SUPPLEMENTARY INFORMATION

Acute sadness enhances human olfactory sensitivity with individual gains linked to right posterior alpha dynamics

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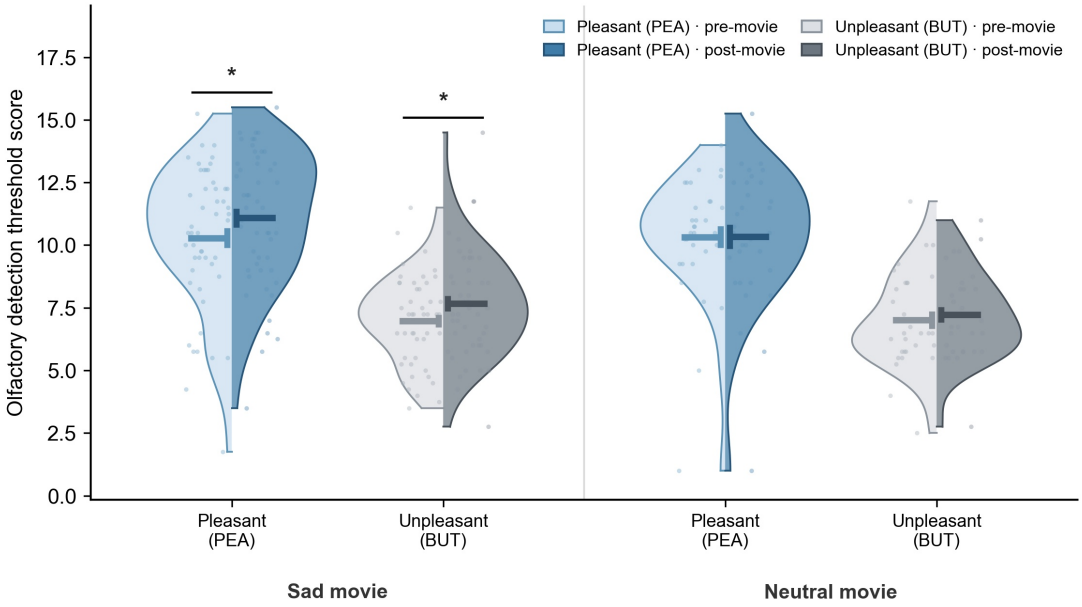

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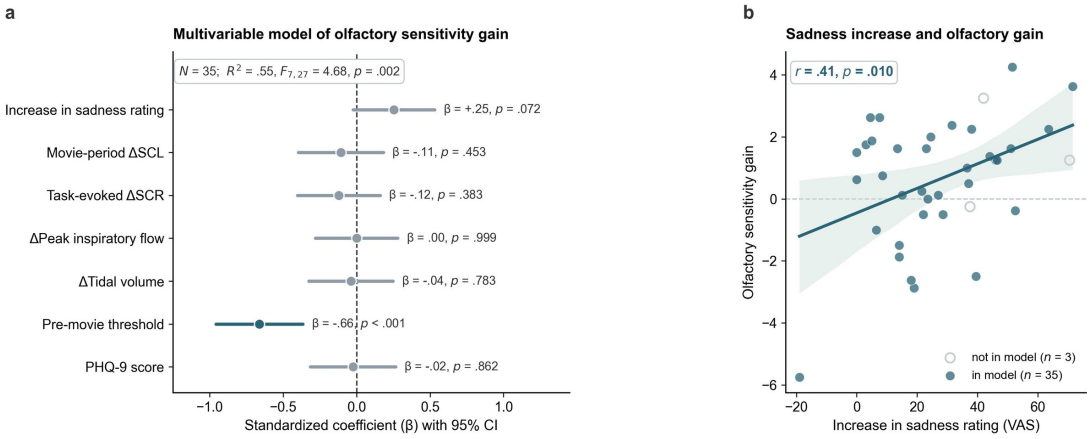
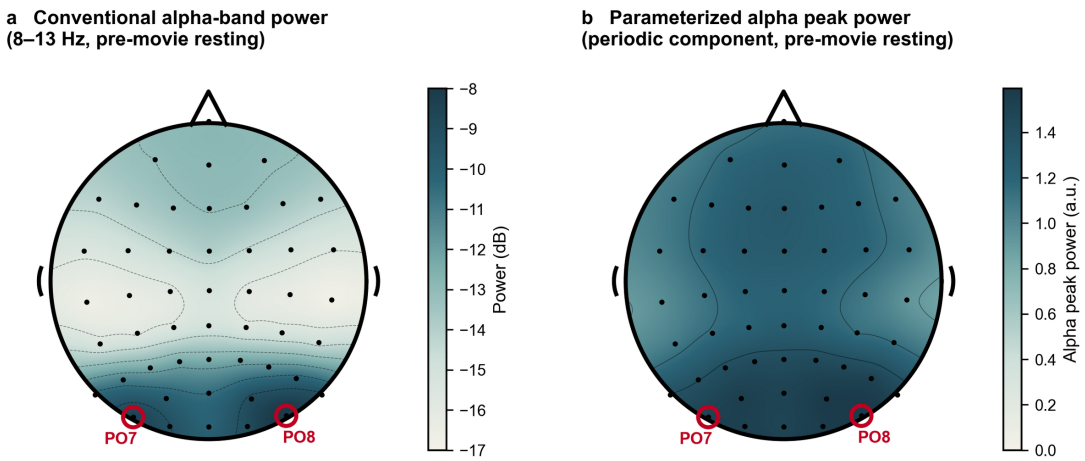


Supplementary Figure 2. Behavioral and physiological predictors of olfactory sensitivity gain. a, Fully standardized coefficients (β) with 95% confidence intervals from the multivariable model reported in the main text ($N = 35$; $R^2 = 0.55$, $F_{7,27} = 4.68$, $p = .002$), relating olfactory sensitivity gain to the increase in sadness ratings, movie-period ΔSCL, task-evoked ΔSCR, Δpeak inspiratory flow, Δtidal volume, pre-movie olfactory threshold and PHQ-9 score. Predictors with $p < .05$ are drawn in dark blue. Apart from the pre-movie threshold, which is mathematically coupled to the change score, the increase in sadness ratings was the only predictor with a non-trivial coefficient. b, Zero-order association between the increase in sadness ratings and olfactory sensitivity gain in the sad-movie group ($N = 38$; $r = 0.41$, $p = .010$), with the linear fit and its bootstrap 95% confidence band. Filled points are the 35 participants entering the model in a; open points are the 3 participants who had both measures but an incomplete predictor set.



