Light Exposure Behavior Assessment (LEBA): Development of a novel instrument to capture light exposure-related behaviours

Mushfiqul Anwar Siraji[1, *], Rafael Robert Lazar[2, 3, *], Juliëtte van Duijnhoven[4], Luc Schlangen[5], Shamsul Haque[1], Vineetha Kalavally[6], Céline Vetter[7, 8], Gena Glickman[9], Karin Smolders[10], & Manuel Spitschan[11, 2, 3]

[1] Monash University, Department of Psychology, Jeffrey Cheah School of Medicine and Health Sciences, Malaysia

[2] Psychiatric Hospital of the University of Basel (UPK), Centre for Chronobiology, Basel, Switzerland

[3] University of Basel, Transfaculty Research Platform Molecular and Cognitive Neurosciences, Basel, Switzerland

[4] Eindhoven University of Technology, Department of the Built Environment, Building Lighting, Eindhoven, Netherlands

[5] Eindhoven University of Technology, Department of Industrial Engineering and Innovation Sciences, Intelligent Lighting Institute, Eindhoven, Netherlands

[6] Monash University, Department of Electrical and Computer Systems Engineering, Malaysia, Selangor, Malaysia

[7] University of Colorado Boulder, Department of Integrative Physiology, Boulder, USA

[8] Ximes GmbH, Frankfurt, Germany

[9] Uniformed Services University of the Health Sciences, Department of Psychiatry,

21   Bethesda, USA

22   [10] Eindhoven University of Technology, Human-Technology Interaction Group,

23   Eindhoven, Netherlands

24   [11] University of Oxford, Department of Experimental Psychology, Oxford, UK

25   * Joint first author

26   Author Note

27   Add complete departmental affiliations for each author here. Each new line herein

28   must be indented, like this line.

29   Enter author note here.

30   The authors made the following contributions. Mushfiqul Anwar Siraji: Formal

31   Analysis, Visualization, Writing – original draft, Writing – review & editing;; Rafael Robert

32   Lazar: Data curation, Investigation, Project administration, Visualization, Writing –

33   original draft, Writing – review & editing;; Juliëtte van Duijnhoven: Conceptualization,

34   Methodology, Investigation, Writing – review & editing; Luc Schlangen:

35   Conceptualization, Methodology, Investigation, Writing – review & editing; Shamsul

36   Haque: Conceptualization, Supervision, Writing – review & editing; Vineetha Kalavally:

37   Supervision, Writing – review & editing; Céline Vetter: Conceptualization, Writing –

38   review & editing; Gena Glickman: Conceptualization, Methodology, Writing – review &

39   editing; Karin Smolders: Conceptualization, Methodology, Writing – review & editing;

40   Manuel Spitschan: Conceptualization, Data curation, Investigation, Project

41   administration, Visualization, Methodology, Writing – original draft, Writing – review &

42   editing.

Abstract

One or two sentences providing a **basic introduction** to the field, comprehensible to a scientist in any discipline.

Two to three sentences of **more detailed background**, comprehensible to scientists in related disciplines.

One sentence clearly stating the **general problem** being addressed by this particular study.

One sentence summarizing the main result (with the words "**here we show**" or their equivalent).

Two or three sentences explaining what the **main result** reveals in direct comparison to what was thought to be the case previously, or how the main result adds to previous knowledge.

One or two sentences to put the results into a more **general context**.

Two or three sentences to provide a **broader perspective**, readily comprehensible to a scientist in any discipline.

Keywords: keywords

Word count: X

Light Exposure Behavior Assessment (LEBA): Development of a novel instrument to capture light exposure-related behaviours

Introduction

- Light exposure is important

- Light exposure Behavior is important

- Table: Overview Existing Related Scales: items in total / items on light exposure (behaviour)

- Existing Scales: Review them in text

- None of these do light exposure behavior.

Methods

Ethical approval

The cantonal ethics commission (Ethikkommission Nordwest- und Zentralschweiz, project ID Req-2021-00488) reviewed this project and issued an official clarification of responsibility (full document see Suppl. Fig X in appendix) stating: "The research project does not fall under the scope of the Human Research Act, because your project is using only anonymised data. An authorisation from the ethics committee is therefore not required and the EKNZ is not responsible for its review."

Data Availability

Survey characteristics

Data was collected in a quantitative cross-sectional approach via a fully anonymous online survey hosted on REDCap (Harris et al., 2019, 2009) by way of the University of

Basel sciCORE. Participants were recruited via the website of a Comic co-released with the survey(Weinzaepflen & Spitschan, 2021) , social media (i.e., LinkedIn, Twitter, Facebook), mailing lists, word of mouth, the investigators' personal contacts, and supported by distribution of the survey link via f.lux software (F.lux Software LLC, 2021).

Completing the online survey took approx. 15 to 20 minutes and was not compensated. The first page of the survey comprised a participant information sheet, where participants' informed consent to participate was obtained before any of the questions were displayed. Underaged participants (<18 years) were urged to obtain assent from their parents/legal guardians, before filling in the survey. Information on the first page included the objectives of the study, inclusion criteria, estimated duration, the use, storage and sharing of the data, compensation (none), and information about the type of questions in the survey. Moreover, participants needed to confirm that they were participating the survey for the first time. To ensure high data quality, five attention check items were included in the survey (e.g., "We want to make sure you are paying attention. What is 4+5?"). The data analysed in this study was collected between 17.05.2021 and 03.09.2021. Questions incorporating retrospective recall were all aligned to the period of "past four weeks," matching the presented LEBA instrument.

In addition to the LEBA questionnaire, which is subject of the current study, the following variables and items were assessed but not included in the analysis:

- Sleep disturbance and sleep-related impairment (adult and pediatric versions) (Bevans et al., 2019; Daniel J. Buysse et al., 2010; Forrest et al., 2018; Harb, Hidalgo, & Martau, 2015; L. Yu et al., 2011)
- Sleep duration, timing, and latency, chronotype, social jetlag, time in bed, work/sleep schedule and outdoor light exposure duration (version for adults and adolescents) (Roenneberg, Wirz-Justice, & Merrow, 2003)
- Sleep environment (Olivier et al., 2016)

107   • Meal timing & caffeine consumption [custom items]

108   • Light sensitivity (photophobia vs. photophilia) (Wu & Hallett, 2017)

109   • Self-reported pubertal stage (only if younger than 18 years old) (Petersen,

110   Crockett, Richards, & Boxer, 1988)

111   Furthermore, the following 1-item demographic variables were assessed:

112   • Age

113   • Sex

114   • Gender identity

115   • Occupational Status

116   • COVID-19 related Occupational setting during the past four weeks

117   • Time zone & country of residence

118   • English as native language

119 **Participants**

120   Table 1 summarizes the survey participants' demographic characteristics. Only

121 participants completing the full LEBA questionnaire were included, thus there are no

122 missing values in the item analyses. XX participants were excluded from analysis due to

123 not passing at least one of the "attention check" items. For exploring initial factor

124 structure (EFA) , a sample of 250-300 is recommended (Comrey & Lee, 1992;

125 Schönbrodt & Perugini, 2013). For estimating the sample size for the confirmatory factor

126 analysis (CFA) we followed the N:q rule (Bentler & Chou, 1987; Jackson, 2003; Kline,

127 2015; Worthington & Whittaker, 2006), where ten participants per parameter is required

128 to earn trustworthiness of the result. Our sample size exceeds these requirements:

129 Anonymous responses from a total of $n = 690$ participants were included in the analysis

130 of the current study, split into samples for exploratory (EFA: $n = 428$) and confirmatory

131 factor analysis (CFA: $n = 262$). The EFA sample included participants filling out the

132 questionnaire from 17.05.2021 to XX.XX.XXXX , whereas participants who filled out the

133 questionnaire from YY.YY.YYYY to 03.09.2021 were included in the CFA analysis.

