

¹ *Light Exposure Behavior Assessment (LEBA): Development of a novel instrument to capture light exposure-related behaviours*

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30 This research is supported by funding from the Wellcome Trust (204686/Z/16/Z),
31 the European Training Network LIGHTCAP (project number 860613) under the Marie
32 Skłodowska-Curie actions framework H2020-MSCA-ITN-2019, the BioClock project
33 (number 1292.19.077) of the research program Dutch Research Agenda: Onderzoek op
34 Routes door Consortia (NWA-ORC) which is (partly) financed by the Dutch Research
35 Council (NWO), and the European Union and the nationals contributing in the context of
36 the ECSEL Joint Undertaking programme (2021-2024) under the grant #101007319.

37 The authors made the following contributions. Mushfiqul Anwar Siraji: Formal
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47 Manuel Spitschan: Conceptualization, Data curation, Investigation, Project
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49 editing.

50

Abstract

51 Light exposure is an important driver of health and well-being. Many aspects of light
52 exposure are modulated by our behaviour. How these light-related behaviours can be
53 shaped to optimise personal light exposure is currently unknown. Here, we present a
54 novel, self-reported and psychometrically validated instrument to capture light
55 exposure-related behaviour, the Light Exposure Behavior Assessment (LEBA). An expert
56 panel prepared the initial 48 item pool. Responses to these items were then collected in
57 an online survey producing responses from an international sample (690 completed
58 responses, 74 countries, 28 time zones). Exploratory factor analysis on an initial subset
59 of our sample ($n=428$) rendered a five-factor solution with 25 items (Wearing blue light
60 filters, spending time outdoors, using phone and smart-watch in bed, using light before
61 bedtime, using light in the morning and during daytime). Confirmatory factor analysis on
62 another subset of participants ($n=262$) yielded the best fit for the five-factor solution after
63 discarding another two items ($CFI=0.97$, $TLI=0.96$, $RMSEA=0.05$, $SRMR=0.09$). The
64 internal consistency reliability coefficient for the total instrument was McDonald's omega
65 =0.73. Measurement model invariance analysis between native and non-native English
66 speakers showed our model attained the highest level of invariance (residual invariance;
67 $CFI=0.95$, $TLI =0.95$, $RMSEA=0.05$). Lastly, a short form of LEBA ($n=18$) was developed
68 using Item Response Theory on the complete sample ($n=690$). The psychometric
69 properties of the LEBA instrument indicate the usability to measure the light
70 exposure-related behaviours across a variety of settings and may offer a scalable
71 solution to characterize light exposure-related behaviours in remote samples.

72 **Keywords:** light exposure, light-related behaviours, non-visual effects of light,
73 psychometrics

74 Word count: X

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

77 **Introduction**

- 78 • Light exposure is important
79 • Light exposure Behavior is important
80 • Table: Overview Existing Related Scales: items in total / items on light exposure
81 (behaviour)
82 • Existing Scales: Review them in text
83 • None of these do light exposure behavior.

84 **Methods**

85 **Ethical approval**

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

92 **Data Availability**

93 All code and data underlying this article is available on a public GitHub repository
94 (<https://github.com/leba-instrument/leba-manuscript>).

95 Survey characteristics

96 Data was collected in a quantitative cross-sectional approach via a fully anonymous
97 online survey hosted on REDCap (Harris et al., 2019, 2009) by way of the University of
98 Basel sciCORE. Participants were recruited via the website of a Comic co-released with
99 the survey(Weinzaepflen & Spitschan, 2021) , social media (i.e., LinkedIn, Twitter,
100 Facebook), mailing lists, word of mouth, the investigators' personal contacts, and
101 supported by distribution of the survey link via f.lux software (F.lux Software LLC, 2021).

102 Completing the online survey took approx. 15 to 20 minutes and was not
103 compensated. The first page of the survey comprised a participant information sheet,
104 where participants' informed consent to participate was obtained before any of the
105 questions were displayed. Underaged participants (<18 years) were urged to obtain
106 assent from their parents/legal guardians, before filling in the survey. Information on the
107 first page included the objectives of the study, inclusion criteria, estimated duration, the
108 use, storage and sharing of the data, compensation (none), and information about the
109 type of questions in the survey. Moreover, participants needed to confirm that they were
110 participating the survey for the first time. To ensure high data quality, five attention check
111 items were included in the survey (e.g., "We want to make sure you are paying attention.
112 What is 4+5?"). The data analysed in this study was collected between 17.05.2021 and
113 03.09.2021. Questions incorporating retrospective recall were all aligned to the period of
114 "past four weeks," matching the presented LEBA instrument.

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

- 117 • Sleep disturbance and sleep-related impairment (adult and pediatric versions)
118 (Bevans et al., 2019; Daniel J. Buysse et al., 2010; Forrest et al., 2018; Harb,
119 Hidalgo, & Martau, 2015; L. Yu et al., 2011)

- 120 • Sleep duration, timing, and latency, chronotype, social jetlag, time in bed,
- 121 work/sleep schedule and outdoor light exposure duration (version for adults and
- 122 adolescents) (Roenneberg, Wirz-Justice, & Merrow, 2003)
- 123 • Sleep environment (Olivier et al., 2016)
- 124 • Meal timing & caffeine consumption [custom items]
- 125 • Light sensitivity (photophobia vs. photophilia) (Wu & Hallett, 2017)
- 126 • Self-reported pubertal stage (only if younger than 18 years old) (Petersen,
- 127 Crockett, Richards, & Boxer, 1988)

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

- 129 • Age
- 130 • Sex
- 131 • Gender identity
- 132 • Occupational Status
- 133 • COVID-19 related Occupational setting during the past four weeks
- 134 • Time zone & country of residence
- 135 • English as native language

136 Participants

137 Table 2 summarizes the survey participants' demographic characteristics. Only
138 participants completing the full LEBA questionnaire were included, thus there are no
139 missing values in the item analyses. XX participants were excluded from analysis due to
140 not passing at least one of the "attention check" items. For exploring initial factor
141 structure (EFA), a sample of 250-300 is recommended (Comrey & Lee, 1992;
142 Schönbrodt & Perugini, 2013). For estimating the sample size for the confirmatory factor
143 analysis (CFA) we followed the N:q rule (Bentler & Chou, 1987; Jackson, 2003; Kline,
144 2015; Worthington & Whittaker, 2006), where ten participants per parameter is required

145 to earn trustworthiness of the result. Our sample size exceeds these requirements:
146 Anonymous responses from a total of $n = 690$ participants were included in the analysis
147 of the current study, split into samples for exploratory (EFA: $n = 428$) and confirmatory
148 factor analysis (CFA: $n = 262$). The EFA sample included participants filling out the
149 questionnaire from 17.05.2021 to XX.XX.XXXX , whereas participants who filled out the
150 questionnaire from YY.YY.YYYY to 03.09.2021 were included in the CFA analysis.
151 Participants indicated filling out the online survey from a diverse range of geographic
152 locations. The ten most common country + timezone combinations included:

- 153 • United States - America/New_York (UTC -04:00): 63 (9.1%)
- 154 • United Kingdom - Europe/London (UTC): 57 (8.3%)
- 155 • Germany - Europe/Berlin (UTC +01:00): 53 (7.7%)
- 156 • India - Asia/Kolkata (UTC +05:30): 38 (5.5%)
- 157 • United States - America/Los_Angeles (UTC -07:00): 37 (5.4%)
- 158 • United States - America/Chicago (UTC -05:00): 30 (4.3%)
- 159 • France - Europe/Paris (UTC +01:00): 22 (3.2%)
- 160 • Switzerland - Europe/Zurich (UTC +01:00): 21 (3.0%)
- 161 • Brazil - America/Sao_Paulo (UTC -03:00): 19 (2.8%)
- 162 • Netherlands - Europe/Amsterdam (UTC +01:00): 19 (2.8%)

163 For a complete list of geographic locations, see Suppl. Table X in the appendix.

164 Age among all participants ranged from 11 years to 84 years [EFA: $\min = 11$, $\max =$
165 84; CFA: $\min = 12$, $\max = 74$], with an overall mean of ~ 33 years of age [Overall: $M =$
166 32.95, $SD = 14.57$; EFA: $M = 32.99$, $SD = 15.11$; CFA: $M = 32.89$, $SD = 13.66$]. In total
167 325 (47%) of the participants indicated female sex [EFA: 189 (44%); CFA: 136 (52%)],
168 351 (51%) indicated male [EFA: 230 (54%); CFA: 121 (46%)] and 14 (2.0%) indicated
169 other sex [EFA: 9 (2.1%), CFA: 5 (1.9%)]. Overall, 49 (7.2%) [EFA: 33 (7.8%); CFA: 16
170 (6.2%)] participants indicated a gender-variant identity. In a “Yes/No” question regarding

native language, 320 (46%) of respondents [EFA: 191 (45%); CFA: 129 (49%)] indicated to be native English speakers. For their “Occupational Status,” more than half of the overall sample reported that they currently work [Overall: 396 (57%); EFA: 235 (55%); CFA: 161 (61%)], whereas 174 (25%) [EFA: 122 (29%); CFA: 52 (20%)] reported that they go to school and 120 (17%) [EFA: 71 (17%); CFA: 49 (19%)] responded that they do “Neither.” With respect to the COVID-19 pandemic we asked participants to indicate their occupational setting during the last four weeks: In the overall sample 303 (44%) [EFA: 194 (45%); CFA: 109 (42%)] of the participants indicated that they were in a home office/home schooling setting, while 109 (16%) overall [EFA: 68 (16%); CFA: 41 (16%)] 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 on vacation)” 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 $q \geq 0.2$).

Item Generation

To ensure construct adequacy we thoroughly assessed the current status of literature and identified a variety of light exposure related scales. However, no scales specifically measuring the behavioral component of light exposure were found (Table 1). Consequentially we pursued to introduce a new openly available scale to address this research gap. For this purpose an expert researcher panel from the fields of

197 chronobiology, light research, neuroscience and psychology (including seven of the
198 authors, see authors roles) generated and collected preliminary item ideas. Special
199 attention was paid to design items circumscribed to assess light exposure *behavior* as
200 opposed to subjective measurements of the light environment (cf.(Eklund & Boyce,
201 1996) & (Dianat, Sedghi, Bagherzade, Jafarabadi, & Stedmon, 2013)) and
202 semi-quantitative assesments of light sources' illuminance (cf. (Bajaj, Rosner, Lockley, &
203 Schernhammer, 2011)) in order to maintain content validity. In a collective effort the
204 generated items were then peer-reviewed, amended, unified, and complemented with a
205 suitable response scale (5 point Likert-scale ranging from 1 "Never/Does not apply/
206 don't know" to 5 "Always"). This process was finalized when all experts were in
207 agreement, resulting in 48 items to implement in the data collection.

208 Analytic Strategies

209 Figure 1 summarizes the steps of our psychometric analysis. In our analysis we
210 used R (version 4.1.0), with several R packages. Initially, our tool had six point Likert
211 type response format (0:Does not apply/I don't know; 1:Never, 2:Rarely; 3:Sometimes;
212 4:Often; 5:Always). Our purpose was to capture light exposure related behavior and
213 these two response options: "Does not apply/I don't know" and "Never" were providing
214 similar information. As such we decided to collapse them into one, making it a 5 point
215 Likert type response format. Necessary assumptions of EFA, including sample
216 adequacy, normality assumptions, quality of correlation matrix, were assessed. Our data
217 violated both the univariate and multivariate normality assumptions. Due to these
218 violations and the ordinal nature of our response data, we used polychoric correlation
219 matrix (Desjardins & Bulut, 2018) for the EFA. We employed principal axis (PA) as factor
220 extraction method with varimax rotation. PA is robust to the normality assumption
221 violations (Watkins, 2020). The obtained latent structure was confirmed by another factor
222 extraction method: "the minimum residuals extraction" as well. We used a combination

223 of factor identification method including scree plot (Cattell, 1966), Horn's parallel analysis
224 (Horn, 1965), minimum average partials method (Velicer, 1976), and hull method
225 (Lorenzo-Seva, Timmerman, & Kiers, 2011) to identify factor numbers. Additionally, to
226 determine the simple structure, we followed the guidelines recommended by
227 psychometricians: (i) no factors with fewer than three items (ii) no factors with a factor
228 loading <0.3 (iii) no items with cross-loading greater than .3 across factors (Bandalos &
229 Finney, 2018). We confirmed the latent structure obtained in the EFA by conducting a
230 categorical "Confirmatory Factor Analysis" (CFA) using "robust weighted least square
231 estimator" (WLSMV). We established the measurement invariance of our tool across the
232 native and non-native English speakers using structural equation model framework. To
233 assess the possible semantic overlap of our tool with the existing tools, we sought to
234 "Semantic Scale Network" (Rosenbusch, Wanders, & Pit, 2020). To assess the possible
235 semantic overlap of our tool with the existing tools, we sought to "Semantic Scale
236 Network" (Rosenbusch et al., 2020). Lastly, we sought "Item Response Theory" (IRT)
237 based analysis on developing a short form of LEBA. We also conducted psychometric
238 analysis on non-merged response options data (Supp. Table C2) and rejected the latent
239 structure obtained as the factors were less interpretable.

240

Results

241 **Item Analysis**

242 Table 3 summarizes the univariate descriptive statistics for the 48 items. Some of
243 the items were skewed with high Kurtosis values. Our data violated both univariate
244 normality (Shapiro-Wilk statistics; (Shapiro & Wilk, 1965)) and multivariate normality
245 assumptions [Marida's test;(Mardia, 1970)]. Multivariate skew was = 583.80 ($p < 0.001$)
246 and multivariate kurtosis was = 2,749.15 ($p < 0.001$). Due to these violations and ordinal
247 nature of the response data polychoric correlations over Pearson's correlations was

248 chosen (Desjardins & Bulut, 2018). The corrected item-total correlation ranges between
249 .03 -.48. However, no item was discarded based on descriptive statistics or item analysis.

250 **Exploratory Factor Analysis**

251 Sampling adequacy was checked using Kaiser-Meyer-Olkin (KMO) measures of
252 sampling adequacy (Kaiser, 1974) . The overall KMO vale for 48 items was 0.63 which
253 was above the cutoff value (.50) indicating a mediocre sample (Hutcheson, 1999).
254 Bartlett's test of sphericity (Bartlett, 1954), χ^2 (1128) = 5042.86, p < .001 indicated the
255 correlations between items are adequate for the EFA. However only 4.96% of the
256 inter-item correlation coefficients were greater than .30. The absolute value of inter-item
257 correlation ranged between .00 to .91. Figure 2 depicts the correlation matrix.

258

259 Scree plot (Figure 3) suggested a six-factor solution. Horn's parallel analysis
260 (Horn, 1965) with 500 iterations also indicated a six-factor solution. However, the
261 minimum average partial (MAP) method (Table A1) (Velicer, 1976) and Hull method
262 (Lorenzo-Seva et al., 2011) (Figure 3) suggested a five-factor solution. As a result, we
263 tested both five-factor and six-factor solutions.

264 With the initial 48 items we conducted three rounds of EFA and gradually discarded
265 problematic items. (cross-loading items and poor factor loading (<.30) items). Finally, a
266 five-factor EFA solution with 25 items was accepted with low RMSR = 0.08 (Brown,
267 2015), all factor-loading higher than .30 and no cross-loading greater than .30. We
268 further confirmed this five-factor latent structure by another EFA using varimax rotation
269 with a minimum residual extraction method (Sup.Table B1). Table 4 displays the
270 factor-loading (structural coefficients) and communality of the items. The absolute value
271 of the factor-loading ranged from .49 to .99 indicating strong coefficients. The

272 commonalities ranged between .11 to .99. Figure 4(A) depicts the obtained five factor
273 structure. However, the histogram of the absolute values of non-redundant
274 residual-correlations (Figure 4(B)) showed 26% correlations were greater than the
275 absolute value of .05, indicating a possible under-factoring. (Desjardins & Bulut, 2018).
276 Subsequently, we fitted a six-factor solution. However, a factor emerged with only two
277 salient variables, thus disqualifying the six-factor solution (Sup.Table C1). Internal
278 consistency reliability coefficient Cronbach's alpha assumes all the factor-loadings of the
279 items under a factor are equal (Graham, 2006; Novick & Lewis, 1967) which is not the
280 case in our sample. Additionally Cronbach's alpha coefficient has a tendency to deflate
281 the estimates for Likert type data as the calculation is based on pearson-correlation
282 matrix which requires that response data should be in continuous of nature (Gadermann,
283 Guhn, & Zumbo, 2012; Zumbo, Gadermann, & Zeisser, 2007). Subsequently to get
284 better estimates of reliability we reported ordinal alpha which used polychoric-correlation
285 matrix and assumed that the responses data were ordered in nature instead of
286 continuous (Zumbo et al., 2007). Ordinal alpha coefficient value ranges from 0 to 1 and
287 higher value represents better reliability. In the five-factor solution, the first factor
288 contained three items and explained 10.25% of the total variance with a internal reliability
289 coefficient ordinal $\alpha = .94$. All the items in this factor stemmed from the individual's
290 preference to use blue light filters in different light environments. The second factor
291 contained six items and explained 9.93% of the total variance with a internal reliability
292 coefficient ordinal $\alpha = .76$. Items under this factor commonly investigated an individual's
293 hours spent outdoor. The third factor contained five items and explained 8.83% of the
294 total variance. Items under this factor dealt with the specific behaviors pertaining to using
295 phone and smart-watch in bed. The internal consistency reliability coefficient was,
296 ordinal $\alpha = .75$. The fourth factor contained five items and explained 8.44% of the total
297 variance with an internal consistency coefficient, ordinal $\alpha = .72$. These five items
298 investigated the behaviors related to individual's light exposure before bedtime. Lastly,

299 the fifth factor contained six items and explained 6.14% of the total variance. This factor
300 captured individual's morning and daytime light exposure related behavior. The internal
301 consistency reliability was, ordinal $\alpha = .62$. It is essential to attain a balance between
302 psychometric properties and interpretability of the common themes when exploring the
303 latent structure. As all of the emerged factors are highly interpretable and relevant
304 towards our aim to capture light exposure related behavior, regardless of the apparent
305 low reliability of the fifth factor, we retain all the five-factors with 23 items for our
306 confirmatory factor analysis (CFA). Two items showed negative factor-loading (items 44
307 and 21). Upon inspection, it was understood that these items are negatively correlated to
308 the common theme, and thus in the CFA analysis, we reversed the response code for
309 these two items. Figure ?? depicts the data distribution and endorsement pattern for the
310 included items in our LEBA tool for both the EFA and CFA sample.