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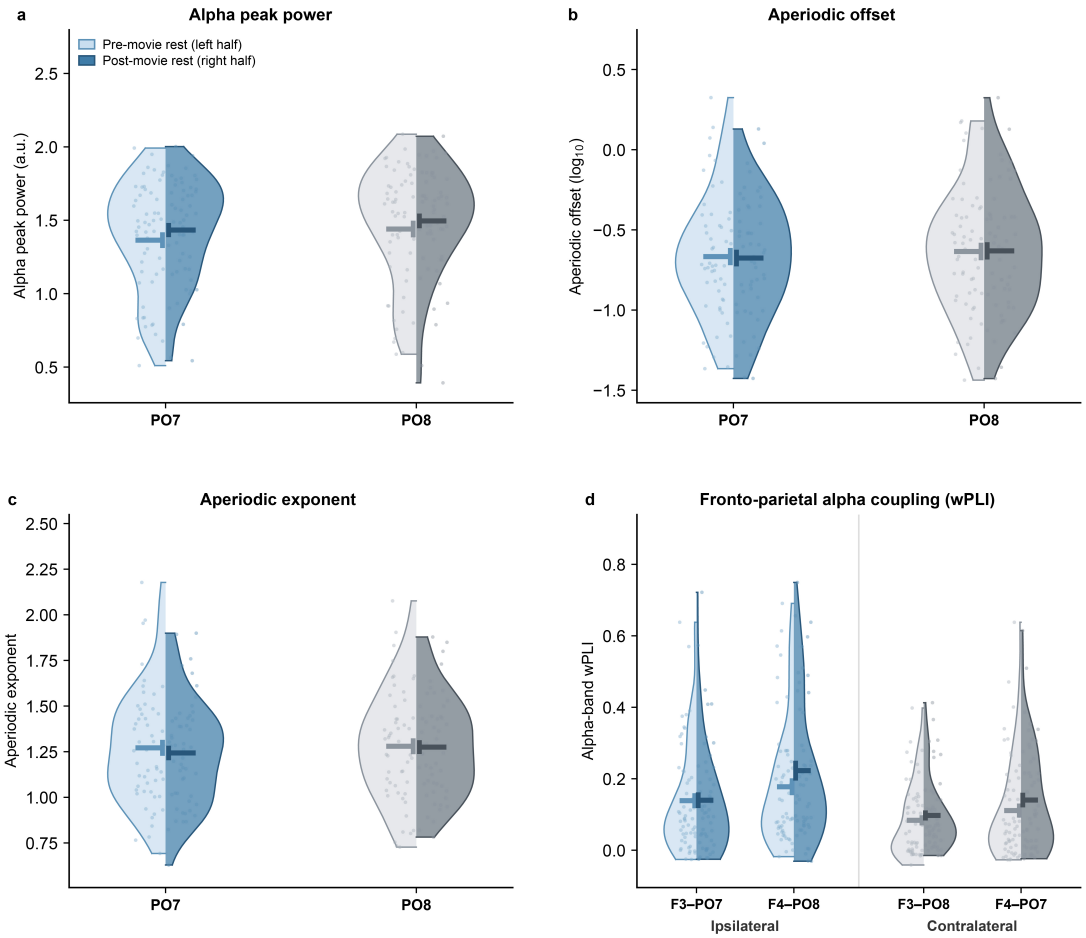

