

Supplementary Table S1

Subjective ratings and central cognitive-task performance across four unilateral temporal-field regional melanopic spatial dose levels.

Indicator	0.00 lx (M±SD)	30.79 lx (M±SD)	61.58 lx (M±SD)	92.50 lx (M±SD)	F (3,96)	p	Partial η^2	Significant Bonferroni-adjusted pairwise comparisons
Visual Comfort Score	26.67±8.72	26.06±7.59	25.27±7.63	22.76±8.39	3.50	0.019	0.098	0.00 lx > 92.50 lx: MD = 3.91, 95% CI [0.41, 7.41], p _{adj} = .020
Task-related Workload Score	16.64±3.49	16.70±3.12	16.45±3.55	16.39±3.51	0.32	0.812	0.010	—
Karolinska Sleepiness Scale (KSS)	3.27±1.57	3.61±1.46	3.97±1.70	3.70±1.85	1.87	0.141	0.055	—
Epworth Sleepiness Scale (ESS)	10.52±3.62	10.73±3.60	10.85±4.20	10.85±4.69	0.50	0.683	0.015	—
Positive Affect score (PA)	27.36±6.58	25.61±7.38	24.64±8.45	25.30±7.97	3.02	0.033	0.086	0.00 lx > 61.58 lx: MD = 2.72, 95% CI [0.17, 5.27], p _{adj} = .030
Negative Affect score (NA)	15.30±5.34	14.82±7.09	15.79±11.47	14.76±7.50	0.37	0.776	0.011	—
2-back Accuracy (%)	85.89±9.85	91.19±5.97	93.37±6.34	93.94±6.25	13.66	<0.001	0.299	30.79 lx > 0.00 lx: MD = 5.30, 95% CI [1.52, 9.08], p _{adj} = .002; 61.58 lx > 0.00 lx: MD = 7.48, 95% CI [3.70, 11.26], p _{adj} < .001; 92.50 lx > 0.00 lx: MD = 8.05, 95% CI [4.27, 11.83], p _{adj} < .001
2-back Incorrect-response Rate (%)	3.12±8.56	1.33±1.92	1.04±1.86	0.76±1.75	1.89	0.136	0.056	—
DCCS Accuracy (%)	97.58±4.02	96.36±5.29	98.59±4.00	97.76±4.32	1.78	0.155	0.053	—
DCCS Error Rate (%)	2.42±4.02	3.64±5.29	1.41±4.00	2.24±4.32	1.78	0.155	0.053	—

Note. Values are presented as mean $\pm$ standard deviation (M $\pm$ SD). A one-way repeated-measures analysis of variance was used to test the main effect of exposure condition on each subjective and cognitive outcome. Partial η^2 is reported for all omnibus effects. Outcomes with a significant omnibus effect were followed by Bonferroni-adjusted pairwise comparisons; only comparisons with adjusted p < .05 are shown. “—” indicates that pairwise comparisons were not performed because the omnibus effect was not significant. Higher visual-comfort scores indicate greater visual comfort. Higher task-related workload, KSS, and ESS scores indicate greater perceived workload, current sleepiness, and daytime dozing propensity, respectively. Higher PA and NA scores indicate stronger positive and negative affect, respectively. PA and NA represent subscale scores from the PANAS-based questionnaire adapted for the experimental task context. KSS = Karolinska Sleepiness Scale; ESS = Epworth Sleepiness Scale; PA = positive affect; NA = negative affect; DCCS = Dimensional Change Card Sort; MD = mean difference; CI = confidence interval; p_{adj} = Bonferroni-adjusted p value. Regional-dose levels of 0.00, 30.79, 61.58, and 92.50 lx correspond to the nominal 0, 700, 1400, and 2100 lx lighting settings, respectively.

Supplementary Table S2

Peripheral autonomic responses across four unilateral temporal-field regional melanopic spatial dose levels.

Indicator	0.00 lx (M±SD)	30.79 lx (M±SD)	61.58 lx (M±SD)	92.50 lx (M±SD)	F(3,96)	p	Partial η^2	Significant Bonferroni-adjusted pairwise comparisons
Resting-state Skin conductance level (SCL, μ S)	7.29±4.88	11.99±9.00	12.82±9.76	13.64±9.39	1.84	0.143	0.041	—
Resting-state SCR count (events)	29.38±21.14	29.91±21.23	38.61±25.73	41.81±30.57	3.14	0.028	0.070	None after adjustment
Resting-state mean SCR amplitude (μ S)	7.82±5.06	12.94±10.00	13.31±10.04	14.33±9.80	4.97	0.003	0.104	30.79 lx > 0.00 lx: MD = 5.12, 95% CI [0.14, 10.10], p_adj = .040; 61.58 lx > 0.00 lx: MD = 5.49, 95% CI [0.51, 10.47], p_adj = .023; 92.50 lx > 0.00 lx: MD = 6.51, 95% CI [1.53, 11.49], p_adj = .004
Task-period SCL during 2-back (μ S)	12.15±8.72	16.83±11.24	17.56±11.89	18.21±11.57	2.01	0.118	0.059	—
Task-period SCL during DCCS (μ S)	14.37±9.65	18.92±12.17	19.68±12.73	20.35±12.38	2.27	0.086	0.066	—
Task-induced Δ SCL during 2-back (μ S)	4.86±3.91	4.84±4.23	4.74±4.15	4.57±4.08	0.12	0.947	0.004	—