311 Confirmatory Factor Analysis

312 We conducted categorical confirmatory factor analysis with robust weighted least
313 square (WLSMV) estimator since our response data was of ordinary nature (Desjardins
314 & Bulut, 2018). Several indices are suggested to measure model fit which can be
315 categorized as absolute, comparative and parsimony fit indices (Brown, 2015). Absolute
316 fit assess the model fit at an absolute level using indices including χ^2 test statistics and
317 the standardized root mean square (SRMR). Parsimony fit indices including the root
318 mean square error of approximation (RMSEA) considers the number of free parameters
319 in the model to assesses the parsimony of the model. Comparative fit indices evaluate
320 the fit of the specified model solution in relation to a more restricted baseline model
321 restricting all covariances among the indicators as zero. Comparative fit index (CFI) and
322 the Tucker Lewis index (TLI) are such two comparative fit indices. Commonly used
323 Model fit guidelines (Hu & Bentle, 1999; Schumacker & Lomax, 2004) includes (i)
324 Reporting of χ^2 test statistics (A non-significant test statistics is required to reflect model

325 fit) (ii) CFI and TLI (CFI/TLI close to .95 or above/ranging between 90-95 and above) (iii)
326 RMSEA (close to .06 or below), (iv) SRMR (close to .08 or below) to estimate the model
327 fit. Table 5 summarizes the fit indices of our fitted model. Our fitted model failed to attain
328 an absolute fit estimated by the χ^2 test. However, the χ^2 test is sensitive to sample size
329 and not recommended to be used as the sole index of absolute model fit (Brown, 2015).
330 Another absolute fit index we obtained in our analysis was SRMR which does not work
331 well with categorical data (C. Yu, 2002). We judged the model fit based on the
332 comparative fit indices: CFI, TLI and parsimony fit index:RMSEA. Our fitted model
333 attained acceptable fit (CFI = .94; TLI = .93); RMSEA = .06,[.05-.07, 90% CI]) with two
334 imposed equity constrain on item pairs 32-33 [I dim my mobile phone screen within 1
335 hour before attempting to fall asleep.;I dim my computer screen within 1 hour before
336 attempting to fall asleep.] and 16-17 [I wear blue-filtering, orange-tinted, and/or
337 red-tinted glasses indoors during the day.;I wear blue-filtering, orange-tinted, and/or
338 red-tinted glasses outdoors during the day.]. Items pair 32-33 stemmed from the
339 preference of dimming electric device's brightness before bed time and items pair 16 and
340 19 stemmed from the preference of using blue filtering or colored glasses during the
341 daytime. Nevertheless, SRMR value was higher than the guideline (SRMR = .12).
342 Further by allowing one pair of items (30-41) [I look at my smartwatch within 1 hour
343 before attempting to fall asleep.;I look at my smartwatch when I wake up at night.] to
344 covary their error variance and discarding two item (item 37 & 26) for very low r-square
345 value, our model attained best fit (CFI = .97; TLI = .96); RMSEA = .05[.04-.06, 90% CI])
346 and SRMR value (SRMR = .09) was also close to the suggestions of Hu and Bentle
347 (1999). Internal consistency ordinal α for the five factors of LEBA were .96, .83, .70, .69,
348 .52 respectively. We also estimated the internal consistency reliability of the total scale
349 using McDonald's ω_t coefficient which is a better reliability estimate for multidimensional
350 constructs (Dunn, Baguley, & Brunsden, 2014; Sijtsma, 2009). McDonald's ω_t coefficient
351 for the total scale was .73. Figure 7 depicts the obtained CFA structure.

352 **Measurement Invariance**

353 Measurement invariance (MI) evaluates whether a construct has the psychometric
354 equivalence and same meaning across groups or measurement occasions (Kline, 2015;
355 Putnick & Bornstein, 2016). We used structural equation modeling framework to assess
356 the measurement invariance of our developed tool across two groups: native English
357 speakers(n= 129) and non-native English speakers (n = 133). For a detailed description
358 these two groups please see Sup. Table ???. Our measurement invariance testing
359 involved successively comparing the nested models: configural, metric, scalar, and
360 residual invariance models with each others (Widaman & Reise, 1997). Among these
361 nested models configural model is the first and least restrictive model. The configural
362 model assumes that the number of factors and item number under each factor will be
363 equal across two groups. The metric invariance model assumes configural invariance of
364 the fitted model and requires the factor-loadings of the items across the two groups to be
365 equal. Having the factor-loadings equal across groups indicates each item contributes to
366 the measured construct equivalently. Scalar invariance assumes the metric invariance of
367 the fitted model demands the item intercepts to be equivalent across groups. This equity
368 of item intercepts indicates the equivalence of response scale across the groups, i.e.,
369 persons with the same level of the underlying construct will score the same across the
370 groups. The residual invariance model assumes metric invariance for the fitted model
371 and adds the assumption of equality in error variances and covariances across the
372 groups. This model is the highest level of MI and assures the equivalence of precision of
373 items across the groups in measuring the underlying constructs. The invariance model fit
374 of our tool was assessed using the fit indices including χ^2 test, CFI and TLI (close to .95
375 or above), RMSEA (close to .06 or below) (Hu & Bentle, 1999). We excluded SRMR
376 from our consideration as it does not behave optimally for categorical variables (C. Yu,
377 2002). Table 6 summarized the fit indices. The comparison among different
378 measurement invariance models was made using the χ^2 difference test ($\Delta\chi^2$) to

379 assess whether our obtained latent structure of “LEBA” attained the highest level of the
380 MI. A non-significant $\Delta\chi^2$ test between two MI models fit indicates mode fit does not
381 significantly decrease for the superior model (Dimitrov, 2010) thus allowing the superior
382 level of invariance model to be accepted. We started our analysis by comparing the
383 model fit of the least restrictive model:configural model to metric MI model and continued
384 successive comparisons. Table 6 indicates that our fitted model had acceptable fit
385 indices for all of the fitted MI models. The model fit did not significantly decrease across
386 the nested models up to the scalar MI model. The chi-square value difference between
387 the scalar and residual model is zero, indicating model fit remained the same for both:
388 scalar and residual MI model, indicating the acceptability of the residual MI model.

389 **Semantic Analysis**

390 To find out if our developed tool (23 items) is overlapping with existing instruments,
391 we subjected the items of LEBA to the “Semantic Scale Network”(SSN) analysis
392 (Rosenbusch et al., 2020). The SSN detects semantically related scales and provides
393 cosine similarity index ranging between -.66 to 1 (Rosenbusch et al., 2020). Pair of
394 scales with a cosine similarity index value of 1 indicates they are perfectly semantically
395 similar scales indicating redundancy. LEBA appeared most strongly related to scales
396 about sleep: “Sleep Disturbance Scale For Children” (Bruni et al., 1996) and
397 “WHO-Composite International Diagnostic Interview (CIDI): Insomnia”(WHO, 1990).The
398 cosine similarities lie between .47 to .51. Flesch-Kincaid Grade Level (Flesch, 1948)
399 analysis on the the 23 items of our scale indicated required educational grade level was
400 3.33 and with a age above 8.33.

402 **Developing Short form of LEBA**

403 We sought the item response theory (IRT) to develop the short form of LEBA. IRT
404 the conventional classical test theory-based analysis by gathering information on item
405 quality by indices like item difficulty, item discrimination, and item information (Baker,
406 2017). Item is judged based on item information in relation to participants' latent trait
407 level (θ). We fitted each factor of LEBA with the graded response model (Samejima,
408 Liden, & Hambleton, 1997) to the combined EFA and CFA sample (n =690). Item
409 discrimination indicates the pattern of variation in the categorical responses with the
410 changes in latent trait level (θ), and item information curve (IIC) indicates the amount of
411 information an item carries along the latent trait continuum. Here, we reported the item
412 discrimination parameter and only discarded the items with relatively flat item information
413 curve (information <.2) to develop the short form of LEBA. Baker (2017) categorized the
414 item discrimination in as none = 0; very low =0.01 to 0.34; low = 0.35 to 0.64; moderate =
415 0.65 to 1.34 ; high = 1.35 to 1.69; very high >1.70. Table 7 summarizes the IRT
416 parameters of our tool. Item discrimination parameters of our tool fell in very high (10
417 items), high (4 items), moderate (4 items), and low (5 items) categorizes indicating a
418 good range of discrimination along the latent trait level (θ). Examination of the item
419 information curve (Sup.fig A2-A5) indicated 5 items (1, 25, 38, 30, & 41) had relatively
420 flat information curves ($I(\theta) < .20$) thus discarded creating a short form of LEBA with 5
421 factors and 18 items.

422 Test information curve (TIC) (Figure 8) indicate the amount of information an the
423 full-scale carry along the latent trait continuum. As we treated each factor of short-LEBA
424 as an unidimensional construct we obtain 5 TICs (Figure 8). These information curves
425 indicated except the first and fifth factors, the other three factor's TICs are roughly
426 centered on the center of the trait continuum (θ).The first and fifth factor had a peak to
427 the right side of the center of latent trait.Thus we conferred the LEBA tool estimated the

428 light exposure related behavior with precision near the center of trait continuum for 2nd,
429 3rd and 4th factors and near the right side of the center of trait continuum for 1st and 5th
430 factors (Baker, 2017).

431 Table 8 summarizes the item fit indexes of the items. All the items fitted well to the
432 respective models as assessed by RMSEA value obtained from Signed- χ^2 index
433 implementation. All of the items had RMSEA value $\leq .06$ indicating adequate fit.
434 Sup.Figure A6 depicts the person fit of out fitted models. Person fit indicates the validity
435 and meaningfulness of the fitted model at the participants latent trait level (Desjardins &
436 Bulut, 2018). We estimated the person fit statistics using standardized fit index Zh
437 statistics (Drasgow, Levine, & Williams, 1985). Zh < -2 should be considered as a misfit.
438 Fig indicates that Zh is larger than -2 for most participants, suggesting a good fit of the
439 selected IRT models.

440 Discussion

441 We developed a self-reported tool to capture different light exposure related
442 behavior and evaluated its psychometric properties using classical test theory and item
443 response theory based analysis.

444 48 items were generated by an expert panel and administered to a large sample (n
445 = 428 to explore the latent structure. Exploratory factor analysis revealed a five factor
446 solution with 25 items. ("Wearing blue light filters," "Spending time outdoors," "Using
447 phone and smart-watch in bed," "Using light before bedtime," and "Using light in the
448 morning and during daytime"). The internal consistency reliability coefficient ordinal
449 alpha ranged between .62-.94. As all the retained factors were meaningful and
450 contributed essentially towards our aim we retained all five factors.

451 A CFA on a separate sample (($n = 262$ gave a five-factor solution (CFI = .97; TLI =
452 .96); RMSEA = .05[.04-.06, 90% CI]) and SRMR = .09) after discarding two item. The

453 internal consistency McDonald's ω_t of the five factors were satisfactory (.96, .83, .70,
454 .69, .52) Internal consistency reliability of the total scale (23 items) was also satisfactory,
455 McDonald's $\omega_t = .73$. In the same sample, our measurement invariance analysis
456 revealed that the latent structure attained the residual measurement invariance across
457 subgroups: male and female (CFI: .98, TLI: .98, SRMR: .98).

458 The "Semantic Scale Network"(SSN) analysis (Rosenbusch et al., 2020) on the
459 retained 23 items showed "LEBA" was related to "Sleep Disturbance Scale For Children"
460 (SDSC) (Bruni et al., 1996) and "WHO-Composite International Diagnostic Interview
461 (CIDI): Insomnia"(WHO, 1990). Upon inspecting the item contents we found items under
462 "Using phone and smart-watch in bed" and "Using light before bedtime" have semantic
463 overlap with the items of SDSC ans CIDI. Items in those two scales were looking into
464 behaviors related to sleep. As such the similarity index obtained is expected.
465 Flesch-Kincaid Grade Level (Flesch, 1948) analysis on the the 23 items of our scale
466 indicated required educational grade level was 3.33 and with a age above 8.33.

467 Lastly, we developed a short-LEBA (n=23) using IRT analysis. We fitted a graded
468 response model model to the combined EFA and CFA sample (n =690). We discarded 5
469 items with relatively flat item information curve [$I(\theta) < .20$]. IRT analysis indicated short
470 form of LEBA is a psychometrically sound measure. Item fit indexes and person fit index
471 for all five fitted model were acceptable. Items had diverse slope parameters indicating a
472 good range of discrimination- the ability to differentiate respondents with different levels
473 of the light exposure related behavior. Test information curve also indicated a good
474 coverage of underlying trait continuum with precision.

475 Conclusion

476 "The Light exposure behavior assessment"(LEBA) gave a five solution with 25
477 items in an exploratory factor analysis. A confirmatory factor analysis with this 25-item

⁴⁷⁸ scale again offered a five-factor solution, but this time two more item was discarded. The
⁴⁷⁹ 23-item “LEBA” was found reliable and valid. A short-form of LEBA was developed using
⁴⁸⁰ IRT analysis. IRT analysis gave a 18-item scale with a good range of coverage across
⁴⁸¹ the underlying trait continuum. All-in-all, we can recommend both forms to be used to
⁴⁸² capture individual’s light exposure related behavior

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Table 1

Releated Scales

Name	Author	Description	Relevant Items	Scale type	Validity evidences
Visual Light Sensitivity Questionnaire-8	Verriotto et al., 2017	Eight-question survey to assess the presence and severity of photosensitivity symptoms	None	5-point Likert scale	Not available
Office Light Survey	Eklundet al., 1996	30 items survey to assess electrical lighting environment in office	Item 29	Mixed response format	Not available

Table 1

Releated Scales (continued)

Name	Author	Description	Relevant Items	Scale type	Validity evidences
Harvard Light Exposure Assessment Questionnaire	Bajaj et al., 2011	1 item semi-quantitative light questionnaire	None	Semi-quantitative	Correlation with physical measurement
Hospital Lighting Survey	Dianat et al., 2013	23 items questionnaire to assess light environment in a hospital	Item 16,17	5-point Likert scale	Face and Content validity
Morningness-Eveningness Questionnaire	Horne et al., 1976	19 items questionnaire to understand your body clock	item 1,2,8,13,14	Mixed response format	Correlation with the oral temperature

Table 1

Releated Scales (continued)

Name	Author	Description	Relevant Items	Scale type	Validity evidences
Munich Chrono-type Questionnaire (MCTQ)	Roenneberg et al., 2003	17 items questionnaire to understand stand individuals phase of entrainment	Time spect outdoors	Mixed response format	Correlation with sleep-logs, actimetry, and physiological parameters
Sleep Practices and Attitudes Questionnaire (SPAQ)	Olivier et.al., 2016	16 Factor questionnaire measuring practice, behavior and attitude related sleep	Subscale 8&9	5-point Likert scale	Face and Construct validity

Table 1

Releated Scales (continued)

Name	Author	Description	Relevant Items	Scale type	Validity evidences
The Pittsburgh Sleep Quality Index (PSQI)	Buysse et al., 1989	9 items inventory to measure sleep quality and sleeping pattern	item 1-4	Mixed response format	Correlation with clinical measurements
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 3,6,22-25 and 29	5-point Likert scale	Construct validity

Table 1

Releated Scales (continued)

Name	Author	Description	Relevant Items	Scale type	Validity evidences
Photosensitivity Assess- ment Question- naire (PAQ)	Bossini et al., 2006	16 dichoto- mous (yes/no) items question- naire to assess "photopho- bia" and "pho- tophilia"	All items	Binary response option	Not available