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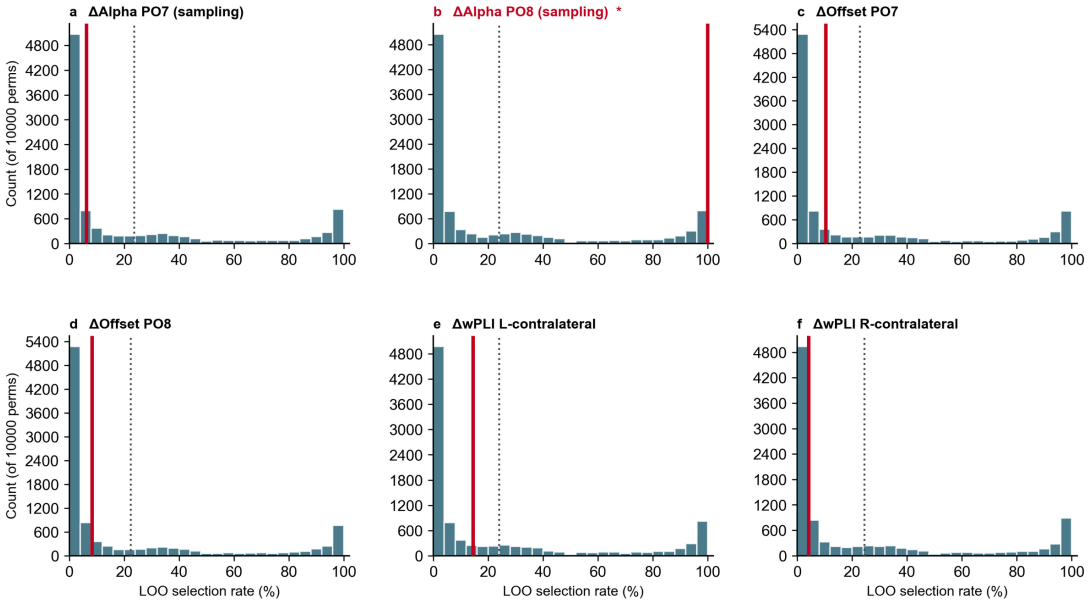
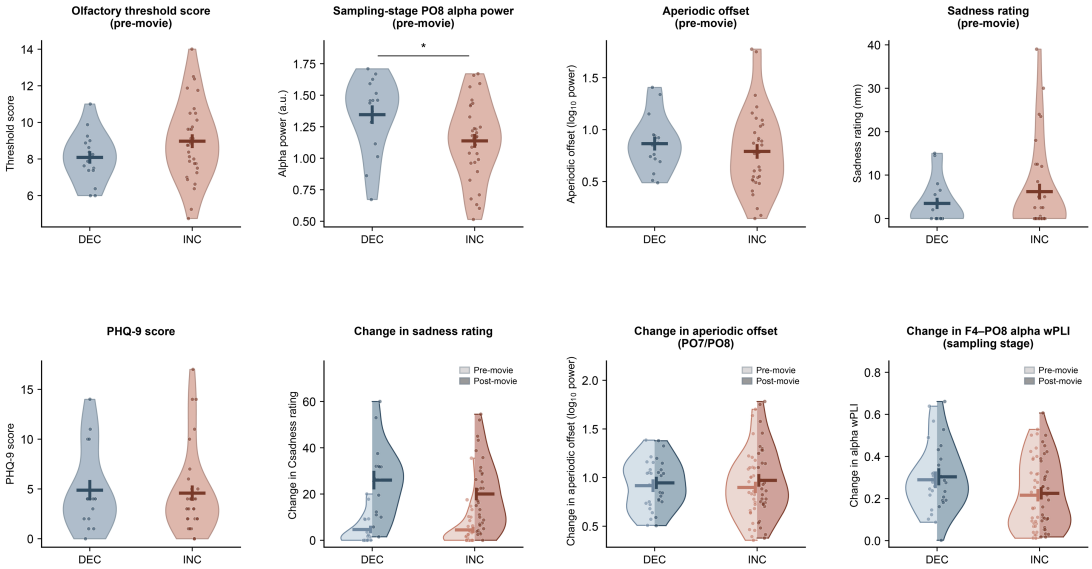
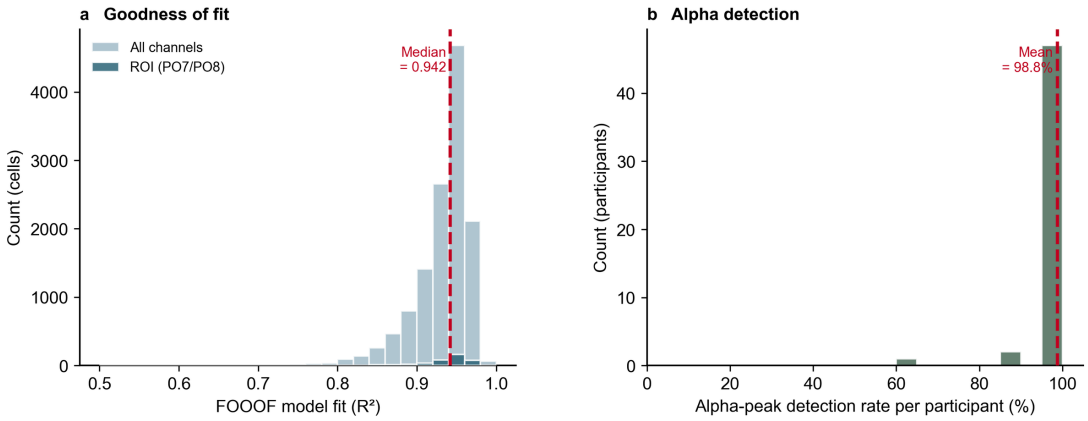


Supplementary Figure 5. Permutation distributions of elastic net feature selection stability. a-f, For each of the six candidate EEG features, a feature-specific null distribution of selection stability was generated by repeating the full nested procedure for 10,000 outcome permutations. Red lines indicate the observed selection rates; dotted lines indicate the means of the feature-specific null distributions. Only sampling-stage PO8 alpha change (b) was retained in all 48 folds, with selection stability at the conventional significance boundary under permutation (p = .050). All other features fell within their feature-specific null distributions, whose means ranged from approximately 22% to 26%. An asterisk after a panel title marks the feature whose observed selection rate reached the significance boundary against its own permutation null ($p \leq .05$); panels without an asterisk did not. The elastic net analysis served as a complementary stability analysis; the primary confirmatory analysis was the Spearman correlation between sampling-stage PO8 alpha change and olfactory sensitivity gain ($\rho = -0.33$, p = .022).



Supplementary Figure 6. Baseline and change measures in alpha Decreasers and Increasers. Distributions of the variables reported in **Supplementary Table 4** for alpha Decreasers (DEC, blue; n = 16) and alpha Increasers (INC, coral; n = 32). Participants were classified according to whether sampling-stage PO8 alpha power decreased or increased from pre- to post-movie. Green titles indicate five baseline measures, with one violin per subgroup. Mauve titles indicate three change measures as split violins, with pre-movie values in the lighter left halves and post-movie values in the darker right halves. Thick bars indicate mean ± 1 SEM; dots represent individual participants. *p < .05 for the DEC–INC comparison. See **Supplementary Table 4** for full statistics, including BF_{01} for nonsignificant comparisons.



Supplementary Figure 7. Quality of spectral parameterization and alpha peak detection. **a**, Distribution of spectral parameterization model fits (R^2) across all participant × channel × stage × phase combinations, shown separately for all channels and the PO7/PO8 parieto-occipital ROI. The median R^2 was 0.94. **b**, Alpha peak detection rate for each participant (mean = 98.8%). Together, the high model fits and detection rates indicate reliable spectral parameterization across participants and analysis conditions (mean $R^2 > 0.93$; detection rate > 95%).

Supplementary Table 1. Demographic and baseline characteristics of the sad-movie and neutral-movie groups.

