

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

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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  $\chi^2$  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 ??). 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 F2) 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),  $\chi^2$  (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 D1) (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 E1). 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 F1). 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  $\chi^2$  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  $\chi^2$  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  $\chi^2$  test. However, the  $\chi^2$  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  $\alpha$  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  $\omega_t$  coefficient which is a better reliability estimate for multidimensional  
350 constructs (Dunn, Baguley, & Brunsden, 2014; Sijtsma, 2009). McDonald's  $\omega_t$  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  $\chi^2$  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  $\chi^2$  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 ( $\theta$ ). 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 ( $\theta$ ), 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 ( $\theta$ ). Examination of the item  
419 information curve (Sup.fig D2-D5) 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 ( $\theta$ ).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- $\chi^2$  index  
433 implementation. All of the items had RMSEA value  $\leq .06$  indicating adequate fit.  
434 Sup. Figure D6 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  $\omega_t$  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\nLightVerriotto Sensitivity Questionnaire 2017	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%)		

<sup>1</sup> Mean (SD); n (%)<sup>2</sup> False discovery rate correction for multiple testing<sup>3</sup> Wilcoxon rank sum test<sup>4</sup> Pearson's Chi-squared test

Table 3

*Descriptive Statistics*

	Mean	SD	Skew	Kurtosis	Shapiro-Wilk Statistics	Item-Total Correlation
Item01	2.27	1.39	0.74	-0.81	0.81*	0.19
Item02	2.87	1.59	0.08	-1.60	0.83*	0.28
Item03	3.36	1.38	-0.48	-1.03	0.87*	0.23
Item04	1.47	1.18	2.38	4.00	0.43*	0.24
Item05	4.01	1.40	-1.22	0.07	0.70*	0.17
Item06	2.79	1.55	0.19	-1.48	0.85*	0.13
Item07	2.26	1.25	0.70	-0.60	0.85*	0.32
Item08	2.97	1.20	-0.06	-0.94	0.91*	0.25
Item09	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
item07		0.5				0.267	0.733
item08		-0.49				0.252	0.748
item09		0.32				0.113	0.887
item27			0.8			0.658	0.342
item03			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
item04					0.41	0.219	0.781
item01					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*

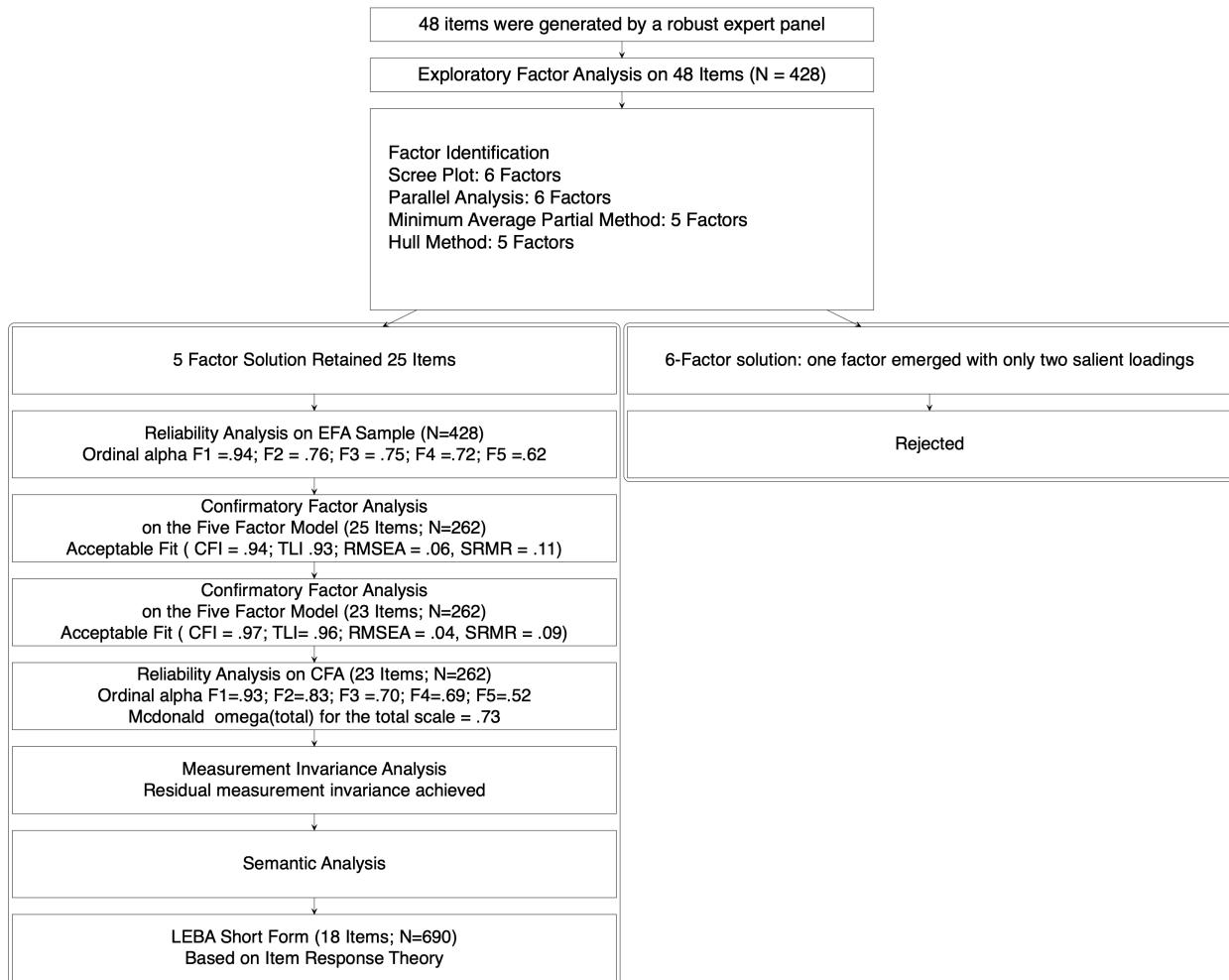
	a	b1	b2	b3	b4
item16	28.13	0.78	0.90	1.06	1.40
item36	4.49	0.94	1.08	1.23	1.40
item17	2.81	0.97	1.11	1.38	1.62
item11	3.27	-0.79	0.65	1.54	2.31
item10	3.07	-1.27	-0.09	0.82	2.00
item12	1.72	-0.67	0.44	1.28	2.11
item07	1.09	-0.50	0.73	1.63	2.97
Ritem08	1.19	-2.26	-0.48	0.64	1.91
item09	0.91	-2.63	-0.96	1.11	3.49
item27	2.21	-1.88	-1.19	-0.73	0.30
item03	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
item04	0.84	2.44	2.80	3.18	3.67
item01	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
item07	67.45	46.00	0.03	0.02
Ritem08	140.90	46.00	0.05	0.00
item09	131.19	45.00	0.05	0.00
item27	16.41	11.00	0.03	0.13
item03	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*