Table 2

Demographic Characteristics

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 False discovery rate correction for multiple testing³ Wilcoxon rank sum test⁴ Pearson's Chi-squared test

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*	0.19
Item2	2.87	1.59	0.08	-1.60	0.83*	0.28
Item3	3.36	1.38	-0.48	-1.03	0.87*	0.23
Item4	1.47	1.18	2.38	4.00	0.43*	0.24
Item5	4.01	1.40	-1.22	0.07	0.70*	0.17
Item6	2.79	1.55	0.19	-1.48	0.85*	0.13
Item7	2.26	1.25	0.70	-0.60	0.85*	0.32
Item8	2.97	1.20	-0.06	-0.94	0.91*	0.25
Item9	2.94	1.03	-0.12	-0.40	0.91*	0.08
Item10	2.74	1.04	0.09	-0.74	0.91*	0.42
Item11	2.18	0.90	0.60	0.12	0.86*	0.41
Item12	2.36	1.22	0.59	-0.62	0.87*	0.48
Item13	2.73	1.46	0.20	-1.36	0.87*	0.25
Item14	2.14	1.31	0.77	-0.78	0.80*	0.28
Item15	3.26	1.09	-0.26	-0.45	0.91*	0.03
Item16	1.56	1.23	2.00	2.45	0.50*	0.28
Item17	1.54	1.21	2.07	2.75	0.49*	0.21
Item18	1.12	0.49	5.02	27.80	0.25*	0.18
Item19	1.05	0.36	7.23	52.98	0.13*	0.17
Item20	1.04	0.33	8.99	85.28	0.10*	0.16
Item21	1.14	0.59	4.79	24.05	0.25*	0.21
Item22	3.57	1.07	-0.65	-0.17	0.88*	0.20
Item23	2.56	1.27	0.33	-1.00	0.89*	0.08

Table 3 continued

	Mean	SD	Skew	Kurtosis	Shapiro-Wilk Statistics	Item-Total Correlation
Item24	4.14	0.99	-1.23	1.14	0.79*	0.22
Item25	2.59	1.41	0.27	-1.27	0.86*	0.15
Item26	2.25	1.27	0.69	-0.64	0.84*	0.08
Item27	3.80	1.29	-0.87	-0.42	0.82*	0.17
Item28	3.76	1.14	-0.68	-0.45	0.86*	0.18
Item29	2.44	1.31	0.38	-1.14	0.86*	0.13
Item30	1.48	1.11	2.18	3.35	0.48*	0.13
Item31	3.00	1.62	-0.08	-1.61	0.83*	0.39
Item32	3.55	1.65	-0.60	-1.34	0.76*	0.33
Item33	3.62	1.64	-0.68	-1.25	0.74*	0.37
Item34	3.42	1.83	-0.45	-1.69	0.69*	0.20
Item35	3.86	1.67	-0.99	-0.85	0.65*	0.20
Item36	1.54	1.25	2.13	2.86	0.46*	0.35
Item37	1.33	0.91	3.03	8.43	0.41*	0.09
Item38	4.30	1.08	-1.79	2.53	0.67*	0.32
Item39	1.96	0.98	1.02	0.69	0.82*	0.07
Item40	2.16	1.19	0.71	-0.54	0.84*	0.25
Item41	1.31	0.81	2.75	6.92	0.43*	0.14
Item42	3.93	1.48	-1.06	-0.44	0.71*	0.15
Item43	1.64	1.18	1.79	2.02	0.60*	0.22
Item44	3.51	1.30	-0.70	-0.59	0.85*	0.40
Item45	2.22	1.48	0.71	-1.02	0.76*	0.29
Item46	1.76	1.23	1.35	0.44	0.66*	0.39
Item47	2.11	1.17	0.77	-0.39	0.83*	0.37

Table 3 continued

	Mean	SD	Skew	Kurtosis	Shapiro-Wilk Statistics	Item-Total Correlation
Item48	2.60	1.25	0.29	-0.86	0.89*	0.36

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-Square	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	28.13	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	1.37	-1.09	-0.98	-0.75	-0.40
item38	0.40	-7.48	-5.56	-4.23	-0.90
item33	12.31	-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

Table 8

Item fit statistics for the fitted models

Item	Signed Chi-square	df	RMSEA	p
item16	2.02	6.00	0.00	0.92
item36	39.07	13.00	0.05	0.00
item17	25.58	13.00	0.04	0.02
item11	55.03	27.00	0.04	0.00
item10	53.19	30.00	0.03	0.01
item12	34.39	42.00	0.00	0.79
item7	67.45	46.00	0.03	0.02
Ritem8	140.90	46.00	0.05	0.00
item9	131.19	45.00	0.05	0.00
item27	16.41	11.00	0.03	0.13
item3	15.09	11.00	0.02	0.18
item40	9.92	9.00	0.01	0.36
item32	41.33	15.00	0.05	0.00
item35	41.71	14.00	0.05	0.00
item33	46.89	14.00	0.06	0.00
item46	19.00	15.00	0.02	0.21
item45	15.05	15.00	0.00	0.45
item25	31.60	15.00	0.04	0.01

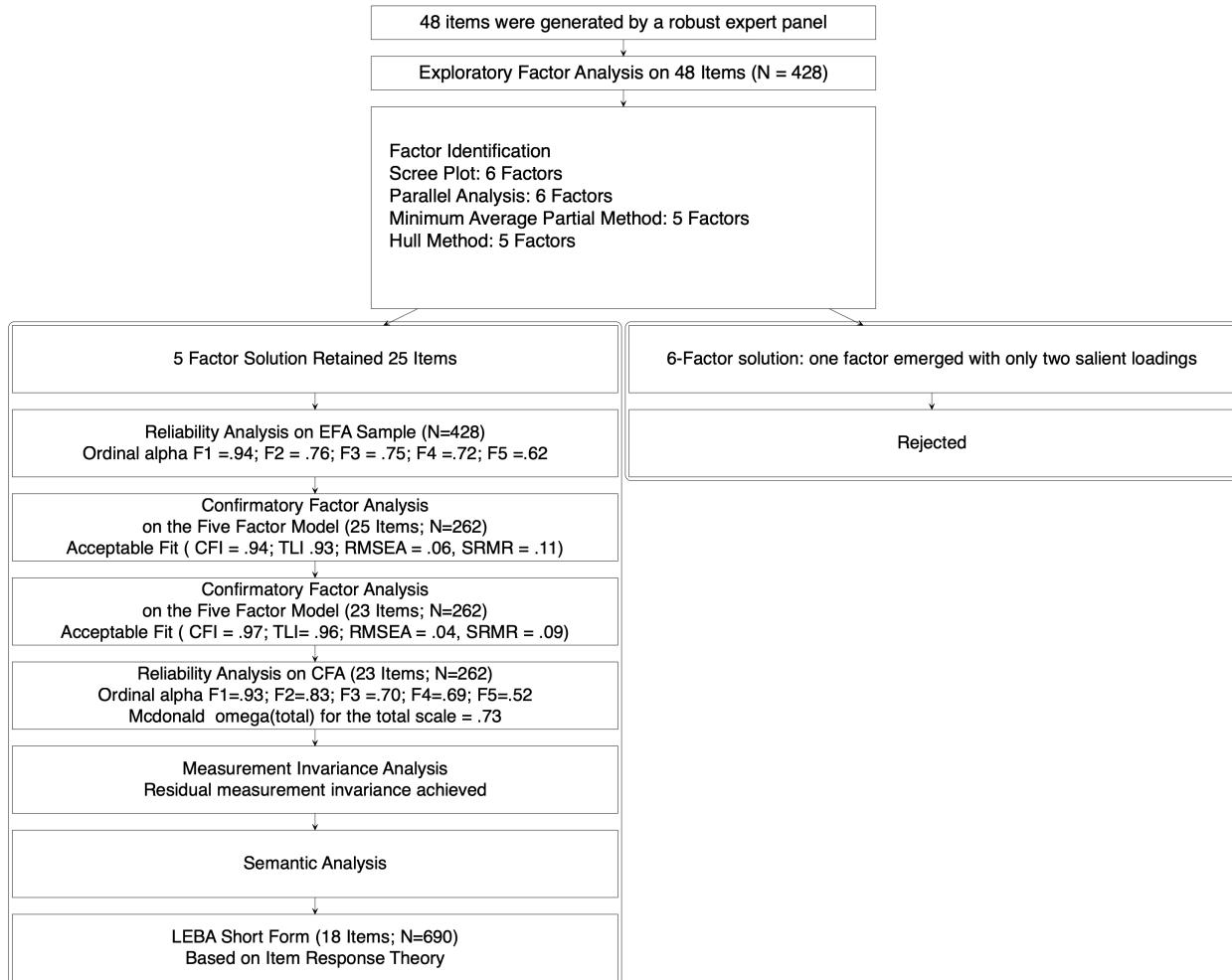


Figure 1. Development of long and short form of LEBA

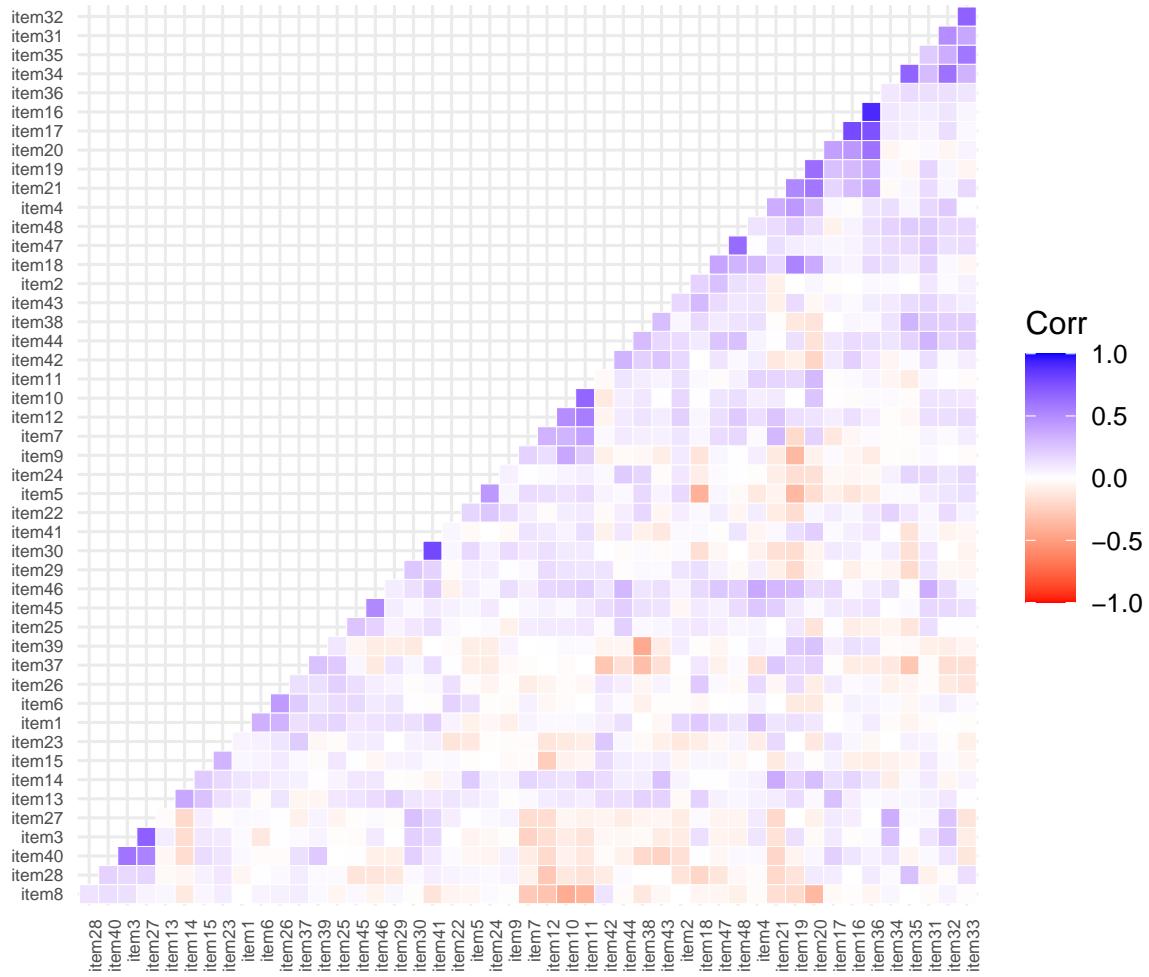


Figure 2. Correlation plot of the items

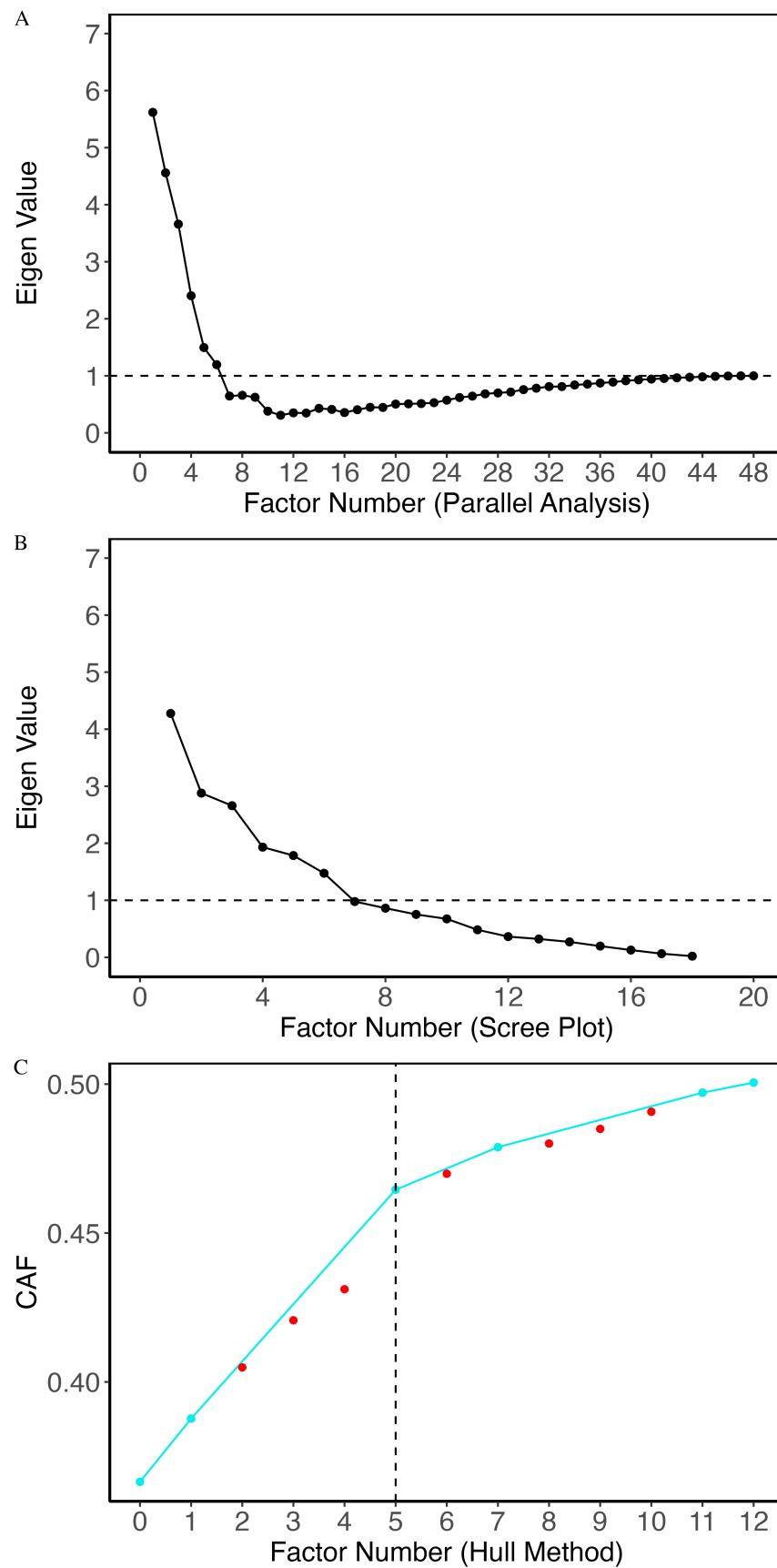


Figure 3. Factor Identification (A) Parallel analysis (B) Scree Plot (C) Hull Method