Variable	Sad-movie (*n* = 56)	Neutral-movie (*n* = 32)	Test statistic	*p*
Age (years)	21.98 (2.74)	21.66 (3.24)	$t_{86} = 0.50$	.615
Sex (female / male)	35 / 21	17 / 15	$\chi^2_1 = 0.74$	.390
PHQ-9 total score	3.36 (3.12)	2.88 (2.95)	$t_{86} = 0.72$	.476
Baseline sadness rating	4.37 (7.18)	3.95 (3.17)	$t_{86} = 0.34$	.736
Pre-movie olfactory threshold	8.61 (2.40)	8.66 (1.58)	$t_{86} = -0.10$	.922
BMI (kg/m²)	21.3 (2.8)	20.9 (2.5)	$t_{86} = 0.68$	.498

Values are M (SD) unless otherwise specified. Comparisons use the full recruited sample (88 participants), matching the demographic description in the main text; the analysed samples were 53 (sad-movie behavioral), 50 (sad-movie EEG) and 32 (neutral-movie). PHQ-9 = Patient Health Questionnaire-9[2].

Supplementary Table 2. Complete 4-way ANOVA results for alpha peak power and aperiodic offset.

Effect	*F* (Alpha)	*p*	η_p^2	*F* (Offset)	*p*	η_p^2
Channel	5.41	.025*	.11	1.41	.241	.03
Stage	14.52	<.001***	.24	27.75	<.001***	.36
Phase	7.67	.008**	.14	17.76	<.001***	.27
Trial Type	0.01	.906	.00	0.36	.550	.01
Stage × Phase	5.05	.030*	.10	1.60	.211	.03
Channel × Phase	3.47	.069	.07	0.58	.449	.01
Stage × Trial Type	2.02	.162	.04	0.28	.600	.01
Phase × Trial Type	0.01	.929	.00	0.06	.806	.00
Channel × Stage	0.02	.886	.00	2.62	.112	.05
Channel × Trial Type	2.38	.130	.05	0.31	.583	.01
Stage × Phase × Trial Type	0.38	.539	.01	5.13	.028*	.09
Channel × Phase × Trial Type	1.19	.281	.03	0.94	.336	.02
Channel × Stage × Phase	0.04	.840	.00	1.71	.198	.03
Channel × Stage × Trial Type	0.82	.371	.02	0.01	.921	.00
4-way	0.02	.898	.00	3.04	.088	.06

Alpha peak-power analyses included 47 participants. No reliable alpha peak could be identified in 6 of the 800 channel × stage × phase × trial-type cells, distributed across three participants; no participant lacked an alpha peak in every cell. All six cells fell in the sampling stage, three at PO7 and three at PO8, with four of them in a single participant. Because the omnibus ANOVA requires every cell of the design to be present, those three participants were removed listwise ($N = 47$, $df2 = 46$). The follow-up simple effects reported in the main text are computed on cell means averaged over the remaining factors and are therefore unaffected by an isolated missing cell, so all 50 participants contribute (t_{49}). Aperiodic-offset analyses included all 50 participants, because the aperiodic fit is defined for every spectrum.

Supplementary Table 3. Complete 5-way ANOVA results for alpha-band wPLI

Effect	$F_{1,49}$	p	η_p^2
Laterality	4.61	.037*	.09
Stage × Phase	4.34	.043*	.08
Stage × Connection Type	6.03	.018*	.11
Stage × Trial Type	9.00	.004**	.16
Stage × Phase × Connection Type × Trial Type	4.44	.040*	.08
Phase	0.60	.443	.01
Stage	1.26	.268	.03
Connection Type	1.52	.224	.03
Trial Type	0.27	.605	.01
Phase × Connection Type	0.00	.976	.00
Phase × Trial Type	0.43	.517	.01
Connection Type × Trial Type	0.26	.610	.01
Stage × Phase × Connection Type	1.82	.184	.04
Stage × Phase × Trial Type	0.43	.514	.01
Stage × Connection Type × Trial Type	2.02	.162	.04
Phase × Connection Type × Trial Type	1.60	.212	.03
5-way	0.02	.884	.00

Significant effects listed first, then non-significant. The 4-way interaction was decomposed by trial type in the main text.

Supplementary Table 4. Comparisons of baseline measures and change scores between DEC and INC subgroups.

Panel A. Baseline measures

Variable	DEC *M* (SD)	INC *M* (SD)	*t*(df)	*p*	*d*	BF_{01}
Olfactory threshold (pre-movie)	8.09 (1.37)	8.97 (2.13)	−1.51 (46)	.137	−0.46	1.34
Alpha PO8 sampling (pre-movie)	1.35 (0.30)	1.14 (0.31)	2.23 (46)	.031*	0.68	—
Aperiodic offset (pre-movie)	0.865 (0.264)	0.790 (0.399)	0.68 (46)	.503	0.21	2.77
VAS sadness (pre)	3.47 (5.16)	6.19 (10.23)	−1.00 (46)	.324	−0.31	2.23
PHQ-9 total	4.88 (4.10)	4.58 (4.29)[a]	0.23 (45)	.822	0.07	3.24

Panel B. Change scores (Δ = post – pre-movie)

Variable	DEC *M* (SD)	INC *M* (SD)	*t*(df)	*p*	*d*	BF_{01}
ΔVAS sadness (post − pre movie)	21.36 (16.00)	15.53 (13.73)	1.31 (46)	.196	0.40	1.67
ΔOffset (PO7/PO8 × Ant/Sam)	0.029 (0.066)	0.073 (0.131)	−1.26 (46)	.213	−0.39	1.76
ΔwPLI F4–PO8 sampling	0.014 (0.099)	0.009 (0.106)	0.16 (46)	.873	0.05	3.29

DEC and INC comprised participants with sampling-stage PO8 ΔAlpha < 0 (n = 16) and > 0 (n = 32), respectively. Group differences were assessed using independent-samples t-tests. [a] For PHQ-9, n = 31 in INC because one participant had missing data. BF_{01} values[3,4] are reported only for nonsignificant comparisons; "—" indicates that BF_{01} was not reported for a significant comparison. *p < 0.05. The higher baseline PO8 alpha in DEC than in INC is a mathematical consequence of partitioning a highly reliable measure (alpha test–retest reliability from pre-movie to post-movie: r = 0.957) by the sign of its change score, rather than a pre-existing trait difference or a noise-driven regression-to-the-mean artefact (see main text). DEC and INC did not differ reliably in the increase in sadness ratings after movie viewing (p = .196), suggesting that the alpha-direction effect was not driven by stronger sadness induction in either subgroup.

