigraphy (Thun et al., 2012), and social schedules (Randler and Jankowski, 2014) were examined (Thun et al., 2012). Future studies testing the relationship between morningness defined by CSM with more objective indicators are expected in Japanese samples as well.

5. Conclusions

In conclusion, our analyses confirmed that the Japanese version of the CSM is a valid two-factor measure of chronotype. We also contributed to the discussion by comparing several measurement models of the CSM to understand the latent structure of CSM. Developing and testing measurement models in different languages may make it possible to do cross-cultural research on morningness in the future.

Declarations

Author contribution statement

Yoshiko Kato: Conceived and designed the experiments; Performed the experiments; Wrote the paper.

Róbert Urbán: Analyzed and interpreted the data; Wrote the paper.

Seiichi Saito, Keigo Yoshida: Conceived and designed the experiments; Performed the experiments.

Michinori Kurokawa: Performed the experiments.

Adrien Rigó: Conceived and designed the experiments; Wrote the paper.

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The authors declare no conflict of interest.

Additional information

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