134 Participants indicated filling out the online survey from a diverse range of geographic

135 locations. The four most common geographic locations included:

	x
United States - America/New_York (UTC -04:00)	63
United Kingdom - Europe/London (UTC)	57
Germany - Europe/Berlin (UTC +01:00)	53
India - Asia/Kolkata (UTC +05:30)	38

137   For a full list of geographic locations, see Suppl. Table X in the appendix.

138   Age among all participants ranged from 11 years to 84 years [EFA: min = 11, max =

139 84; CFA: min = 12, max = 74], with an overall mean of ~ 33 years of age [Overall: M =

140 32.95, SD = 14.57; EFA: M = 32.99, SD = 15.11; CFA: M = 32.89, SD = 13.66]. In total

141 325 (47%) of the participants indicated female sex [EFA: 189 (44%); CFA: 136 (52%)],

142 351 (51%) indicated male [EFA: 230 (54%); CFA: 121 (46%)] and 14 (2.0%) indicated

143 other sex [EFA: 9 (2.1%), CFA: 5 (1.9%)]. Overall, 49 (7.2%) [EFA: 33 (7.8%); CFA: 16

144 (6.2%)] participants indicated a gender-variant identity. In a "Yes/No" question regarding

145 native language, 320 (46%) of respondents [EFA: 191 (45%); CFA: 129 (49%)] indicated

146 to be native English speakers. For their "Occupational Status," more than half of the

147 overall sample reported that they currently work [Overall: 396 (57%); EFA: 235 (55%);

148 CFA: 161 (61%)], whereas 174 (25%) [EFA: 122 (29%); CFA: 52 (20%)] reported that

149 they go to school and 120 (17%) [EFA: 71 (17%); CFA: 49 (19%)] responded that they do

150 "Neither." With respect to the COVID-19 pandemic we asked participants to indicate their

151 occupational setting during the last four weeks: In the overall sample 303 (44%) [EFA:

152 194 (45%); CFA: 109 (42%)] of the participants indicated that they were in a home office/

153 home schooling setting., while 109 (16%) overall [EFA: 68 (16%) ; CFA: 41 (16%)]

154 reported face-to-face work/schooling. Lastly, 147 (21%) overall [EFA: 94 (22%) ; CFA: 53

(20%)] reported a combination of home- and face-to-face work/schooling, whereas 131

(19%) overall [EFA: 72 (17%); CFA: 59 (23%)] filled in the "Neither (no work or school, or

indication)" response option. We tested all demographic variables in Table 1 for

significant group differences between the EFA and CFA sample, applying Wilcoxon rank

sum test for the continuous variable "Age" and Pearson's χ^2 test for all other categorical

variables via the gtsummary R package's "add_p" function (Sjoberg et al., 2021a) . The

p-values were corrected for multiple testing applying false discovery rate (FDR) via the

"add_q" function of the same package. After p-value (FDR) correction for multiple testing,

none of the demographic variables were significantly different between the EFA sample

and the CFA sample (all q-values $q \geq 0.2$, indicating equivalence).

1. Describe EFA and CFA sample separately.

2. Sampling technique: Convince sampling (non-probability sample)

3. Method: cross-sectional survey

4. How many missing data?

5. How incomplete data were addressed.

6. Why such sample was chosen?

Procedure

Development of the Scale.

1. How the items were generated

2. How the literature was reviewed to identify construct adequacy of the items.

3. Discuss the expert panel review process to assess content validity

Data Collection.   Timeline of data collection, mode of data collection.

Analytic Strategies

We used R (version 4.1.0), including several R packages, for our analyses.Initially,

our tool have six point Likert type response scale (0:Does not apply/I don't know; 1:Never,

2:Rarely; 3:Sometimes; 4:Often; 5: Always). As our purpose was to capture light

exposure related behavior, "Does not apply/I don't know" and "Never" were providing

similar information. As such we decided to collapse "Does not apply/I don't know" and

"Never" options into one making it a 5 point Likert type response scale. Necessary

assumptions of EFA, including sample adequacy, normality assumptions, quality of

correlation matrix, were assessed. Our data violated both the univariate and multivariate

normality assumptions. Due to these violations and the ordinal nature of our response

data, we used a polychoric correlation matrix (C. Desjardins & Bulut, 2018) for the EFA.

We employed principal axis (PA) as a factor extraction method with varimax rotation. PA

is robust to the normality assumption violations (Watkins, 2020). The obtained latent

structure was confirmed by another factor extraction method: the minimum residuals

extraction method as well. We used a combination factor identification method including

scree plot(Cattell, 1966), Horn's parallel analysis (Horn, 1965), minimum average

partials method(Velicer, 1976), and hull method (Lorenzo-Seva, Timmerman, & Kiers,

2011) to identify factor numbers. Additionally, to determine the simple structure, we

followed the following guidelines recommended by psychometricians (i) no factors with

fewer than three items (ii) no factors with a factor loading <0.3 (iii) no items with

cross-loading greater than .3 across factors (Bandalos & Finney, 2018) We also

conducted psychometric analysis on non-merged response options data (supplementary

analysis) and rejected the latent structure obtained as the factors were less interpretable.

<center>**Results**</center>

Exploratory Factor Analysis

Sampling adequacy was checked using Kaiser-Meyer-Olkin (KMO) measures of sampling adequacy(Kaiser, 1974) . The overall KMO vale for 48 items was 0.63 which was above the cutoff value (.50) indicating a mediocre sample (Hutcheson, 1999). Table3 summarizes the univariate descriptive statistics for the 48 items. some of the items were skewed with high Kurtosis values. Our data violated both univariate normality (Shapiro-Wilk statistics; (Shapiro & Wilk, 1965)) and multivariate normality assumptions (Marida's test;(Mardia, 1970)). Multivariate skew was = 583.80 (p <0.001) and multivariate kurtosis was = 2,749.15 (p <0.001). Due to these violations and ordinal nature of the response data polychoric correlations over Pearson's correlations was chosen (C. Desjardins & Bulut, 2018). Bartlett's test of sphericity (Bartlett, 1954), χ^2 (1128) = 5042.86, p < .001] indicated the correlations between items are adequate for the EFA. However only 4.96% of the inter-item correlation coefficients were greater than .30. The inter item correlation ranged between .44 to .91. And the corrected item-total correlations ranged between .10 to .44.

Scree plot (Figure 3) suggested a six-factor solution. Horn's parallel analysis (Horn, 1965) with 500 iterations also indicated a six-factor solution. However, the minimum average partial (MAP) method (Velicer, 1976) and Hull method (Lorenzo-Seva et al., 2011) suggested a five-factor solution. As a result, we tested both five-factor and six-factor solutions.

With initial 48 items we conducted three rounds of EFA gradually discarded problematic items. (cross-loading items and poor factor loading (<.30) items). Finally, a five-factor EFA solution with 25 items was accepted with low RMSR = 0.08 (Brown,

225 2015), all factor-loading higher than .30 and no cross-loading greater than .30. We

226 confirmed this five-factor latent structure using varimax rotation with a minimum residual

227 extraction method (Table**??**). Table4 displays the factor-loading (structural coefficients)

228 and communality of the items. The absolute value of the factor-loading ranged from -.49

229 to .99 indicating strong coefficients. The commonalities ranged between .11 to .99.

230 However, the histogram of the absolute values of non-redundant residual-correlations

231 Fig5 showed 26% correlations greater than the absolute value of .05, indicating a

232 possible under-factoring. (C. D. Desjardins, 2018). Subsequently, we fitted a six-factor

233 solution. However, a factor emerged with only one salient variable loading in the

234 six-factor solution, thus disqualifying the six-factor solution (Table**??**).

235   Internal consistency reliability coefficient Cronbach's alpha assumes that all the

236 factor- loading of the items under a factor are equal (Graham, 2006; Novick & Lewis,

237 1967) which is not the case in our sample. Additionally Cronbach's alpha coefficient has

238 a tendency to deflate the estimates for Likert type data as the calculation is based on

239 pearson-correlation matrix which requires that response data should be in continuous of

240 nature (Gadermann, Guhn, & Zumbo, 2012; Zumbo, Gadermann, & Zeisser, 2007).