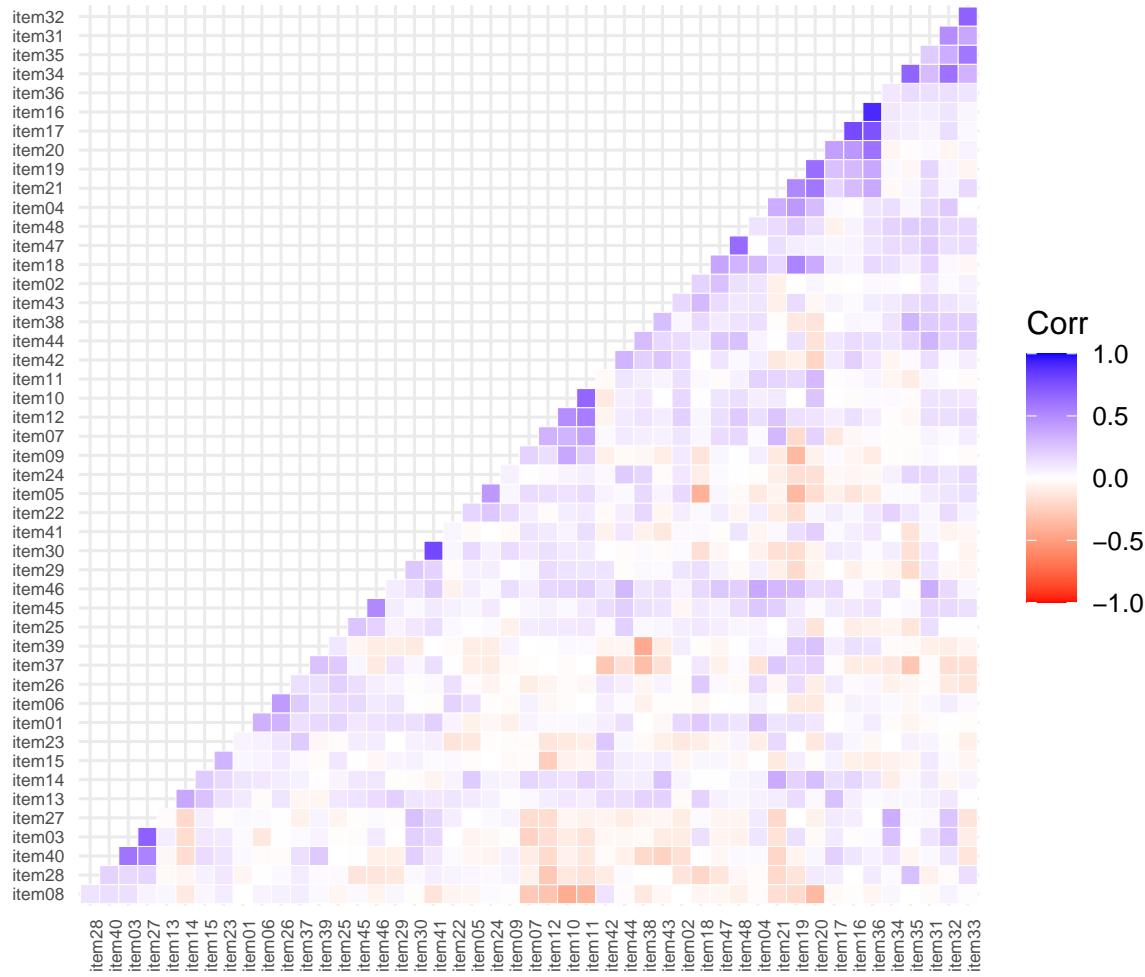


Figure 2. Correlation plot of the items

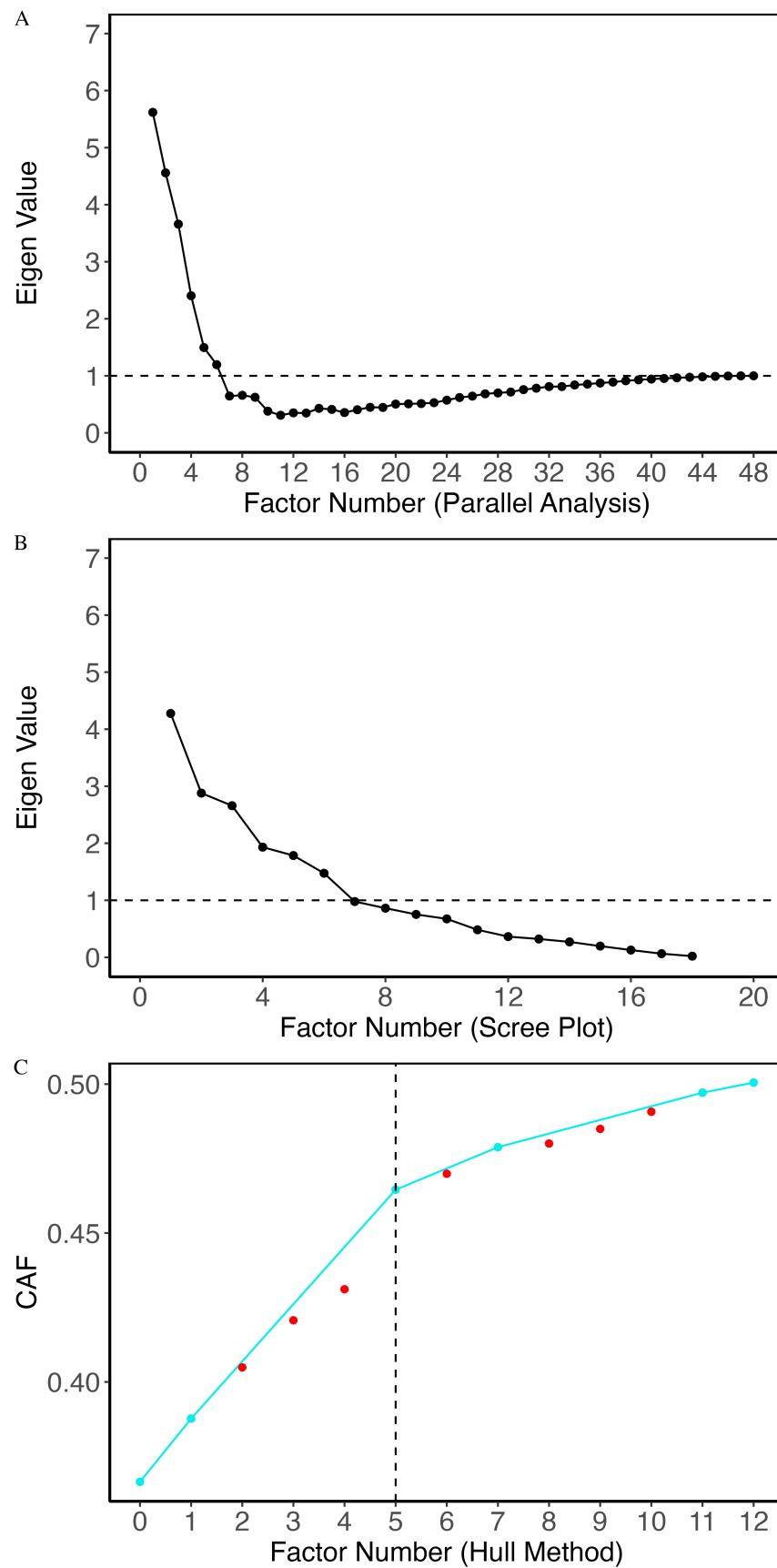


Figure 3. Factor Identification (A) Parallel analysis (B) Scree Plot (C) Hull Method