Supplementary Table 5. Candidate sad-movie clips evaluated in the pilot study.

Clip	Film title	Language	Duration	Theme	Selected
1	Manchester by the Sea (海边的曼彻斯特)	Chinese dub	5:09	Parental loss	
2	Dying to Survive (我不是药神)	Chinese	4:02	Terminal illness	
3	The Pianist (钢琴家)	Chinese dub	5:47	War & separation	
4	The Boy in the Striped Pyjamas (穿条纹睡衣的男孩)	Chinese dub	4:30	Child death	
5	To Live (活着)	Chinese	5:30	Family loss	
6	Heaven's Gaze (天堂的张望)	Chinese	5:16	Child illness	✓
7	Next Sohee (下一个素熙)	Chinese sub	4:22	Workplace tragedy	
8	I'm Fine Far Away (我在他乡挺好的)	Chinese	4:34	Homesickness	✓

All clips depicted themes of loss, separation or bereavement. A check mark (✓) indicates clips selected for the main study. A 3-min guided meditation video was presented between clips to reduce emotional carryover.

Supplementary Table 6. Sadness ratings for the eight candidate sad-movie clips in the pilot study (*n* = 20).

	Clip 1	Clip 2	Clip 3	Clip 4	Clip 5	Clip 6 ✓	Clip 7	Clip 8 ✓
n	12	13	15	9	13	14	13	15
Mdiff	27.67	15.23	20.47	30.78	23.92	38.57	23.00	30.20
Sadness (Z)	3.06**	3.19**	3.18**	2.67**	2.76**	3.30**	3.18**	3.30**

Each of the 20 participants rated a randomly assigned subset of five clips; therefore, n varied across clips. Mdiff denotes the mean increase in sadness ratings from baseline. Z denotes the Wilcoxon signed-rank statistic; this test was used because of the small clip-specific samples and non-normal change scores. **$p < .01$. A check mark (✓) indicates clips selected for the main study. Only sadness ratings were used for clip selection in this pilot.

Supplementary Table 7. Candidate neutral-movie clips evaluated in the pilot study.

Clip	Content description	Language	Duration	Selected
1	Weather forecast (Germany)	German	3:11	
2	Red lantern plant growth (红灯笼生长过程)	Instrumental	3:07	✓
3	Weather forecast (Russia)	Russian	4:09	
4	Zoigê grassland documentary (若尔盖自然纪录片)	Chinese	2:26	
5	Carnivorous plant documentary (食肉草纪录片)	English	3:38	✓
6	Weather forecast (Tibet) (藏语天气预报)	Tibetan	3:37	
7	Weather forecast (Spain)	Spanish	2:00	
8	News broadcast (France)	French	3:24	

A check mark (✓) indicates clips selected for the main study. Selected clips produced no significant changes from baseline in any of the five affective dimensions (all *p*s > .05 for Clip 2; all *p*s > .15 for Clip 5). Clip 6 was not selected because it produced a significant decrease in sadness ratings from baseline (t_{18} = 2.38, p = .029).

Supplementary Table 8. Changes from baseline across five affective dimensions for the eight candidate neutral-movie clips (*n* = 19).

Emotion	Clip 1	Clip 2 ✓	Clip 3	Clip 4	Clip 5 ✓	Clip 6	Clip 7	Clip 8
Happiness (t)	1.94	0.15	1.99	−0.84	1.19	1.44	1.51	2.31*
Interest (t)	4.21***	−0.61	4.52***	1.14	−0.56	2.05	2.82*	3.74**
Well-being (t)	1.99	0.02	1.94	−1.39	0.82	1.42	1.78	1.97
Sadness (t)	1.98	1.18	3.40**	2.87*	0.89	2.38*	2.23*	2.58*
Emptiness (t)	0.17	1.67	−0.50	3.20**	0.72	0.20	0.08	0.99

*$p < .05$, **$p < .01$, ***$p < .001$. A check mark (✓) indicates clips selected for the main study. Positive t values indicate higher ratings at baseline than after the clip. Clips 2 and 5 produced no significant change in any affective dimension.

Supplementary Methods

Sad-movie stimulus selection

Sad-movie clips were selected in an independent pilot study of 20 healthy adults aged 18–40 years. The sample size was determined by an a priori power analysis (effect size = 0.85, β = .05). None of the pilot participants participated in the main study. Eight Chinese-language movie clips lasting 4–6 min and depicting themes of loss, separation or bereavement were drawn from major film and streaming platforms (**Supplementary Table 5**). Each participant viewed a randomly assigned subset of five clips in a dimmed, quiet room. Participants rated five affective dimensions using 0–100 visual analogue scales: happiness, interest, well-being, sadness and emptiness. Only sadness ratings were used for sad-movie selection, whereas all five dimensions were used to screen the neutral-movie clips. A 3-min guided meditation video, comprising calm instrumental music and on-screen breathing prompts, was presented between consecutive clips to reduce emotional carryover. Because the sadness ratings were non-normally distributed and the clip-specific samples were small, changes from baseline were tested using Wilcoxon signed-rank tests. All eight clips elicited significant increases in sadness (all Zs ≥ 2.67, all ps ≤ .008; Supplementary Table 6). The two clips producing the most consistent increases were retained for the main study: Clip 6, *Heaven's Gaze* (天堂的张望; Z = 3.30, p = .001; VAS sadness M = 50.43 mm, SD = 15.85), and Clip 8, *I'm Fine Far Away* (我在他乡挺好的; Z = 3.30, p = .001; VAS sadness M = 40.87 mm, SD = 24.96).