241 Subsequently to get better estimates of reliability we reported ordinal alpha which used

242 polychoric-correlation matrix and assumed that the responses data were ordered in

243 nature instead of continuous. Ordinal alpha coefficient value ranges from 0 to 1 and

244 higher value represents better reliability. In the five-factor solution, the first factor

245 contained three items and explained 10.25% of the total variance with a internal reliability

246 coefficient ordinal α = .94. All the items in this factor stemmed from the individual's

247 preference to use blue light filters in different light environments. The second factor

248 contained six items and explained 9.93% of the total variance with a internal reliability

249 coefficient ordinal α = .76. Items under this factor commonly investigate an individual's

250 hours spent outdoor. The third factor contained five items and explained 8.83% of the

251 total variance. Items under this factor dealt with the specific behaviors pertaining to

sleep. The internal consistency reliability coefficient was, ordinal α = .75. The fourth

factor contained five items and explained 8.44% of the total variance with an internal

consistency coefficient, ordinal α = .72. These five items stemmed from the behavior

related to an individual's cellphone usage during the sleep-wakeup time. Lastly, the fifth

factor contained six items and explained 6.14% of the total variance. This factor tried to

measure an individual's behavior lead by the awareness of light's influence on health.

The internal consistency reliability was, ordinal α = .62 . It is essential to attain a balance

between psychometric properties and interpretability of the common themes when

exploring the latent structure. As all of the emerged factors are highly interpretable and

relevant towards our aim to capture light exposure related behavior, regardless of the

apparent low reliability of the fifth factor, we retain all the five-factors with 23 items for our

confirmatory factor analysis (CFA). Two items showed negative factor-loading (items 44

and 21). Upon inspection, it was understood that these items are negatively correlated to

the common theme, and thus in the CFA analysis, we reversed the response code for

these two items.

Confirmatory Factor Analysis

We conducted a categorical confirmatory factor analysis with robust weighted least

square (WLSMV) estimator as our response data was in ordinary nature(C. Desjardins &

Bulut, 2018). Several indices are suggested to measure model fit. These indices can be

categorized as absolute, comparative and parsimony fit indices (Brown, 2015). Absolute

fit assess the model fit at an absolute level using indices including χ^2 test statistics and

the standardized root mean square (SRMR).parsimony fit indices including the root

mean square error of approximation (RMSEA) considers the number of free parameters

in the model to assess the parsimony of the model. Comparative fit indices evaluate the

fit of the specified model solution in relation to a more restricted baseline model

restricting all covariances among the idicators as zero. Comparative fit index (CFI) and

the Tucker Lewis index (TLI) are such two comparative fit indices. Commonly used

Model fit guidelines (Hu & Bentle, 1999; Schumacker & Lomax, 2004) includes (i)

Reporting of χ^2 test statistics (A non-significant test statistics is required to reflect model

fit) (i) CFI and TLI (CFI/TLI close to .95 or above/ranging between 90-95 and above) (ii)

RMSEA (close to .06 or below), (iii) SRMR (close to .08 or below) to estimate the model

fit. Table 5 summarizes the fit indices of our fitted model. Our fitted model failed to attain

an absolute fit estimated by the χ^2 test. However, the χ^2 test is sensitive to sample size

and not recommended to be used as the sole index of absolute model fit (Brown, 2015).

Another absolute fit index we obtained in our analysis was SRMR which does not work

well with categorical data (C.-Y. Yu, 2002). Subsequently, we judged the model fit based

on the comparative fit indices: CFI, TLI and parsimony fit index-RMSEA. Our fitted model

attained acceptable fit (CFI =.94; TLI = .93); RMSEA = .06,[.05-.07, 90% CI]) with two

imposed equity constrain on item pairs 32-33 and 19-17 . However SRMR value was

higher than the guideline (SRMR = .12). Further by allowing one pair of items (30-41) to

covary their error variance and discarding two item (item 37 & 26) for very low r-square

value, our model attained best fit (CFI =.97; TLI = .96); RMSEA = .05[.04-.06, 90% CI])

and SRMR value (SRMR = .09) was also close to the suggestions of Hu and Bentle

(1999).

Internal consistency ordinal α for the five factors of LEBA were .96, .83, .70, .69,

.52 respectively. We also estimated the internal consistency reliability of the total scale

using Mcdonald's omega(total) coefficient which is a better reliability estimate for

multidimensional constructs(Dunn, Baguley, & Brunsden, 2014; Sijtsma, 2009).

McDonald's omega(total) coefficient for the total scale was .73.

Measurement Invariance

Measurement invariance (MI) evaluates whether a construct has the psychometric

equivalence and same meaning across groups or measurement occasions (Kline, 2015;

Putnick & Bornstein, 2016). We used structural equation modeling framework to assess

measurement invariance of our developed tool across two groups: **native English**

speakers and **non-native English speakers**. Our measurement invariance testing

involved establishing configural, metric , scalar , and residual invariance (Widaman &

Reise, 1997). MI models are nested type models of which configural model is the first

and least restrictive model. Configural model assumes that the number of factors and

item number under each factors will be equal across two groups. Metric invariance

model along with the assumption of configural model assumes that factor-loadings of the

items across the two groups will be equal indicating each item contributes to the

measured construct equivalently for the both groups. Along with these assumptions

scalar invariance assumes that item intercepts to be equivalent across groups. Scalar

invariance model indicates the equivalence of response scale across the groups,

i.e. persons with the same level of the underlying construct will score the same across

the groups. Residual invariance model holds all the mentioned assumptions as true and

also adds the assumption of equality in error variances and covariances across the

groups. This model is the highest level of MI and assures the equivalence of precision of

items across the groups in measuring the underlying constructs. The invariance model fit

was assessed using the fit indices including χ^2 test, CFI and TLI (close to .95 or above) ,

RMSEA (close to .06 or below). following the guidelines of Hu and Bentle (1999). We

excluded SRMR from our consideration as it does not behave optimally for categorical

variables (C.-Y. Yu, 2002). Table 6 summarized the fit indices. The comparison among

different measurement invariance model was made by using χ^2 difference test ($\Delta\chi^2$) to

assess whether our obtained latent structure of "LEBA" attains the highest level of the MI.

If the $\Delta\chi^2$ is not statistically significant (p<0.05) (Dimitrov, 2010) the particular

invariance model was accepted. We started our analysis by comparing the model fit of

the lest restrictive model:configural model to metric MI model and continued successive

comparisons. Table 6 indicates that our fiited model attains residual invariance: the

331 highest level of invariance in terms of CFI, TLI, RMSEA and non-significant $\Delta\chi^2$ test.

Analysing the quality of items by Item Information Theory

333   We sought the IRT to gether information regarding the item quality. IRT

334 complements the conventional classical test theory-based analysis by gathering

335 information on item discrimination and item difficulty(Baker, 2017). Here, an item's

336 quality is judged based on item information in relation to participants' latent trait level (θ).

337 We gathered evidence on item quality by fitting each factor of LEBA with the graded

338 response model (7 to the combined EFA sample and CFA sample (n =690). Item

339 discrimination indicates the pattern of variation in the categorical responses with the

340 changes in latent trait, and item information curve (IIC) indicates the amount of

341 information an item carries along the latent trait continuum. Here, we reported the item

342 discrimination parameter and only discarded the items with relatively flat item information

343 curve (information <.2) to develop the short form of LEBA. Baker (2017) categorized the

344 item discrimination in as none = 0; very low =0.01 to 0.34; low = 0.35 to 0.64; moderate =

345 0.65 to 1.34 ; high = 1.35 to 1.69; very high >1.70. Item discrimination parameters of our

346 scale fell in very high (10 items), high (4 items), moderate (4 items), low (5 items)

347 indicating a good range of discrimination along the latent trait. Examination of the item

348 information curve indicated 6 items (1, 25, 9, 38, 30, & 41) had relatively flat information

349 curves thus discarded. We also gathered evidence of item fit and person fit to our fitted

350 model.

351   Test information curve (TIC) indicate the amount of information an the full-scale

352 carry along the latent trait continuum. As we treated each factor of LEBA as an

353 unidmensional construct we obtain 5 TICs. These information curves indicated except

354 blue filter factor, the other factor's TICs are roughly centered on the center of the trait

355 continuum ((θ)). Also the amount of information changed rather steadily with the change

356 of (θ). Thus we conferred the LEBA scale (except blue filter) estimated the light

exposure related behavior with precision near the center of trait continuum (Baker, 2017)

which is sufficient to discriminate between latent trait measured by the each factor. The

blue filter factor had a peak to the right side of the center of latent trait indicating its ability

to providing information only for people who already have some preference towards

using blue-filters.