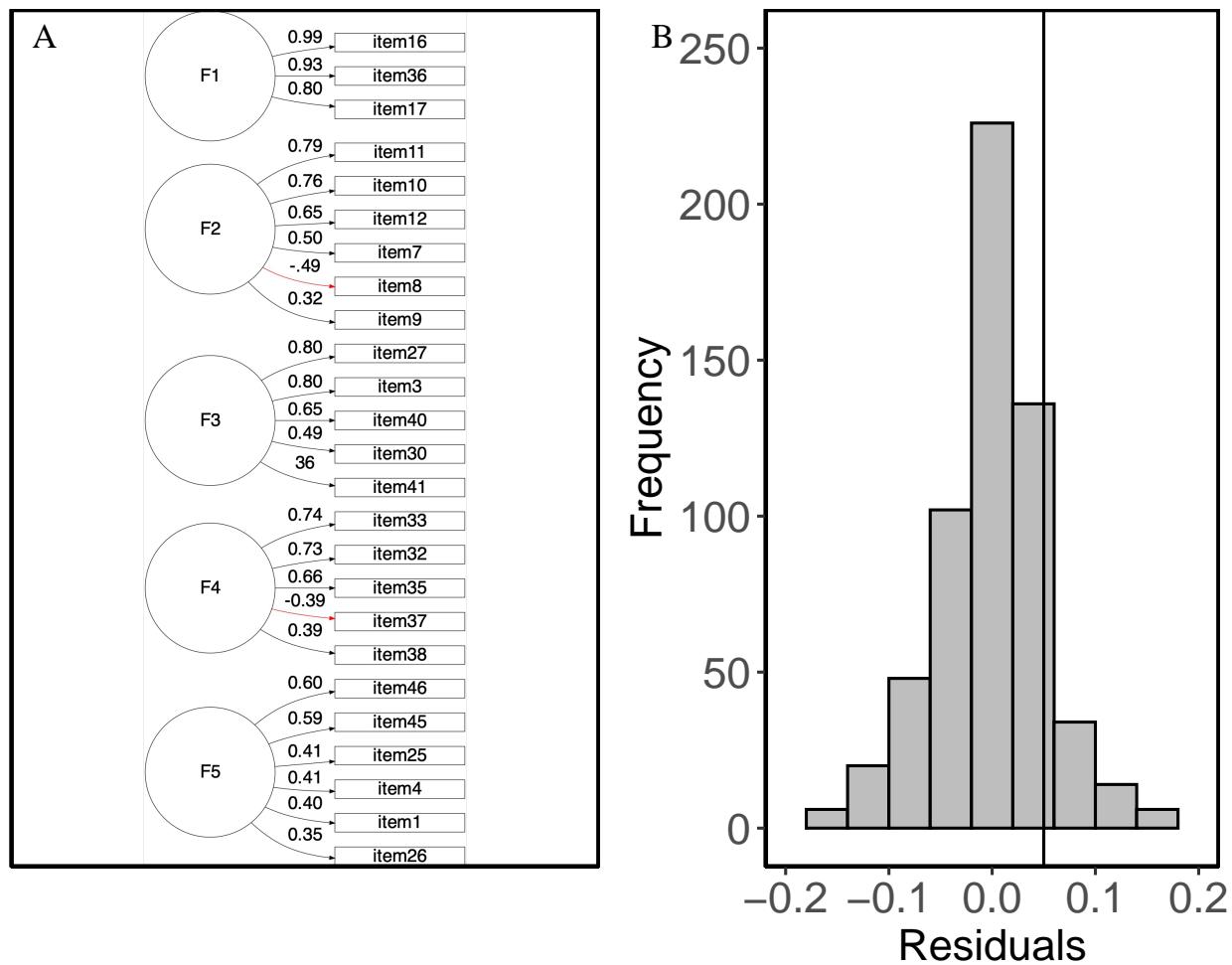


Figure 4. (A) Five Factor Solution obtained in Exploratory Factor Analysis (B) Histogram of nonredundent residula correlations

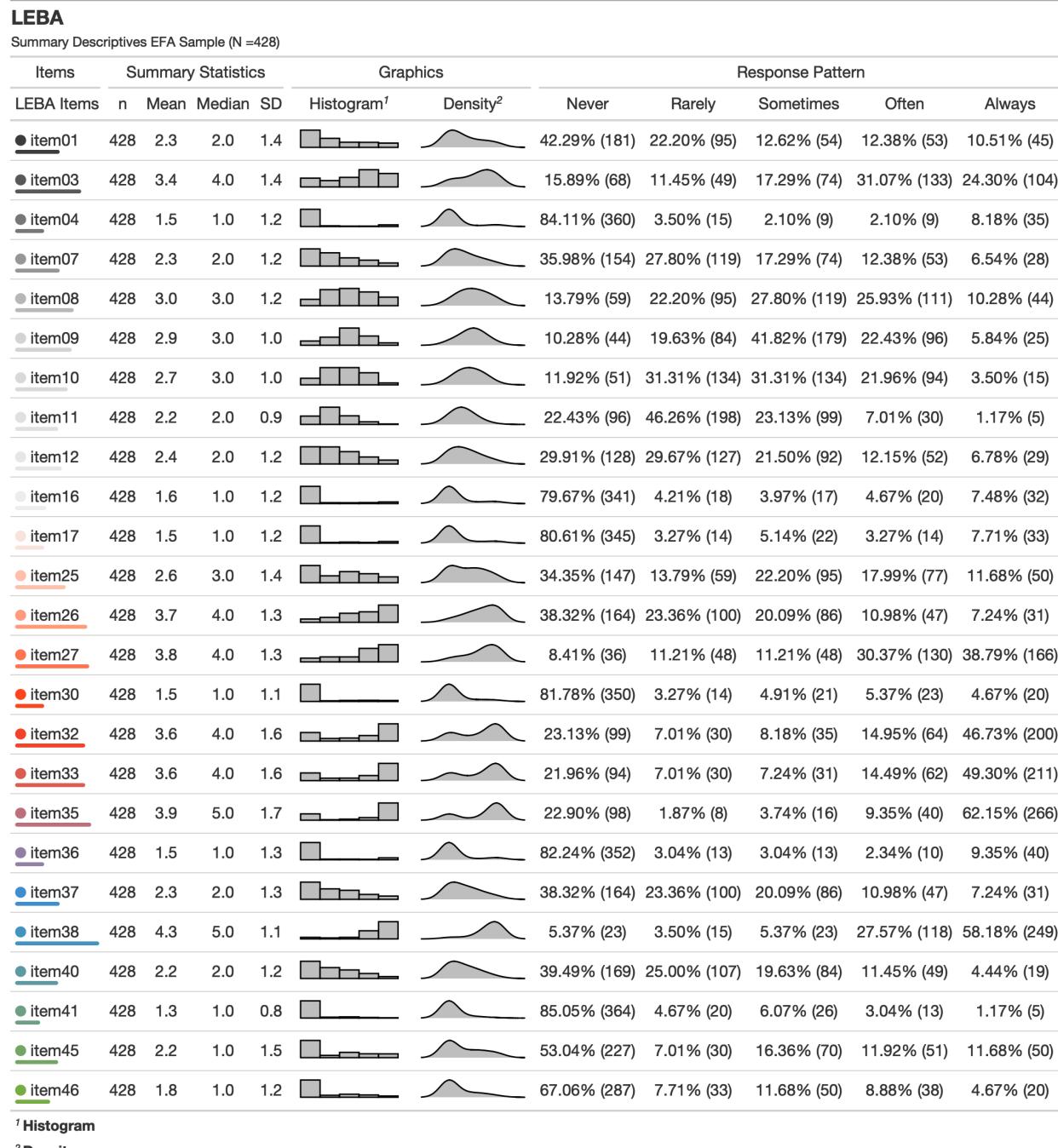


Figure 5. Summary Descriptives EFA Sample

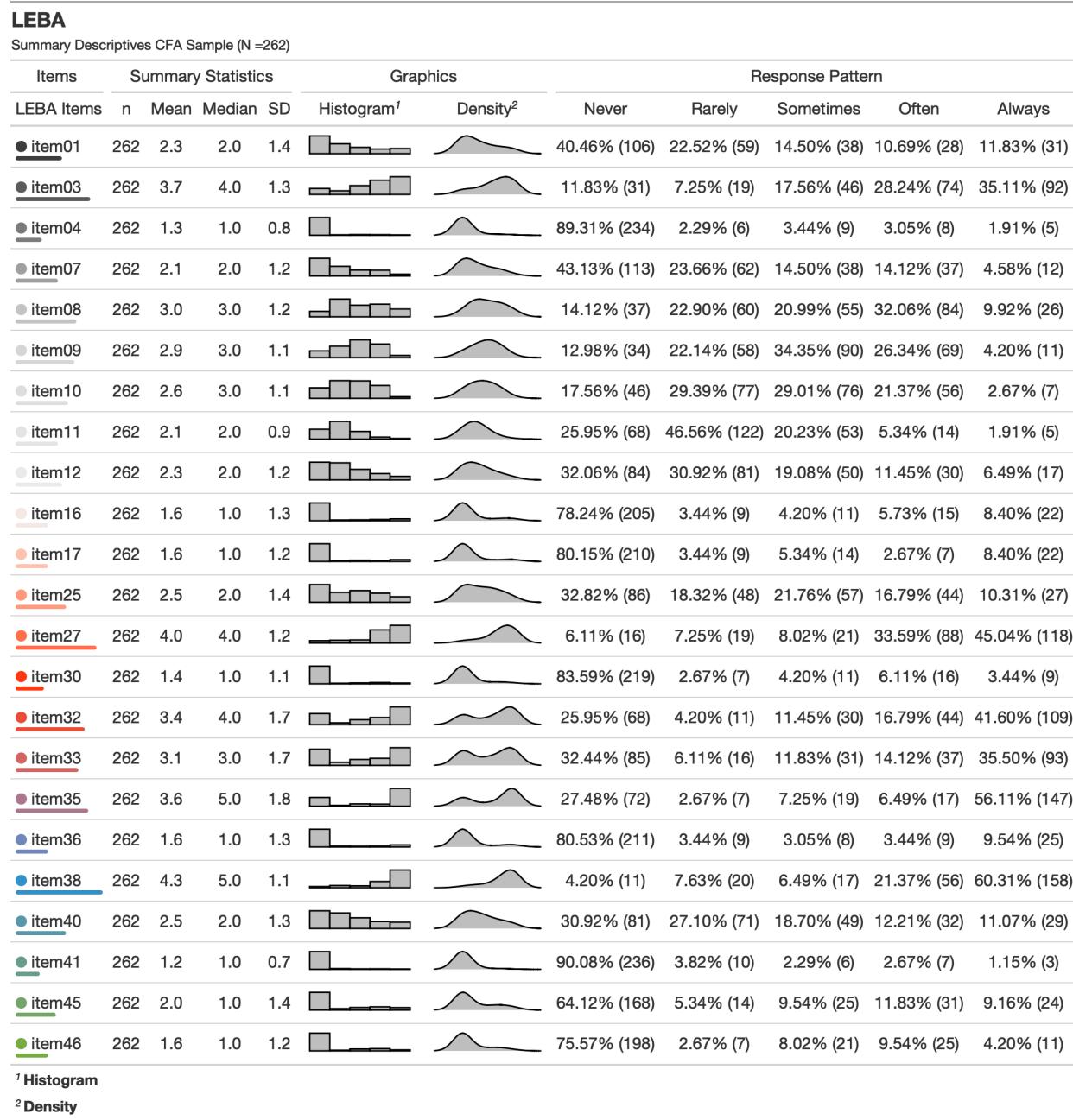


Figure 6. Summary Descriptives of CFA Sample

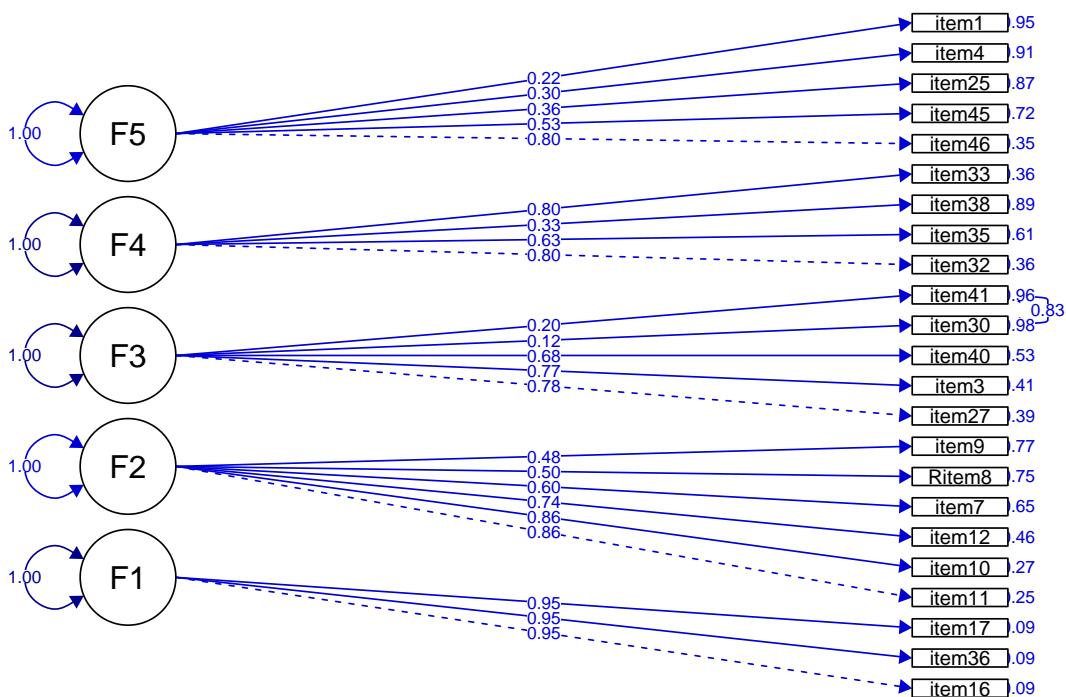


Figure 7. Five Factor CFA Model of LEBA

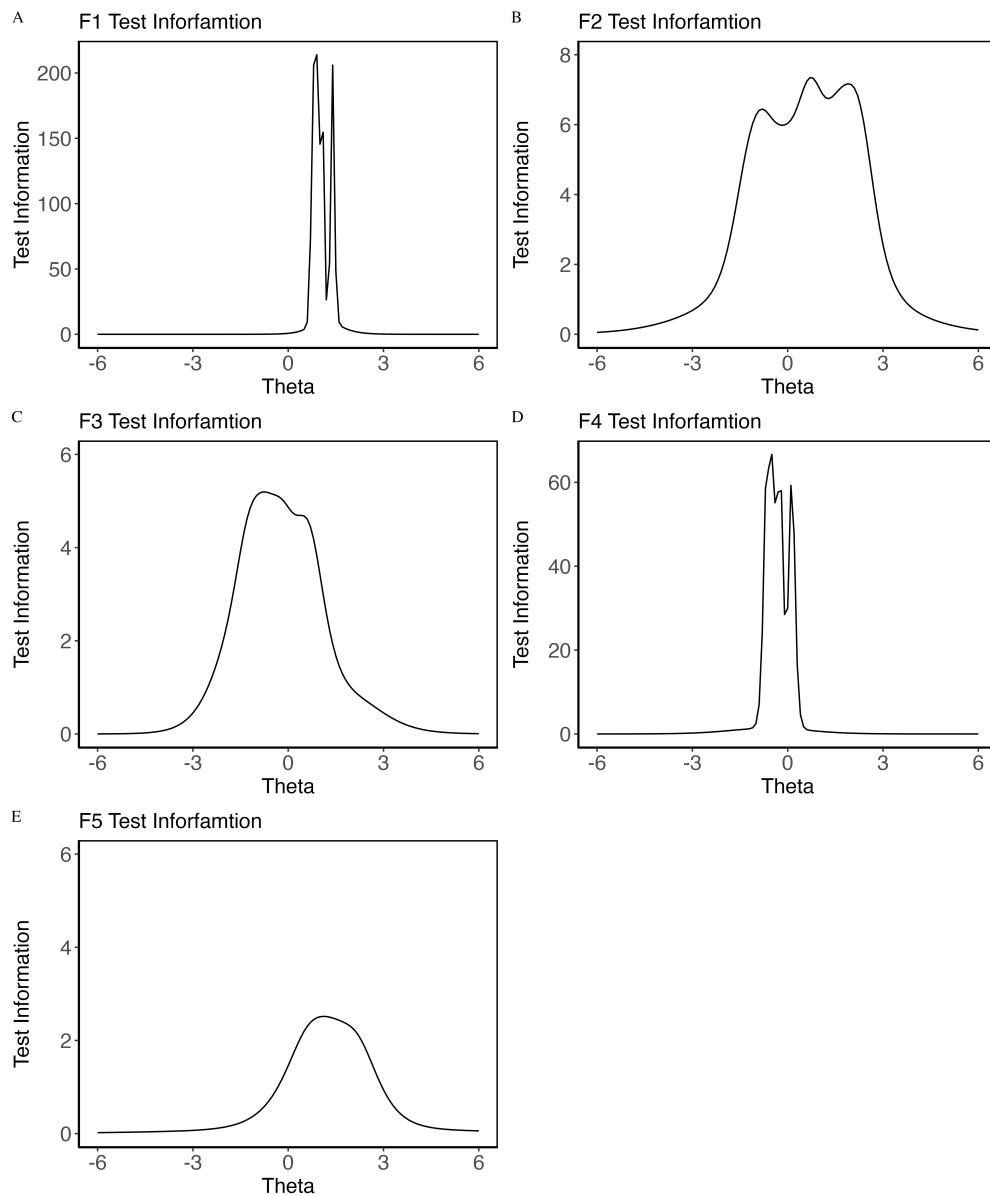


Figure 8. Test information curves (a) Wearing blue light filters (b) Spending time outdoors (c) Using phone and smartwatchin bed (d) Using light before bedtime (e) Using light in the morning and during daytime

