Investigating Emotional Reactivity in Experienced Users of Psychedelics: a cross-sectional fMRI study

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Abstract

Classic psychedelics profoundly influence emotional states, eliciting intense acute emotional experiences followed by subtle, sustained changes in emotional reactivity lasting up to several weeks. While clinical studies with controlled participant screening, dosing, and settings provide evidence for these effects, the impact of psychedelics is highly context-dependent. Thus, it remains unclear whether naturalistic, less-controlled psychedelic use similarly modulates emotional reactivity. To address this, our preregistered, cross-sectional fMRI study compared experienced psychedelic users (≥10 lifetime experiences; N = 33) with a matched group of non-users (N = 34) on behavioral and neural responses to emotional facial expressions. Psychedelic users demonstrated faster and more accurate recognition of angry facial expressions, suggesting reduced interference from threat-related stimuli during task performance. Whole-brain fMRI analyses revealed diminished neural responses to anger in limbic and salience network regions, coupled with enhanced responses to happiness in parietal and sensorimotor areas, consistent with prior clinical findings. Additionally, users showed increased precuneus activation in response to fearful facial expressions. Region-of-interest analyses further indicated reduced differentiation of emotional categories in two default mode network regions—the frontal medial cortex and parahippocampal gyrus. In conclusion, our study provides a nuanced view of neurofunctional alterations in emotional processing associated with naturalistic psychedelic use, advancing our understanding of its potential long-term effects.

Introduction

Classic psychedelics, such as psilocybin, lysergic acid diethylamide (LSD), and N,N-dimethyltryptamine (DMT), are known for their profound ability to induce alterations in sensory perception, mood, self-awareness, and cognition (Preller & Vollenweider, 2018). In recent years, a growing body of evidence has been accumulated indicating that psychedelics have also potential to induce long-lasting psychological benefits, including enhanced well-being, reduced symptoms of depression and anxiety, and increased psychological flexibility (Aday et al., 2020; Barrett et al., 2020; Vollenweider & Preller, 2020; Hendricks et al., 2015).

Modulation of emotional reactivity is hypothesized to constitute one of the core mechanisms through which psychedelics exert these effects (Moujaes et al., 2025). Interventional studies have documented acute and sustained reductions in negative affect and increases in positive affect following controlled administration of psychedelics. For example, Barrett et al. (2020) showed that positive mood changes and emotional regulation improvements persisted weeks after a psilocybin session. Similarly, controlled clinical trials by Ross et al. (2016) and Griffiths et al. (2016) indicated enhanced emotional empathy and reduced anxiety and depression, assessed via validated self-report instruments.

At the neural level, the administration of substances such as psilocybin and LSD has been shown to robustly modulate neural activity in brain regions involved in emotional processing. Most importantly, in three previous fMRI studies, amygdala exhibited reduced responsiveness to negatively valenced emotional stimuli during the acute phase of the psychedelic experience (Kraehenmann et al., 2015; Mueller et al., 2017; Armand et al., 2024). Further, in a controlled randomized clinical trial conducted by Barrett et al. (2020) lasting improvements in emotional regulation observed after psilocybin administration were accompanied by decreased amygdala reactivity to negative stimuli and increased prefrontal cortex activation linked to emotional control. Finally, in a resting-state fMRI study, administration of DMT increased functional connectivity between the supramarginal gyrus, precuneus, posterior cingulate gyrus, amygdala, and orbitofrontal cortex, indicating psychedelic-induced upregulation of brain regions involved in emotional processing (Soares et al., 2024).

Psychedelics have also been shown to modulate activity of large-scale functional networks implicated in processing of emotion. Functional magnetic resonance imaging (fMRI) studies report consistent decreases in functional connectivity and activity within the Default Mode Network (DMN)—a network associated with self-focused rumination, mind-wandering, and autobiographical memory, as well as reduced activity and integrity of the Salience Network (SN), which is key for detecting and prioritizing emotionally relevant stimuli (Carhart-Harris et al., 2012; Lebedev et al., 2015; Vollenweider & Preller, 2020). These network-level and regional alterations collectively suggest that psychedelics reshape both bottom-up emotional processing and top-down cognitive control mechanisms, facilitating changes in emotionality.

Most of what is known about how psychedelics affect the brain comes from controlled experimental or therapeutic contexts, where participants undergo preparatory screening and receive psychological support during drug administration. In contrast,

naturalistic use is more variable in a range of aspects including dosage, motivation, and environmental factors—all of which have been shown to significantly influence the acute psychedelic experience as well as its lasting effects (Hartogsohn, 2016; Carhart-Harris et al., 2018; Adamczyk et al., 2025). Naturalistic use represents the predominant pattern worldwide, often characterized by self-medication motivated by increasing awareness of clinical results, yet it remains unclear whether the psychological and neural effects observed in clinical trials, including the effects on emotional reactivity, generalize to these less-controlled settings.

To address this question, we recently conducted a large-scale cross-sectional study in which questionnaire data from over 2,500 participants, including regular psychedelic users, were analyzed. Our findings revealed that psychedelic use was associated with an adaptive emotional reactivity profile, where psychedelic users exhibited higher positive emotional reactivity and lower negative emotional reactivity compared to non-users (Orłowski et al., 2022). Complementing these self-report findings, our recent EEG study (Orłowski et al., 2023) investigated neural responses to emotional facial expressions in experienced psychedelic users compared to non-users. Results revealed significantly reduced early neural reactivity (N170 and N200 components) to fearful faces among users, suggesting a decreased automatic neural response to negative emotional stimuli. No differences were observed in later cognitive ERP components (P200, P300), indicating that modulation might be specific to early perceptual stages of emotional processing. Also we did not find any effects of increased positive emotional reactivity in psychedelic users. Other naturalistic studies have also reported associations between psychedelic use and improved emotion regulation, mood and well-being (e.g., Watts et al., 2017; Thomson & Thomacos, 2025), although neuroimaging studies investigating the persistent brain changes associated with prolonged neural effects of naturalistic psychedelic use remains scarce.

Building upon prior EEG findings from our group (Orłowski et al., 2023), the current study employs fMRI to explore whole-brain and region-specific neural activity during an emotional face classification task. We aimed to investigate whether brain activity patterns evoked by perceiving emotional facial expressions differ between regular users of classic psychedelics and non-users. Guided by evidence from acute pharmacological studies (Carhart-Harris et al., 2012; Lebedev et al., 2015; Stoliker et al., 2022), we hypothesize that users will show attenuated neural reactivity to negative emotional stimuli, reflecting a persistent modulation of emotion-processing neural networks.

Methods

The methods and hypotheses for this study were preregistered on the Open Science Framework (https://doi.org/10.17605/OSF.IO/CQUJR). The study was conducted in accordance with the Declaration of Helsinki and was approved by the Human Ethics Committee of SWPS University of Social Sciences and Humanities, Warsaw, Poland (approval no. 13/2020).

Recruitment Survey

A total of 2573 individuals completed the online recruitment survey, which was created in the Qualtrics software (Qualtrics, Provo, UT) and disseminated through social media profiles of the Centre for Brain Research and several Polish organizations supporting

harm reduction and drug policy (including the Polish Psychedelic Society, Społeczna Inicjatywa Narkopolityki, and Terapia Psychodeliczna.info). Participants read and electronically accepted the General Data Protection Regulation (GDPR) clause and the informed consent form before filling out the survey.