        Our result also indicated all the items fitted well to the respective models as

assessed by assessed by RMSEA value obtained from Signed-X2 index implementation.

All of the items had RMSEA value <.06 indicating adequate fit. Person fit indicates the

validity and meaningfulness of the fitted model at the participants latent trait level (C.

Desjardins & Bulut, 2018). We estimated the person fit statistics using standardized fit

index Zh statistics (Drasgow, Levine, & Williams, 1985). Zh < -2 should be considered as

a misfit. Fig indicates that Zh is larger than -2 for most participants, suggesting a good fit

of the selected IRT models.

        The overall we can concluded that IRT analysis indicated LEBA is a

psychometrically sound measure. Item fit indexes and person fit index for all five fitted

model were acceptable. Items had diverse slope parameters indicating a good range of

discrimination- the ability to differentiate respondents with different levels of the light

exposure related behavior. All-in-all we can recommend the LEBA to be used to capture

light exposure related behavior.

Discussion

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Table 1

Releated Scales

Name	Author	Description	Relevant Items
Visual Light Sensitivity Questionnaire-8	Verriotto et al., 2017	Eight-question survey to assess the presence and severity of photosensitivity symptoms	NA
Office Light Survey	Eklundet al., 1996	A survey to assess electrical lighting environment in office	NA
Harvard Light Exposure Assessment Questionnaire	Bajaj et al., 2011	Self-administered semi-quantitative light questionnaire	NA
Hospital Lighting Survey	Dianat et el.,.2013	23 items questionnaire to assess light environment in a hospital	NA
Morningness-Eveningness Questionnaire	Horne et al.,1976	19 items questionnaire to understand your body clock	NA

Table 1

Releated Scales (continued)

Name	Author	Description	Relevant Items
Munich Chronotype Questionnaire (MCTQ)	Roenneberg et al.,2003	17 items questionnaire to understand individuals phase of entrainment	NA
Assessment of Sleep Environment	Olivier et.al.,.2016]	13 items questionnaire measuring your sleep environment quality	NA
The Pittsburgh Sleep Quality Index (PSQI)	Buysse ei al.,1989	9 items inventory to measure sleep quality and sleeping pattern	NA
Self-Rating of Biological Rhythm Disorder for Adolescents (SBRDA)	Xie et al.,2021	29 Items questionnaire assessing four dimensions of biological rhythm disorder in adolescents	Item 3,22-25 and 29

Table 1

Releated Scales (continued)

Name	Author	Description	Relevant Items
Photosensitivity Assessment Questionnaire (PAQ)	Wu et al.,2017	16 dichotomous (yes/no) items questionnaire to assess "photophobia" and "photophilia"	All itms

Table 2

Dempgraphics

Variable	Overall, N = 690	1. EFA Sample, N = 428	2. CFA Sample, N = 262	p-value	q-value
Age	32.95 (14.57)	32.99 (15.11)	32.89 (13.66)	0.5	0.5
Sex				0.14	0.4
Female	325 (47%)	189 (44%)	136 (52%)		
Male	351 (51%)	230 (54%)	121 (46%)		
Other	14 (2.0%)	9 (2.1%)	5 (1.9%)		
Gender-Variant Identity	49 (7.2%)	33 (7.8%)	16 (6.2%)	0.4	0.5
Native English Speaker	320 (46%)	191 (45%)	129 (49%)	0.2	0.5
Occupational Status				0.040	0.2
Work	396 (57%)	235 (55%)	161 (61%)		
School	174 (25%)	122 (29%)	52 (20%)		
Neither	120 (17%)	71 (17%)	49 (19%)		
Occupational setting				0.3	0.5
Home office/Home schooling	303 (44%)	194 (45%)	109 (42%)		
Face-to-face work/Face-to-face schooling	109 (16%)	68 (16%)	41 (16%)		
Combination of home- and face-to-face- work/schooling	147 (21%)	94 (22%)	53 (20%)		
Neither (no work or school, or in vacation)	131 (19%)	72 (17%)	59 (23%)		

[1] Mean (SD); n (%)

[2] Wilcoxon rank sum test; Pearson's Chi-squared test

[3] False discovery rate correction for multiple testing

Table 3

Descriptive Statistics

	Mean	SD	Skew	Kurtosis	Shapiro-Wilk Statistics	Item-Total Correlation
Item1	2.27	1.39	0.74	-0.81	0.81*	.25
Item2	2.87	1.59	0.08	-1.60	0.83*	.19
Item3	3.36	1.38	-0.48	-1.03	0.87*	.16
Item4	1.47	1.18	2.38	4.00	0.43*	.28
Item5	4.01	1.40	-1.22	0.07	0.70*	.13
Item6	2.79	1.55	0.19	-1.48	0.85*	.20
Item7	2.26	1.25	0.70	-0.60	0.85*	.19
Item8	2.97	1.20	-0.06	-0.94	0.91*	-.10
Item9	2.94	1.03	-0.12	-0.40	0.91*	.10
Item10	2.74	1.04	0.09	-0.74	0.91*	.28
Item11	2.18	0.90	0.60	0.12	0.86*	.26
Item12	2.36	1.22	0.59	-0.62	0.87*	.25
Item13	2.73	1.46	0.20	-1.36	0.87*	.33
Item14	2.14	1.31	0.77	-0.78	0.80*	.26
Item15	3.26	1.09	-0.26	-0.45	0.91*	.14
Item16	1.56	1.23	2.00	2.45	0.50*	.32
Item17	1.54	1.21	2.07	2.75	0.49*	.31
Item18	1.12	0.49	5.02	27.80	0.25*	.16
Item19	1.05	0.36	7.23	52.98	0.13*	.18
Item20	1.04	0.33	8.99	85.28	0.10*	.16
Item21	1.14	0.59	4.79	24.05	0.25*	.16
Item22	3.57	1.07	-0.65	-0.17	0.88*	.21
Item23	2.56	1.27	0.33	-1.00	0.89*	.11

Table 3 continued

	Mean	SD	Skew	Kurtosis	Shapiro-Wilk Statistics	Item-Total Correlation
Item24	4.14	0.99	-1.23	1.14	0.79*	.19
Item25	2.59	1.41	0.27	-1.27	0.86*	.19
Item26	2.25	1.27	0.69	-0.64	0.84*	.18
Item27	3.80	1.29	-0.87	-0.42	0.82*	.17
Item28	3.76	1.14	-0.68	-0.45	0.86*	.00
Item29	2.44	1.31	0.38	-1.14	0.86*	.11
Item30	1.48	1.11	2.18	3.35	0.48*	.24
Item31	3.00	1.62	-0.08	-1.61	0.83*	.44
Item32	3.55	1.65	-0.60	-1.34	0.76*	.43
Item33	3.62	1.64	-0.68	-1.25	0.74*	.32
Item34	3.42	1.83	-0.45	-1.69	0.69*	.33
Item35	3.86	1.67	-0.99	-0.85	0.65*	.23
Item36	1.54	1.25	2.13	2.86	0.46*	.36
Item37	1.33	0.91	3.03	8.43	0.41*	.01
Item38	4.30	1.08	-1.79	2.53	0.67*	.22
Item39	1.96	0.98	1.02	0.69	0.82*	.05
Item40	2.16	1.19	0.71	-0.54	0.84*	.14
Item41	1.31	0.81	2.75	6.92	0.43*	.21
Item42	3.93	1.48	-1.06	-0.44	0.71*	.18
Item43	1.64	1.18	1.79	2.02	0.60*	.15
Item44	3.51	1.30	-0.70	-0.59	0.85*	.39
Item45	2.22	1.48	0.71	-1.02	0.76*	.30
Item46	1.76	1.23	1.35	0.44	0.66*	.38
Item47	2.11	1.17	0.77	-0.39	0.83*	.32

Table 3 continued

	Mean	SD	Skew	Kurtosis	Shapiro-Wilk Statistics	Item-Total Correlation
Item48	2.60	1.25	0.29	-0.86	0.89*	.35