Table A1

Map Statistics

MAP Statistics	dof	chisq	fit	RMSEA	BIC	eChisq	SRMR
.01125	1,080.00	4,344.31	0.18	0.08	-2,199.54	8,678.73	0.09
.01062	1,033.00	3,735.35	0.30	0.08	-2,523.72	6,414.94	0.08
.01077	987.00	3,065.44	0.38	0.07	-2,914.91	5,022.94	0.07
.01042	942.00	2,661.78	0.45	0.07	-3,045.92	3,969.03	0.06
.00938	898.00	2,237.56	0.51	0.06	-3,203.53	2,971.15	0.06
.00943	855.00	2,040.02	0.56	0.06	-3,140.53	2,441.92	0.05
.00973	813.00	1,861.69	0.59	0.05	-3,064.37	2,063.72	0.05
.00999	772.00	1,620.64	0.62	0.05	-3,057.00	1,707.87	0.04

Appendix A

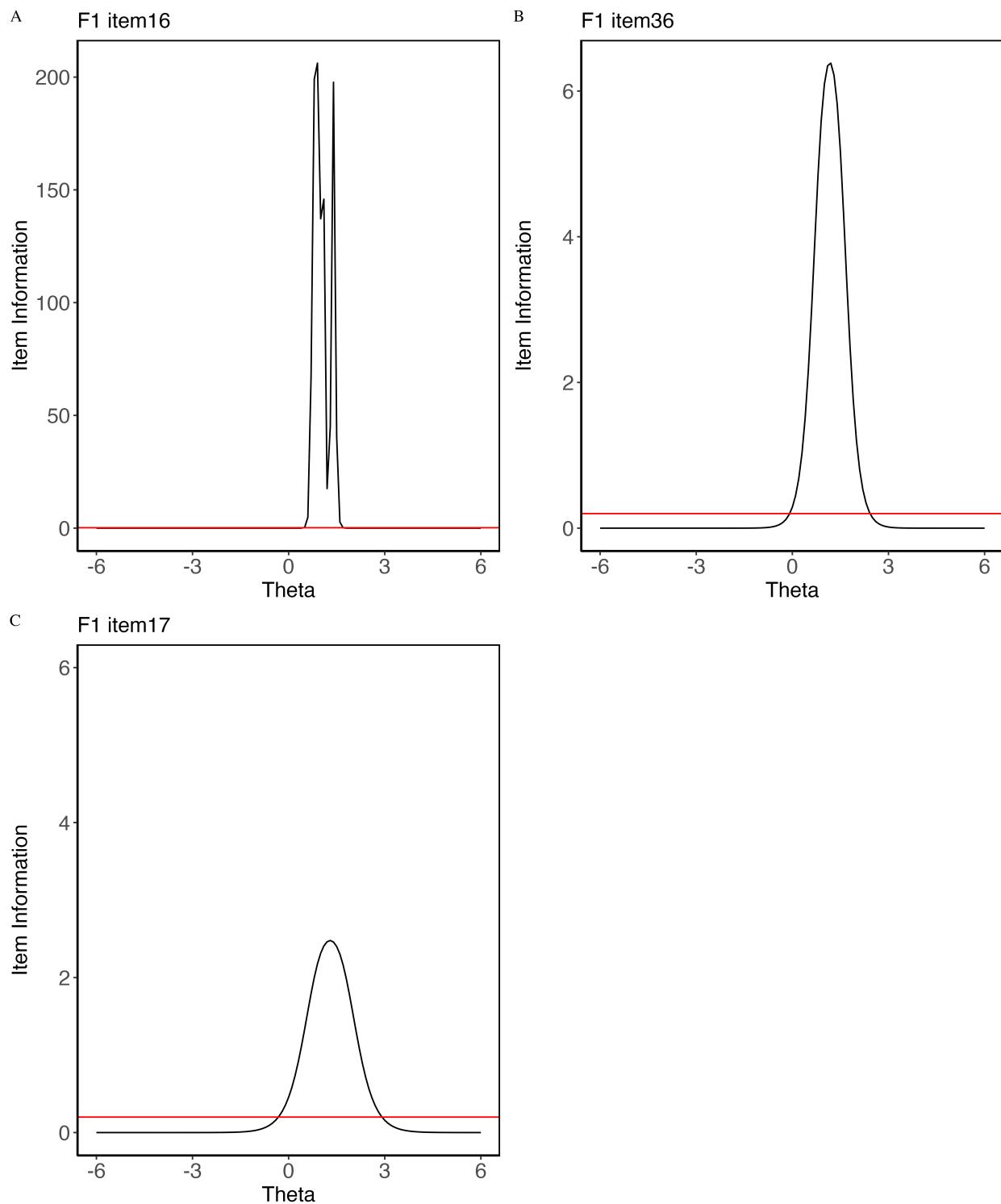


Figure A1. Item information curve of LEBA F1

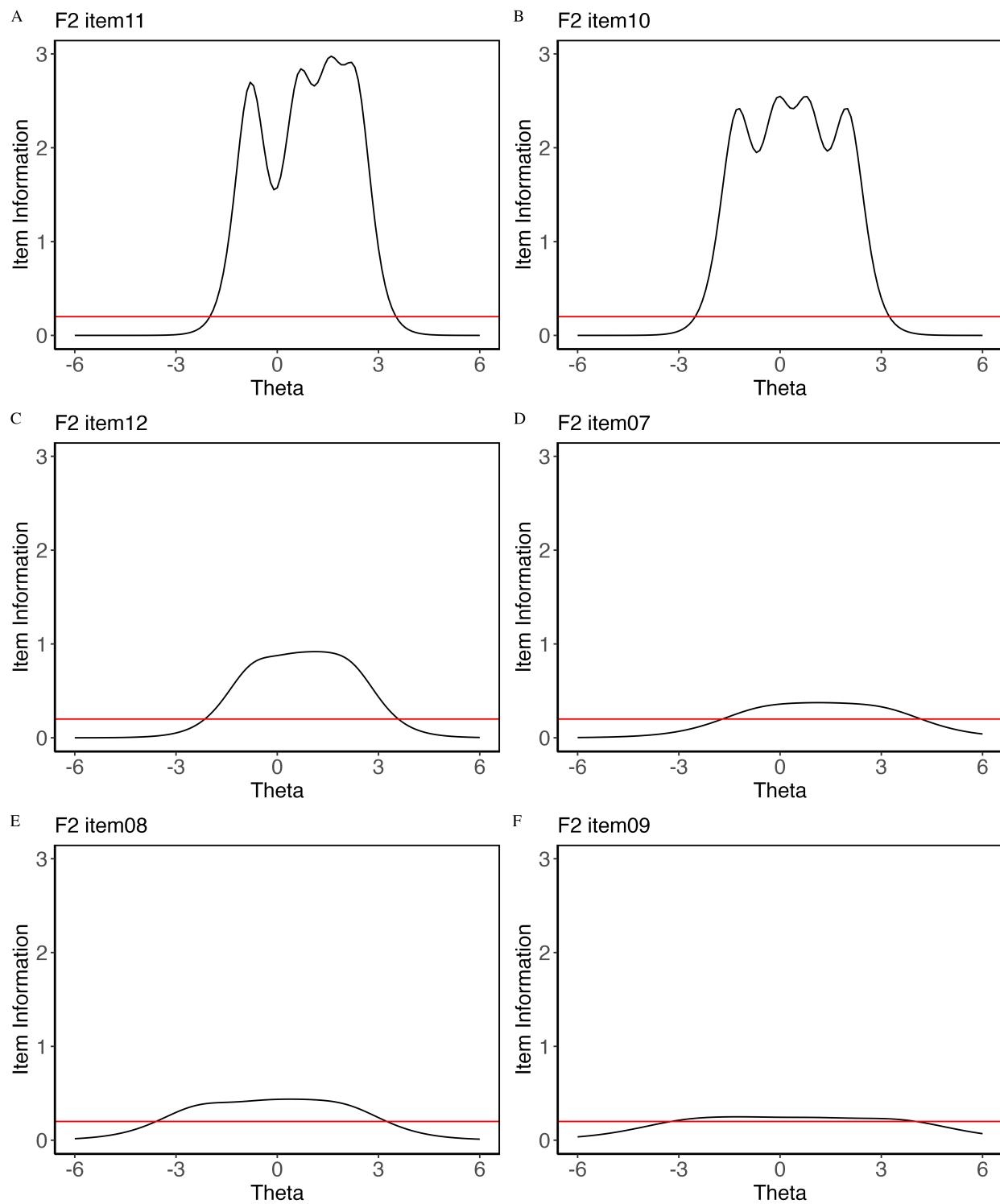


Figure A2. Item information curve of LEBA F1

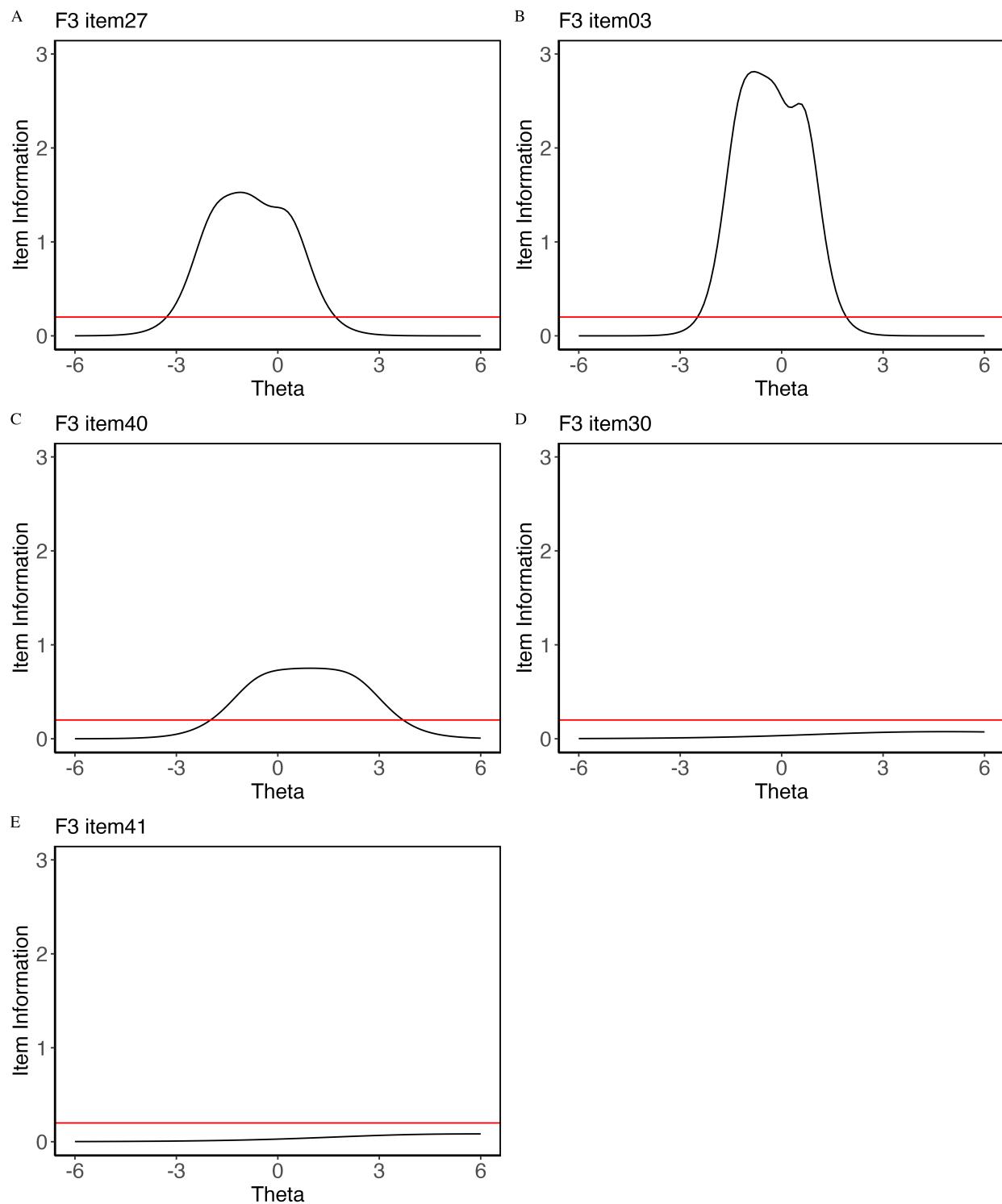


Figure A3. Item information curve of LEBA F1

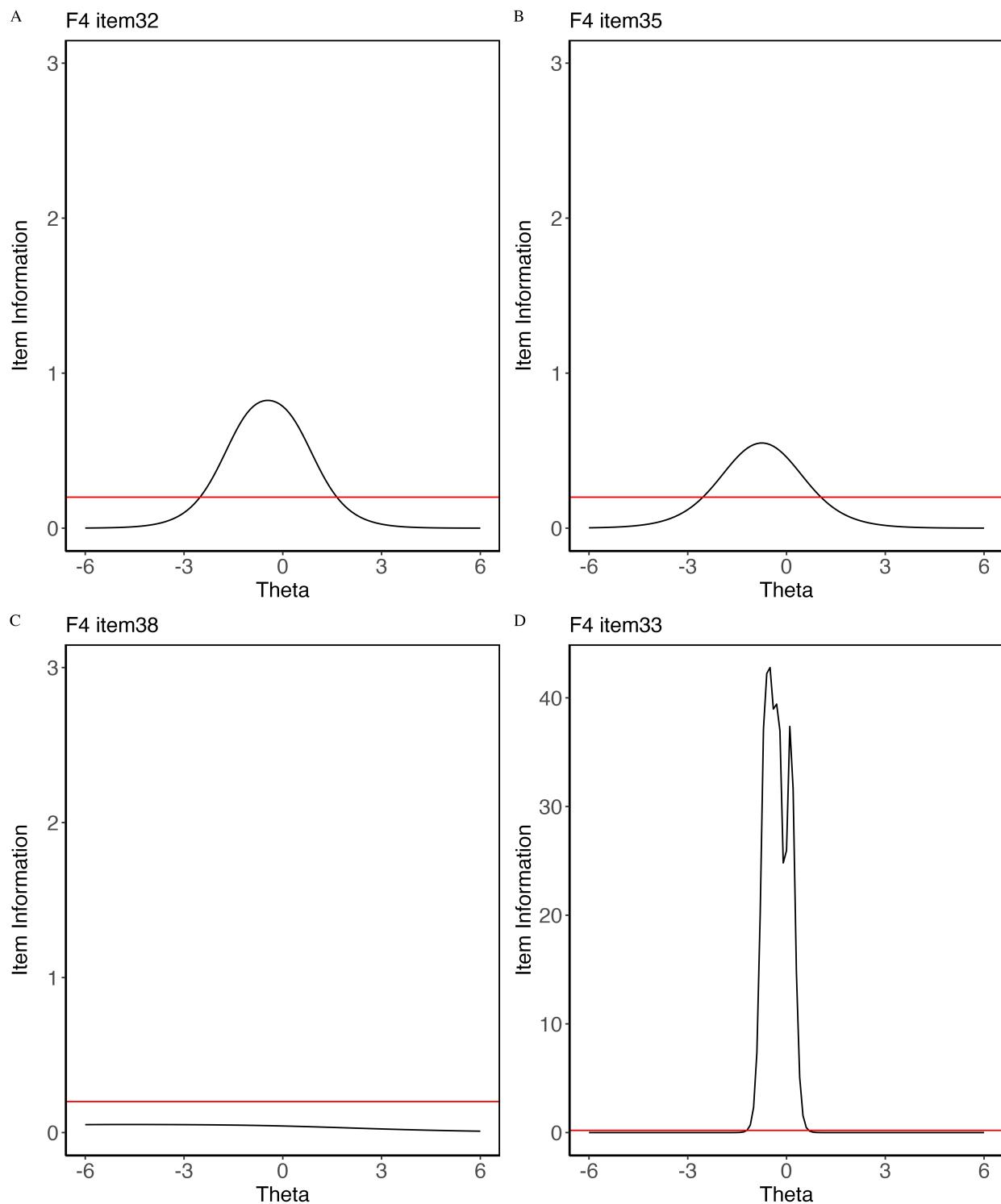


Figure A4. Item information curve of LEBA F1

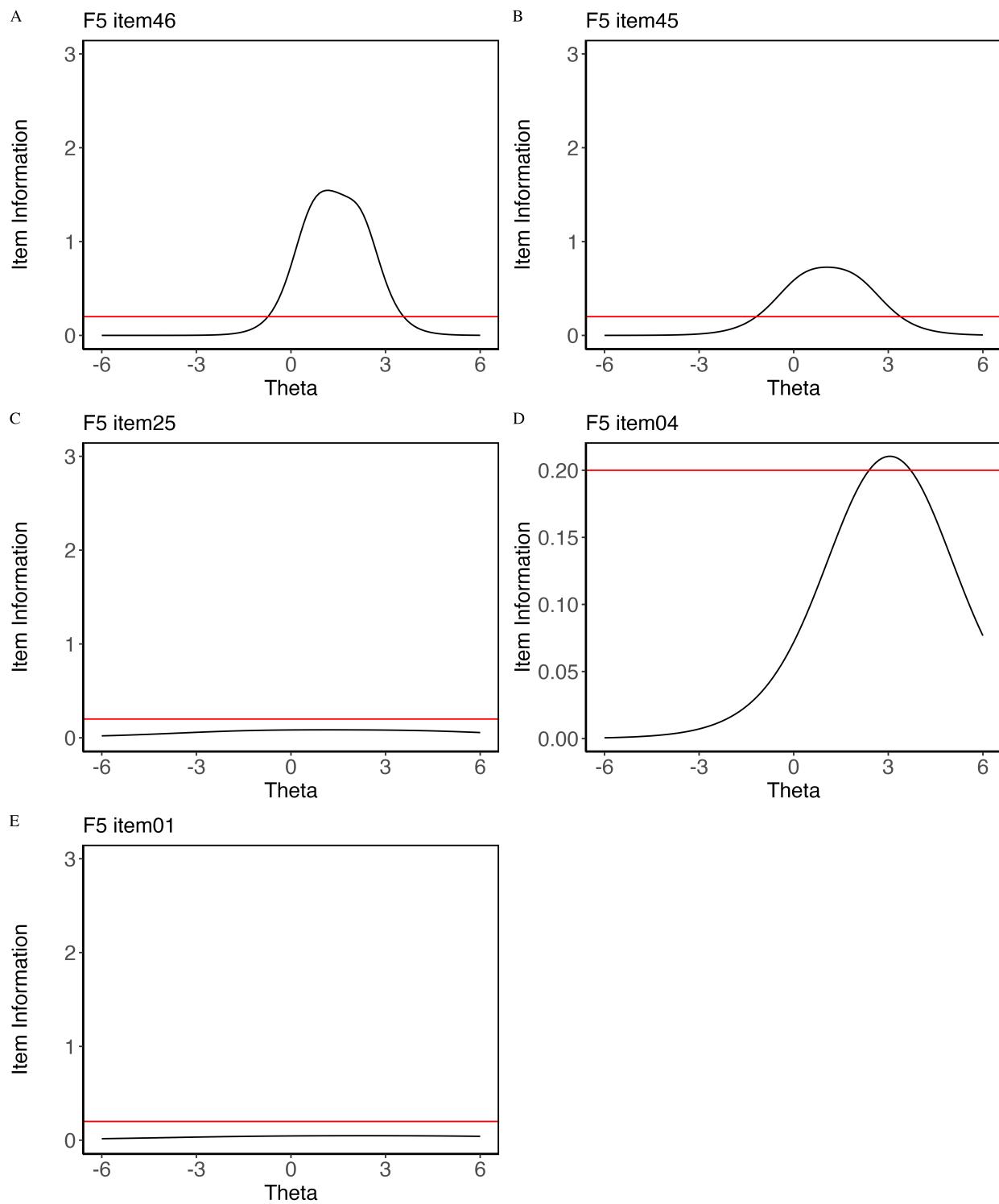


Figure A5. Item information curve of LEBA F1

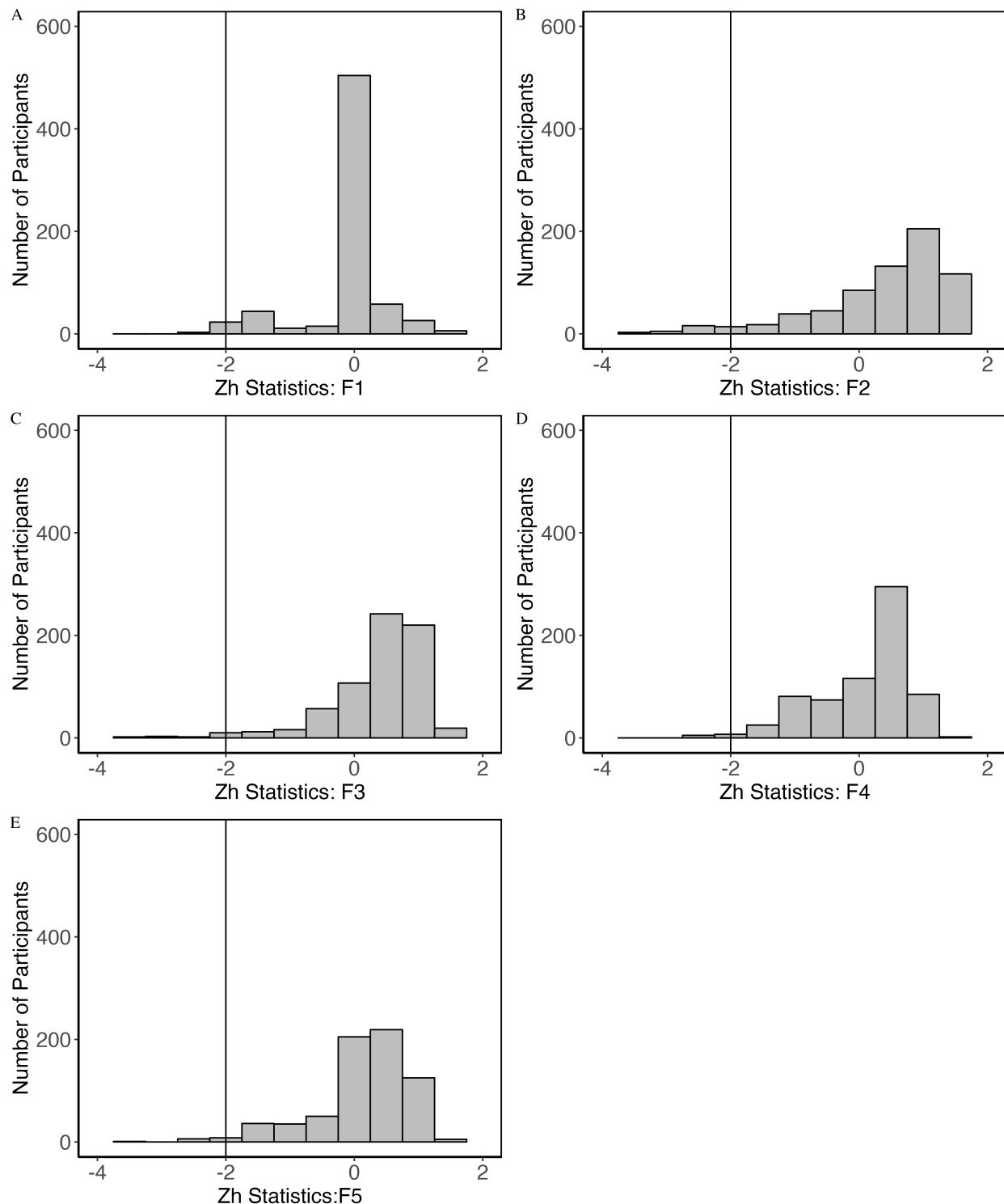


Figure A6. Person fit of the five fitted IRT models (a) Wearing blue light filters (b) Spending time outdoors (c) Using phone and smartwatch in bed (d) Using light before bedtime (e) Using light in the morning and during daytime

Table A2

Demographic Characteristics: Native English Speakers

Variable	Overall, N = 262	Yes, N = 129	No, N = 133	p-value	q-value
Age	32.89 (13.66)	34.08 (15.32)	31.74 (11.77)	0.5	0.6
Sex				0.002	0.009
Female	136 (52%)	80 (62%)	56 (42%)		
Male	121 (46%)	48 (37%)	73 (55%)		
Other	5 (1.9%)	1 (0.8%)	4 (3.0%)		
Occupational Status				0.7	0.7
Work	161 (61%)	76 (59%)	85 (64%)		
School	52 (20%)	27 (21%)	25 (19%)		
Neither	49 (19%)	26 (20%)	23 (17%)		
Occupational setting				0.4	0.6
Home office/Home schooling	109 (42%)	50 (39%)	59 (44%)		
Face-to-face work/Face-to-face schooling	41 (16%)	22 (17%)	19 (14%)		
Combination of home- and face-to-face- work/schooling	53 (20%)	23 (18%)	30 (23%)		
Neither (no work or school, or in vacation)	59 (23%)	34 (26%)	25 (19%)		

¹ Mean (SD); n (%)² False discovery rate correction for multiple testing³ Wilcoxon rank sum test⁴ Fisher's exact test⁵ Pearson's Chi-squared test

Appendix B

Table B1

Factor loadings and communality of the retained items (Minimum 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

Table B1 continued

item	MR1	MR2	MR3	MR4	MR5	Communality	Uniqueness
item1				0.4	0.17		0.83
item26					0.35	0.165	
% of Variance	0.1	0.1	0.09	0.08	0.06		

Note. Only loading higher than .30 is reported

Appendix C
Factor analysis with six factors

Table C1

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

item	PA1	PA2	PA3	PA4	PA5	PA6	Communality	Uniqueness
item16	0.99						0.987	0.013
item36	0.94						0.896	0.104
item17	0.8						0.674	0.326
item11		0.82					0.698	0.302
item10		0.81					0.656	0.344
item12		0.64					0.467	0.533
item8		-0.48					0.254	0.746
item7		0.47					0.257	0.743
item9		0.33					0.122	0.878
item33			0.97				0.978	0.022
item32			0.77				0.69	0.31
item35			0.54		0.3	0.408	0.592	
item31			0.49				0.332	0.668
item3				0.84			0.728	0.272
item27				0.81			0.666	0.334
item40				0.69			0.535	0.465
item46					0.65	0.525	0.475	
item45					0.57	0.355	0.645	
item4					0.48	0.332	0.668	
item25					0.4	0.238	0.762	
item1					0.35	0.134	0.866	
item26					0.35	0.161	0.839	
item37						-0.8	0.682	0.318

Table C1 continued

item	PA1	PA2	PA3	PA4	PA5	PA6	Communality	Uniqueness
item38						0.39	0.245	0.755
% of Variance	0.11	0.1	0.09	0.09	0.06	0.05		

Note. Only loading higher than .30 is reported; Sixth factor has only two salient loadings

827

Table C2

Factor loadings and communality of the retained items in five factor solution [Unmerged Responses]

item	PA1	PA2	PA5	PA3	PA4	Communality	Uniqueness
item19	0.99					1.007	-0.007
item20	0.91					0.874	0.126
item18	0.82					0.711	0.289
item21	0.8					0.683	0.317
item4	0.47					0.25	0.75
item11		0.83				0.687	0.313
item10		0.81				0.67	0.33
item12		0.56				0.371	0.629
item8		-0.44				0.206	0.794
item7		0.42				0.226	0.774
item9		0.33				0.115	0.885
item16			0.95			0.946	0.054
item17			0.74			0.595	0.405
item36	0.3		0.73			0.653	0.347

Table C2 continued

item	PA1	PA2	PA5	PA3	PA4	Communality	Uniqueness
item3				0.85		0.746	0.254
item27				0.78		0.624	0.376
item40				0.71		0.512	0.488
item35					0.58	0.351	0.649
item48					0.57	0.354	0.646
item33					0.55	0.32	0.68