The survey content was presented in a fixed sequence, reflecting the order described here. It began by collecting basic sociodemographic information, including sex, age, education level, and place of residence. Next, participants completed standardized screening measures for alcohol use (the Alcohol Use Disorders Identification Test—Concise, AUDIT-C; Bush et al., 1998) and cannabis use (items 1–3 of the Cannabis Use Disorders Identification Test—Revised, CUDIT-R; Adamson et al., 2010).

Following this, respondents were asked whether they had ever used, or intended to use in the future, any substance classified as a classic psychedelic (i.e., LSD, psilocybin mushrooms, DMT, changa, mescaline, or ayahuasca). Those who indicated at least one psychedelic experience were additionally asked to specify the number of lifetime and past-year uses. Participants also reported their lifetime and past-year non-medical use of other psychoactive substances, including stimulants (e.g., cocaine, amphetamine, mephedrone), empathogens (e.g., 3,4-methylenedioxymethamphetamine (MDMA), 3,4-methylenedioxyamphetamine (MDA)), dissociatives (e.g., ketamine, dextromethorphan (DXM), benzodiazepines (e.g., alprazolam, diazepam, lorazepam), opioids (e.g., heroin, morphine), and synthetic cannabinoids (e.g., Spice, K2).

Meditation practice was assessed by asking participants about their total duration of practice (in months), frequency of sessions (e.g., number of sessions per week or month), and average session length (in minutes). Participants then completed a set of psychological questionnaires, including the Perth Emotional Reactivity Scale—Short Form (PERS-S; Preece et al., 2019). Other questionnaires were also administered but are not reported here as they were not analyzed in the current study. They also reported any neurological or psychiatric diagnoses and use of prescribed psychoactive medications.

At the end of the survey, participants consented to be contacted for further participation in the fMRI study and provided their contact details. The survey took approximately 15 minutes to complete.

Group Assignment and Matching

The above-described survey responses were subsequently analyzed to select a suitable group of participants for the fMRI study. Exclusion criteria included a current or past psychiatric or neurological diagnosis, a history of substance dependence, current use of psychoactive medications (e.g., SSRIs or sedatives), contraindications for MRI scanning, or left-handedness to avoid confounds in fMRI analysis. Applicants meeting none of these exclusion criteria were considered eligible for group assignment.

The inclusion criterion for the Users group was having at least ten lifetime experiences with classic psychedelics, while the Non-Users group consisted of individuals who had never used any of the classic psychedelics but expressed a willingness to do so in the future. To minimize potential influence of confounding variables in this cross-sectional comparison, the two groups were matched on key demographic characteristics (age, gender, education level, and place of residence categorized by settlement size) as well as on patterns

of psychoactive substance use, including alcohol and cannabis use (AUDIT-C, CUDIT-R scores) and lifetime and past-year use counts for stimulants, empathogens, dissociatives, benzodiazepines, opioids, and synthetic cannabinoids. Total lifetime meditation experience was also included in the matching criteria. Matching was verified with statistical tests appropriate to the variables' types and distributions (t-tests, Mann-Whitney U tests, or chi-square tests).

Participants selected through this procedure were invited for fMRI sessions and instructed to abstain from psychedelics for at least 30 days prior to scanning.

fMRI Experiment Sample

The preregistered target sample size for the fMRI experiment was 70 participants. Ultimately, 69 fMRI sessions were conducted—34 psychedelic users and 35 non-users—closely matching the recruitment plan. The data collection took place at the Centre for Brain Research, Jagiellonian University (Cracow, Poland). Data from two participants (one User) were excluded from analyses: one due to discontinuation of the fMRI session as a result of distress in the scanner, and one due to disclosure of non-compliance with inclusion criteria during the fMRI session. Detailed group characteristics of the participants included in the analysis are presented in Table 1.

All participants provided written informed consent and received monetary compensation of 150 PLN (approximately 35 EUR). Transportation costs of up to 160 PLN were also reimbursed. All participants were native Polish speakers with normal or corrected-to-normal vision.

	Users (N = 33)	**Non-users (N = 34)**
Male sex	15 (45.5%)	16 (47.1%)
***M* (*SD*) Age in years**	29.0 (5.16)	29.5 (7.55)
Education		
Secondary	24.2%	32.4%
Bachelor's degree	33.3%	23.5%
Master's degree	39.4%	35.3%
Doctoral degree	3.0%	8.8%
Place of residence		
Village	12.1%	8.8%
City - population up to 50K	12.1%	11.8%
City - population from 50K to 150K	6.0%	2.9%
City - population from 150K to 500K	12.1%	11.8%
City - population over 500K	57.6%	64.7%
***M* Task accuracy**		
Angry faces*	93.8%	90.4%
Fearful faces	95.7%	94.4%

Happy faces	98.4%	98.3%
Neutral faces	95.5%	96.2%
***M* (*SD*) Reaction Times**		
Angry faces*	1.26 (0.37)	1.32 (0.37)
Fearful faces	1.24 (0.35)	1.31 (0.35)
Happy faces	1.11 (0.28)	1.06 (0.28)
Neutral faces	1.11 (0.27)	1.12 (0.29)
***MED (IQR)* Lifetime meditation in hours**	18 (48.7)	60.5 (28)
***MED (IQR)* AUDIT-C (max score = 12)**	3 (3)	4 (2.5)
***MED (IQR)* CUDIT-R (max score = 12)**	3 (3)	2.5 (3)
***MED (IQR)* Lifetime psychedelics use**	18 (15)	0 (0)
***MED (IQR)* Lifetime stimulants use**	1 (3)	0 (3.5)
***MED (IQR)* Lifetime empathogens use**	3 (5)	1 (6)
***MED (IQR)* Lifetime dissociatives use**	0 (1)	0 (0)
***MED (IQR)* Lifetime benzodiazepines use**	0 (0)	0 (0)
***MED (IQR)* Lifetime opioids use**	0 (0)	0 (0)
***MED (IQR)* Lifetime synthetic cannabinoids use**	0 (0)	0 (0)
***MED (IQR)* Positive emotional reactivity (PERS-S; max score = 45)**	36 (2)	35 (8)
***MED (IQR)* Negative emotional reactivity (PERS-S; max score = 45)**	25 (7)	27 (9.25)

M - mean, MED - median, SD - standard deviation; IQR - interquartile range;
AUDIT-C - Alcohol Use Disorders Identification Test—Concise (Bush et al., 1998);
CUDIT-R - Cannabis Use Disorders Identification Test—Revised,(Adamson et al., 2010);
PERS-S - Perth Emotional Reactivity Scale—Short Form (Preece et al., 2019)

Table 1. Descriptive statistics for demographic characteristics, substance use variables, meditation practice, questionnaire scores, and behavioral performance in the classification task for Users and Non-Users. Groups were compared using independent sample t-tests, Mann-Whitney U tests, or χ^2 tests according to variable type, and linear or generalized linear mixed-effects models (LMMs/GLMMs) for reaction times and classification accuracy in the experimental task. Statistical significance of between-group differences is indicated by *$p < 0.05$

Stimuli

A set of images selected from the Warsaw Set of Emotional Facial Expression Pictures (Olszanowski et al., 2015) was used as a stimuli. The set comprised color photographs of 13 female models (IDs: AD, JS, KO, KP, Ks, MJ, MK1, MR1, MS, OG, PS, SO, and SS) and 13 male models (IDs: AG, DC, HW, KA, KM, MG, MK, MR2, PA, PB, PO, RA, and RB). For each model, we included four images depicting angry, fearful, happy, and neutral facial expressions, resulting in a total of 104 images used as experimental stimuli. The same stimuli were previously employed in our related EEG study (Orłowski et al., 2023), ensuring methodological consistency across studies.