Note. *p<.001

Table 4

Factor loadings and communality of the retained items

item	PA1	PA2	PA3	PA4	PA5	Communality	Uniqueness
item16	0.99					0.993	0.007
item36	0.94					0.899	0.101
item17	0.8					0.658	0.342
item11		0.79				0.642	0.358
item10		0.76				0.592	0.408
item12		0.65				0.465	0.535
item7		0.5				0.267	0.733
item8		-0.49				0.252	0.748
item9		0.32				0.113	0.887
item27			0.8			0.658	0.342
item3			0.8			0.682	0.318
item40			0.65			0.464	0.536
item30			0.45			0.353	0.647
item41			0.36			0.329	0.671
item33				0.74		0.555	0.445
item32				0.73		0.624	0.376
item35				0.66		0.454	0.546
item37				-0.39		0.174	0.826
item38				0.38		0.178	0.822
item46					0.6	0.422	0.578
item45					0.59	0.374	0.626
item25					0.41	0.193	0.807
item4					0.41	0.219	0.781
item1					0.4	0.17	0.83
item26					0.35	0.165	0.835
% of Variance	0.1	0.1	0.09	0.08	0.06		

Note. Only loading higher than .30 is reported

Table 5

Fit indices of CFA

Model	Chi-Squre	df	CFI	TLI	RMSEA	RMSEA 90% Lower CI	RMSEA 90% Upper CI	SRMR
Five factor model:25	448.51	222.00	.94	0.93	0.06	0.05	0.07	0.12
Five factor model:23	346.59	221.00	.97	0.96	0.05	0.04	0.06	0.09

Note. df: Degrees of Freedom; CFI: Comparative Fit Index; TLI: Tucker Lewis Index;RMSEA:Root Mean Square Error of

Approximation; CI: Confidence Interval; SRMR: Standardized Root Mean Square

Table 6

Invariance Analysis

	Chi-Square	df	CFI	TLI	RMSEA	RMSEA 90% Lower CI	RMSEA 90% Upper	Chi-Square Difference	df difference*	p
Configural	632.20	442.00	0.95	0.94	0.06	0.05	0.07	-	-	-
Metric	644.58	458.00	0.95	0.95	0.06	0.05	0.07	18.019a	16	0.323
Scalar	714.19	522.00	0.95	0.95	0.05	0.04	0.06	67.961b	64	0.344
Residual	714.19	522.00	0.95	0.95	0.05	0.04	0.06	0c	0	NA

Note. a = Metric vs Configural; b = Scalar vs Metric; c = Residual vs Scalar; d = Structural vs Residual;* = df of model comparison

Table 7

IRT Item parameters for the LEBA Scale

	a	b1	b2	b3	b4
item16	28.55	0.78	0.90	1.06	1.40
item36	4.49	0.94	1.08	1.23	1.40
item17	2.81	0.97	1.11	1.38	1.62
item11	3.27	-0.79	0.65	1.54	2.31
item10	3.07	-1.27	-0.09	0.82	2.00
item12	1.72	-0.67	0.44	1.28	2.11
item7	1.09	-0.50	0.73	1.63	2.97
Ritem8	1.19	-2.26	-0.48	0.64	1.91
item9	0.91	-2.63	-0.96	1.11	3.49
item27	2.21	-1.88	-1.19	-0.73	0.30
item3	3.03	-1.24	-0.77	-0.20	0.66
item40	1.55	-0.51	0.46	1.32	2.22
item30	0.49	3.27	3.74	4.64	6.52
item41	0.51	3.87	4.78	6.39	8.91
item32	1.62	-1.03	-0.78	-0.42	0.16
item35	1.36	-1.09	-0.98	-0.75	-0.40
item38	0.40	-7.50	-5.58	-4.25	-0.91
item33	13.51	-0.66	-0.48	-0.24	0.13
item46	2.22	0.68	0.89	1.38	2.17
item45	1.51	0.30	0.55	1.17	1.91
item25	0.52	-1.37	-0.04	1.89	4.22
item4	0.84	2.44	2.80	3.18	3.67
item1	0.39	-0.91	1.52	3.25	5.53

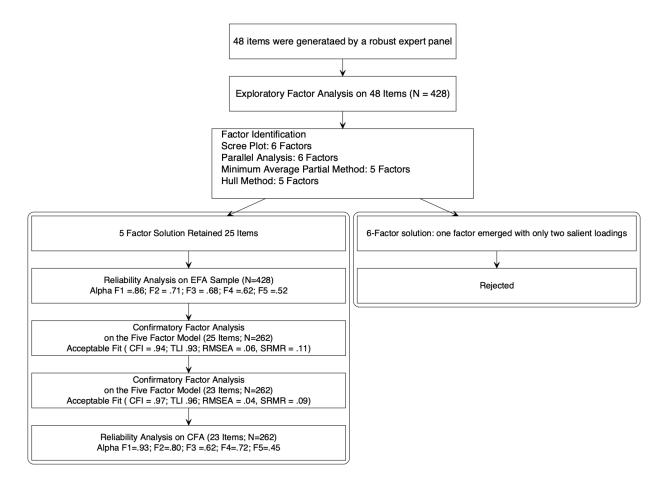*Note.* a = item discrimination parameter; b(1-4) = response category difficulty parameter
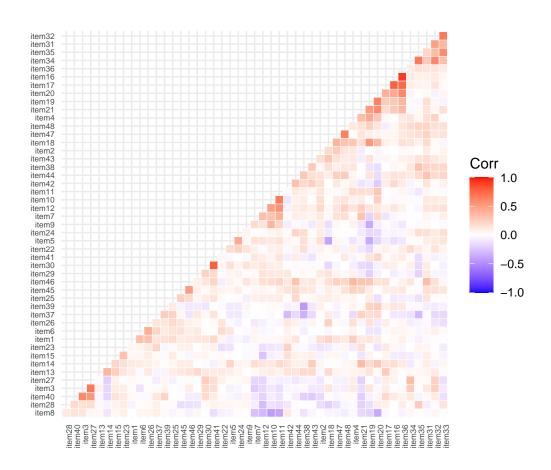
Figure 1. Development of LEBA

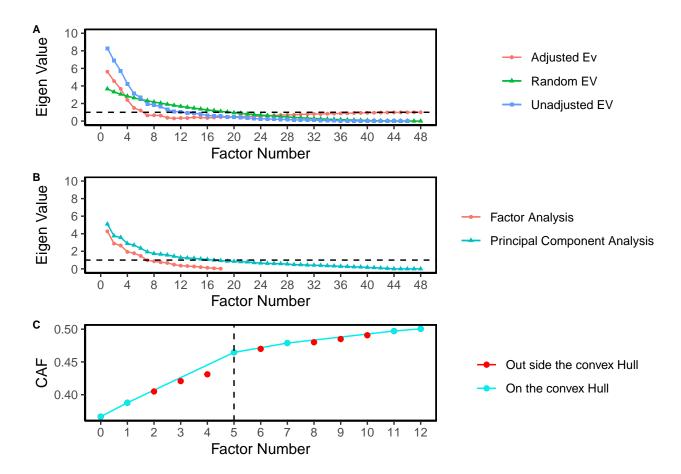*Figure 2.* Correlation plot of the items

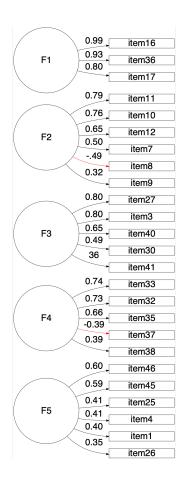*Figure 3*. Factor Identification (A) Parallel analysis (B) Scree Plot (C) Hull Method
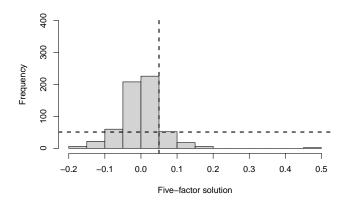
Figure 4. Five Factor Solution

Figure 5. Histogram of residulas: five-factor solution

LEBA
Summary results of LEBA (N =690)