item47					0.52	0.294	0.706
item44					0.45	0.216	0.784
item31					0.41	0.206	0.794
item38					0.33	0.129	0.871
% of Variance	0.15	0.09	0.09	0.08	0.08		

Note. Only loading higher than .30 is reported

828

Table C3

*Factor loadings and communality of the retained items in six factor solution
[Unmerged Responses]*

item	PA1	PA2	PA3	PA4	PA6	PA5	Communality	Uniqueness
item19	0.98						0.995	0.005
item20	0.92						0.904	0.096
item21	0.79						0.666	0.334
item4	0.49						0.296	0.704
item43	0.32					0.31	0.282	0.718
item10		0.81					0.67	0.33

Table C3 continued

item	PA1	PA2	PA3	PA4	PA6	PA5	Communality	Uniqueness
item11		0.81					0.668	0.332
item12		0.58					0.408	0.592
item8		-0.45					0.218	0.782
item7		0.42					0.229	0.771
item9		0.33					0.115	0.885
item3			0.85				0.731	0.269
item27			0.77				0.606	0.394
item40			0.72				0.533	0.467
item35				0.64			0.426	0.574
item33				0.62			0.413	0.587
item48				0.52			0.305	0.695
item47				0.48			0.259	0.741
item31				0.39			0.206	0.794
item38				0.32			0.18	0.82
item17					0.85		0.786	0.214
item16					0.78		0.681	0.319
item13						0.57	0.336	0.664
item14						0.5	0.356	0.644
item15						0.48	0.277	0.723
item42						0.37	0.168	0.832
item26							0.064	0.936
% of Variance	0.11	0.08	0.07	0.06	0.06	0.05		

Note. Only loading higher than .30 is reported

830 Items Retained in the Five Factor Solution [Unmerged Responses]

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.

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.

Five Factor Solution [Unmerged Responses] (24 Items)

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.

I wear blue-filtering, orange-tinted, and/or red-tinted glasses within 1 hour before attempting to fall asleep.

Table C5

Geographical Location

**N =

690**

Time zone - Country

United States - America/New_York (UTC -04:00)	63 (9.1%)
United Kingdom - Europe/London (UTC)	57 (8.3%)
Germany - Europe/Berlin (UTC +01:00)	53 (7.7%)
India - Asia/Kolkata (UTC +05:30)	38 (5.5%)
United States - America/Los_Angeles (UTC -07:00)	37 (5.4%)
United States - America/Chicago (UTC -05:00)	30 (4.3%)
France - Europe/Paris (UTC +01:00)	22 (3.2%)
Switzerland - Europe/Zurich (UTC +01:00)	21 (3.0%)
Brazil - America/Sao_Paulo (UTC -03:00)	19 (2.8%)
Netherlands - Europe/Amsterdam (UTC +01:00)	19 (2.8%)
Canada - America/Toronto (UTC -04:00)	16 (2.3%)

Table C5

Geographical Location (continued)

	**N =
	690**
Poland - Europe/Warsaw (UTC +01:00)	15 (2.2%)
Canada - America/Edmonton (UTC -06:00)	14 (2.0%)
Finland - Europe/Helsinki (UTC +02:00)	9 (1.3%)
Indonesia - Asia/Jakarta (UTC +07:00)	9 (1.3%)
Italy - Europe/Rome (UTC +01:00)	9 (1.3%)
Chile - America/Santiago (UTC -03:00)	8 (1.2%)
Russian Federation - Europe/Moscow (UTC +03:00)	8 (1.2%)
China - Asia/Shanghai (UTC +08:00)	7 (1.0%)
Malaysia - Asia/Kuala_Lumpur (UTC +08:00)	7 (1.0%)
Spain - Europe/Madrid (UTC +01:00)	7 (1.0%)
United States - America/Phoenix (UTC -07:00)	7 (1.0%)
Canada - America/Vancouver (UTC -07:00)	6 (0.9%)
New Zealand - Pacific/Auckland (UTC +13:00)	6 (0.9%)
Philippines - Asia/Manila (UTC +08:00)	6 (0.9%)
Turkey - Europe/Istanbul (UTC +03:00)	6 (0.9%)
United States - America/Denver (UTC -06:00)	6 (0.9%)
United States - America/Detroit (UTC -04:00)	6 (0.9%)
Argentina - America/Argentina/Buenos_Aires (UTC -03:00)	5 (0.7%)
Australia - Australia/Melbourne (UTC +11:00)	5 (0.7%)
Ireland - Europe/Dublin (UTC)	5 (0.7%)

Table C5

Geographical Location (continued)

	**N =
	690**
Lithuania - Europe/Vilnius (UTC +02:00)	5 (0.7%)
South Africa - Africa/Johannesburg (UTC +02:00)	5 (0.7%)
Australia - Australia/Brisbane (UTC +10:00)	4 (0.6%)
Belgium - Europe/Brussels (UTC +01:00)	4 (0.6%)
Israel - Asia/Jerusalem (UTC +02:00)	4 (0.6%)
Sweden - Europe/Stockholm (UTC +01:00)	4 (0.6%)
United States - America/Boise (UTC -06:00)	4 (0.6%)
Czech Republic - Europe/Prague (UTC +01:00)	3 (0.4%)
Denmark - Europe/Copenhagen (UTC +01:00)	3 (0.4%)
Germany - Europe/Busingen (UTC +01:00)	3 (0.4%)
Greece - Europe/Athens (UTC +02:00)	3 (0.4%)
Iran	3 (0.4%)
Japan - Asia/Tokyo (UTC +09:00)	3 (0.4%)
Norway - Europe/Oslo (UTC +01:00)	3 (0.4%)
Romania - Europe/Bucharest (UTC +02:00)	3 (0.4%)
Serbia - Europe/Belgrade (UTC +01:00)	3 (0.4%)
Slovenia - Europe/Ljubljana (UTC +01:00)	3 (0.4%)
Taiwan	3 (0.4%)
United States - America/Anchorage (UTC -08:00)	3 (0.4%)
United States - America/Indiana/Indianapolis (UTC -04:00)	3 (0.4%)