Experimental Procedure

Prior to entering the MRI scanner, participants completed a brief practice session to familiarize themselves with the emotional facial expression perception task procedure. During the experimental session, three types of neuroimaging data were acquired in the following sequence: (1) structural brain scans (T1-weighted images), (2) functional resting-state scans (10 minutes; not analyzed in the present study), and (3) task-based functional MRI data collected during an emotional facial expression perception task (BOLD signal; approximately 28 minutes, split into two runs).

The emotional facial expression perception task comprised 208 trials, equally distributed across four emotional conditions (Happy, Fearful, Angry, and Neutral; 52 trials per condition). The task was administered in two runs of 104 trials each, separated by a brief break. Faces of female and male models were presented in equal numbers within each condition. Images were shown in a pseudo-randomized sequence, with constraints to ensure that no more than two consecutive trials featured the same model, emotion, or gender.

On each trial, participants performed an emotion recognition task. They were instructed to maintain gaze fixation on a central cross and to identify the displayed facial emotion as quickly and accurately as possible using a four-button response pad, with the assignment of buttons to specific emotions counterbalanced across participants.

Each trial began with a fixation cross (3,600 ms, jittered by ±600 ms), followed by the presentation of a face image (500 × 500 pixels) for 300 ms. After stimulus offset, a response screen appeared for 2,000 ms, displaying the four emotion labels in an arrangement matching the response button mapping (Figure 1). Participants were required to indicate the perceived emotion by pressing the appropriate button within the allotted time. Importantly, the assignment of specific emotion labels to response buttons and their on-screen positions was randomized across participants.

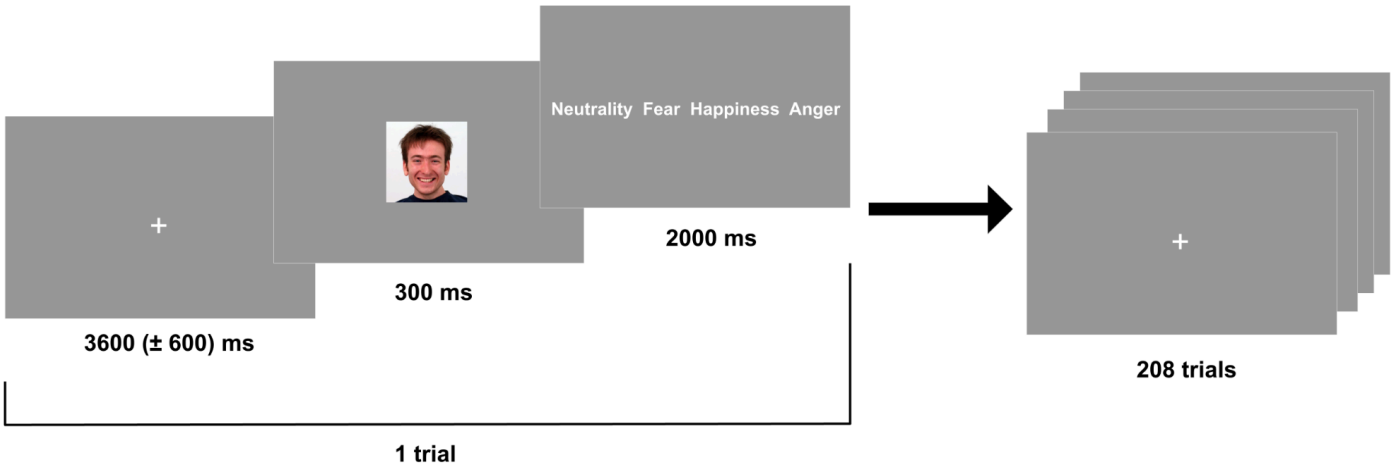

Figure 1. Scheme of the emotional perceptual task procedure.

MRI Data Acquisition

MRI data were collected using a 3T Siemens Magnetom Prisma scanner equipped with a 64-channel head coil.

Structural images were acquired using a 3D sagittal T1-weighted MPRAGE sequence (192 slices, voxel size 0.9×0.9×0.9mm, field of view 240mm, TR=2300ms, TE=2.32ms, TI=900ms, flip angle 8°, base resolution 256, GRAPPA acceleration factor 2, phase encoding direction anterior-to-posterior).

Functional images were collected using a T2*-weighted 2D multiband echo-planar imaging (EPI) sequences from the Center for Magnetic Resonance Research (CMRR), University of Minnesota (Moeller, et.al 2010; Feinberg, et.al 2010; Xu et.al 2013) (42 axial slices, voxel size 3×3×3mm, field of view 192mm, slice thickness 3mm, TR=1,200ms, TE=27ms, flip angle 75°, base resolution 64, GRAPPA acceleration factor 2, multi-band acceleration factor 2, phase encoding direction anterior-to-posterior). To correct for spatial distortions in functional images, the same sequence with reverse phase was collected.

Data analysis

Behavioral data analysis

Behavioral data from the emotional facial expression classification task, recorded during the fMRI session, were analyzed for both reaction times and classification accuracy. Responses were considered correct if the participant identified the emotion corresponding to the presented facial stimulus within the 2-second response window. Trials in which no response was given, or in which the incorrect emotion was selected, were classified as errors. In cases where more than one response was registered within the response window, only the first response was included in the analysis.

Reaction time (RT) data, including both correct and incorrect responses, were analyzed using linear mixed-effects models (LMMs), implemented with the lmer() function from the lme4 package in R (R Core Team, 2021; Bates et al., 2015). Classification accuracy was analyzed using generalized linear mixed-effects models (GLMMs) with a binomial link, implemented via the glmer() function from lme4. For both outcome measures, the models included Group (Users vs. Non-Users), Emotional Condition (angry, fearful, happy, neutral), and their interaction as fixed effects, as well as a random intercept for participants. Statistical significance of fixed effects was assessed using Type III Wald chi-square tests via the Anova() function from the car package.

When a significant main effect of Emotional Condition was observed, post hoc pairwise comparisons between emotional conditions were conducted using the emmeans package, applying Holm's correction for multiple comparisons. Additionally, when a significant Group × Emotional Condition interaction was observed, post hoc pairwise comparisons between groups within each emotional condition were performed using the same approach.

Neuroimaging data analysis

Functional and anatomical MRI data were preprocessed using fMRIPrep 24.0.1 (Esteban et al., 2019). The preprocessing workflow included correction for intensity

non-uniformity and skull-stripping of T1-weighted anatomical images, segmentation into gray matter, white matter, and cerebrospinal fluid, and nonlinear spatial normalization to the MNI template.