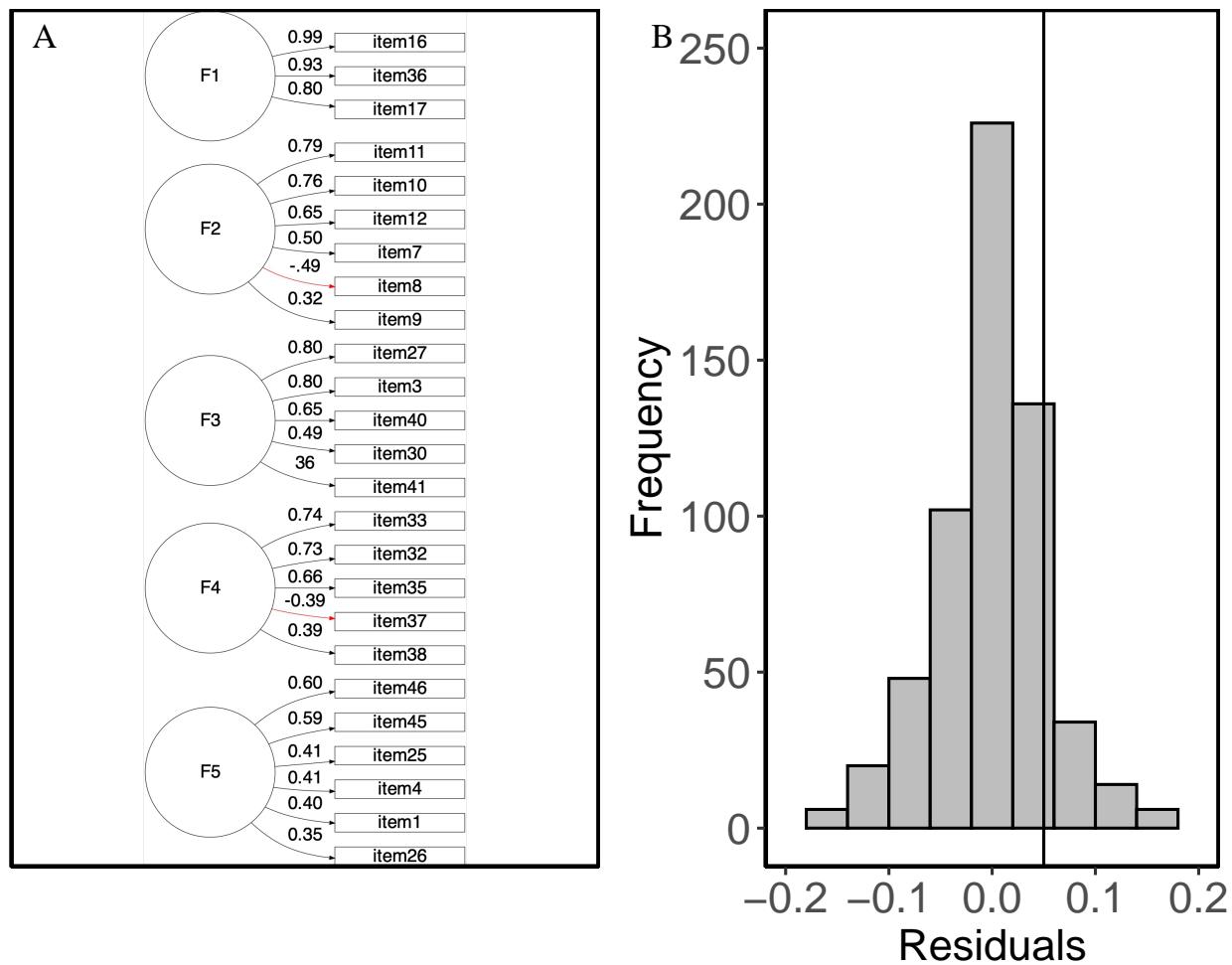


Figure 4. (A) Five Factor Solution obtained in Exploratory Factor Analysis (B) Histogram of nonredundent residula correlations