Neutral-movie stimulus selection

A separate pilot study (n = 19; 12 female, 7 male; age 18–40 years; M = 23.37, SD = 4.95) used the same viewing and rating procedures to select the neutral-movie clips. Eight candidate neutral clips were screened (**Supplementary Table 7**), including weather forecasts in minority languages, time-lapse nature footage and documentaries. Baseline and post-clip ratings were compared on all five affective dimensions using paired t tests (df = 18; **Supplementary Table 8**). Clips were eligible for selection only if they produced no significant change in any dimension. Clip 2 (red lantern plant growth / 红灯笼生长过程; instrumental music; 3:07) showed no significant changes (all ps > .05; VAS sadness M_{diff} = 5.05 mm, SD = 18.72, p = .255).

Clip 5 (carnivorous plant documentary / 食肉草纪录片; English narration; 3:38) likewise showed no significant changes (all *p*s > .15; VAS sadness M_{diff} = 1.95 mm, *SD* = 9.52, *p* = .385). By contrast, Clip 6, a Tibetan-language weather forecast, produced a significant decrease in sadness from baseline (t_{18} = 2.38, *p* = .029), consistent with relaxation rather than the induction of negative affect, and was therefore not selected.

Parieto-occipital region of interest selection

The parieto-occipital ROI (PO7, PO8) was defined exclusively from pre-movie resting-state data, independently of all task-related and movie-related effects, to avoid circular inference[5]. Two complementary measures of posterior alpha activity were derived from the pre-movie resting-state recording. First, conventional alpha-band power was calculated: for each channel, power spectral density was estimated using Welch's method, and mean power between 8 and 13 Hz was extracted in dB. The grand-average topography showed bilateral parieto-occipital maxima, with PO7 and PO8 among the most prominent posterior channels (**Supplementary Fig. 3a**).

Second, the spectra were parameterized using FOOOF[1]. The algorithm was applied to each channel's average power spectrum between 1 and 40 Hz, and alpha peak height, defined as the periodic alpha component above the aperiodic fit, was extracted for each channel. This analysis confirmed the same bilateral parieto-occipital pattern (**Supplementary Fig. 3b**). Both approaches identified PO7 and PO8 as prominent posterior alpha sites. The convergence between total alpha-band power and parameterized periodic alpha supported the robustness of the ROI definition. PO7 and PO8 overlie bilateral parieto-occipital scalp regions previously implicated in supramodal attentional gating[6–8].

Additional procedures for movie-period EEG analysis

Movie segments were defined using onset and offset triggers recorded in the EEG data. Alongside the spectral measures, fronto-parietal alpha coupling during movie viewing was computed with the pipeline used for the task data (surface Laplacian; debiased wPLI[9] averaged over 8–13 Hz; the four F3/F4–PO7/PO8 connections). Because movie trials are not locked to a

stimulus, within-movie coupling change was defined as the last third of trials minus the first third, rather than over 60-s bins, and the whole-movie value was retained as the corresponding level measure. For every measure the late-minus-early difference was the primary index of within-movie change; the linear slope across 60-s bins and the mean movie-period level were retained as complementary indices, and are reported here rather than in the main text. Neither the within-movie change in aperiodic offset ($\rho = 0.07$, $p = .625$, $N = 48$), the within-movie change in aperiodic exponent ($\rho = 0.06$, $p = .691$, $N = 48$), nor the within-movie change in fronto-parietal alpha coupling (right contralateral $\rho = -0.23$, $p = .115$; contralateral average $\rho = -0.17$, $p = .259$, $N = 48$) was associated with olfactory sensitivity gain. The linear-slope index of within-movie PO8 alpha change reproduced the primary late-minus-early result ($\rho = -0.31$, $p = .039$, $N = 46$). Recordings in which neither trigger was valid were excluded. When only one valid trigger was available, the missing movie boundary was reconstructed using the median recorded duration of the corresponding movie clip. Robustness was assessed using leave-one-out resampling, winsorization and partial correlations that separately adjusted for the increase in sadness ratings and movie-period SCL change, or for pre-movie PO8 alpha, baseline olfactory threshold, PHQ-9 score and sad-movie clip identity. The association between movie-period and sampling-stage PO8 alpha change was treated as a sequential association rather than a formal mediation. All random procedures used fixed seeds.

Multivariable analysis of affective and physiological predictors

To determine which affective and physiological measures independently tracked olfactory sensitivity gain, we fitted a multiple linear regression model in the sad-movie group. The outcome was the change in olfactory threshold score from before to after movie viewing, averaged across odorants. The seven predictors were the change in sadness ratings, movie-period SCL change, changes in task-evoked SCR, peak inspiratory flow and tidal volume, baseline olfactory threshold score and PHQ-9 score. Movie-period SCL change was calculated as mean SCL during movie viewing minus mean SCL during the immediately preceding eyes-open resting baseline, consistent with the group-level analysis. Changes in the three olfactory-task measures were calculated as post-movie minus pre-movie values. All variables, including the outcome,

were standardized before model fitting, so the coefficients are fully standardized β (change in outcome SD per 1 SD of the predictor). The elastic net coefficient reported in the main text is the one exception: there only the predictors were standardized, so it is expressed in threshold-score units per 1 SD of the feature and is reported as b. Complete-case analysis left 35 participants, with missingness arising primarily from the sadness-rating and SCL measures. Predictor-level *p* values were uncorrected and interpreted descriptively. Interaction terms were not included because the seven main effects left limited residual degrees of freedom.

Elastic net feature selection

To identify which EEG feature was most consistently associated with individual differences in olfactory sensitivity gain, we used elastic net regression[10], which combines L1 (lasso) and L2 (ridge) penalties for simultaneous feature selection and coefficient shrinkage. Six candidate EEG features were entered as predictors of olfactory sensitivity gain (Δthreshold): sampling-stage ΔAlpha at PO7 and PO8; ΔOffset at PO7 and PO8 averaged across stages; and left and right contralateral ΔwPLI interaction contrasts on blank trials. All Δ values were calculated as post-movie minus pre-movie, and each wPLI interaction contrast was calculated as Δsampling minus Δanticipation. Complete data were available for 48 participants. All predictors were standardized using parameters estimated from the training data within each fold.