Functional runs underwent slice timing correction, head-motion correction, and co-registration to the participant's anatomical image using boundary-based registration. Susceptibility distortion correction was performed utilizing two images with different phase-encoding directions. Confound regressors related to head motion, global signal components, and physiological noise were extracted.

All spatial transformations were concatenated and applied in a single interpolation step using cubic spline interpolation to minimize data degradation. Detailed preprocessing procedures and quality control metrics are comprehensively described in the fMRIPrep-generated reports. A representative summary of these reports including the full description of preprocessing steps, is provided in the Supplementary Material.

First-level (subject-level) analyses were performed using FEAT (FMRI Expert Analysis Tool) from FSL version 6.0.7.13 (Jenkinson et al., 2012). Within FEAT, additional preprocessing steps included brain extraction using Brain Extraction Tool (BET), spatial smoothing with a Gaussian kernel of 4 mm full width at half maximum (FWHM), grand-mean intensity normalization, and temporal high-pass filtering with a cutoff of 100 seconds. For each participant, separate general linear models (GLMs) were estimated for each of the two experimental runs to account for run-specific variance. Each first-level model included regressors for both experimental conditions and task performance. Four regressors captured the presentation of face stimuli for the four emotional conditions (angry, fearful, happy, and neutral); taking into account the duration of the stimulus presentation period for each emotion. In contrast, three additional regressors accounted for task performance—correct response trials, error trials, and no-response trials—each of which was modeled as covering the entire trial duration, from onset of the fixation cross to the response window. All regressors were convolved with a canonical gamma hemodynamic response function (HRF) using standard parameters (phase = 0 s, standard deviation = 3 s, mean lag = 6 s). Six head motion parameters (translations and rotations along the x, y, and z axes) estimated during realignment, as well as the mean cerebrospinal fluid (CSF) signal, were included as nuisance regressors; these were modeled as regressors of no interest and were not convolved with the HRF. For each participant, first-level contrasts from both runs were combined using a fixed-effects model to produce condition-specific activation maps for subsequent group analysis.

Whole-Brain Analysis

An exploratory (i.e., non-preregistered) analysis of whole-brain group-level data was conducted using AFNI version 25.1.08 (Cox, 1996). A linear mixed-effects model was implemented with the 3dLME program (Chen et al., 2013), including Emotional Condition (Angry, Fearful, Happy, Neutral; within-subject factor) and Group (Users, Non-Users; between-subjects factor) as fixed effects. This allowed assessment of main effects and Emotional Condition × Group interactions. After model estimation, three key contrasts were computed by subtracting the activation for neutral faces from that for each emotional expression (Angry – Neutral, Fearful – Neutral, Happy – Neutral), using the neutral condition

as the baseline in these difference contrasts. Group differences were evaluated for each contrast.

All group-level statistical tests used type III sums of squares, with random effects included to account for inter-individual variability. Significance was determined using a voxel-wise Z-threshold of 2.5, considering only clusters that exceeded a minimum size of 25 contiguous voxels (with cluster adjacency defined by any shared face or edge).

ROI Analysis

The preregistered region-of-interest (ROI) analysis was conducted using masks derived from the Harvard-Oxford cortical probabilistic atlas included in the FSL software. ROIs included the anterior division of the cingulate gyrus (denoted here as ACC - anterior cingulate cortex), frontal medial cortex, frontal pole, middle frontal gyrus, bilateral amygdala, fusiform gyrus (created by merging occipital fusiform gyrus, temporal occipital fusiform cortex and the anterior and posterior divisions of the temporal fusiform cortex), and parahippocampal gyrus (anterior and posterior divisions combined). ROI masks were resampled to the functional data resolution and thresholded at 50% probability to retain voxels assigned with high anatomical confidence. Composite ROIs (fusiform gyrus and parahippocampal gyrus) were formed by merging relevant subregions as specified.

For each participant, mean beta values were extracted and averaged within each ROI for all emotional conditions. Statistical analysis was performed in R using mixed-design ANOVAs (aov_ez() function from the afex package; Singmann et al., 2015), with Group (Users vs. Non-users) as a between-subjects factor and Emotional condition as a within-subject factor. Sphericity violations were assessed, and when present, Greenhouse-Geisser correction was applied to F-tests to adjust degrees of freedom accordingly. When significant main effects of Emotional condition or Emotional condition × Group interactions were observed ($p < 0.05$), post hoc comparisons were performed using the emmeans() function , with Bonferroni correction applied to control for multiple comparisons.

Results

Behavioral data

Mixed-effects linear modeling of reaction times revealed a significant main effect of Emotional Condition ($F(3, 13356) = 526.76$, $p < 0.001$). Post hoc pairwise comparisons indicated that reaction times differed significantly between all emotional conditions, with the longest reaction times for angry ($M = 1.31$ s, $SD = 0.37$) and fearful faces ($M = 1.27$ s, $SD = 0.35$) and the shortest for happy faces ($M = 1.08$ s, $SD = 0.28$). There was no significant main effect of Group on reaction times ($F(1, 65) = 0.63$, $p = 0.43$). However, a significant Group × Emotional Condition interaction was observed ($F(3, 13,356) = 45.31$, $p < 0.001$). Post hoc comparisons exploring this interaction revealed that Users responded significantly faster than Non-Users during classification of angry faces (Users: $M = 1.26$ s, $SD = 0.37$; Non-Users: $M = 1.36$ s, $SD = 0.37$; estimate = 0.10, SE = 0.04, $p = 0.008$), while no significant group differences emerged for the other emotional conditions.

Mixed-effects logistic regression analysis of classification task accuracy revealed a significant main effect of Emotional Condition ($\chi^2(3) = 109.64$, $p < 0.001$). Post hoc tests

showed that accuracy was highest for happy faces (M = 98.3%, SD = 12.7%) and lowest for angry faces (M = 92.1%, SD = 27.1%). There was also a significant main effect of Group ($\chi^2(1) = 4.47$, $p = 0.034$), with Users demonstrating better overall accuracy (Users: M = 95.9%, SD = 19.9%; Non-Users: M = 94.8%, SD = 22.2%). Moreover, we found a Group × Emotional Condition interaction effect ($\chi^2(3) = 9.79$, $p = 0.020$). Post hoc analysis revealed that Users performed significantly better than Non-Users specifically during classification of angry faces (Users: M = 93.8%, SD = 24.2%; Non-Users: M = 90.4%, SD = 29.5%; estimate = –0.44, SE = 0.21, p = 0.03), whereas no significant between-group differences were found for fearful, happy, or neutral faces.

Whole-Brain analysis

In the whole-brain analysis, the hemodynamic response related to perception of emotional facial expression (Angry, Fearful, Happy) was assessed relative to the neutral baseline (i.e., the difference between each emotional condition and the Neutral condition). For each emotion, significant group differences in activation (Users vs. Non-Users) are reported below and presented in Table 2.

Angry

Compared to Non-Users, Psychedelic Users showed lower activations during perception of Angry faces in the left insula, left supplementary motor area, and bilateral inferior frontal gyri. Conversely, Users showed higher angry-related activation in the right inferior parietal lobule.