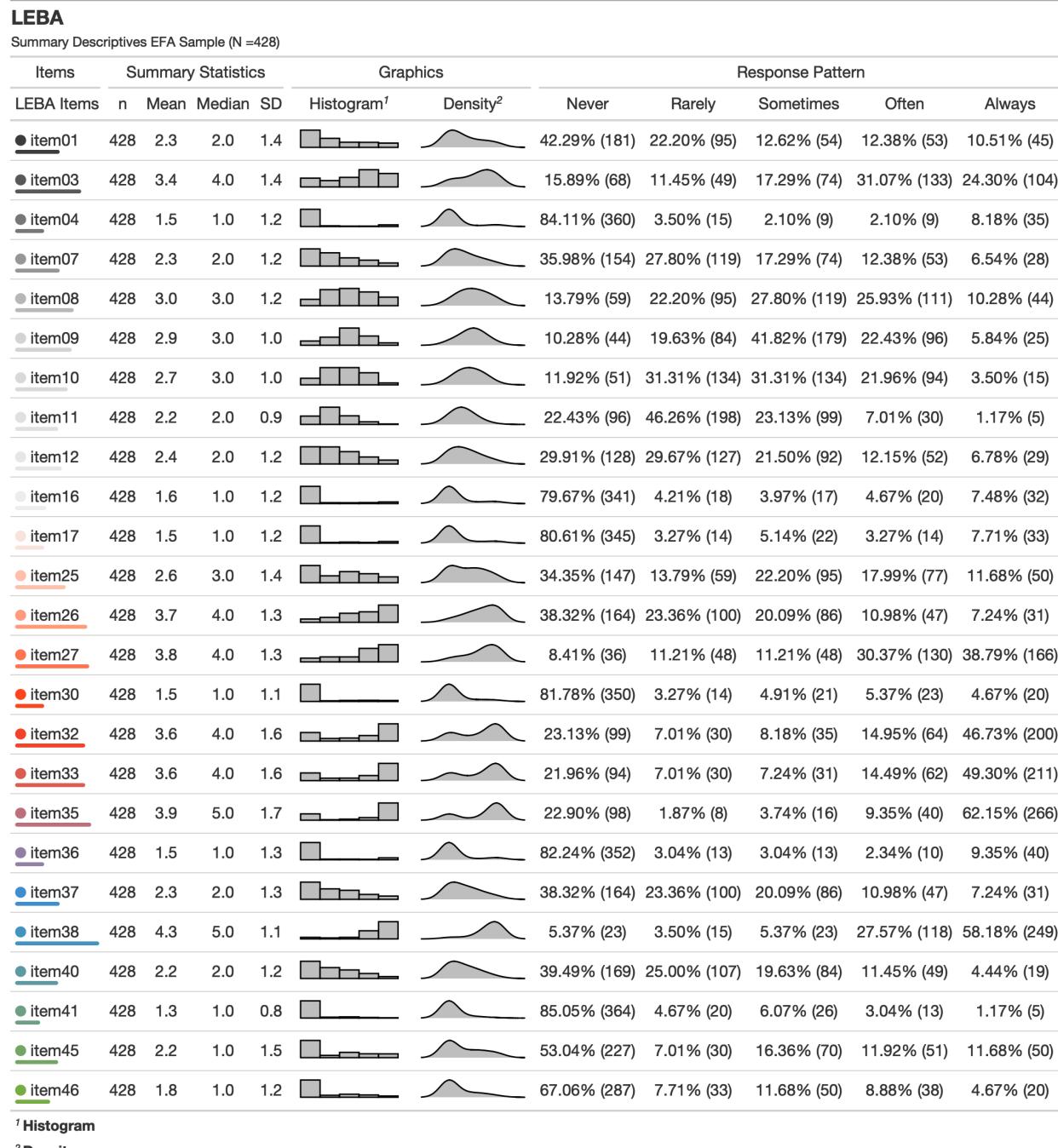


Figure 5. Summary Descriptives EFA Sample

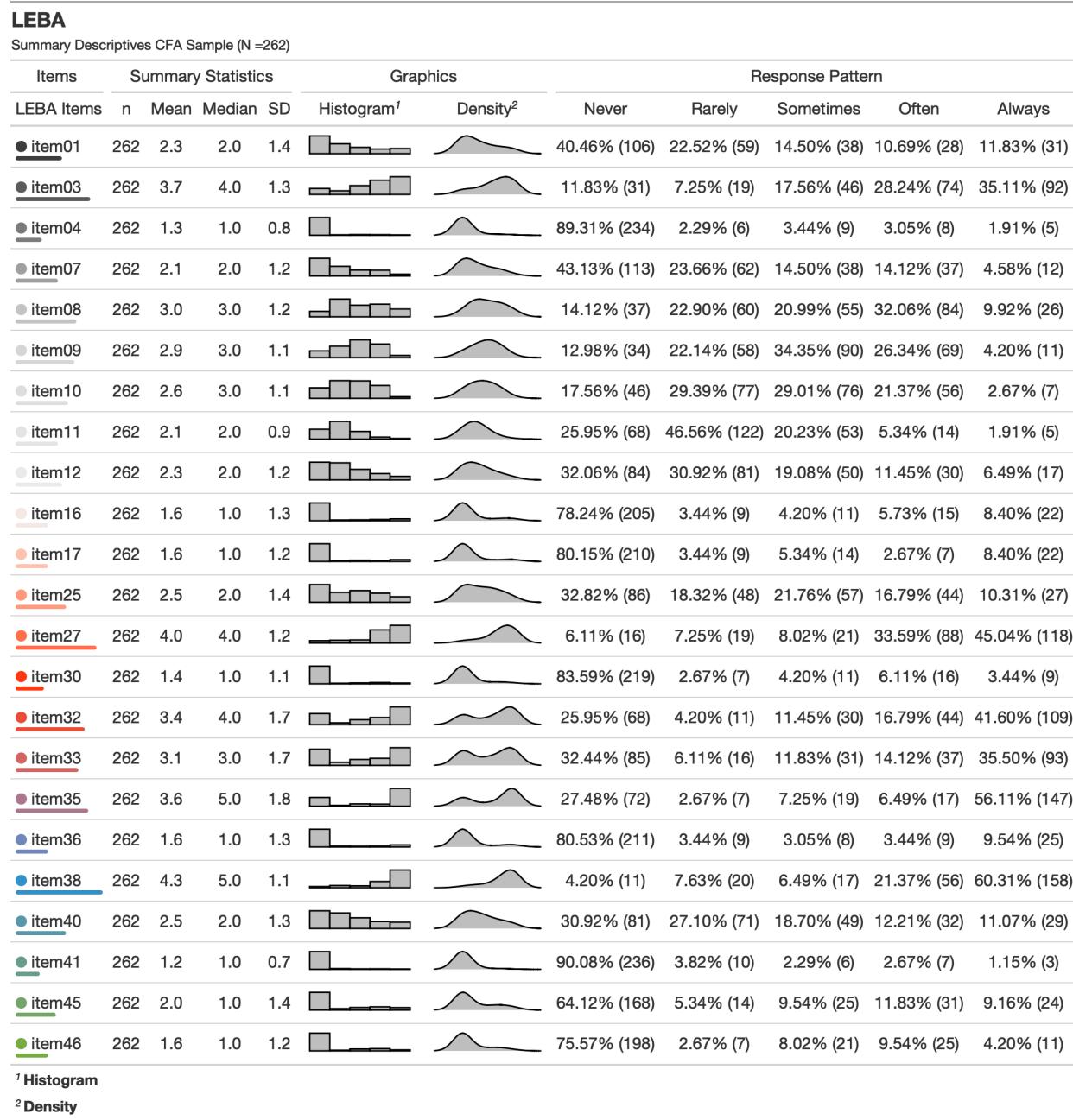