The L1 ratio was fixed at 0.3, and λ was selected from a 20-value regularization path using three-fold inner cross-validation nested within a leave-one-out outer loop (48 outer folds). Feature selection stability was defined as the proportion of outer folds in which each feature received a nonzero coefficient. Sampling-stage PO8 alpha change was the only feature retained in all 48 folds (100% selection rate; next highest: left contralateral ΔwPLI, 14.6%). In the model fitted to the full sample, sampling-stage PO8 alpha change was the only feature with a nonzero coefficient ($b = -0.174$; all other $b = 0$).

Selection stability was evaluated using 10,000 outcome permutations that repeated the full nested procedure with shuffled Δthreshold values[11], yielding a feature-specific null distribution of selection rates. The one-sided p value was the proportion of permuted selection rates equal

to or greater than the observed rate. Sampling-stage PO8 alpha change showed a 100% selection rate and was selected more consistently than expected under permutation (p = .050). Mean null selection rates were similar across features, ranging from approximately 22% to 26% (overall mean, 23.5%); no other feature showed above-chance selection stability (Supplementary Fig. 5).

Because the primary confirmatory analysis tested the association between sampling-stage PO8 alpha change and olfactory sensitivity gain using Spearman correlation ($\rho = -0.33$, p = .022, bootstrap 95% CI [−0.56, −0.05]), this elastic net analysis was treated as a complementary stability analysis rather than an independent confirmatory test.

Sign-based subgroup **analysis**

Participants were classified as alpha Decreasers (DEC) or alpha Increasers (INC) according to whether sampling-stage PO8 alpha decreased or increased from pre-movie to post-movie. The subgroup difference in olfactory sensitivity gain was tested with Welch's t-test. Stability was assessed using a label-permutation test with 10,000 shuffles, leave-one-out estimates of Cohen's d and a core-only analysis excluding the 16 participants with absolute PO8 alpha changes closest to zero. A hierarchical regression adjusted for pre-movie olfactory threshold, pre-movie PO8 alpha, pre-movie sadness, PHQ-9, ΔOffset and ΔwPLI. A nested model additionally tested whether adding the sign of alpha change improved fit beyond continuous PO8 alpha change.

Supplementary Results

Sample size sensitivity and baseline characteristics

At 80% power with a two-tailed α of 0.05, the achieved sample in the sad-movie group ($n = 53$) could detect a within-subject effect of $dz \geq 0.39$. The achieved behavioral samples for the between-group comparison (sad-movie group, $n = 53$; neutral-movie group, $n = 32$) could detect a standardized mean difference of $d \geq 0.64$. These are the behavioral samples; the task-EEG sample ($n = 50$) was not used for any behavioral power calculation. The observed between-group effect ($d = 0.49$) was below this sensitivity threshold, indicating that the analysis was adequately powered to detect medium-to-large, but not smaller, between-group effects. The groups did not differ reliably in age, sex, PHQ-9 score or pre-movie sadness rating (all ps > 0.06; **Supplementary Table 1**).

Behavioral and physiological predictors of olfactory sensitivity gain

To identify which behavioral and physiological changes were associated with olfactory sensitivity gain, we fitted a multivariable model in the sad-movie group. Olfactory sensitivity gain, calculated as the post-movie minus pre-movie threshold score averaged across odorants, was modeled using seven standardized predictors: the increase in sadness ratings after movie viewing (ΔVAS), movie-period SCL change (ΔSCL), changes in task-evoked SCR, peak inspiratory flow and tidal volume, baseline olfactory threshold and PHQ-9 score. The model explained substantial variance in olfactory sensitivity gain ($N = 35$; $R^2 = 0.55$; $F_{7,27} = 4.68$, $p = .002$; Supplementary Fig. 2a).

Changes in movie-period SCL, task-evoked SCR, peak inspiratory flow and tidal volume were not associated with olfactory sensitivity gain (all ps ≥ .38), and neither was PHQ-9 score ($p = .86$). The same pattern was observed in a larger-sample model that omitted ΔVAS and ΔSCL, the two variables with more missing observations ($N = 50$; all ps > .37). Among the behavioral and physiological changes, only the increase in sadness ratings showed evidence of an association with olfactory sensitivity gain at the bivariate level ($r = +0.41$, $p = .010$; Supplementary Fig. 2b). Its adjusted coefficient remained positive but did not reach

conventional significance in the full model (standardized β = 0.25, p = .072). ΔVAS was uncorrelated with ΔSCL (r = 0.03), indicating that reported sadness and electrodermal arousal captured distinct responses to sad movie viewing.

Movie-period SCL change was defined as mean SCL during movie viewing minus the immediately preceding eyes-open resting baseline, using the same baseline-referenced approach as the group-level analysis (**Fig. 2b**). An earlier specification of the model used raw mean movie-period SCL without baseline adjustment. This specification produced a negative partial coefficient (β = −0.73) despite a non-significant zero-order association (r = −0.29, p = .074), consistent with a suppression artifact arising from substantial between-participant variability in absolute SCL (coefficient of variation ≈ 1.0). The baseline-referenced ΔSCL avoided this suppression pattern and was not associated with olfactory sensitivity gain (r = +0.01).

Effects of trial type on task-related EEG measures

The Sniffin' Sticks threshold test included odor and blank trials within a three-alternative forced-choice design. Trial Type (odor vs blank) was therefore included as a within-subject factor in all task EEG analyses to determine whether changes after sad movie viewing depended on odor presence. For alpha peak power, the four-way ANOVA revealed neither a main effect of Trial Type ($F_{1,46}$ = 0.01, p = .906, BF_{01} = 3.03) nor any significant interaction involving Trial Type (all $BF_{01} \geq 3$; **Supplementary Table 2**). These results provide Bayesian evidence that the alpha increase after sad movie viewing did not depend on odor presence, supporting the averaging of odor and blank trials in analyses relating EEG measures to olfactory sensitivity gain.