Fearful

Users exhibited higher fearful-related activation in the precuneus compared to Non-Users.

Happy

Users showed greater activation during perception of happy faces in the right inferior parietal lobule / supramarginal gyrus, right inferior parietal lobule / postcentral gyrus, left superior parietal lobule, left cerebellum, right supplementary motor area, and right superior parietal lobule. Conversely, in the right inferior frontal gyrus, Users displayed lower happy-related activation than Non-Users.

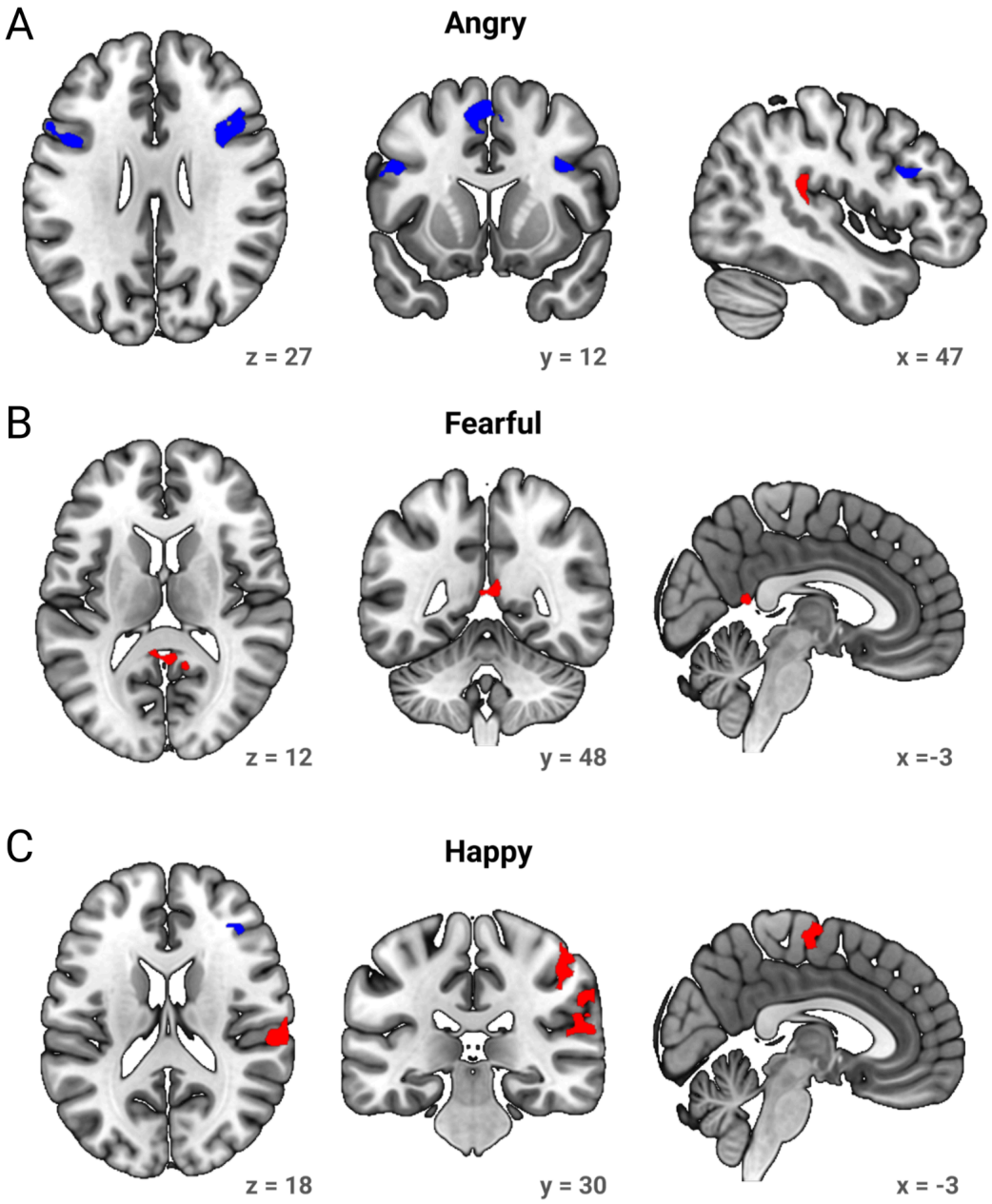

Figure 2. Whole-brain group differences in neural activation evoked by emotional facial expressions. Results of the whole-brain analysis are presented for three contrasts, each comparing activation during perception of emotional faces to a neutral baseline: (A) Angry–Neutral, (B) Fearful–Neutral, and (C) Happy–Neutral. Statistical maps display clusters in which significant between-group differences in activation were observed (Users vs. Non-Users). Regions marked in red indicate higher activation in Users, whereas blue regions represent lower activation in Users compared to Non-Users. Statistical significance was determined using a voxel-wise Z-threshold of 2.5, considering only clusters of at least 25 contiguous voxels (adjacency defined by any shared face or edge).

Contrast	Anatomical Region	Hemisphere	Peak MNI coordinates (x, y, z) RAS	Cluster Size (voxels)	Peak Z-value
Angry	Insula	Left	(-42, 21, -3)	117	-4.14
	Supplementary Motor Area	Left	(-3, 12, 57)	72	-4.20
	Inferior Parietal Lobule	Right	(66, -21, 18)	60	4.13
	Inferior Frontal Gyrus	Right	(36, 9, 30)	46	-3.70
	Inferior Frontal Gyrus	Left	(-48, 9, 30)	43	-3.92
Fearful	Precuneus	Bilateral	(3, -48, 12)	26	4.28
Happy	Inferior Parietal Lobule / Supramarginal Gyrus	Right	(57, -27, 18)	73	4.10
	Inferior Parietal Lobule / Postcentral Gyrus	Right	(48, -30, 48)	59	3.54
	Superior Parietal Lobule	Left	(-42, -39, 66)	58	3.50
	Cerebellum	Left	(-36, -51 -33)	46	4.10
	Superior Parietal Lobule	Left	(-57, -30, 54)	46	3.50
	Supplementary Motor Area	Right	(3, -12, 66)	40	4.11
	Inferior Frontal Gyrus	Right	(39, 33, 9)	29	-3.80
	Superior Parietal Lobule	Right	(36, -36, 54)	28	3.74

Table 2. Results of the whole-brain analysis: Anatomical regions showing significant group differences in activation for each emotional facial expression (Angry, Fearful, Happy) compared to the activation evoked by Neutral faces. The Peak Z-value indicates the direction and magnitude of the group effect (Users minus Non-Users) for the emotion–neutral contrast: positive values reflect greater activation differences in Users, whereas negative values indicate lower activation differences in Users compared to Non-Users.

ROI

In this section, we present detailed results only for ROIs in which statistically a significant interaction between Emotion x Group was observed (as this interaction allows testing our main hypothesis). Comprehensive summaries of all ROI analyses, including detailed statistics for non-significant effects, are provided in Supplementary Results. Note that all numerical results, including those not discussed in detail here, are summarized in Table 3.