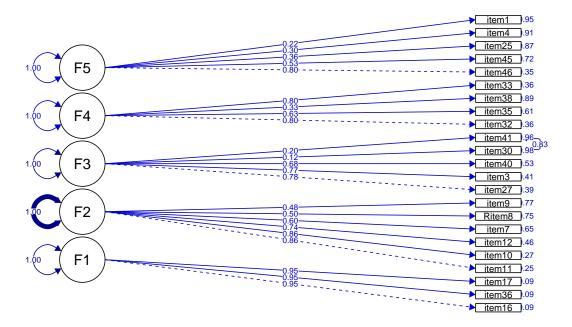| LEBA Items	n	Mean	Median	SD	Histogram[1]	Density[2]	Never	Rarely	Sometimes	Often	Always
EFA (n = 428)											
item01	428	2.3	2.0	1.4			42.29% (181)	22.20% (95)	12.62% (54)	12.38% (53)	10.51% (45)
item03	428	3.4	4.0	1.4			15.89% (68)	11.45% (49)	17.29% (74)	31.07% (133)	24.30% (104)
item04	428	1.5	1.0	1.2			84.11% (360)	3.50% (15)	2.10% (9)	2.10% (9)	8.18% (35)
item07	428	2.3	2.0	1.2			35.98% (154)	27.80% (119)	17.29% (74)	12.38% (53)	6.54% (28)
item08	428	3.0	3.0	1.2			13.79% (59)	22.20% (95)	27.80% (119)	25.93% (111)	10.28% (44)
item09	428	2.9	3.0	1.0			10.28% (44)	19.63% (84)	41.82% (179)	22.43% (96)	5.84% (25)
item10	428	2.7	3.0	1.0			11.92% (51)	31.31% (134)	31.31% (134)	21.96% (94)	3.50% (15)
item11	428	2.2	2.0	0.9			22.43% (96)	46.26% (198)	23.13% (99)	7.01% (30)	1.17% (5)
item12	428	2.4	2.0	1.2			29.91% (128)	29.67% (127)	21.50% (92)	12.15% (52)	6.78% (29)
item16	428	1.6	1.0	1.2			79.67% (341)	4.21% (18)	3.97% (17)	4.67% (20)	7.48% (32)
item17	428	1.5	1.0	1.2			80.61% (345)	3.27% (14)	5.14% (22)	3.27% (14)	7.71% (33)
item25	428	2.6	3.0	1.4			34.35% (147)	13.79% (59)	22.20% (95)	17.99% (77)	11.68% (50)
item26	428	3.7	4.0	1.3			38.32% (164)	23.36% (100)	20.09% (86)	10.98% (47)	7.24% (31)
item27	428	3.8	4.0	1.3			8.41% (36)	11.21% (48)	11.21% (48)	30.37% (130)	38.79% (166)
item30	428	1.5	1.0	1.1			81.78% (350)	3.27% (14)	4.91% (21)	5.37% (23)	4.67% (20)
item32	428	3.6	4.0	1.6			23.13% (99)	7.01% (30)	8.18% (35)	14.95% (64)	46.73% (200)
item33	428	3.6	4.0	1.6			21.96% (94)	7.01% (30)	7.24% (31)	14.49% (62)	49.30% (211)
item35	428	3.9	5.0	1.7			22.90% (98)	1.87% (8)	3.74% (16)	9.35% (40)	62.15% (266)
item36	428	1.5	1.0	1.3			82.24% (352)	3.04% (13)	3.04% (13)	2.34% (10)	9.35% (40)
item37	428	2.3	2.0	1.3			38.32% (164)	23.36% (100)	20.09% (86)	10.98% (47)	7.24% (31)
item38	428	4.3	5.0	1.1			5.37% (23)	3.50% (15)	5.37% (23)	27.57% (118)	58.18% (249)
item40	428	2.2	2.0	1.2			39.49% (169)	25.00% (107)	19.63% (84)	11.45% (49)	4.44% (19)
item41	428	1.3	1.0	0.8			85.05% (364)	4.67% (20)	6.07% (26)	3.04% (13)	1.17% (5)
item45	428	2.2	1.0	1.5			53.04% (227)	7.01% (30)	16.36% (70)	11.92% (51)	11.68% (50)
item46	428	1.8	1.0	1.2			67.06% (287)	7.71% (33)	11.68% (50)	8.88% (38)	4.67% (20)
CFA (n =262)											
item01	262	2.3	2.0	1.4			40.46% (106)	22.52% (59)	14.50% (38)	10.69% (28)	11.83% (31)
item03	262	3.7	4.0	1.3			11.83% (31)	7.25% (19)	17.56% (46)	28.24% (74)	35.11% (92)
item04	262	1.3	1.0	0.8			89.31% (234)	2.29% (6)	3.44% (9)	3.05% (8)	1.91% (5)
item07	262	2.1	2.0	1.2			43.13% (113)	23.66% (62)	14.50% (38)	14.12% (37)	4.58% (12)
item08	262	3.0	3.0	1.2			14.12% (37)	22.90% (60)	20.99% (55)	32.06% (84)	9.92% (26)
item09	262	2.9	3.0	1.1			12.98% (34)	22.14% (58)	34.35% (90)	26.34% (69)	4.20% (11)
item10	262	2.6	3.0	1.1			17.56% (46)	29.39% (77)	29.01% (76)	21.37% (56)	2.67% (7)
item11	262	2.1	2.0	0.9			25.95% (68)	46.56% (122)	20.23% (53)	5.34% (14)	1.91% (5)
item12	262	2.3	2.0	1.2			32.06% (84)	30.92% (81)	19.08% (50)	11.45% (30)	6.49% (17)
item16	262	1.6	1.0	1.3			78.24% (205)	3.44% (9)	4.20% (11)	5.73% (15)	8.40% (22)
item17	262	1.6	1.0	1.2			80.15% (210)	3.44% (9)	5.34% (14)	2.67% (7)	8.40% (22)
item25	262	2.5	2.0	1.4			32.82% (86)	18.32% (48)	21.76% (57)	16.79% (44)	10.31% (27)
item27	262	4.0	4.0	1.2			6.11% (16)	7.25% (19)	8.02% (21)	33.59% (88)	45.04% (118)
item30	262	1.4	1.0	1.1			83.59% (219)	2.67% (7)	4.20% (11)	6.11% (16)	3.44% (9)
item32	262	3.4	4.0	1.7			25.95% (68)	4.20% (11)	11.45% (30)	16.79% (44)	41.60% (109)
item33	262	3.1	3.0	1.7			32.44% (85)	6.11% (16)	11.83% (31)	14.12% (37)	35.50% (93)
item35	262	3.6	5.0	1.8			27.48% (72)	2.67% (7)	7.25% (19)	6.49% (17)	56.11% (147)
item36	262	1.6	1.0	1.3			80.53% (211)	3.44% (9)	3.05% (8)	3.44% (9)	9.54% (25)
item38	262	4.3	5.0	1.1			4.20% (11)	7.63% (20)	6.49% (17)	21.37% (56)	60.31% (158)
item40	262	2.5	2.0	1.3			30.92% (81)	27.10% (71)	18.70% (49)	12.21% (32)	11.07% (29)
item41	262	1.2	1.0	0.7			90.08% (236)	3.82% (10)	2.29% (6)	2.67% (7)	1.15% (3)
item45	262	2.0	1.0	1.4			64.12% (168)	5.34% (14)	9.54% (25)	11.83% (31)	9.16% (24)
item46	262	1.6	1.0	1.2			75.57% (198)	2.67% (7)	8.02% (21)	9.54% (25)	4.20% (11)

[1] Histogram
[2] Density

Figure 6
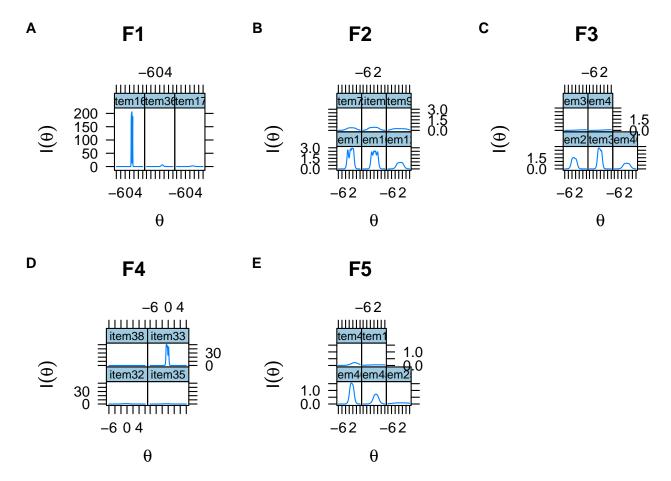
Figure 7. (A) Five Factor Model of LEBA