Table C5

Geographical Location (continued)

	**N =
	690**
United States - America/Kentucky/Louisville (UTC -04:00)	3 (0.4%)
Argentina - America/Argentina/Cordoba (UTC -03:00)	2 (0.3%)
Australia - Australia/Adelaide (UTC +10:30)	2 (0.3%)
Australia - Australia/Perth (UTC +08:00)	2 (0.3%)
Australia - Australia/Sydney (UTC +11:00)	2 (0.3%)
Brazil - America/Araguaina (UTC -03:00)	2 (0.3%)
Brazil - America/Bahia (UTC -03:00)	2 (0.3%)
Canada - America/Moncton (UTC -03:00)	2 (0.3%)
Colombia - America/Bogota (UTC -05:00)	2 (0.3%)
Costa Rica - America/Costa_Rica (UTC -06:00)	2 (0.3%)
Croatia - Europe/Zagreb (UTC +01:00)	2 (0.3%)
Ecuador - America/Guayaquil (UTC -05:00)	2 (0.3%)
Estonia - Europe/Tallinn (UTC +02:00)	2 (0.3%)
Hong Kong - Asia/Hong_Kong (UTC +08:00)	2 (0.3%)
Hungary - Europe/Budapest (UTC +01:00)	2 (0.3%)
Jordan - Asia/Amman (UTC +03:00)	2 (0.3%)
Latvia - Europe/Riga (UTC +02:00)	2 (0.3%)
Malaysia - Asia/Kuching (UTC +08:00)	2 (0.3%)
Mexico - America/Mexico_City (UTC -06:00)	2 (0.3%)
Nepal - Asia/Kathmandu (UTC +05:45)	2 (0.3%)

Table C5

Geographical Location (continued)

	**N =
	690**
Portugal - Europe/Lisbon (UTC)	2 (0.3%)
Slovakia - Europe/Bratislava (UTC +01:00)	2 (0.3%)
Spain - Africa/Ceuta (UTC +01:00)	2 (0.3%)
Sudan - Africa/Khartoum (UTC +02:00)	2 (0.3%)
United States - America/Adak (UTC -09:00)	2 (0.3%)
United States - Pacific/Honolulu (UTC -10:00)	2 (0.3%)
Viet Nam - Asia/Ho_Chi_Minh (UTC +07:00), British - America/Tortola (UTC -04:00)	2 (0.3%)
Albania - Europe/Tirane (UTC +01:00)	1 (0.1%)
Argentina - America/Argentina/Jujuy (UTC -03:00)	1 (0.1%)
Australia - Antarctica/Macquarie (UTC +11:00)	1 (0.1%)
Australia - Australia/Darwin (UTC +09:30)	1 (0.1%)
Austria - Europe/Vienna (UTC +01:00)	1 (0.1%)
Bangladesh - Asia/Dhaka (UTC +06:00)	1 (0.1%)
Brazil - America/Cuiaba (UTC -04:00)	1 (0.1%)
Brazil - America/Fortaleza (UTC -03:00)	1 (0.1%)
Bulgaria - Europe/Sofia (UTC +02:00)	1 (0.1%)
Cameroon - Africa/Douala (UTC +01:00)	1 (0.1%)
Canada - America/Blanc-Sablon (UTC -04:00)	1 (0.1%)
Canada - America/Halifax (UTC -03:00)	1 (0.1%)
Canada - America/Resolute (UTC -05:00)	1 (0.1%)

Table C5

Geographical Location (continued)

	**N =
	690**
Cayman Islands - America/Cayman (UTC -05:00)	1 (0.1%)
Chile - Pacific/Easter (UTC -05:00)	1 (0.1%)
Cyprus - Asia/Famagusta (UTC +02:00)	1 (0.1%)
Guatemala - America/Guatemala (UTC -06:00)	1 (0.1%)
Korea, Republic of - Asia/Seoul (UTC +09:00)	1 (0.1%)
Macedonia	1 (0.1%)
Martinique - America/Martinique (UTC -04:00)	1 (0.1%)
Mexico - America/Monterrey (UTC -06:00)	1 (0.1%)
Mongolia - Asia/Ulaanbaatar (UTC +08:00)	1 (0.1%)
Myanmar - Asia/Yangon (UTC +06:30)	1 (0.1%)
New Zealand - Pacific/Chatham (UTC +13:45)	1 (0.1%)
Nigeria - Africa/Lagos (UTC +01:00)	1 (0.1%)
Pakistan - Asia/Karachi (UTC +05:00)	1 (0.1%)
Panama - America/Panama (UTC -05:00)	1 (0.1%)
Russian Federation - Asia/Barnaul (UTC +07:00)	1 (0.1%)
Russian Federation - Asia/Novosibirsk (UTC +07:00)	1 (0.1%)
Russian Federation - Asia/Tomsk (UTC +07:00)	1 (0.1%)
Russian Federation - Asia/Vladivostok (UTC +10:00)	1 (0.1%)
Russian Federation - Asia/Yekaterinburg (UTC +05:00)	1 (0.1%)
Saudi Arabia - Asia/Riyadh (UTC +03:00)	1 (0.1%)

Table C5

Geographical Location (continued)

	**N =
	690**
Singapore - Asia/Singapore (UTC +08:00)	1 (0.1%)
Spain - Atlantic/Canary (UTC)	1 (0.1%)
Tanzania	1 (0.1%)
Ukraine - Europe/Kiev (UTC +02:00)	1 (0.1%)
United States - America/Indiana/Tell_City (UTC -05:00)	1 (0.1%)
United States - America/North_Dakota/Center (UTC -05:00)	1 (0.1%)
United States - America/North_Dakota/New_Salem (UTC -05:00)	1 (0.1%)
Aland Islands - Europe/Mariehamn (UTC +02:00)	0 (0%)
Afghanistan - Asia/Kabul (UTC +04:30)	0 (0%)
Algeria - Africa/Algiers (UTC +01:00)	0 (0%)
American Samoa - Pacific/Pago_Pago (UTC -11:00)	0 (0%)
Andorra - Europe/Andorra (UTC +01:00)	0 (0%)
Angola - Africa/Luanda (UTC +01:00)	0 (0%)
Anguilla - America/Anguilla (UTC -04:00)	0 (0%)
Antarctica - Antarctica/Casey (UTC +11:00)	0 (0%)
Antarctica - Antarctica/Davis (UTC +07:00)	0 (0%)
Antarctica - Antarctica/DumontDUrville (UTC +10:00)	0 (0%)
Antarctica - Antarctica/Mawson (UTC +05:00)	0 (0%)

Table C5

Geographical Location (continued)

	**N =
	690**
Antarctica - Antarctica/Mcmurdo (UTC +13:00)	0 (0%)
Antarctica - Antarctica/Palmer (UTC -03:00)	0 (0%)
Antarctica - Antarctica/Rothera (UTC -03:00)	0 (0%)
Antarctica - Antarctica/Syowa (UTC +03:00)	0 (0%)
Antarctica - Antarctica/Troll (UTC)	0 (0%)
Antarctica - Antarctica/Vostok (UTC +06:00)	0 (0%)
Antigua and Barbuda - America/Antigua (UTC -04:00)	0 (0%)
Argentina - America/Argentina/Catamarca (UTC -03:00)	0 (0%)
Argentina - America/Argentina/La_Rioja (UTC -03:00)	0 (0%)
Argentina - America/Argentina/Mendoza (UTC -03:00)	0 (0%)
Argentina - America/Argentina/Rio_Gallegos (UTC -03:00)	0 (0%)
Argentina - America/Argentina/Salta (UTC -03:00)	0 (0%)
Argentina - America/Argentina/San_Juan (UTC -03:00)	0 (0%)
Argentina - America/Argentina/San_Luis (UTC -03:00)	0 (0%)
Argentina - America/Argentina/Tucuman (UTC -03:00)	0 (0%)

Table C5

Geographical Location (continued)

	**N =
	690**
Argentina - America/Argentina/Ushuaia (UTC -03:00)	0 (0%)
Armenia - Asia/Yerevan (UTC +04:00)	0 (0%)
Aruba - America/Aruba (UTC -04:00)	0 (0%)
Australia - Australia/Broken_Hill (UTC +10:30)	0 (0%)
Australia - Australia/Currie (UTC +11:00)	0 (0%)
Australia - Australia/Eucla (UTC +08:45)	0 (0%)
Australia - Australia/Hobart (UTC +11:00)	0 (0%)
Australia - Australia/Lindeman (UTC +10:00)	0 (0%)
Australia - Australia/Lord_Howe (UTC +11:00)	0 (0%)
Azerbaijan - Asia/Baku (UTC +04:00)	0 (0%)
Bahamas - America/Nassau (UTC -04:00)	0 (0%)
Bahrain - Asia/Bahrain (UTC +03:00)	0 (0%)
Barbados - America/Barbados (UTC -04:00)	0 (0%)
Belarus - Europe/Minsk (UTC +03:00)	0 (0%)
Belize - America/Belize (UTC -06:00)	0 (0%)
Benin - Africa/Porto-Novo (UTC +01:00)	0 (0%)
Bermuda - Atlantic/Bermuda (UTC -03:00)	0 (0%)
Bhutan - Asia/Thimphu (UTC +06:00),Plurinational	0 (0%)
State of - America/La_Paz (UTC -04:00)	
Bolivia,Sint Eustatius and Saba - America/Kralendijk (UTC -04:00)	0 (0%)

Table C5

Geographical Location (continued)

	**N =
	690**
Bonaire	0 (0%)
Bosnia and Herzegovina - Europe/Sarajevo (UTC +01:00)	0 (0%)
Botswana - Africa/Gaborone (UTC +02:00)	0 (0%)
Brazil - America/Belem (UTC -03:00)	0 (0%)
Brazil - America/Boa_Vista (UTC -04:00)	0 (0%)
Brazil - America/Campo_Grande (UTC -04:00)	0 (0%)
Brazil - America/Eirunepe (UTC -05:00)	0 (0%)
Brazil - America/Maceio (UTC -03:00)	0 (0%)
Brazil - America/Manaus (UTC -04:00)	0 (0%)
Brazil - America/Noronha (UTC -02:00)	0 (0%)
Brazil - America/Porto_Velho (UTC -04:00)	0 (0%)
Brazil - America/Recife (UTC -03:00)	0 (0%)
Brazil - America/Rio_Branco (UTC -05:00)	0 (0%)
Brazil - America/Santarem (UTC -03:00)	0 (0%)
British Indian Ocean Territory - Indian/Chagos (UTC +06:00)	0 (0%)
Brunei Darussalam - Asia/Brunei (UTC +08:00)	0 (0%)
Burkina Faso - Africa/Ouagadougou (UTC)	0 (0%)
Burundi - Africa/Bujumbura (UTC +02:00)	0 (0%)
Cambodia - Asia/Phnom_Penh (UTC +07:00)	0 (0%)

Table C5

Geographical Location (continued)

	**N =
	690**
Canada - America/Atikokan (UTC -05:00)	0 (0%)
Canada - America/Cambridge_Bay (UTC -06:00)	0 (0%)
Canada - America/Creston (UTC -07:00)	0 (0%)
Canada - America/Dawson (UTC -07:00)	0 (0%)
Canada - America/Dawson_Creek (UTC -07:00)	0 (0%)
Canada - America/Fort_Nelson (UTC -07:00)	0 (0%)
Canada - America/Glace_Bay (UTC -03:00)	0 (0%)
Canada - America/Goose_Bay (UTC -03:00)	0 (0%)
Canada - America/Inuvik (UTC -06:00)	0 (0%)
Canada - America/Iqaluit (UTC -04:00)	0 (0%)
Canada - America/Nipigon (UTC -04:00)	0 (0%)
Canada - America/Pangnirtung (UTC -04:00)	0 (0%)
Canada - America/Rainy_River (UTC -05:00)	0 (0%)
Canada - America/Rankin_Inlet (UTC -05:00)	0 (0%)
Canada - America/Regina (UTC -06:00)	0 (0%)
Canada - America/St_Johns (UTC -02:30)	0 (0%)
Canada - America/Swift_Current (UTC -06:00)	0 (0%)
Canada - America/Thunder_Bay (UTC -04:00)	0 (0%)
Canada - America/Whitehorse (UTC -07:00)	0 (0%)
Canada - America/Winnipeg (UTC -05:00)	0 (0%)
Canada - America/Yellowknife (UTC -06:00)	0 (0%)

Table C5

Geographical Location (continued)

	**N =
	690**
Cape Verde - Atlantic/Cape_Verde (UTC -01:00)	0 (0%)
Central African Republic - Africa/Bangui (UTC +01:00)	0 (0%)
Chad - Africa/Ndjamena (UTC +01:00)	0 (0%)
Chile - America/Punta_Arenas (UTC -03:00)	0 (0%)
China - Asia/Urumqi (UTC +06:00)	0 (0%)
Christmas Island - Indian/Christmas (UTC +07:00)	0 (0%)
Cocos (Keeling) Islands - Indian/Cocos (UTC +06:30)	0 (0%)
Comoros - Indian/Comoro (UTC +03:00)	0 (0%)
Congo - Africa/Brazzaville (UTC +01:00),the	0 (0%)
Democratic Republic of the - Africa/Kinshasa (UTC +01:00)	0 (0%)
Congo,the Democratic Republic of the - Africa/Lubumbashi (UTC +02:00)	0 (0%)
Congo	0 (0%)
Cook Islands - Pacific/Rarotonga (UTC -10:00)	0 (0%)
Cuba - America/Havana (UTC -04:00)	0 (0%)
Curaçao - America/Curacao (UTC -04:00)	0 (0%)
Cyprus - Asia/Nicosia (UTC +02:00)	0 (0%)
Côte d'Ivoire - Africa/Abidjan (UTC)	0 (0%)
Djibouti - Africa/Djibouti (UTC +03:00)	0 (0%)

Table C5

Geographical Location (continued)

	**N =
	690**
Dominica - America/Dominica (UTC -04:00)	0 (0%)
Dominican Republic - America/Santo_Domingo (UTC -04:00)	0 (0%)
Ecuador - Pacific/Galapagos (UTC -06:00)	0 (0%)
Egypt - Africa/Cairo (UTC +02:00)	0 (0%)
El Salvador - America/El_Salvador (UTC -06:00)	0 (0%)
Equatorial Guinea - Africa/Malabo (UTC +01:00)	0 (0%)
Eritrea - Africa/Asmara (UTC +03:00)	0 (0%)
Ethiopia - Africa/Addis_Ababa (UTC +03:00)	0 (0%)
Falkland Islands (Malvinas) - Atlantic/Stanley (UTC -03:00)	0 (0%)
Faroe Islands - Atlantic/Faroe (UTC)	0 (0%)
Fiji - Pacific/Fiji (UTC +12:00)	0 (0%)
French Guiana - America/Cayenne (UTC -03:00)	0 (0%)
French Polynesia - Pacific/Gambier (UTC -09:00)	0 (0%)
French Polynesia - Pacific/Marquesas (UTC -09:30)	0 (0%)
French Polynesia - Pacific/Tahiti (UTC -10:00)	0 (0%)
French Southern Territories - Indian/Kerguelen (UTC +05:00)	0 (0%)
Gabon - Africa/Libreville (UTC +01:00)	0 (0%)
Gambia - Africa/Banjul (UTC)	0 (0%)
Georgia - Asia/Tbilisi (UTC +04:00)	0 (0%)

Table C5

Geographical Location (continued)

	**N =
	690**
Ghana - Africa/Accra (UTC)	0 (0%)
Gibraltar - Europe/Gibraltar (UTC +01:00)	0 (0%)
Greenland - America/Danmarkshavn (UTC)	0 (0%)
Greenland - America/Nuuk (UTC -03:00)	0 (0%)
Greenland - America/Scoresbysund (UTC -01:00)	0 (0%)
Greenland - America/Thule (UTC -03:00)	0 (0%)
Grenada - America/Grenada (UTC -04:00)	0 (0%)
Guadeloupe - America/Guadeloupe (UTC -04:00)	0 (0%)
Guam - Pacific/Guam (UTC +10:00)	0 (0%)
Guernsey - Europe/Guernsey (UTC)	0 (0%)
Guinea - Africa/Conakry (UTC)	0 (0%)
Guinea-Bissau - Africa/Bissau (UTC)	0 (0%)
Guyana - America/Guyana (UTC -04:00)	0 (0%)
Haiti - America/Port-au-Prince (UTC -04:00)	0 (0%)
Holy See (Vatican City State) - Europe/Vatican (UTC +01:00)	0 (0%)
Honduras - America/Tegucigalpa (UTC -06:00)	0 (0%)
Iceland - Atlantic/Reykjavik (UTC)	0 (0%)
Indonesia - Asia/Jayapura (UTC +09:00)	0 (0%)
Indonesia - Asia/Makassar (UTC +08:00)	0 (0%)