Frontal medial cortex

In the frontal medial cortex, where mean beta values were predominantly negative (indicating deactivation relative to baseline), we found a significant main effect of Emotional condition ($F = 6.18$; $p < 0.001$): the deactivation level was significantly greater—meaning lower beta values—during the perception of both Angry ($t = -3.50$, $p = 0.005$) and Fearful faces ($t = -3.20$, $p = 0.013$) compared to Happy faces. No significant main effect of Group was detected ($F = 1.08$, $p = 0.302$). A significant Emotion × Group interaction was found

($F = 2.78$, $p = 0.048$). Post hoc analyses revealed that, within the Non-user group, deactivation for both Angry ($t = -4.65$, $p < 0.001$) and Fearful faces ($t = -3.33$, $p = 0.009$) was significantly greater than for Happy faces, but no significant differences between emotional conditions were observed within the User group. No significant between-group differences were found within any of the Emotional conditions.

Parahippocampal gyrus

In the parahippocampal gyrus, where mean beta values were predominantly negative (again showing deactivation relative to baseline), there was a significant main effect of Emotional condition ($F = 8.38$, $p < 0.001$). Post hoc comparisons showed that deactivation was significantly greater during the perception of Angry ($t = -4.24$, $p < 0.001$) and Fearful faces ($t = -3.99$, $p = 0.001$) compared to Happy faces. Additional comparisons revealed stronger deactivation for Angry faces relative to Neutral faces ($t = -2.80$, $p = 0.040$). The main effect of Group was not significant ($F = 0.59$, $p = 0.447$). A significant Emotion × Group interaction was found ($F = 3.54$, $p = 0.017$): in the Non-user group, deactivation for both Angry ($t = -4.86$, $p < 0.001$) and Fearful faces ($t = -4.83$, $p = 0.001$) was significantly greater than for Happy faces, and deactivation was also stronger for Angry compared to Neutral faces ($t = -3.30$, $p = 0.010$). No significant differences between emotional conditions were observed within the User group, nor were any between-group effects found within any specific Emotional condition.

ROI	Effect	df	F-value	P-value
Anterior Cingulate Cortex	Emotion	(2.94, 191.05)	1.88	0.135
	Group	(1,65)	1.40	0.242
	Emotion x Group	(2.94, 191.05)	0.59	0.617
Frontal Medial Cortex	Emotion	(2.72, 176.62)	6.18	< 0.001***
	Group	(1,65)	1.08	0.302
	Emotion x Group	(2.72, 176.62)	2.78	0.048*
Frontal Pole	Emotion	(2.84, 184.89)	6.32	< 0.001***
	Group	(1,65)	0.59	0.444
	Emotion x Group	(2.84, 184.89)	1.59	0.196
Left Amygdala	Emotion	(2.91, 189.00)	0.61	0.603
	Group	(1,65)	0.06	0.804
	Emotion x Group	(2.91, 189.00)	0.84	0.468
Right Amygdala	Emotion	(2.91, 188.88)	3.13	0.028*
	Group	(1,65)	0.04	0.835
	Emotion x Group	(2.91, 188.88)	1.00	0.392
Parahippocampal gyrus	Emotion	(2.87, 186.59)	8.38	< 0.001***
	Group	(1,65)	0.59	0.447
	Emotion x Group	(2.87, 186.59)	3.54	0.017*
Fusiform gyrus	Emotion	(2.81, 182.46)	2.98	0.036*
	Group	(1,65)	0.67	0.417
	Emotion x Group	(2.81, 182.46)	0.14	0.925

Table 3. Results of the ROI analysis. Degrees of freedom were corrected with Greenhouse-Geisser method in case of sphericity violations.

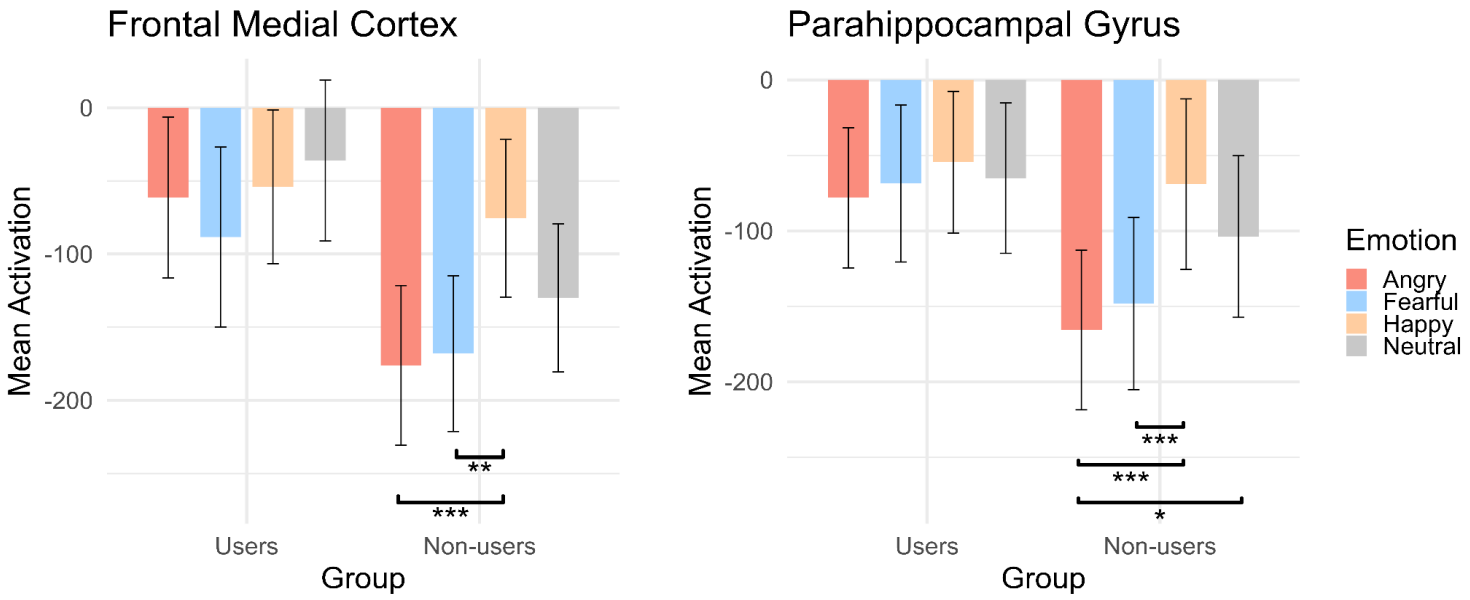

Figure 3. Mean beta values associated with the perception of emotional facial expressions (Angry, Fearful, Happy, and Neutral) in two groups (Users and Non-Users) and two regions of interest (frontal medial cortex and parahippocampal gyrus). Statistical significance of post hoc comparisons is indicated: *p < 0.05, **p < 0.01, ***p < 0.001.