Figure 8. Item information curves (A) blue filter (B) natural light (C)smart device (D)sleep environment (E)electic light
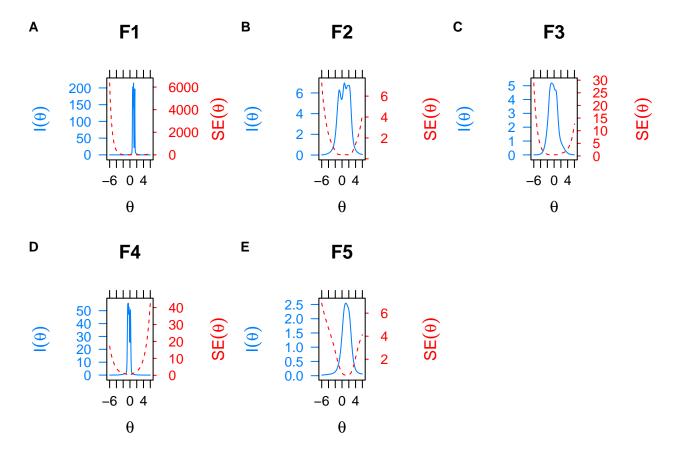
Figure 9. Test information curves (A) blue filter (B) natural light (C)smart device (D)sleep environment (E)electic light

Appendix A

Table A1

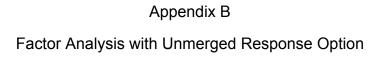*Factor loadings and communality of the retained items(Minmum Residual)*

item	MR1	MR2	MR3	MR4	MR5	Communality	Uniqueness
item16	1					0.996	0.004
item36	0.94					0.897	0.103
item17	0.8					0.658	0.342
item11		0.79				0.642	0.358
item10		0.76				0.592	0.408
item12		0.65				0.465	0.535
item7		0.5				0.267	0.733
item8		-0.49				0.252	0.748
item9		0.32				0.113	0.887
item27			0.8			0.659	0.341
item3			0.8			0.683	0.317
item40			0.65			0.464	0.536
item30			0.45			0.353	0.647
item41			0.36			0.329	0.671
item33				0.74		0.555	0.445
item32				0.73		0.623	0.377
item35				0.66		0.455	0.545
item37				-0.39		0.175	0.825
item38				0.38		0.178	0.822
item46					0.6	0.422	0.578
item45					0.59	0.374	0.626
item25					0.41	0.193	0.807
item4					0.41	0.219	0.781
item1					0.4	0.17	0.83
item26					0.35	0.165	0.835
% of Variance	0.1	0.1	0.09	0.08	0.06		

Note. Only loading higher than .30 is reported

Table A2

Factor loadings and communality of the retained items(six factor)

item	PA1	PA4	PA2	PA3	PA5	PA6	Communality	Uniqueness
item19	1.78						3.318	-2.318
item5							0.11	0.89
item16		1					1.004	-0.004
item36		0.91					0.86	0.14
item17		0.81					0.691	0.309
item11			0.83				0.71	0.29
item10			0.79				0.638	0.362
item12			0.63				0.465	0.535
item8			-0.5				0.269	0.731
item7			0.47				0.268	0.732
item9			0.32				0.163	0.837
item33				0.83			0.698	0.302
item32				0.75			0.666	0.334
item35				0.64			0.446	0.554
item31				0.48			0.331	0.669
item38				0.39			0.191	0.809
item37				-0.35			0.153	0.847
item3					0.85		0.748	0.252
item27					0.8		0.644	0.356
item40					0.68		0.507	0.493
item46						0.6	0.431	0.569
item45						0.56	0.341	0.659
item4						0.43	0.265	0.735
item25						0.4	0.178	0.822
item1						0.36	0.142	0.858
item26						0.36	0.173	0.827
item13							0.087	0.913
item29							0.108	0.892

Appendix B

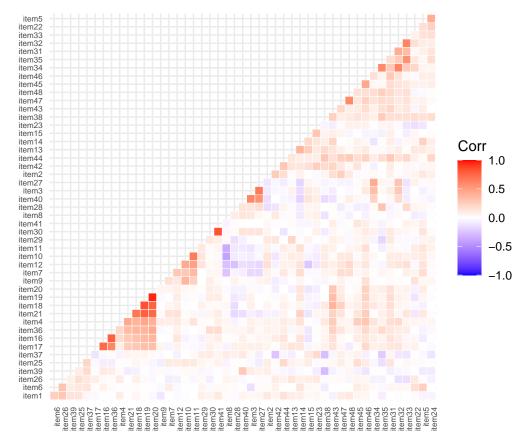Factor Analysis with Unmerged Response Option

Figure B1. Correlation plot of the items

692   Horn's parallel analysis with 500 iterations indicated a five-factor solution. However,

693 Scree plot and the MAP method suggested 6-factor solution. five-factor solution . As a

694 result, we tested both five-factor and six-factor solutions.

Five Factor Solution[Unmerged Responses] (24 Items)

F1

I use light therapy applying a blue light box.

I use light therapy applying a light visor.

I use light therapy applying a white light box.

I use light therapy applying another form of light device.

Five Factor Solution[Unmerged Responses] (24 Items)

I use an alarm with a dawn simulation light.

F2

I spend more than 3 hours per day (in total) outside.

I spend between 1 and 3 hours per day (in total) outside.

I spend as much time outside as possible.

I spend 30 minutes or less per day (in total) outside.

I go for a walk or exercise outside within 2 hours after waking up.

I spend between 30 minutes and 1 hour per day (in total) outside.

F3

I look at my mobile phone screen immediately after waking up.

I use my mobile phone within 1 hour before attempting to fall asleep.

I check my phone when I wake up at night.

F4

I use a blue-filter app on my computer screen within 1 hour before attempting to fall asleep.

I seek out knowledge on how to improve my light exposure.

I dim my computer screen within 1 hour before attempting to fall asleep.

I discuss the effects of light on my body with other people.

I modify my light environment to match my current needs.

I dim my room light within 1 hour before attempting to fall asleep.

I use as little light as possible when I get up during the night.

F5

I wear blue-filtering, orange-tinted, and/or red-tinted glasses indoors during the day.

I wear blue-filtering, orange-tinted, and/or red-tinted glasses outdoors during the day.

Five Factor Solution[Unmerged Responses] (24 Items)

I wear blue-filtering, orange-tinted, and/or red-tinted glasses within 1 hour before attempting to fall asleep.
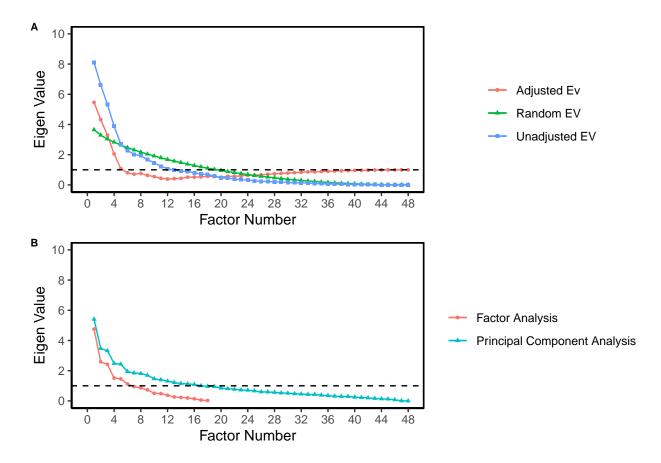
Figure B2. Factor Identification (A) Parallel analysis (B) Scree Plot