Figure 6. Summary Descriptives of CFA Sample

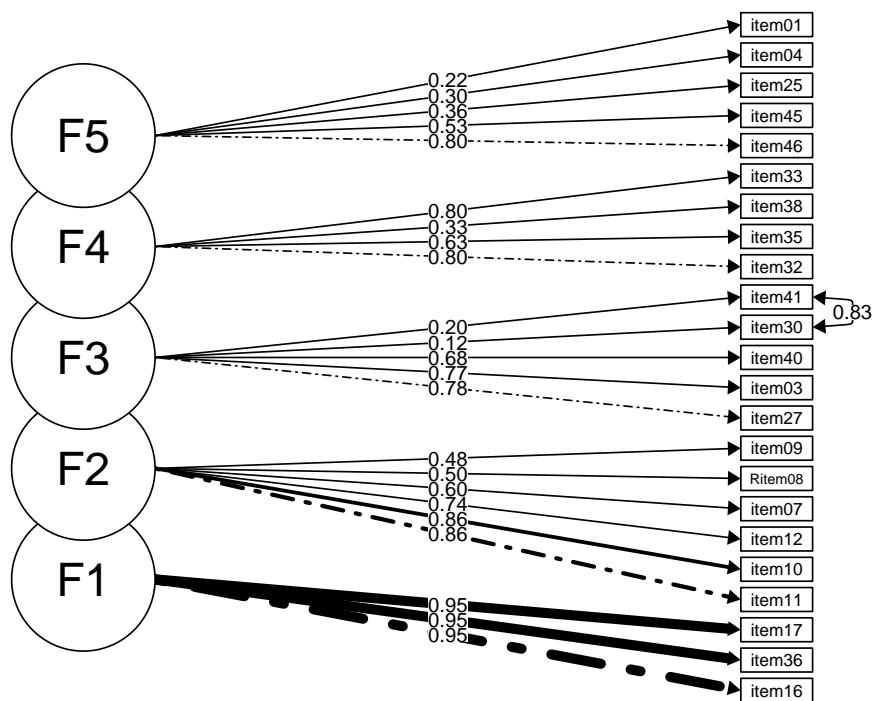
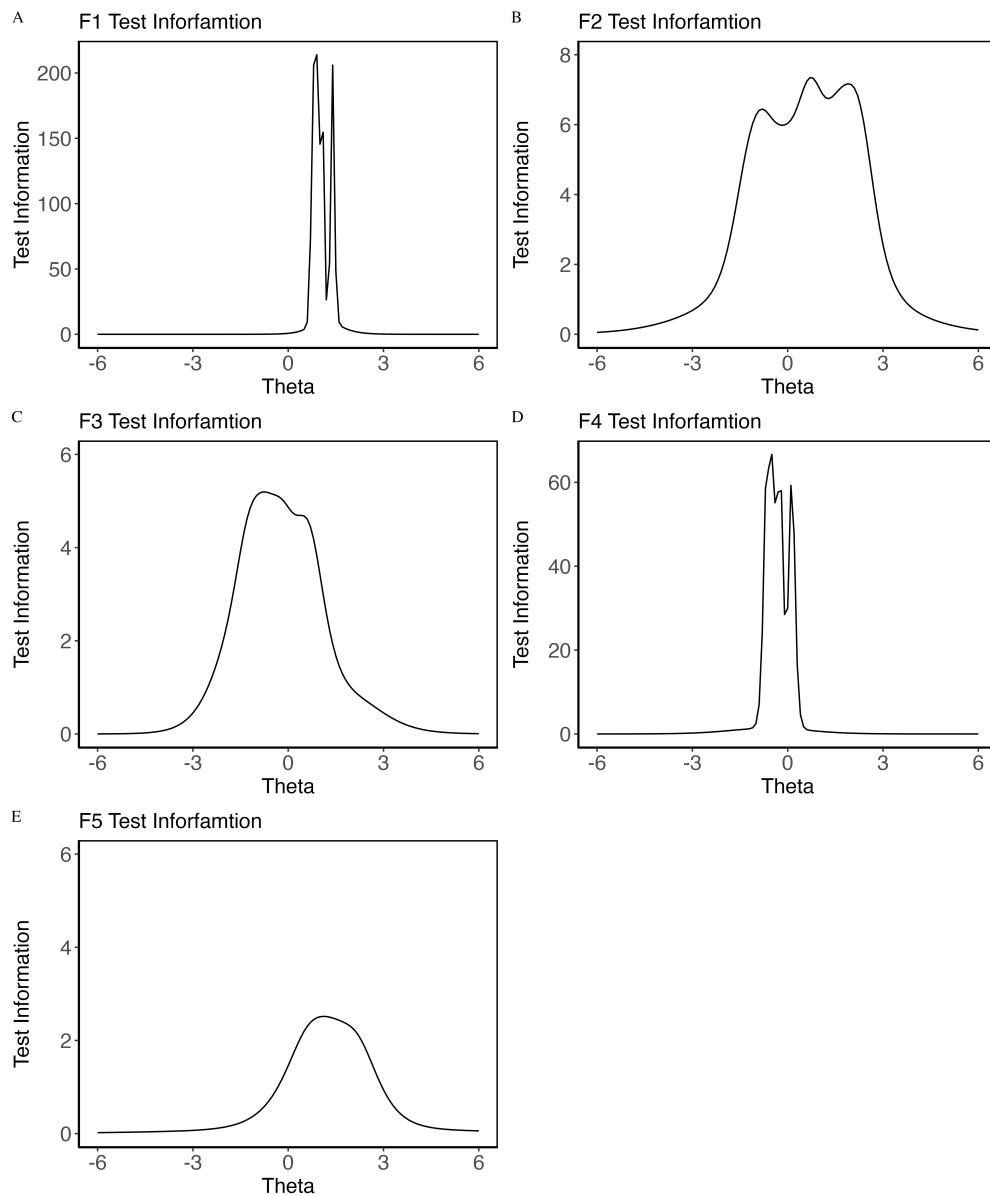


Figure 7. Five Factor CFA Model of LEBA



*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*

## Appendix A

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

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

Appendix B  
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.					

<sup>834</sup> Latent Structure, Reliability and Structural Validity

<sup>835</sup> 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)

<sup>836</sup> LEBA -long form showed satisfactory structural validity (CFI = .97; TLI = .96; RMSEA = .05[.04-.06, 90% CI]; SRMR = .09).

<sup>838</sup> How to cite:

## Appendix C

## 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.					

839 Latent Structure, Reliability and Structural Validity

840 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

841 How to cite:

Table D1

*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 D

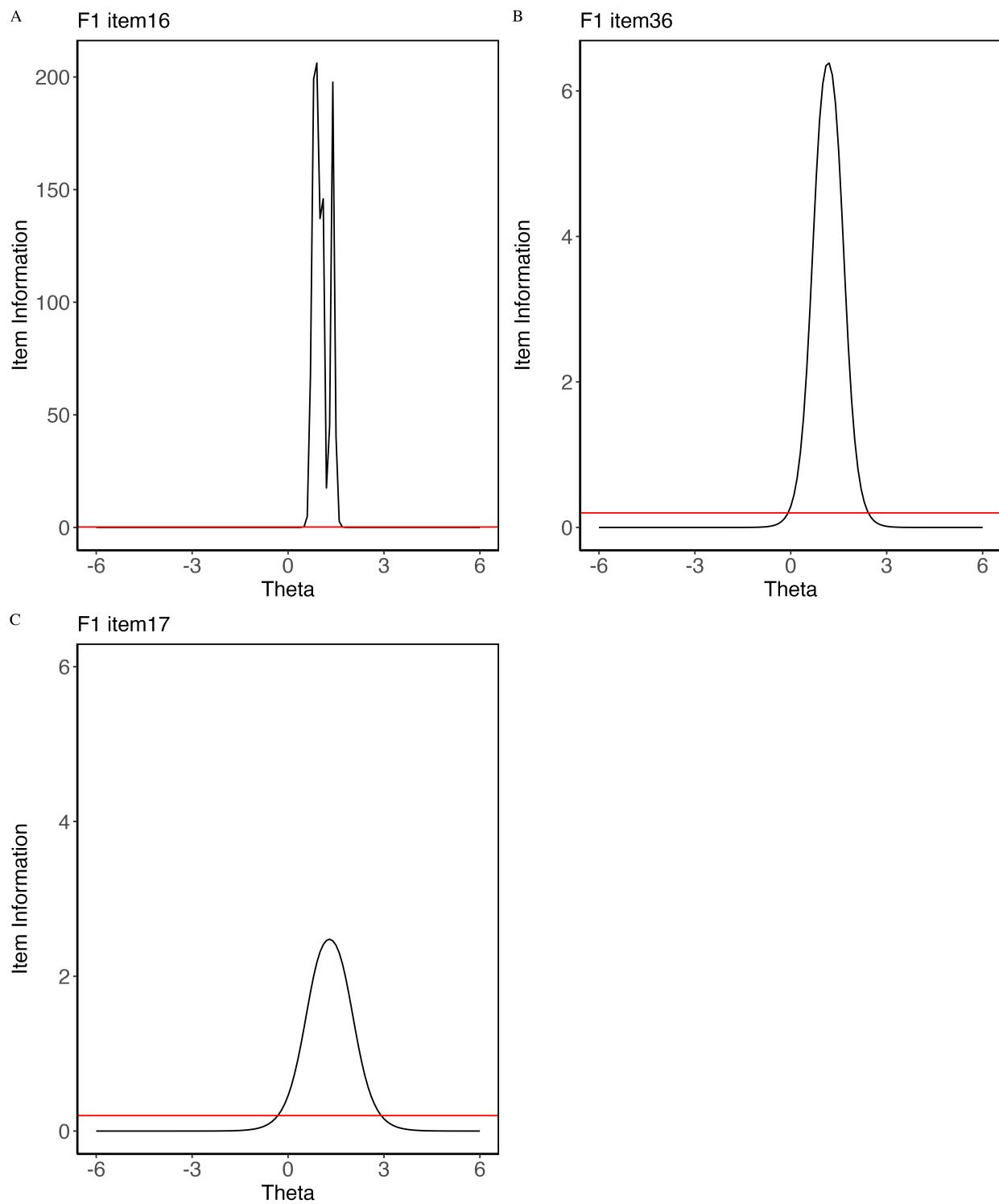


Figure D1. Item information curve of LEBA F1

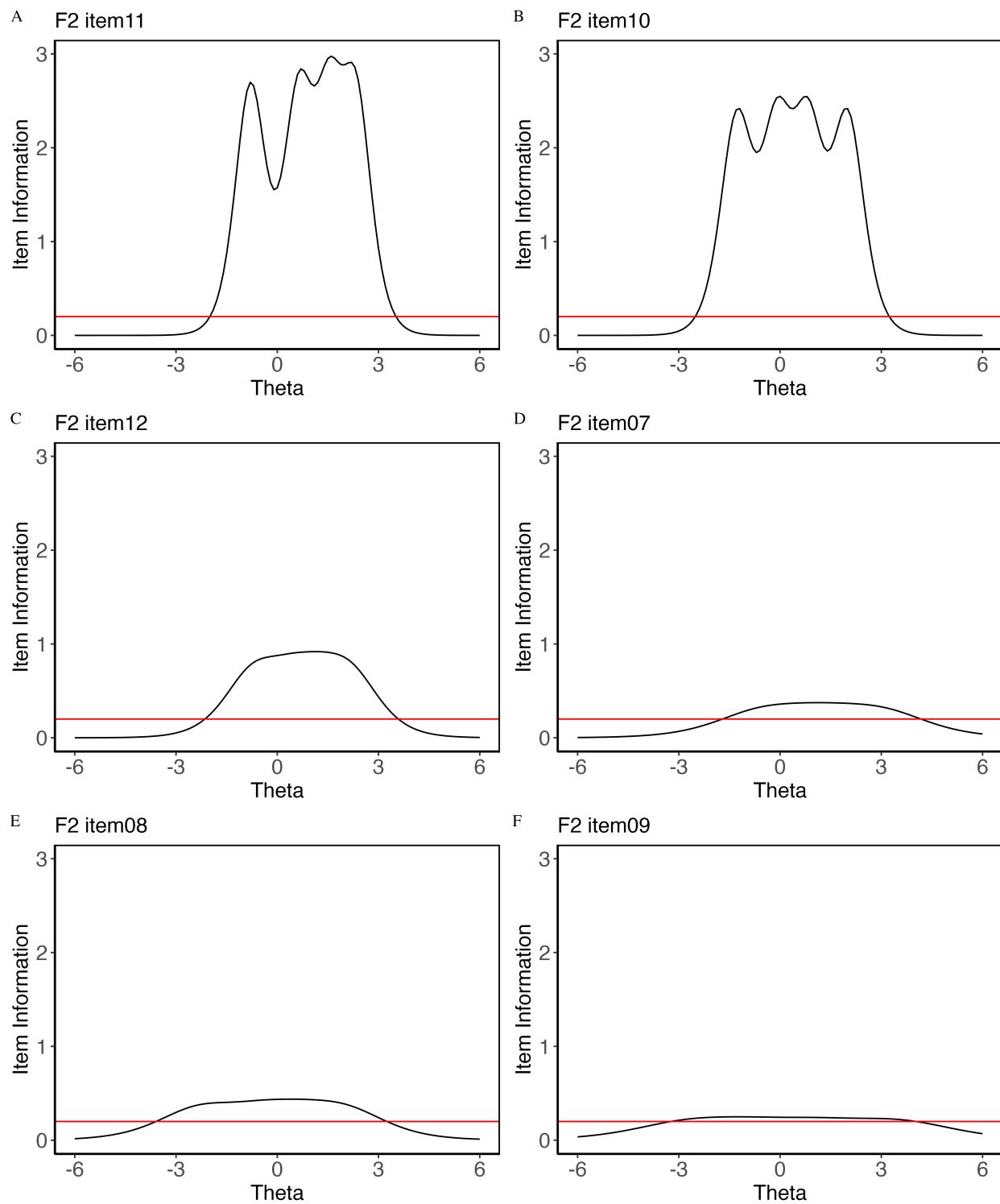


Figure D2. Item information curve of LEBA F1

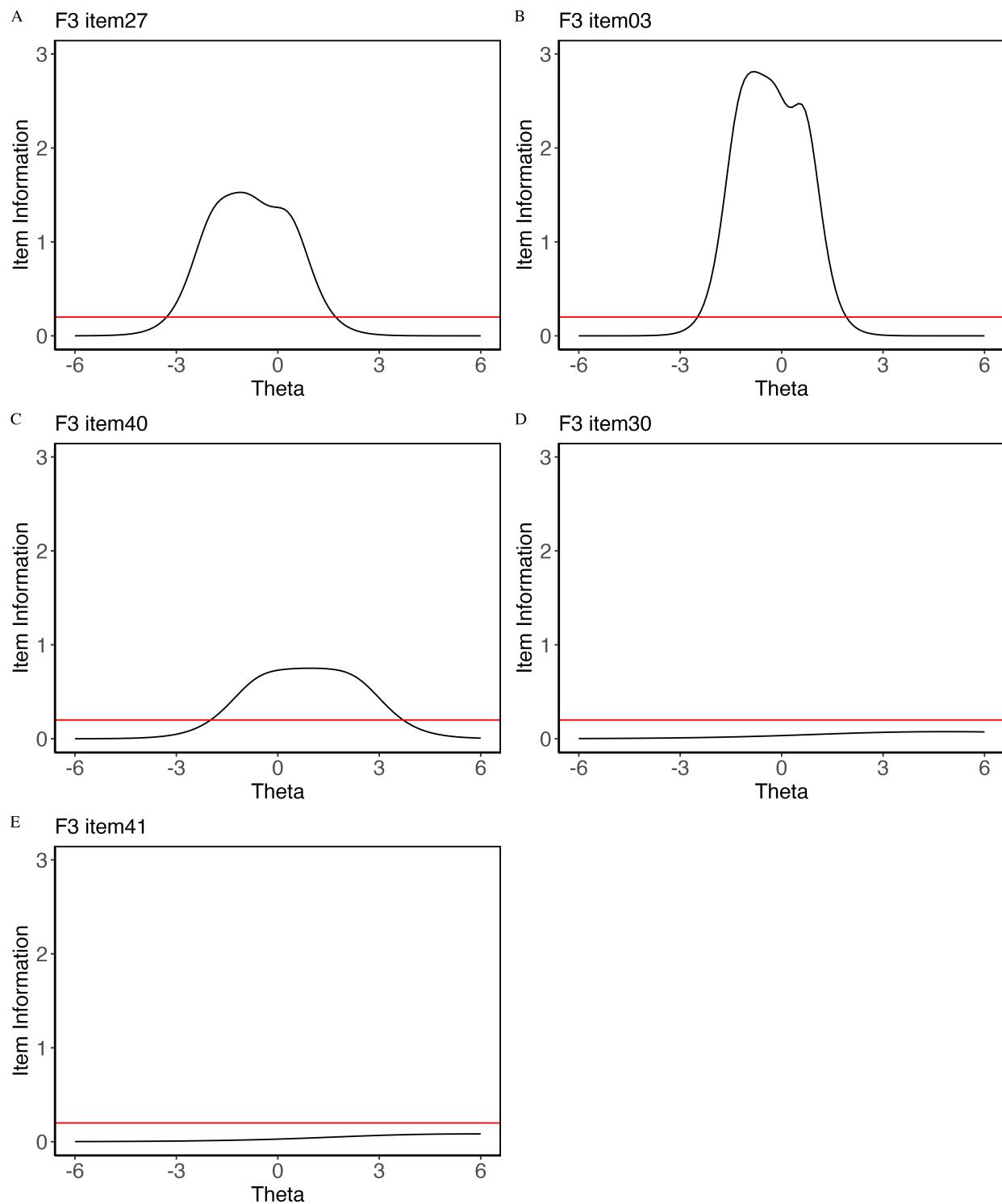


Figure D3. Item information curve of LEBA F1

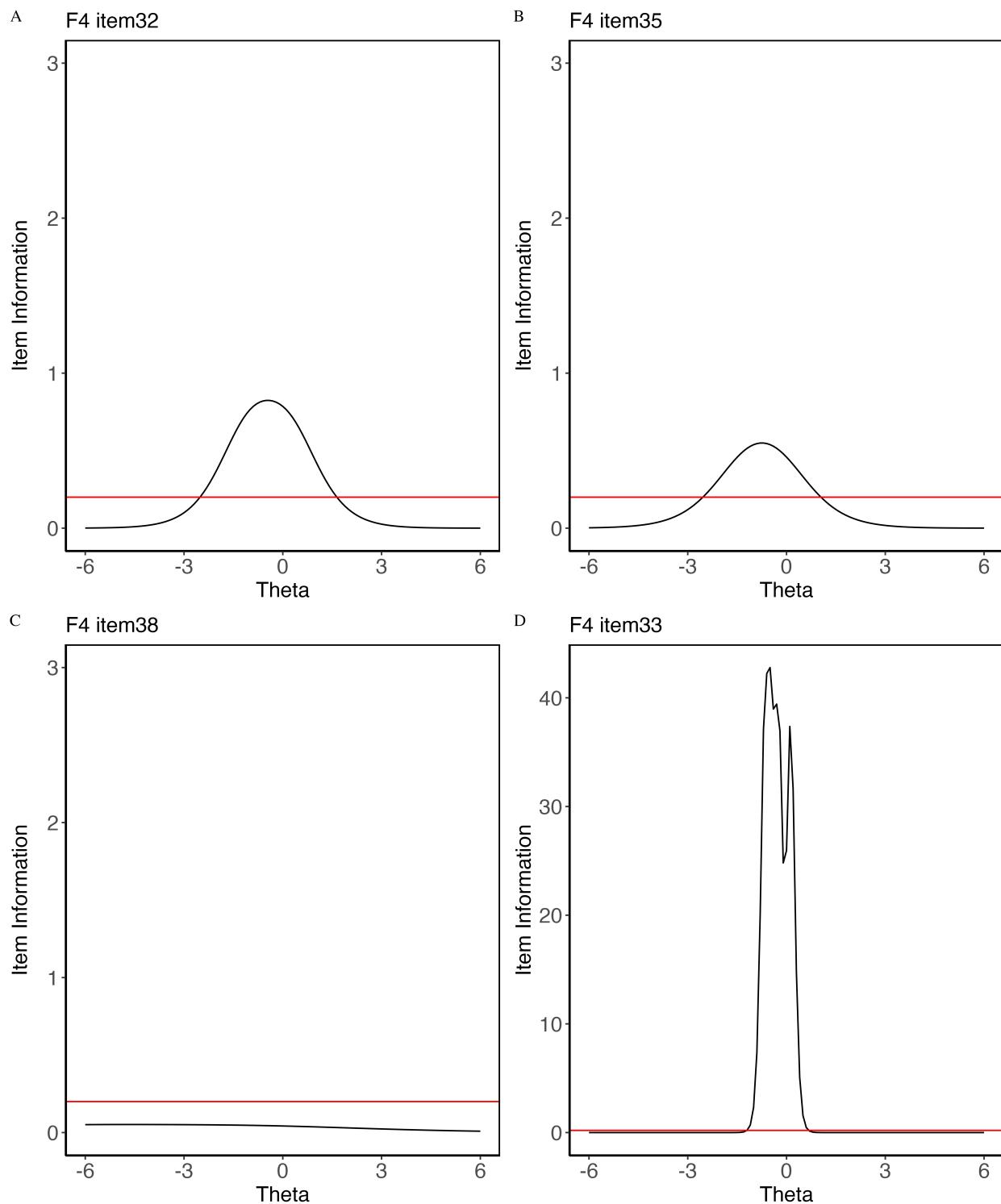


Figure D4. Item information curve of LEBA F1

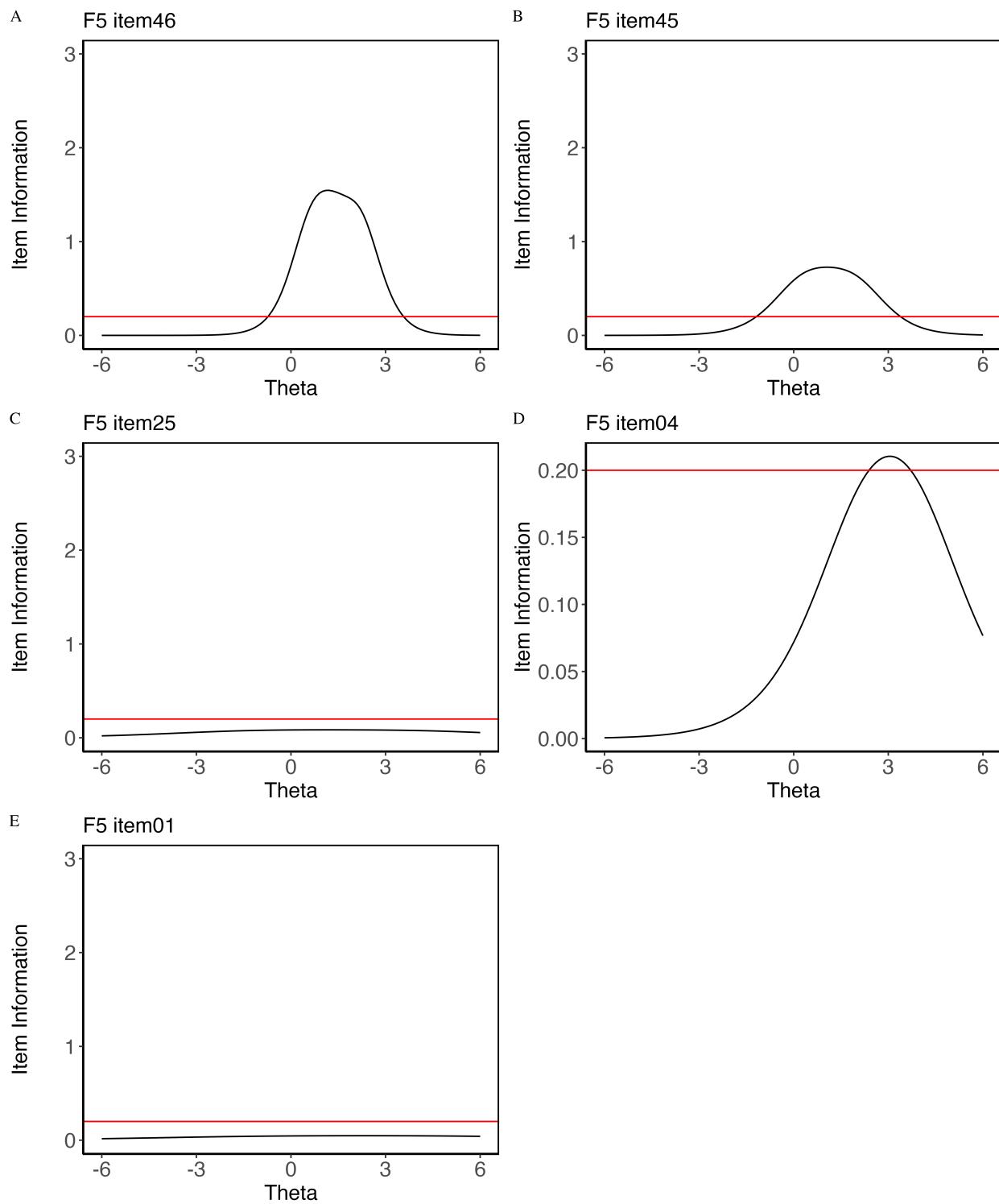
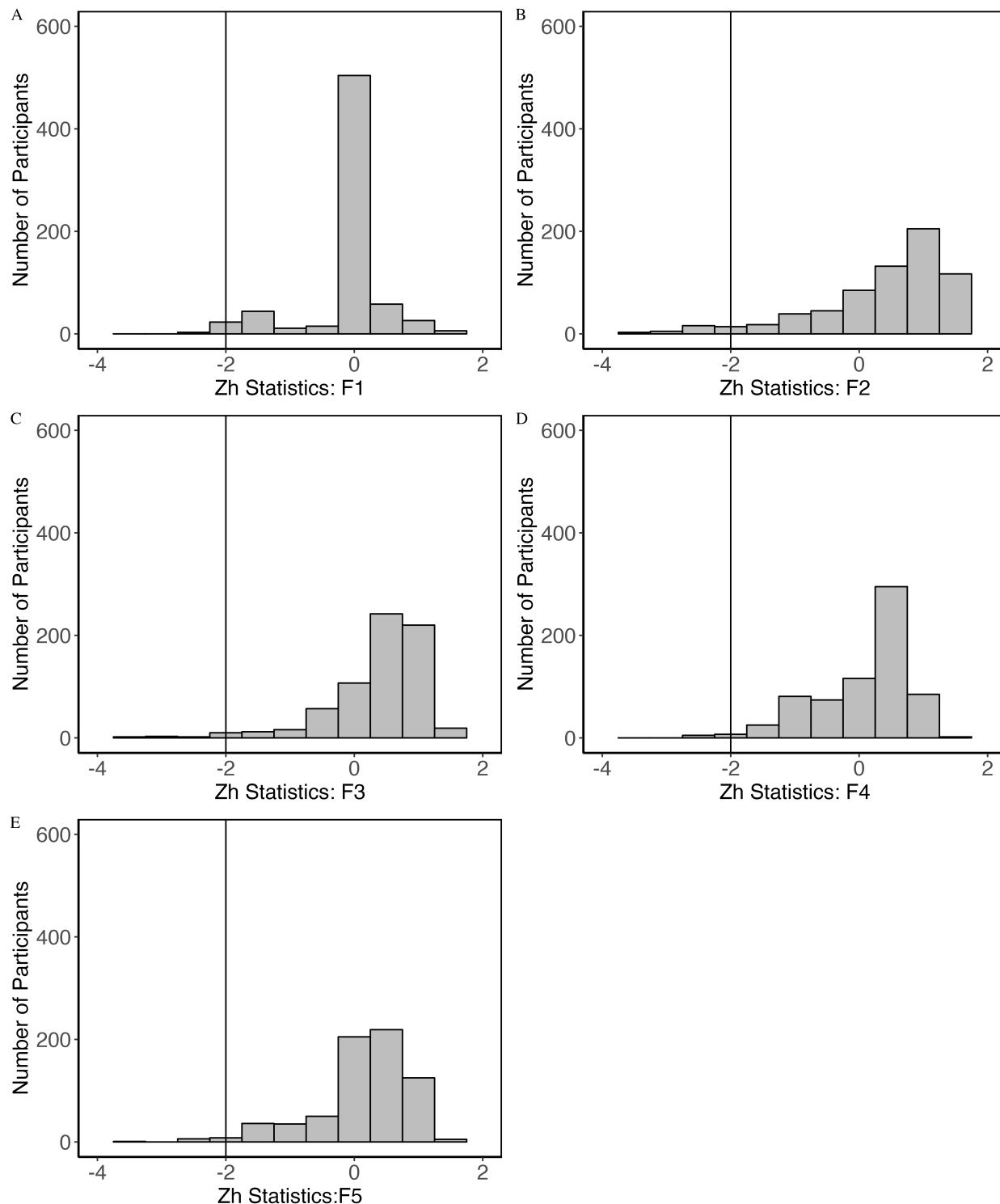


Figure D5. Item information curve of LEBA F1



*Figure D6.* 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 D2

*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%)		

<sup>1</sup> Mean (SD); n (%)<sup>2</sup> False discovery rate correction for multiple testing<sup>3</sup> Wilcoxon rank sum test<sup>4</sup> Fisher's exact test<sup>5</sup> Pearson's Chi-squared test

## Appendix E

**Table E1**

*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
item07		0.5				0.267	0.733
item08		-0.49				0.252	0.748
item09		0.32				0.113	0.887
item27			0.8			0.659	0.341
item03			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
item04					0.41	0.219	0.781

Table E1 continued

item	MR1	MR2	MR3	MR4	MR5	Communality	Uniqueness
item01				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 F

### Factor analysis with six factors

Table F1

*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
item08		-0.48					0.254	0.746
item07		0.47					0.257	0.743
item09		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
item03				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
item04					0.48	0.332		0.668
item25					0.4	0.238		0.762
item01					0.35	0.134		0.866
item26					0.35	0.161		0.839
item37						-0.8	0.682	0.318

Table F1 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

843

Table F2

*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
item04	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
item08		-0.44				0.206	0.794
item07		0.42				0.226	0.774
item09		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 F2 continued

item	PA1	PA2	PA5	PA3	PA4	Communality	Uniqueness
item03				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

844

Table F3

*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
item04	0.49						0.296	0.704
item43	0.32					0.31	0.282	0.718
item10		0.81					0.67	0.33

Table F3 continued

item	PA1	PA2	PA3	PA4	PA6	PA5	Community	Uniqueness
item11		0.81					0.668	0.332
item12		0.58					0.408	0.592
item08		-0.45					0.218	0.782
item07		0.42					0.229	0.771
item09		0.33					0.115	0.885
item03			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

---

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

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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.

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.

F3

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 F5

*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 F5

*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 F5

*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 F5

*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 F5

*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 F5

*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 F5

*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 F5

*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 F5

*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 State of - America/La_Paz (UTC -04:00)	0 (0%)
Bolivia,Sint Eustatius and Saba - America/Kralendijk (UTC -04:00)	0 (0%)

Table F5

*Geographical Location (continued)*


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	**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%)

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Table F5

*Geographical Location (continued)*


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	**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%)

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Table F5

*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 F5

*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 F5

*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 F5

*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 F5

*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 F5

*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 F5

*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 F5

*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 F5

*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 F5

*Geographical Location (continued)*


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**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%)

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Table F5

*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 F5

*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 F5

*Geographical Location (continued)*


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**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%)

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