Discussion

Psychedelic substances are able to strongly affect the subjective qualities of emotional experiences (Preller & Vollenweider, 2018). Therefore, studying perception and processing of emotions has been one of the core areas of interest in psychedelic research. Extensive empirical evidence indeed supports the view that emotional reactivity might be modulated, both acutely and in the long-term, by psychedelic substances (Vollenweider & Preller, 2020). Importantly, adaptive changes in emotional reactivity—such as reduced sensitivity to negative affect— have been proposed to underpin many of the mental health benefits related with psychedelic use (Moujaes et al., 2025). However, the majority of data comes from highly controlled clinical studies, in which the context of psychedelics intake is not representative of real-world environments. Not much is known about effects of using psychedelics in naturalistic context as relevant research remains scarce and is often limited by methodological challenges, such as the retrospective and self-report nature of the employed measures (Carvalho et al., 2025). To address this gap the current study investigated differences in the perception of emotional facial expressions between experienced psychedelic users and matched non-users using behavioral and fMRI data.

Main findings

Analysis of behavioral data from the emotion recognition task revealed that psychedelic users were faster when recognizing angry faces compared to non-users. Importantly, this effect was specific to angry faces, as no significant group differences were observed for fearful, happy, or neutral faces. Regarding recognition accuracy, we found

higher overall accuracy in the users group but, in line with the reaction times analysis, this effect was mainly driven by users' better recognition of angry faces. We interpret this pattern of results as indicating that users might be less prone to interference from the emotional, threat-related information when performing the recognition task, compared to non-users. In line, Stroud and colleagues (2018) reported that patients suffering from treatment-resistant depression undergoing psilocybin-assisted therapy exhibited improved emotion recognition performance, in terms of both reaction times and accuracy, in an emotional face recognition task (however no emotion-specific differences in performance were observed in their study). Together, their findings and the behavioral enhancement observed in our study suggest that these effects are attributable to psychedelic use rather than to other uncontrolled factors.

In line with the behavioral outcome, whole-brain fMRI analyses revealed that psychedelic users exhibited lower activations in key limbic and salience network regions during perception of angry faces. This result aligns with findings from previous clinical and experimental studies, which consistently reported that psychedelics attenuated the processing of negative emotional stimuli and enhanced emotional regulation (e.g., Kraehenmann et al., 2015; Barrett et al., 2020). However, we also observed that psychedelic users showed increased activation in the precuneus in response to fearful faces. Notably, this effect was not reflected in behavioral performance, and it contrasts with the patterns reported in previous studies.

Regarding positive stimuli, perception of happy faces resulted in generally greater activations in widespread parietal and sensorimotor regions among psychedelic users. Although this pattern was not accompanied by significant differences in behavioral measures, it is consistent with accumulating evidence that psychedelics enhance neural sensitivity to positively valenced emotional stimuli. Previous functional neuroimaging studies have reported greater activation of parietal, sensorimotor, and prefrontal regions following psychedelic administration in response to positive emotions (Moujaes et al., 2025; Barrett et al., 2020). Additionally, psilocybin has been shown to bias facial emotion recognition and goal-directed behavior toward positive rather than negative emotions (Kometer et al., 2012). Such enhanced reactivity to positive emotional stimuli has been linked to the improvements in mood and well-being frequently reported after psychedelic experiences. Therefore, our findings align with existing evidence from clinical studies and suggest that similar neurofunctional patterns may be associated with naturalistic psychedelic use.

Furthermore, our previous work revealed, first, that psychedelics users reported lower negative and higher positive emotional reactivity when measured by questionnaires (Orłowski et al., 2022); and second, that they exhibited reduced amplitudes of early ERP components in response to fearful faces, likely indicating attenuated early-stage automatic processing of negative emotion (Orłowski et al., 2023). Importantly, despite differences in behavioral paradigms used —specifically a passive viewing paradigm with emotion as a task-irrelevant feature in the EEG study versus explicit emotion recognition task in the fMRI study—these effects were observed in both studies, providing converging evidence of their reliability. Regarding differences, the current study indicates increased neural responses to positive emotional stimuli in psychedelic users, whereas we did not find a similar effect in the EEG study. This discrepancy may stem from the fact that fMRI might be better suited to detect broader, integrative neural network responses that are not accessible through EEG.

Additionally, positive emotional processing may be particularly sensitive to task characteristics, as positive emotions are generally less salient than negative ones (Vaish et al., 2008), making implicit processing of emotions potentially a better way to detect related effects.

Finally, between group differences in emotional processing were further confirmed in the ROI analyses. Specifically, we observed reduced differentiation of brain responses to emotional categories in the frontal medial cortex and the parahippocampal gyrus. Both areas are hubs of the DMN, with the former constituting a core region and the latter part of the medial-temporal subsystem. Thus, our findings suggest that naturalistic psychedelic use may induce long-term changes in DMN function, reflected in diminished neural sensitivity to distinct emotional categories, particularly through reduced reactivity to negative emotions. This result resonates with clinical observations that psychedelics decrease negative affect and improve emotional regulation (e.g., Ross et al., 2016; Kraehenmann et al., 2015; Roseman et al., 2018; Barrett et al., 2020), potentially by modulating DMN activity. Furthermore, diminished differentiation within this system is consistent with reports linking reduced DMN overactivity to alleviated rumination and mood improvement in depression (Hamilton et al., 2011, 2015), conditions for which psychedelic therapies have demonstrated efficacy (Carhart-Harris et al., 2021). Thus, our result of a flattened emotional response profile in DMN regions may represent a neurobiological signature of persisted increase of emotional resilience associated with naturalistic psychedelic use.

Notably, in the ROI analysis we observed no significant group differences in the amygdala activation, despite its known role in processing negative emotional stimuli. This finding can be considered at odds with numerous prior studies in which decreases in amygdala reactivity were observed both in the acute phase (Kraehenmann et al., 2015; Mueller et al., 2017; Armand et al., 2024), as well up to 7 days (Barrett et al., 2020) or even 30 days after the psychedelic administration (Ross et al., 2016). This discrepancy may stem from contextual differences: clinical trials often include controlled dosing, therapeutic support, and motivated participants, which may amplify or prolong neural effects. In contrast, naturalistic use, characterized by variable doses, motivations, and environments, may produce subtler or less enduring modulation of amygdala activity. Moreover, prior neuroimaging studies typically measured brain activity shortly (days to weeks) after psychedelic use, whereas our sample consisted of individuals who had used psychedelics regularly but abstained from using for at least 30 days before the measurement. Therefore, it is plausible that amygdala effects observed acutely or subacutely dissipate over longer periods, and do not represent stable long-term neural changes following naturalistic psychedelic use.

To sum up, our findings from the whole-brain and ROI analyses reveal a mixed and regionally specific pattern of effects, highlighting the nuanced and dynamic nature of psychedelic modulation of emotion processing. As Moujaes and colleagues (2025) emphasize, empirical evidence remains inconsistent, likely stemming from limited granularity in measuring discrete emotions, temporal dynamics of psychedelic effects, and differences between clinical and non-clinical populations. Psychedelics may foster emotional flexibility through modulating emotion regulation, yet the temporal course and specific circuit-level adaptations require further investigation. Overall, our results contribute to this emerging narrative by highlighting that psychedelic-mediated emotional modulation is

unlikely to be a unitary phenomenon, instead reflecting a network-level reorganization with emotion- and region-specific effects, modulated by individual and contextual factors.