Table B1

Descriptive Statistics for Unmerged response options

	Mean	SD	Skew	Kurtosis	Shapiro-Wilk Statistics	Item-Total Correlation
Item1	2.16	1.51	0.49	-0.86	0.90*	.21
Item2	2.76	1.75	-0.10	-1.42	0.88*	.20
Item3	3.34	1.43	-0.58	-0.77	0.88*	.18
Item4	1.30	1.31	1.93	2.92	0.62*	.32
Item5	3.95	1.56	-1.42	0.75	0.70*	.19
Item6	2.70	1.66	0.02	-1.33	0.90*	.18
Item7	2.23	1.28	0.60	-0.59	0.89*	.18
Item8	2.95	1.24	-0.19	-0.70	0.93*	-.07
Item9	2.92	1.09	-0.37	0.11	0.91*	.14
Item10	2.73	1.07	-0.03	-0.52	0.92*	.27
Item11	2.17	0.93	0.44	0.20	0.89*	.25
Item12	2.34	1.26	0.46	-0.58	0.91*	.24
Item13	2.71	1.49	0.14	-1.29	0.89*	.28
Item14	2.11	1.34	0.68	-0.78	0.84*	.24
Item15	3.26	1.11	-0.34	-0.21	0.91*	.11
Item16	1.46	1.31	1.71	1.90	0.65*	.33
Item17	1.43	1.30	1.76	2.12	0.64*	.30
Item18	0.92	0.67	2.00	9.41	0.62*	.32
Item19	0.85	0.56	1.71	10.74	0.55*	.34
Item20	0.83	0.54	1.76	13.92	0.53*	.31
Item21	0.94	0.75	2.46	10.66	0.58*	.27
Item22	3.57	1.08	-0.72	0.08	0.88*	.19
Item23	2.53	1.31	0.22	-0.91	0.92*	.11
Item24	4.13	1.01	-1.39	2.01	0.78*	.19
Item25	2.57	1.43	0.22	-1.23	0.88*	.17
Item26	2.23	1.30	0.50	-0.63	0.88*	.16

Table B2

Factor loadings and communality of the retained items [Unmerged Responses]

item	PA1	PA2	PA5	PA3	PA4	Communality	Uniqueness	Complexity
item19	0.99					1.007	-0.007	1.058
item20	0.91					0.874	0.126	1.114
item18	0.82					0.711	0.289	1.123
item21	0.8					0.683	0.317	1.163
item4	0.47					0.25	0.75	1.298
item11		0.83				0.687	0.313	1.007
item10		0.81				0.67	0.33	1.031
item12		0.56				0.371	0.629	1.374
item8		-0.44				0.206	0.794	1.106
item7		0.42				0.226	0.774	1.614
item9		0.33				0.115	0.885	1.1
item16			0.95			0.946	0.054	1.097
item17			0.74			0.595	0.405	1.168
item36	0.3		0.73			0.653	0.347	1.431
item3				0.85		0.746	0.254	1.048
item27				0.78		0.624	0.376	1.028
item40				0.71		0.512	0.488	1.05
item35					0.58	0.351	0.649	1.091
item48					0.57	0.354	0.646	1.144
item33					0.55	0.32	0.68	1.085
item47					0.52	0.294	0.706	1.186
item44					0.45	0.216	0.784	1.145
item31					0.41	0.206	0.794	1.477
item38					0.33	0.129	0.871	1.317
% of Variance	0.15	0.09	0.09	0.08	0.08			

Note. Only loading higher than .30 is reported

Figure B3. Histogram of residulas: five-factor solution

Appendix C

697   LEBA captures light exposure-related behaviours on a 5 point Likert type scale

698   ranging from 1 to 5 (Never/Does not apply/I don't know = 1; Rarely = 2; Sometimes = 3;

699   Often = 4; Always = 5). The score of each factor is calculated by the summation of

700   scores of items belonging to the corresponding factor. The following instruction is given

701   before displaying the items: "Please indicate how often you performed the following

702   behaviours in the past 4 weeks."

Appendix D

LEBA Long Form (23 Items)

	Items	Never/Does not apply/I don't know	Rarely	Sometimes	Often	Always
1	I wear blue-filtering, orange-tinted, and/or red-tinted glasses indoors during the day.					
2	I wear blue-filtering, orange-tinted, and/or red-tinted glasses outdoors during the day.					
3	I wear blue-filtering, orange-tinted, and/or red-tinted glasses within 1 hour before attempting to fall asleep.					
4	I spend 30 minutes or less per day (in total) outside.					

	Items	Never/Does not apply/I don't know	Rarely	Sometimes	Often	Always
5	I spend between 1 and 3 hours per day (in total) outside.					
6	I spend between 30 minutes and 1 hour per day (in total) outside.					
7	I spend more than 3 hours per day (in total) outside.					
8	I spend as much time outside as possible.					
9	I go for a walk or exercise outside within 2 hours after waking up.					
10	I use my mobile phone within 1 hour before attempting to fall asleep.					

	Items	Never/Does not apply/I don't know	Rarely	Sometimes	Often	Always
11	I look at my mobile phone screen immediately after waking up.					
12	I check my phone when I wake up at night.					
13	I look at my smartwatch within 1 hour before attempting to fall asleep.					
14	I look at my smartwatch when I wake up at night.					
15	I dim my mobile phone screen within 1 hour before attempting to fall asleep.					
16	I use a blue-filter app on my computer screen within 1 hour before attempting to fall asleep.					

	Items	Never/Does not apply/I don't know	Rarely	Sometimes	Often	Always
17	I use as little light as possible when I get up during the night.					
18	I dim my computer screen within 1 hour before attempting to fall asleep.					
19	I use tunable lights to create a healthy light environment.					
20	I use LEDs to create a healthy light environment.					
21	I use a desk lamp when I do focused work.					
22	I use an alarm with a dawn simulation light.					
23	I turn on the lights immediately after waking up.					

703 **Latent Structure, Reliability and Structural Validity**

704   The long form of LEBA consists 23 items with five factors.

Factor names	Items	Reliability Coefficients: McDonald's Omega	Reliability Coefficients: Cronbach's alpha
F1: Wearing blue light filters	1-3	.93	.90
F2: Spending time outdoors	4-9 (Item 4 is reversed)	.80	.78
F3: Using phone and smartwatch in bed	10-14	.61	.62
F4: Using light before bedtime	15-18	.72	.62
F5: Using light in the morning and during daytime	19-23	.45	.41
		.73(Total scale)	

705   LEBA -long form showed satisfactory structural validity (CFI =.97; TLI = .96; RMSEA = .05[.04-.06, 90% CI]; SRMR =

706 .09).

707 **How to cite:**

Appendix E

LEBA Short Form (17 Items)

	Short Form (17 Items)	Never/Does not apply/I don't know	Rarely	Sometimes	Often	Always
01	I wear blue-filtering, orange-tinted, and/or red-tinted glasses indoors during the day.					
02	I wear blue-filtering, orange-tinted, and/or red-tinted glasses outdoors during the day.					
03	I wear blue-filtering, orange-tinted, and/or red-tinted glasses within 1 hour before attempting to fall asleep.					
04	I spend 30 minutes or less per day (in total) outside.					

	Short Form (17 Items)	Never/Does not apply/I don't know	Rarely	Sometimes	Often	Always
05	I spend between 1 and 3 hours per day (in total) outside.					
06	I spend more than 3 hours per day (in total) outside.					
07	I spend as much time outside as possible.					
08	I go for a walk or exercise outside within 2 hours after waking up.					
09	I use my mobile phone within 1 hour before attempting to fall asleep.					
10	I look at my mobile phone screen immediately after waking up.					
11	I check my phone when I wake up at night.					

	Short Form (17 Items)	Never/Does not apply/I don't know	Rarely	Sometimes	Often	Always
12	I dim my mobile phone screen within 1 hour before attempting to fall asleep.					
13	I use a blue-filter app on my computer screen within 1 hour before attempting to fall asleep.					
14	I dim my computer screen within 1 hour before attempting to fall asleep.					
15	I use tunable lights to create a healthy light environment.					
16	I use LEDs to create a healthy light environment.					
17	I use an alarm with a dawn simulation light.					

708 **Latent Structure, Reliability and Structural Validity**

709 The short form of LEBA consists 23 items with five factors.

Factor names	Items
F1: Wearing blue light filters	1-3
F2: Spending time outdoors	4-8 (Item 4 is reversed)
F3: Using phone and smart-watch in bed	9-11
F4: Using light before bedtime	12-14
F5: Using light in the morning and during daytime	15-17

710 **How to cite:**