Note. Values are presented as mean $\pm$ standard deviation (M $\pm$ SD). A one-way repeated-measures analysis of variance was used to test the main effect of exposure condition on each inferentially analyzed electrodermal outcome. Partial η^2 is reported for all omnibus effects. Outcomes with a significant omnibus effect were followed by Bonferroni-adjusted pairwise comparisons; only comparisons with adjusted $p < .05$ are shown. “—” indicates that pairwise comparisons were not performed because the omnibus effect was not significant. “None after adjustment” indicates that the omnibus effect was significant but no individual pairwise comparison remained significant after Bonferroni adjustment. SCL = skin conductance level; SCR = skin conductance response; SCR count = number of automatically detected phasic responses within the predefined resting-state period; Δ SCL = 2-back SCL minus the immediately preceding resting-state SCL; MD = mean difference; CI = confidence interval; p_adj = Bonferroni-adjusted p value. Regional-dose levels of 0.00, 30.79, 61.58, and 92.50 lx correspond to the nominal 0, 700, 1400, and 2100 lx lighting settings, respectively.

Supplementary Table S3

Limited-channel EEG indices across four unilateral temporal-field regional melanopic spatial dose levels.

Indicator	0.00 lx (M±SD)	30.79 lx (M±SD)	61.58 lx (M±SD)	92.50 lx (M±SD)	F(3,96)	p	Partial η^2	Significant Bonferroni-adjusted pairwise comparisons
Resting-state Prefrontal β power (μV^2)	1.79±0.42	1.53±0.36	1.32±0.30	1.18±0.27	8.24	<0.001	0.205	0.00 lx > 61.58 lx: MD = 0.47, 95% CI [0.12, 0.82], p_{adj} = .003; 0.00 lx > 92.50 lx: MD = 0.61, 95% CI [0.26, 0.96], p_{adj} < .001
Resting-state Prefrontal α/θ ratio	3.22±0.66	3.28±0.70	3.35±0.67	3.39±0.69	0.31	0.817	0.010	—
Resting-state Parietal α_2 power (μV^2)	2.12±0.50	1.86±0.45	1.64±0.39	1.49±0.36	9.17	<0.001	0.223	0.00 lx > 61.58 lx: MD = 0.48, 95% CI [0.13, 0.83], p_{adj} = .002; 0.00 lx > 92.50 lx: MD = 0.63, 95% CI [0.28, 0.98], p_{adj} < .001; 30.79 lx > 92.50 lx: MD = 0.37, 95% CI [0.02, 0.72], p_{adj} = .029
2-Back-task Prefrontal β power (μV^2)	2.02±0.49	1.75±0.43	1.53±0.38	1.39±0.34	7.69	<0.001	0.194	0.00 lx > 61.58 lx: MD = 0.49, 95% CI [0.11, 0.87], p_{adj} = .004; 0.00 lx > 92.50 lx: MD = 0.63, 95% CI [0.25, 1.01], p_{adj} < .001
2-Back-task Prefrontal α/θ ratio	2.99±0.63	3.05±0.66	3.12±0.64	3.18±0.67	0.42	0.741	0.013	—
2-Back-task Parietal α_2 power (μV^2)	2.35±0.55	2.08±0.50	1.85±0.44	1.70±0.41	8.83	<0.001	0.216	0.00 lx > 61.58 lx: MD = 0.50, 95% CI [0.14, 0.86], p_{adj} = .002; 0.00 lx > 92.50 lx: MD = 0.65, 95% CI [0.29, 1.01], p_{adj} < .001; 30.79 lx > 92.50 lx: MD = 0.38, 95% CI [0.02, 0.74], p_{adj} = .035
DCCS-task Prefrontal β power (μV^2)	2.18±0.53	1.90±0.47	1.68±0.42	1.54±0.37	7.12	<0.001	0.182	0.00 lx > 61.58 lx: MD = 0.50, 95% CI [0.10, 0.90], p_{adj} = .006; 0.00 lx > 92.50 lx: MD = 0.64, 95% CI [0.24, 1.04], p_{adj} < .001
DCCS-task Prefrontal α/θ ratio	2.85±0.60	2.92±0.62	2.99±0.61	3.05±0.63	0.38	0.767	0.012	—
DCCS-task Parietal α_2 power (μV^2)	2.52±0.58	2.24±0.53	2.01±0.47	1.86±0.44	8.45	<0.001	0.209	0.00 lx > 61.58 lx: MD = 0.51, 95% CI [0.13, 0.89], p_{adj} = .003; 0.00 lx > 92.50 lx: MD = 0.66, 95% CI [0.28, 1.04], p_{adj} < .001; 30.79 lx > 92.50 lx: MD = 0.38, 95% CI [0.003, 0.757], p_{adj} = .047

Note. Values are presented as mean $\pm$ standard deviation (M $\pm$ SD). A one-way repeated-measures analysis of variance was used to test the main effect of exposure condition on each EEG outcome during the resting-state, 2-back, and DCCS stages. Partial η^2 is reported for all omnibus effects. Outcomes with a significant omnibus effect were followed by Bonferroni-adjusted pairwise comparisons; only comparisons with adjusted $p < .05$ are shown. “—” indicates that pairwise comparisons were not performed because the omnibus effect was not significant. Prefrontal values were averaged across FP1/FP2, and parietal values were averaged across P3/P4. EEG power values are expressed in μV^2 , whereas the α/θ ratio is unitless. DCCS = Dimensional Change Card Sort; MD = mean difference; CI = confidence interval; p_{adj} = Bonferroni-adjusted p value. Regional-dose levels of 0.00, 30.79, 61.58, and 92.50 lx correspond to the nominal 0, 700, 1400, and 2100 lx lighting settings, respectively.