For aperiodic offset, neither the Trial Type main effect nor the Phase × Trial Type interaction was reliable (both $BF_{01} \geq 3$). However, a Stage × Phase × Trial Type interaction was significant ($F_{1,49}$ = 5.13, p = .028; **Supplementary Table 2**). For wPLI, the five-way ANOVA showed no reliable Phase × Trial Type interaction ($F_{1,49}$ = 0.43, p = .517, BF_{01} = 5.70), whereas the Stage × Phase × Connection Type × Trial Type interaction was significant ($F_{1,49}$ = 4.44, p = .040;

Supplementary Table 3). Follow-up analyses of these interactions are reported in the main **Results**.

Resting-state EEG control analyses

To verify that phase-related neural changes were specific to the olfactory task, we examined resting-state EEG recorded before and after sad movie viewing (N = 52; two participants had usable resting-state but not task data). The pre-movie recording was the resting run acquired immediately before movie viewing and the post-movie recording was the run acquired after the second olfactory test; these are the same two recordings used for resting connectivity below. As for connectivity, the six paired tests (three measures × two channels) were corrected together with the Benjamini–Hochberg procedure. No measure changed reliably: alpha peak power PO7 Δ = +0.069, t_{51} = 2.41, q = .076; PO8 Δ = +0.055, t_{51} = 2.30, q = .076; aperiodic offset PO7 Δ = −0.009, t_{51} = 0.31, q = .915; PO8 Δ = +0.004, t_{51} = 0.11, q = .915; aperiodic exponent PO7 Δ = −0.028, t_{51} = 1.05, q = .602; PO8 Δ = −0.005, t_{51} = 0.16, q = .915 (Supplementary Fig. 4a–c). For the aperiodic measures the Bayes factors provide moderate evidence for the null (BF_{01} = 3.95–6.58). For alpha peak power the Bayes factors fall below 1 (PO7 BF_{01} = 0.48; PO8 BF_{01} = 0.60): alpha shifted at rest in the same direction as during the task, and although this did not survive correction, these data are uninformative rather than supportive of the null. The task-related changes reported in the main text therefore cannot be attributed to a general shift in cortical state of comparable magnitude, although a smaller resting change is not excluded.

Fronto-parietal alpha coupling was examined in the same recordings, using the pipeline applied to the task data (surface Laplacian; debiased wPLI averaged over 8–13 Hz; two-day average, as for the spectral measures). As in the task connectivity analysis, the four connections were tested together and p values were corrected with the Benjamini–Hochberg procedure. No connection changed reliably: F3–PO7 Δ = +0.001, t_{51} = 0.07, q = .942; F4–PO8 Δ = +0.045, t_{51} = 2.38, q = .084; F3–PO8 Δ = +0.014, t_{51} = 0.86, q = .527; F4–PO7 Δ = +0.030, t_{51} = 1.92, q = .120 (Supplementary Fig. 4d). The ipsilateral and contralateral averages likewise showed no reliable change (ipsilateral t_{51} = 1.97, p = .055, BF_{01} = 1.12; contralateral t_{51} = 1.93, p = .059,

BF_{01} = 1.19). For coupling the Bayes factors lie near 1, so these data are uninformative rather than supportive of the null.

Robustness of the PO8 alpha sign effect

The difference in olfactory sensitivity gain between alpha Decreasers (DEC) and alpha Increasers (INC) remained stable across several sensitivity analyses. A label-permutation test using 10,000 shuffles supported the subgroup difference (p = 0.002). Separately, 1.1% of the permutation distribution produced an absolute effect size of at least 0.80. Excluding the 16 participants whose absolute PO8 alpha changes were closest to zero also preserved the effect (d = 0.97, n = 32). Across leave-one-out iterations, Cohen's d remained within [0.90, 1.16]. Bootstrap resampling of whole participants (5,000 iterations) gave a mean Cohen's d of 1.03 with a bootstrap 95% confidence interval of [0.44, 1.65]; 99.9% of resamples showed a positive DEC–INC difference (N = 48).

DEC and INC did not differ reliably in baseline olfactory threshold, baseline aperiodic offset, pre-movie sadness, PHQ-9 score, the increase in sadness ratings after movie viewing, ΔOffset or ΔwPLI (all $ps \geq 0.137$; **Supplementary Table 4** and **Supplementary Fig. 6**). Pre-movie PO8 alpha power was higher in DEC than INC (p = 0.031), but the subgroup difference remained after adjustment for baseline alpha. In a hierarchical regression controlling for baseline olfactory threshold, baseline PO8 alpha, pre-movie sadness, PHQ-9, ΔOffset and ΔwPLI, subgroup membership remained the only significant neural predictor (b = −1.32, t_{37} = −2.57, p = 0.014, ΔR^2 = 0.074).

Finally, adding the sign of alpha change (+ or -) to a model containing continuous PO8 alpha change significantly improved model fit (nested $F_{1,45}$ = 5.93, p = 0.019), indicating that the sign of alpha change was more informative than its magnitude.

Elastic net feature-selection results

Sampling-stage PO8 alpha change was retained in all 48 outer folds and was the only feature with a nonzero coefficient in the full-sample model (b = −0.174; all other coefficients = 0). The

next-highest selection rate was 14.6% for left contralateral ΔwPLI. Feature-specific permutation testing showed that PO8 alpha change was selected more consistently than expected under permutation (p = .050); no other feature exceeded its null distribution (mean null selection rates approximately 22–26%; **Supplementary Fig. 5**). The direction of this multivariate result converged with the primary Spearman correlation between sampling-stage PO8 alpha change and olfactory sensitivity gain ($\rho = -0.33$, p = .022, bootstrap 95% CI [−0.56, −0.05]).

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