Table C5

Geographical Location (continued)

	**N =
	690**
Indonesia - Asia/Pontianak (UTC +07:00), Islamic Republic of - Asia/Tehran (UTC +03:30)	0 (0%)
Iraq - Asia/Baghdad (UTC +03:00)	0 (0%)
Isle of Man - Europe/Isle_of_Man (UTC)	0 (0%)
Jamaica - America/Jamaica (UTC -05:00)	0 (0%)
Jersey - Europe/Jersey (UTC)	0 (0%)
Kazakhstan - Asia/Almaty (UTC +06:00)	0 (0%)
Kazakhstan - Asia/Aqttau (UTC +05:00)	0 (0%)
Kazakhstan - Asia/Aqtobe (UTC +05:00)	0 (0%)
Kazakhstan - Asia/Atyrau (UTC +05:00)	0 (0%)
Kazakhstan - Asia/Oral (UTC +05:00)	0 (0%)
Kazakhstan - Asia/Qostanay (UTC +06:00)	0 (0%)
Kazakhstan - Asia/Qyzylorda (UTC +05:00)	0 (0%)
Kenya - Africa/Nairobi (UTC +03:00)	0 (0%)
Kiribati - Pacific/Enderbury (UTC +13:00)	0 (0%)
Kiribati - Pacific/Kiritimati (UTC +14:00)	0 (0%)
Kiribati - Pacific/Tarawa (UTC +12:00), Democratic Peoples Republic of - Asia/Pyongyang (UTC +09:00)	0 (0%)
Korea	0 (0%)
Kuwait - Asia/Kuwait (UTC +03:00)	0 (0%)
Kyrgyzstan - Asia/Bishkek (UTC +06:00)	0 (0%)

Table C5

Geographical Location (continued)

	**N =
	690**
Lao Peoples Democratic Republic - Asia/Vientiane (UTC +07:00)	0 (0%)
Lebanon - Asia/Beirut (UTC +02:00)	0 (0%)
Lesotho - Africa/Maseru (UTC +02:00)	0 (0%)
Liberia - Africa/Monrovia (UTC)	0 (0%)
Libya - Africa/Tripoli (UTC +02:00)	0 (0%)
Liechtenstein - Europe/Vaduz (UTC +01:00)	0 (0%)
Luxembourg - Europe/Luxembourg (UTC +01:00)	0 (0%)
Macao - Asia/Macau (UTC +08:00),the Former	0 (0%)
Yugoslav Republic of - Europe/Skopje (UTC +01:00)	
Madagascar - Indian/Antananarivo (UTC +03:00)	0 (0%)
Malawi - Africa/Blantyre (UTC +02:00)	0 (0%)
Maldives - Indian/Maldives (UTC +05:00)	0 (0%)
Mali - Africa/Bamako (UTC)	0 (0%)
Malta - Europe/Malta (UTC +01:00)	0 (0%)
Marshall Islands - Pacific/Kwajalein (UTC +12:00)	0 (0%)
Marshall Islands - Pacific/Majuro (UTC +12:00)	0 (0%)
Mauritania - Africa/Nouakchott (UTC)	0 (0%)
Mauritius - Indian/Mauritius (UTC +04:00)	0 (0%)
Mayotte - Indian/Mayotte (UTC +03:00)	0 (0%)
Mexico - America/Bahia_Banderas (UTC -06:00)	0 (0%)

Table C5

Geographical Location (continued)

	**N =
	690**
Mexico - America/Cancun (UTC -05:00)	0 (0%)
Mexico - America/Chihuahua (UTC -07:00)	0 (0%)
Mexico - America/Hermosillo (UTC -07:00)	0 (0%)
Mexico - America/Matamoros (UTC -05:00)	0 (0%)
Mexico - America/Mazatlan (UTC -07:00)	0 (0%)
Mexico - America/Merida (UTC -06:00)	0 (0%)
Mexico - America/Ojinaga (UTC -06:00)	0 (0%)
Mexico - America/Tijuana (UTC -07:00),Federated States of - Pacific/Chuuk (UTC +10:00)	0 (0%)
Micronesia,Federated States of - Pacific/Kosrae (UTC +11:00)	0 (0%)
Micronesia,Federated States of - Pacific/Pohnpei (UTC +11:00)	0 (0%)
Micronesia,Republic of - Europe/Chisinau (UTC +02:00)	0 (0%)
Moldova	0 (0%)
Monaco - Europe/Monaco (UTC +01:00)	0 (0%)
Mongolia - Asia/Choibalsan (UTC +08:00)	0 (0%)
Mongolia - Asia/Hovd (UTC +07:00)	0 (0%)
Montenegro - Europe/Podgorica (UTC +01:00)	0 (0%)
Montserrat - America/Montserrat (UTC -04:00)	0 (0%)
Morocco - Africa/Casablanca (UTC +01:00)	0 (0%)

Table C5

Geographical Location (continued)

	**N =
	690**
Mozambique - Africa/Maputo (UTC +02:00)	0 (0%)
Namibia - Africa/Windhoek (UTC +02:00)	0 (0%)
Nauru - Pacific/Nauru (UTC +12:00)	0 (0%)
New Caledonia - Pacific/Noumea (UTC +11:00)	0 (0%)
Nicaragua - America/Managua (UTC -06:00)	0 (0%)
Niger - Africa/Niamey (UTC +01:00)	0 (0%)
Niue - Pacific/Niue (UTC -11:00)	0 (0%)
Norfolk Island - Pacific/Norfolk (UTC +12:00)	0 (0%)
Northern Mariana Islands - Pacific/Saipan (UTC +10:00)	0 (0%)
Oman - Asia/Muscat (UTC +04:00)	0 (0%)
Palau - Pacific/Palau (UTC +09:00), State of - Asia/Gaza (UTC +02:00)	0 (0%)
Palestine, State of - Asia/Hebron (UTC +02:00)	0 (0%)
Palestine	0 (0%)
Papua New Guinea - Pacific/Bougainville (UTC +11:00)	0 (0%)
Papua New Guinea - Pacific/Port_Moresby (UTC +10:00)	0 (0%)
Paraguay - America/Asuncion (UTC -03:00)	0 (0%)
Peru - America/Lima (UTC -05:00)	0 (0%)

Table C5

Geographical Location (continued)

	**N =
	690**
Pitcairn - Pacific/Pitcairn (UTC -08:00)	0 (0%)
Portugal - Atlantic/Azores (UTC -01:00)	0 (0%)
Portugal - Atlantic/Madeira (UTC)	0 (0%)
Puerto Rico - America/Puerto_Rico (UTC -04:00)	0 (0%)
Qatar - Asia/Qatar (UTC +03:00)	0 (0%)
Russian Federation - Asia/Anadyr (UTC +12:00)	0 (0%)
Russian Federation - Asia/Chita (UTC +09:00)	0 (0%)
Russian Federation - Asia/Irkutsk (UTC +08:00)	0 (0%)
Russian Federation - Asia/Kamchatka (UTC +12:00)	0 (0%)
Russian Federation - Asia/Khandyga (UTC +09:00)	0 (0%)
Russian Federation - Asia/Krasnoyarsk (UTC +07:00)	0 (0%)
Russian Federation - Asia/Magadan (UTC +11:00)	0 (0%)
Russian Federation - Asia/Novokuznetsk (UTC +07:00)	0 (0%)
Russian Federation - Asia/Omsk (UTC +06:00)	0 (0%)
Russian Federation - Asia/Sakhalin (UTC +11:00)	0 (0%)
Russian Federation - Asia/Srednekolymsk (UTC +11:00)	0 (0%)
Russian Federation - Asia/Ust-Nera (UTC +10:00)	0 (0%)
Russian Federation - Asia/Yakutsk (UTC +09:00)	0 (0%)

Table C5

Geographical Location (continued)

	**N =
	690**
Russian Federation - Europe/Astrakhan (UTC +04:00)	0 (0%)
Russian Federation - Europe/Kaliningrad (UTC +02:00)	0 (0%)
Russian Federation - Europe/Kirov (UTC +03:00)	0 (0%)
Russian Federation - Europe/Samara (UTC +04:00)	0 (0%)
Russian Federation - Europe/Saratov (UTC +04:00)	0 (0%)
Russian Federation - Europe/Ulyanovsk (UTC +04:00)	0 (0%)
Russian Federation - Europe/Volgograd (UTC +04:00)	0 (0%)
Rwanda - Africa/Kigali (UTC +02:00)	0 (0%)
Réunion - Indian/Reunion (UTC +04:00)	0 (0%)
Saint Barthélemy - America/St_Barthelemy (UTC -04:00), Ascension and Tristan da Cunha - Atlantic/St_Helena (UTC)	0 (0%)
Saint Helena	0 (0%)
Saint Kitts and Nevis - America/St_Kitts (UTC -04:00)	0 (0%)
Saint Lucia - America/St_Lucia (UTC -04:00)	0 (0%)
Saint Martin (French part) - America/Marigot (UTC -04:00)	0 (0%)

Table C5

Geographical Location (continued)

	**N =
	690**
Saint Pierre and Miquelon - America/Miquelon (UTC -02:00)	0 (0%)
Saint Vincent and the Grenadines - America/St_Vincent (UTC -04:00)	0 (0%)
Samoa - Pacific/Apia (UTC +14:00)	0 (0%)
San Marino - Europe/San_Marino (UTC +01:00)	0 (0%)
Sao Tome and Principe - Africa/Sao_Tome (UTC)	0 (0%)
Senegal - Africa/Dakar (UTC)	0 (0%)
Seychelles - Indian/Mahe (UTC +04:00)	0 (0%)
Sierra Leone - Africa/Freetown (UTC)	0 (0%)
Sint Maarten (Dutch part) - America/Lower_Princes (UTC -04:00)	0 (0%)
Solomon Islands - Pacific/Guadalcanal (UTC +11:00)	0 (0%)
Somalia - Africa/Mogadishu (UTC +03:00)	0 (0%)
South Georgia and the South Sandwich Islands - Atlantic/South_Georgia (UTC -02:00)	0 (0%)
South Sudan - Africa/Juba (UTC +03:00)	0 (0%)
Sri Lanka - Asia/Colombo (UTC +05:30)	0 (0%)
Suriname - America/Paramaribo (UTC -03:00)	0 (0%)
Svalbard and Jan Mayen - Arctic/Longyearbyen (UTC +01:00)	0 (0%)

Table C5

Geographical Location (continued)

	**N =
	690**
Swaziland - Africa/Mbabane (UTC +02:00)	0 (0%)
Syrian Arab Republic - Asia/Damascus (UTC +03:00), Province of China - Asia/Taipei (UTC +08:00)	0 (0%)
Tajikistan - Asia/Dushanbe (UTC +05:00), United Republic of - Africa/Dar_es_Salaam (UTC +03:00)	0 (0%)
Thailand - Asia/Bangkok (UTC +07:00)	0 (0%)
Timor-Leste - Asia/Dili (UTC +09:00)	0 (0%)
Togo - Africa/Lome (UTC)	0 (0%)
Tokelau - Pacific/Fakaofo (UTC +13:00)	0 (0%)
Tonga - Pacific/Tongatapu (UTC +13:00)	0 (0%)
Trinidad and Tobago - America/Port_of_Spain (UTC -04:00)	0 (0%)
Tunisia - Africa/Tunis (UTC +01:00)	0 (0%)
Turkmenistan - Asia/Ashgabat (UTC +05:00)	0 (0%)
Turks and Caicos Islands - America/Grand_Turk (UTC -04:00)	0 (0%)
Tuvalu - Pacific/Funafuti (UTC +12:00)	0 (0%)
Uganda - Africa/Kampala (UTC +03:00)	0 (0%)
Ukraine - Europe/Simferopol (UTC +03:00)	0 (0%)
Ukraine - Europe/Uzhgorod (UTC +02:00)	0 (0%)
Ukraine - Europe/Zaporozhye (UTC +02:00)	0 (0%)

Table C5

Geographical Location (continued)

	**N =
	690**
United Arab Emirates - Asia/Dubai (UTC +04:00)	0 (0%)
United States - America/Indiana/Knox (UTC -05:00)	0 (0%)
United States - America/Indiana/Marengo (UTC -04:00)	0 (0%)
United States - America/Indiana/Petersburg (UTC -04:00)	0 (0%)
United States - America/Indiana/Vevay (UTC -04:00)	0 (0%)
United States - America/Indiana/Vincennes (UTC -04:00)	0 (0%)
United States - America/Indiana/Winamac (UTC -04:00)	0 (0%)
United States - America/Juneau (UTC -08:00)	0 (0%)
United States - America/Kentucky/Monticello (UTC -04:00)	0 (0%)
United States - America/Menominee (UTC -05:00)	0 (0%)
United States - America/Metlakatla (UTC -08:00)	0 (0%)
United States - America/Nome (UTC -08:00)	0 (0%)
United States - America/North_Dakota/Beulah (UTC -05:00)	0 (0%)
United States - America/Sitka (UTC -08:00)	0 (0%)
United States - America/Yakutat (UTC -08:00)	0 (0%)

Table C5

Geographical Location (continued)

	**N =
	690**
United States Minor Outlying Islands - Pacific/Midway (UTC -11:00)	0 (0%)
United States Minor Outlying Islands - Pacific/Wake (UTC +12:00)	0 (0%)
Uruguay - America/Montevideo (UTC -03:00)	0 (0%)
Uzbekistan - Asia/Samarkand (UTC +05:00)	0 (0%)
Uzbekistan - Asia/Tashkent (UTC +05:00)	0 (0%)
Vanuatu - Pacific/Efate (UTC +11:00),Bolivarian Republic of - America/Caracas (UTC -04:00)	0 (0%)
Venezuela	0 (0%)
Virgin Islands,U.S. - America/St_Thomas (UTC -04:00)	0 (0%)
Virgin Islands	0 (0%)
Wallis and Futuna - Pacific/Wallis (UTC +12:00)	0 (0%)
Western Sahara - Africa/El_Aaiun (UTC +01:00)	0 (0%)
Yemen - Asia/Aden (UTC +03:00)	0 (0%)
Zambia - Africa/Lusaka (UTC +02:00)	0 (0%)
Zimbabwe - Africa/Harare (UTC +02:00)	0 (0%)

Appendix D

831 **Disclaimer:** This is a non-public version of LEBA (dated January 5, 2022) and still a work
832 in progress. Please do not distribute!

833 LEBA captures light exposure-related behaviours on a 5 point Likert type scale
834 ranging from 1 to 5 (Never/Does not apply/I don't know = 1; Rarely = 2; Sometimes = 3;
835 Often = 4; Always = 5). The score of each factor is calculated by the summation of
836 scores of items belonging to the corresponding factor. The following instruction is given
837 before displaying the items: "Please indicate how often you performed the following
838 behaviours in the past 4 weeks."

Appendix E
LEBA Long Form (23 Items)

Items	Never	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.					
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.					

Items	Never	Rarely	Sometimes	Often	Always
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.					
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.					

Items	Never	Rarely	Sometimes	Often	Always
16 I use a blue-filter app on my computer screen within 1 hour before attempting to fall asleep.					
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.					

⁸³⁹ Latent Structure, Reliability and Structural Validity

⁸⁴⁰ The long form of LEBA consists 23 items with five factors.

Factor names	Items	Reliability Coefficients: ordinal alpha
F1: Wearing blue light filters	1-3	.96
F2: Spending time outdoors	4-9 (Item 4 is reversed)	.83
F3: Using phone and smartwatch in bed	10-14	.70
F4: Using light before bedtime	15-18	.69
F5: Using light in the morning and during daytime	19-23	.52
McDonald's Omega coefficient for the total scale		.73 (Total scale)

⁸⁴¹ LEBA -long form showed satisfactory structural validity (CFI = .97; TLI = .96; RMSEA = .05[.04-.06, 90% CI]; SRMR = .09).

⁸⁴³ How to cite:

Appendix F
LEBA Short Form (18 Items)

	Short Form (18 Items)	Never	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.					
05	I spend between 30 minutes and 1 hour per day (in total) outside.					
06	I spend between 1 and 3 hours per day (in total) outside.					
07	I spend more than 3 hours per day (in total) outside.					

	Short Form (18 Items)	Never	Rarely	Sometimes	Often	Always
08	I spend as much time outside as possible.					
09	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.					
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 dim my mobile phone screen within 1 hour before attempting to fall asleep.					
14	I use a blue-filter app on my computer screen within 1 hour before attempting to fall asleep.					
15	I dim my computer screen within 1 hour before attempting to fall asleep.					

	Short Form (18 Items)	Never	Rarely	Sometimes	Often	Always
16	I use tunable lights to create a healthy light environment.					
17	I use LEDs to create a healthy light environment.					
18	I use an alarm with a dawn simulation light.					

844 Latent Structure, Reliability and Structural Validity

845 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

846 How to cite: