Appendix A: Standardised Relative Spectral Sensitivity Values $V(\lambda)$

λ	$V(\lambda)$	λ	$V(\lambda)$	λ	$V(\lambda)$
400	0.000396	500	0.323000	600	0.631000
405	0.000640	505	0.407300	605	0.566800
410	0.001210	510	0.503000	610	0.503000
415	0.002180	515	0.608200	615	0.441200
420	0.004000	520	0.710000	620	0.381000
425	0.007300	525	0.793200	625	0.321000
430	0.011600	530	0.862000	630	0.265000
435	0.016840	535	0.914850	635	0.217000
440	0.023000	540	0.954000	640	0.175000
445	0.029800	545	0.980300	645	0.138200
450	0.038000	550	0.994950	650	0.107000
455	0.048000	555	1.000000	655	0.081600
460	0.060000	560	0.995000	660	0.061000
465	0.073900	565	0.978600	665	0.044580
470	0.090980	570	0.952000	670	0.032000
475	0.112600	575	0.915400	675	0.023200
480	0.139020	580	0.870000	680	0.017000
485	0.169300	585	0.816300	685	0.011920
490	0.208020	590	0.757000	690	0.008210
495	0.258600	595	0.694900	695	0.005723
CIE (1926)				700	0.004102

W. van Bommel, *Interior Lighting*, https://doi.org/10.1007/978-3-030-17195-7

Appendix B: Calculation of x–y Chromaticity Coordinates

The CIE 1931 standard colorimetric observer is defined by the set of three colour-matching functions $\bar{x}(\lambda)$, $\bar{y}(\lambda)$ and $\bar{z}(\lambda)$ given in Fig. 2.4. For the calculation, the values of these functions are given in tabular form in 5 nm wavelength intervals below (ISO/CIE 2007 and 2012). With these functions the tristimulus values X, Y and Z are calculated for a given spectral distribution $\Phi(\lambda)$, which should also be available in tabular form in the same wavelength intervals, from

$$X = \sum_{i=1}^{n} \Phi(\lambda)_i * \bar{x}(\lambda)_i$$

$$Y = \sum_{i=1}^{n} \Phi(\lambda)_i * \bar{y}(\lambda)_i$$

$$Z = \sum_{i=1}^{n} \Phi(\lambda)_i * \bar{z}(\lambda)_i$$

The chromaticity coordinates x and y are then calculated with

$$x = \frac{X}{X + Y + Z}$$

$$y = \frac{Y}{X + Y + Z}$$

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CIE Colour-Matching Functions

λ (nm)	$\bar{x}(\lambda)$	$\bar{y}(\lambda)$	$\bar{z}(\lambda)$	$\bar{x}_{10}(\lambda)$	$\bar{y}_{10}(\lambda)$	$\bar{z}_{10}(\lambda)$
380	0.0014	0.0000	0.0065	0.0002	0.0000	0.0007
385	0.0022	0.0001	0.0105	0.0007	0.0001	0.0029
390	0.0042	0.0001	0.0201	0.0024	0.0003	0.0105
395	0.0076	0.0002	0.0362	0.0072	0.0008	0.0323
400	0.0143	0.0004	0.0679	0.0191	0.0020	0.0860
405	0.0232	0.0006	0.1102	0.0434	0.0045	0.1971
410	0.0435	0.0012	0.2074	0.0847	0.0088	0.3894
415	0.0776	0.0022	0.3713	0.1406	0.0145	0.6568
420	0.1344	0.0040	0.6456	0.2045	0.0214	0.9725
425	0.2148	0.0073	10.391	0.2647	0.0295	12.825
430	0.2839	0.0116	13.856	0.3147	0.0387	15.535
435	0.3285	0.0168	16.230	0.3577	0.0496	17.985
440	0.3483	0.0230	17.471	0.3837	0.0621	19.673
445	0.3481	0.0298	17.826	0.3867	0.0747	20.273
450	0.3362	0.0380	17.721	0.3707	0.0895	19.948
455	0.3187	0.0480	17.441	0.3430	0.1063	19.007
460	0.2908	0.0600	16.692	0.3023	0.1282	17.454
465	0.2511	0.0739	15.281	0.2541	0.1528	15.549
470	0.1954	0.0910	12.876	0.1956	0.1852	13.176
475	0.1421	0.1126	10.419	0.1323	0.2199	10.302
480	0.0956	0.1390	0.8130	0.0805	0.2536	0.7721
485	0.0580	0.1693	0.6162	0.0411	0.2977	0.5701
490	0.0320	0.2080	0.4652	0.0162	0.3391	0.4153
495	0.0147	0.2586	0.3533	0.0051	0.3954	0.3024
500	0.0049	0.3230	0.2720	0.0038	0.4608	0.2185
505	0.0024	0.4073	0.2123	0.0154	0.5314	0.1592
510	0.0093	0.5030	0.1582	0.0375	0.6067	0.1120
515	0.0291	0.6082	0.1117	0.0714	0.6857	0.0822
520	0.0633	0.7100	0.0782	0.1177	0.7618	0.0607
525	0.1096	0.7932	0.0573	0.1730	0.8233	0.0431
530	0.1655	0.8620	0.0422	0.2365	0.8752	0.0305
535	0.2257	0.9149	0.0298	0.3042	0.9238	0.0206
540	0.2904	0.9540	0.0203	0.3768	0.9620	0.0137
545	0.3597	0.9803	0.0134	0.4516	0.9822	0.0079
550	0.4334	0.9950	0.0087	0.5298	0.9918	0.0040
555	0.5121	10.000	0.0057	0.6161	0.9991	0.0011
560	0.5945	0.9950	0.0039	0.7052	0.9973	0.0000
565	0.6784	0.9786	0.0027	0.7938	0.9824	0.0000
570	0.7621	0.9520	0.0021	0.8787	0.9556	0.0000
575	0.8425	0.9154	0.0018	0.9512	0.9152	0.0000
580	0.9163	0.8700	0.0017	10.142	0.8689	0.0000

(continued)

λ (nm)	$\bar{x}(\lambda)$	$\bar{y}(\lambda)$	$\bar{z}(\lambda)$	$\bar{x}_{10}(\lambda)$	$\bar{y}_{10}(\lambda)$	$\bar{z}_{10}(\lambda)$
585	0.9786	0.8163	0.0014	10.743	0.8256	0.0000
590	10.263	0.7570	0.0011	11.185	0.7774	0.0000
595	10.567	0.6949	0.0010	11.343	0.7204	0.0000
600	10.622	0.6310	0.0008	11.240	0.6583	0.0000
605	10.456	0.5668	0.0006	10.891	0.5939	0.0000
610	10.026	0.5030	0.0003	10.305	0.5280	0.0000
615	0.9384	0.4412	0.0002	0.9507	0.4618	0.0000
620	0.8544	0.3810	0.0002	0.8563	0.3981	0.0000
625	0.7514	0.3210	0.0001	0.7549	0.3396	0.0000
630	0.6424	0.2650	0.0000	0.6475	0.2835	0.0000
635	0.5419	0.2170	0.0000	0.5351	0.2283	0.0000
640	0.4479	0.1750	0.0000	0.4316	0.1798	0.0000
645	0.3608	0.1382	0.0000	0.3437	0.1402	0.0000
650	0.2835	0.1070	0.0000	0.2683	0.1076	0.0000
655	0.2187	0.0816	0.0000	0.2043	0.0812	0.0000
660	0.1649	0.0610	0.0000	0.1526	0.0603	0.0000
665	0.1212	0.0446	0.0000	0.1122	0.0441	0.0000
670	0.0874	0.0320	0.0000	0.0813	0.0318	0.0000
675	0.0636	0.0232	0.0000	0.0579	0.0226	0.0000
680	0.0468	0.0170	0.0000	0.0409	0.0159	0.0000
685	0.0329	0.0119	0.0000	0.0286	0.0111	0.0000
690	0.0227	0.0082	0.0000	0.0199	0.0077	0.0000
695	0.0158	0.0057	0.0000	0.0138	0.0054	0.0000
700	0.0114	0.0041	0.0000	0.0096	0.0037	0.0000
705	0.0081	0.0029	0.0000	0.0066	0.0026	0.0000
710	0.0058	0.0021	0.0000	0.0046	0.0018	0.0000
715	0.0041	0.0015	0.0000	0.0031	0.0012	0.0000
720	0.0029	0.0010	0.0000	0.0022	0.0008	0.0000
725	0.0020	0.0007	0.0000	0.0015	0.0006	0.0000
730	0.0014	0.0005	0.0000	0.0010	0.0004	0.0000
735	0.0010	0.0004	0.0000	0.0007	0.0003	0.0000
740	0.0007	0.0002	0.0000	0.0005	0.0002	0.0000
745	0.0005	0.0002	0.0000	0.0004	0.0001	0.0000
750	0.0003	0.0001	0.0000	0.0003	0.0001	0.0000
755	0.0002	0.0001	0.0000	0.0002	0.0001	0.0000
760	0.0002	0.0001	0.0000	0.0001	0.0000	0.0000
765	0.0001	0.0000	0.0000	0.0001	0.0000	0.0000
770	0.0001	0.0000	0.0000	0.0001	0.0000	0.0000
775	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
780	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Appendix C: RVP Model of Weston

Formulas to calculate, based on Weston (1953) and CIE (2002), Weston's relative visual performance RVP values for different contrast values (C), background luminances (L_b), visual angle α and age (a). The actual meaning of some of the intermediate parameters to be calculated is given in reference CIE (2002). Here we treat these parameters just as intermediate calculation functions.

For $C \geq 0.35$ and $\alpha \geq 1.5$:

$$X = 0.119 * (\log L_b + 1.923)^{0.0840} * (C + 1.516)^{-0.655}$$

$$Y = 0.814 * (\alpha - 1.182)^{-0.783} * (C + 1.054)^{-3.062}$$

$$Z = 0.575 * (\log L_b + 0.267)^{-0.390} * (\alpha - 0.830)^{-0.764}$$

$$E = (C + 0.199)^{-0.148} + 1.024$$

$$\mathrm{AF} = 1 - \left(1.317 * 10^{-4}\right) * (a - 20)^{E}$$

$$\mathrm{RVP} = 0.930 * (\alpha - 1.499)^{X} * (\log L_b + 0.0920)^{Y} * (C - 0.253)^{Z} * \mathrm{AF}$$

For $C < 0.35$ and $\alpha \geq 1.5$:

$$X = 0.082 * (\log L_b + 0.113)^{-0.638} * (C + 0.0224)^{-0.23}$$

$$Y = 0.145 * (\alpha - 0.0041)^{-0.185} * (C - 0.099)^{0.117}$$

$$Z = 1.291 * (\log L_b + 0.264)^{-0.387} * (\alpha - 0.218)^{-0.523}$$

$$E = (C + 0.199)^{-0.148} + 1.024$$

$$\mathrm{AF} = 1 - \left(1.317 * 10^{-4}\right) * (a - 20)^{E}$$

$$\mathrm{RVP} = 1.137 * (\alpha - 1.499)^{X} * (\log L_b + 0.035)^{Y} * (C - 0.0852)^{Z} * \mathrm{AF}$$

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Appendix D: RVP Model of Rea

Go through steps 1–7 to calculate relative visual performance RVP for different contrast values (C_v), adaptation luminances (L_A) and age (a). The actual meaning of the intermediate parameters to be calculated in the different steps is given in reference (Rea and Ouellette 1991). Here we treat these parameters just as intermediate calculation functions.

- Step 1

$$I_{R'} = P * L_A * \pi * r^2$$

where
L_A = adaptation luminance in cd/m^2

$$r = 2.39 - \{1.22 * \tanh(0.3 * \log L_A)\}$$
$$P = 1 - 0.017 * (a - 20)$$

where
a = age of observer for 20–65 years

- Step 2

$$C'_{t,d} = \varepsilon * 10^{(-1.364-0.179*A-0.813*L+0.226*A^2-0.0772*L^2+0.169*A*L)}$$

where

$$A = \text{logtanh}(20,000 * \omega)$$

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$$L = \text{loglog}\left(10 * \frac{I_{R'}}{\pi}\right)$$

$$\varepsilon = 1 + (0.00251) * (a - 20)$$

where

ω = area of the object in steradians

- Step 3

$$K = 10^{\left(-1.763 - 0.175 * \text{AA} - 0.0310 * \text{LL} + 0.112 * \text{AA}^2\right) + 0.171 * \text{LL}^2 + 0.0622 * \text{AA} * \text{LL}}$$

$$\text{AA} = \text{logtanh}(5000 * \omega)$$

$$\text{LL} = \text{logtanh}\left(0.04 * \frac{I_{R'}}{\pi}\right)$$

- Step 4

$$R_{\max} = 0.000196 * \log I_{R'} + 0.0027$$

- Step 5

$$\text{RT} = \frac{\Delta C_{\text{d}}^{0.97} + K^{0.97}}{\Delta C_{\text{d}}^{0.97} * R_{\max}}$$

$$\Delta C_{\text{d}} = C_{\text{v}} - C'_{\text{t,d}}; \quad \Delta C_{\text{d}} > 0$$

$$C_{\text{v}} = \frac{|L_{\text{B}} - L_{\text{T}}|}{L_{\text{B}}} = \frac{|E * \rho/\pi - L_{\text{T}}|}{L_{\text{B}}}$$

where:

L_{B} = background luminance in cd/m^2 (with uniform luminance $L_{\text{B}} = L_{\text{A}}$)
L_{T} = target (object) luminance in cd/m^2
L_{veil} = equivalent veiling luminance in cd/m^2
E = illuminance on object in lux
ρ = reflectance factor of object

- Step 6

$$\Delta T_{\text{vis}} = 305.4 - \text{RT}$$

- Step 7

$$\text{RVP} = 0.998 * \left(\frac{\Delta T_{\text{vis}} + 800}{777}\right)$$

$$\text{RVP} < 0 \rightarrow \text{RVP} = 0 \quad \text{RVP} > 1 \rightarrow \text{RVP} = 1$$

Appendix E: E_{vector}/E_{scalar} Ratio

Calculationbased on cubic illumination (Cuttle 1997) (Fig. E.1).

$E(x)$ and $E(-x)$ are two opposing illuminances on the x-axis
$E(y)$ and $E(-y)$ are two opposing illuminances on the y-axis
$E(z)$ and $E(-z)$ are two opposing illuminances on the z-axis
$'E(x) = E(x) - E(-x)$ is the magnitude of the illumination vector in the x-axis
$'E(y) = E(y) - E(-y)$ is the magnitude of the illumination vector in the y-axis
$'E(z) = E(z) - E(-z)$ is the magnitude of the illumination vector in the z-axis

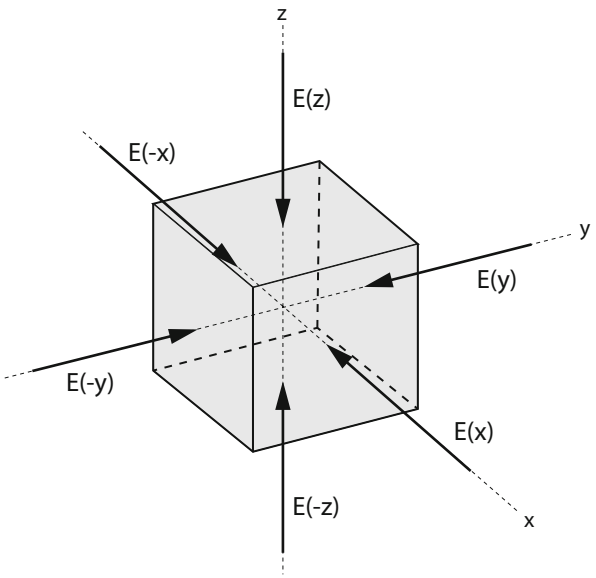

Fig. E.1 Cubic illumination at a point

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$$|E| = \sqrt{'E(x)^2 + 'E(y)^2 + 'E(z)^2}$$

with

$|E|$ is the magnitude of the illumination vector (as a result of all light incidences)

$$e(x) = 'E(x)/\mid E \mid \quad e(y) = 'E(y)/|E| \quad e(z) = 'E(z)/\mid E \mid$$

with

$e(x, y, z)$ the direction of the illumination vector in the x, y, z coordinating system

$\sim E(x)$ is the lesser of $E(x)$ and $E(-x)$
$\sim E(y)$ is the lesser of $E(y)$ and $E(-y)$
$\sim E(z)$ is the lesser of $E(z)$ and $E(-z)$

$$\text{Esr} = \frac{|E|}{4} + \frac{\sim E(x) + \sim E(y) + \sim E(z)}{3}$$

with

Esr is the scalar illumination

$$E_{\text{vector}}/E_{\text{scalar}} \text{ ratio} = \frac{|E|}{\text{Esr}}$$

Appendix F: Position Indices, *p*

Position indices, *p*, are needed for the calculation of UGR. The parameters *x*, *y* and h' refer to the rectangular coordinating system shown in Fig. 4.22 (CIE 1995)

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h'/y x/y	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90
0.00	1.00	1.26	1.53	1.90	2.35	2.86	3.50	4.20	5.00	6.00	7.00	8.10	9.25	10.35	11.70	13.15	14.70	16.20		
0.10	1.05	1.22	1.46	1.80	2.20	2.75	3.40	4.10	4.80	5.80	6.80	8.00	9.10	10.30	11.60	13,00	14.60	16.10		
0.20	1.12	1.30	1.50	1.80	2.20	2.66	3.18	3.88	4.60	5.50	6.50	7.60	8.75	9.85	11.20	12.70	14.00	15.70		
0.30	1.22	1.38	1.60	1.87	2.25	2.70	3.25	3.90	4.60	5.45	6.45	7.40	8.40	9.50	10.85	12.10	13.70	15.00		
0.40	1.32	1.47	1.70	1.96	2.35	2.80	3.30	3.90	4.60	5.40	6.40	7.30	8.30	9.40	19.60	11.90	13.20	14.60	16.00	
0.50	1.43	1.60	1.82	2.10	2.48	2.91	3.40	3.98	4.70	5.50	6.40	7.30	8.30	9.40	10.50	11.75	13.00	14.40	15.70	
0.60	1.55	1.72	1.98	2.30	2.65	3.10	3.60	4.10	4.80	5.50	6.40	7.35	8.40	9.40	10.50	11.70	13.00	14.10	15.40	
0.70	1.70	1.88	2.12	2.48	2.87	3.30	3.78	4.30	4.88	5.60	6.60	7.40	8.50	9.50	10.50	11.70	12.85	14.00	15.20	
0.80	1.82	2.00	2.32	2.70	3.08	3.50	3.92	4.50	5.10	5.75	6.60	7.50	8.60	9.50	10.60	11.75	12.80	14.00	16.10	
0.90	1.95	2.20	2.54	2.90	3.30	3.70	4.20	4.75	5.30	6.00	6.75	7.70	8.70	9.65	10.75	11.80	12.90	14.00	15.00	16.00
1.00	2.11	2.40	2.75	3.10	3.50	3.91	4.40	5.00	5.60	6.20	7.00	7.90	8.80	9.75	10.80	11.90	12.95	14.00	15.00	16.00
1.1	2.30	2.55	2.92	3.30	3.72	4.20	4.70	5.25	5.80	6.55	7.20	7.16	9.00	9.90	10.95	12.00	13.00	14.00	15.00	16.00
1.20	2.40	2.75	3.12	3.50	3.90	4.35	4.85	5.50	6.05	6.70	7.50	8.30	9.20	10.00	11.02	12.10	13.10	14.00	15.00	16.00
1.30	2.55	2.90	3.30	3.70	4.20	4.65	5.20	5.70	6.30	7.00	7.70	8.55	9.35	10.20	11.20	12.25	13.20	14.00	15.00	16.00
1.40	2.70	3.10	3.50	3.90	4.35	4.85	5.35	585	6.50	7.25	8.00	8.70	9.50	10.40	11.4	12.40	13.25	14.05	15.00	16.00
1.50	2.85	3.15	3.65	4.10	4.55	5.00	5.50	6.20	6.80	7.50	8.20	8.85	9.70	10.55	11.50	12.50	13.30	14.05	15.02	16.00
1.60	2.95	3.40	3.80	4.25	4.75	5.20	5.75	6.30	7.00	7.65	8.40	9.00	9.80	10.80	11.75	12.60	13.40	14.20	15.10	16.00
1.70	3.10	3.55	4.00	4.50	4.90	5.40	5.95	6.50	7.20	7.80	8.50	9.20	10.00	10.85	11.85	12.75	13.45	14.20	15.10	16.00
1.80	3.25	3.70	4.20	4.65	5.10	5.60	6.10	6.75	7.40	8.00	8.65	9.35	10.10	11.00	11.90	12.80	13.50	14.20	15.10	16.00

1.90	3.43	3.86	4.30	4.75	5.20	5.70	6.30	6.90	7.50	8.17	8.80	9.50	10.20	11.00	12.00	12.82	13.55	14.20	15.10	16.00
2.00	3.50	4.00	4.50	4.90	5.35	5.80	6.40	7.10	7.70	8.30	8.90	9.60	10.40	11.10	12.00	12.85	13.60	14.30	15.10	16.00
2.10	3.60	4.17	4.65	5.05	5.50	6.00	6.60	7.20	7.82	8.45	9.00	9.75	10.50	11.20	12.10	12.90	13.70	14.35	15.10	16.00
2.20	3.75	4.25	4.72	5.20	5.60	6.10	6.70	7.35	8.00	8.55	9.15	9.85	10.60	11.30	12.10	12.90	13.70	14.40	15.15	16.00
2.30	3.85	4.35	4.80	5.25	5.70	6.22	6.80	7.40	8.10	8.65	9.30	9.90	10.70	11.40	12.20	12.95	13.70	14.40	15.20	16.00
2.40	3.95	4.40	4.90	5.35	5.80	6.30	6.90	7.50	8.20	8.80	9.40	10.00	10.80	11.50	12.25	13.00	13.75	14.45	15.20	16.00
2.50	4.00	4.50	4.95	5.40	5.85	6.40	6.95	7.55	8.25	8.85	9.50	10.05	10.85	11.55	12.30	13.00	13.80	14.50	15.25	16.00
2.60	4.07	4.55	5.05	5.47	5.95	6.45	7.00	7.65	8.35	8.95	9.65	10.10	10.90	11.60	12.32	13.00	13.80	14.50	15.25	16.00
2.70	4.10	4.60	5.10	5.53	6.00	6.50	7.05	7.70	8.40	9.00	9.60	10.16	10.92	11.63	12.35	13.00	13.80	14.50	15.25	16.00
2.80	4.15	4.62	5.15	5.56	6.05	6.55	7.08	7.73	8.45	9.05	9.65	10.20	10.95	11.65	12.35	13.00	13.80	14.50	15.25	16.00
2.90	4.20	4.65	5.17	5.60	6.07	6.57	7.12	7.75	8.50	9.10	9.70	10.23	10.95	11.65	12.35	13.00	13.80	14.50	15.25	16.00
3.00	4 22	4.67	5.20	5.65	6.12	6.60	7.15	7.80	8.55	9.12	9.70	10.23	10.95	11.65	12.35	13.00	13.80	14.50	15.25	16.00

Appendix G: Groningen Sleep Quality Scale

1	I had a deep sleep last night	True	False
2	I feel like I slept poorly last night	True	False
3	It took me more than half an hour to fall asleep last night	True	False
4	I felt tired after waking up this morning	True	False
5	I woke up several times last night	True	False
6	I feel like I didn't get enough sleep last night	True	False
7	I got up in the middle of the night	True	False
8	I felt rested after waking up this morning	True	False
9	I feel like I only had a couple of hours of sleep last night	True	False
10	I feel I slept well last night	True	False
11	I didn't sleep a wink last night	True	False
12	I didn't have any trouble falling asleep last night	True	False
13	After I woke up last night, I have trouble falling asleep again	True	False
14	I tossed and turned all night last night	True	False
15	I didn't get more than 5 h of sleep last night	True	False

Scoring:
The first question doesn't count towards the total score
One point if answer is "True" for questions 2, 3, 4, 5, 6, 7, 9, 11, 13, 14, 15
One point if answer is "false" for questions 8, 10, 12
Maximum score of 14 points indicates poor sleep the night before
Note: The Groningen Sleep Quality Scale (Meijman et al. 1988) is a tool that can be used to understand your patterns in overall sleep quality. Answer these 15 questions for at least 14 days in a row to help understand your individual sleep patterns

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Appendix H: Normalised Formula for SVM according to CIE (2016)

$$\mathrm{SVM} = \sqrt[3.7]{\sum \left(\frac{C_i}{T_i}\right)^{3.7}}$$

SVM = stroboscopic visibility measure
C_i = the amplitude of the ith Fourier component
T_i = the visibility threshold for a sine wave at the frequency of the ith Fourier component
T = 1/*Stroboscopic sensitivity* of Fig. 10.8

T as formula:

$$T_i(f) = \frac{1}{1 + \mathrm{e}^{-a(f-b)}} + 20\mathrm{e}^{-f/10}$$

f = frequency of the ith Fourier component in Hz
a = 0.00518
b = 306.6

W. van Bommel, *Interior Lighting*, https://doi.org/10.1007/978-3-030-17195-7

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