Methodological aspects and limitations

The key limitation of our work is the inability to draw causal conclusions regarding psychedelic use, which is as consequence of the cross-sectional design of the study. Therefore, our results complement rather than extend previous clinical findings. Further, although demographic and lifestyle factors were matched between groups and potential confounds were statistically controlled, the influence of residual confounds and biases, as well as expectancy effects on our results cannot be ruled out.

Another important limitation arises from the potential self-selection bias in the Users group. Recruited participants reported at least ten lifetime uses, suggesting they are likely individuals who have had predominantly positive experiences and continued psychedelic use. Such a self-selection bias, common in naturalistic psychedelic research, may lead to an overrepresentation of individuals with favorable outcomes and underrepresentation of those who had challenging or adverse experiences (Aday et al., 2020; Muthukumaraswamy et al., 2022). Furthermore, as individuals currently under psychiatric medication or diagnosed with psychiatric disorders were excluded from our sample, the generalizability of findings to clinical populations undergoing psychedelic-assisted psychotherapy is limited.

Finally, it is important to consider that the use of an event-related fMRI design may have influenced our ability to detect amygdala activation differences. In contrast to block designs, which typically involve sustained presentation of stimuli from the same condition, event-related designs present stimuli from different conditions in a randomized manner. This can reduce statistical power for detecting subtle activations, particularly in small subcortical regions such as the amygdala (Chee et al., 2003; Paret et al., 2014). Many prior neuroimaging studies of emotional face perception that reported amygdala engagement employed block designs (Barrett et al., 2020; Armand et al., 2024), potentially explaining their greater sensitivity to amygdala responses.

Conclusion

The present study provides novel insights into mechanisms taking part in processing of emotional facial expressions in a group of participants who have engaged in repetitive naturalistic use of classic psychedelics. Importantly, the observed pattern of results is partially consistent with findings from previous experimental and clinical studies. However, due to a cross-sectional design, causal inferences about the effects of psychedelic use cannot be made, and the findings should be interpreted with consideration of the inherent limitations. Nevertheless, our results contribute to a growing understanding of the nuanced neurofunctional alterations associated with long-term psychedelic use and their potential relevance for emotional processing and therapeutic outcomes.

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Supplementary material

Investigating Emotional Reactivity in Experienced Users of Psychedelics: a cross-sectional fMRI study

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Supplementary Methods

This section provides a detailed description of the MRI data preprocessing pipeline used in this study, including information generated automatically by fMRIPrep 24.0.1. The following text is the official boilerplate description provided by fMRIPrep to ensure reproducibility and transparency.

Preprocessing of B0 inhomogeneity mappings

A total of 3 fieldmaps were found available within the input BIDS structure for this particular subject. A *B0*-nonuniformity map (or *fieldmap*) was estimated based on two (or more) echo-planar imaging (EPI) references with `topup` (@topup; FSL None).

Anatomical data preprocessing

A total of 1 T1-weighted (T1w) images were found within the input BIDS dataset. The T1w image was corrected for intensity non-uniformity (INU) with `N4BiasFieldCorrection` [@n4], distributed with ANTs 2.5.1 [@ants, RRID:SCR_004757], and used as T1w-reference throughout the workflow. The T1w-reference was then skull-stripped with a *Nipype* implementation of the `antsBrainExtraction.sh` workflow (from ANTs), using OASIS30ANTs as target template. Brain tissue segmentation of cerebrospinal fluid (CSF), white-matter (WM) and gray-matter (GM) was performed on the brain-extracted T1w using `fast` [FSL (version unknown), RRID:SCR_002823, @fsl_fast]. Brain surfaces were reconstructed using `recon-all` [FreeSurfer 7.3.2, RRID:SCR_001847, @fs_reconall], and the brain mask estimated previously was refined with a custom variation of the method to reconcile ANTs-derived and FreeSurfer-derived segmentations of the cortical gray-matter of Mindboggle [RRID:SCR_002438, @mindboggle]. Volume-based spatial normalization to one standard space (MNI152NLin2009cAsym) was performed through nonlinear registration with `antsRegistration` (ANTs 2.5.1), using brain-extracted versions of both T1w reference and the T1w template. The following template was were selected for spatial normalization and accessed with *TemplateFlow* [24.2.0, @templateflow]: *ICBM 152 Nonlinear Asymmetrical template version 2009c* [@mni152nlin2009casym, RRID:SCR_008796; TemplateFlow ID: MNI152NLin2009cAsym].

Functional data preprocessing

For each of the 3 BOLD runs found per subject (across all tasks and sessions), the following preprocessing was performed. First, a reference volume was generated, using a custom methodology of *fMRIPrep*, for use in head motion correction. Head-motion parameters with respect to the BOLD reference (transformation matrices, and six corresponding rotation and translation parameters) are estimated before any spatiotemporal filtering using `mcflirt` [FSL , @mcflirt]. The estimated *fieldmap* was then aligned with rigid-registration to the target EPI (echo-planar imaging) reference run. The field coefficients

were mapped on to the reference EPI using the transform. The BOLD reference was then co-registered to the T1w reference using `bbregister` (FreeSurfer) which implements boundary-based registration [@bbr]. Co-registration was configured with six degrees of freedom. Several confounding time-series were calculated based on the *preprocessed BOLD*: framewise displacement (FD), DVARS and three region-wise global signals. FD was computed using two formulations following Power (absolute sum of relative motions, @power_fd_dvars) and Jenkinson (relative root mean square displacement between affines, @mcflirt). FD and DVARS are calculated for each functional run, both using their implementations in *Nipype* [following the definitions by @power_fd_dvars]. The three global signals are extracted within the CSF, the WM, and the whole-brain masks. Additionally, a set of physiological regressors were extracted to allow for component-based noise correction [*CompCor*, @compcor]. Principal components are estimated after high-pass filtering the *preprocessed BOLD* time-series (using a discrete cosine filter with 128s cut-off) for the two *CompCor* variants: temporal (tCompCor) and anatomical (aCompCor). tCompCor components are then calculated from the top 2% variable voxels within the brain mask. For aCompCor, three probabilistic masks (CSF, WM and combined CSF+WM) are generated in anatomical space. The implementation differs from that of Behzadi et al. in that instead of eroding the masks by 2 pixels on BOLD space, a mask of pixels that likely contain a volume fraction of GM is subtracted from the aCompCor masks. This mask is obtained by dilating a GM mask extracted from the FreeSurfer's *aseg* segmentation, and it ensures components are not extracted from voxels containing a minimal fraction of GM. Finally, these masks are resampled into BOLD space and binarized by thresholding at 0.99 (as in the original implementation). Components are also calculated separately within the WM and CSF masks. For each CompCor decomposition, the *k* components with the largest singular values are retained, such that the retained components' time series are sufficient to explain 50 percent of variance across the nuisance mask (CSF, WM, combined, or temporal). The remaining components are dropped from consideration. The head-motion estimates calculated in the correction step were also placed within the corresponding confounds file. The confound time series derived from head motion estimates and global signals were expanded with the inclusion of temporal derivatives and quadratic terms for each [@confounds_satterthwaite_2013]. Frames that exceeded a threshold of 0.5 mm FD or 1.5 standardized DVARS were annotated as motion outliers. Additional nuisance timeseries are calculated by means of principal components analysis of the signal found within a thin band (*crown*) of voxels around the edge of the brain, as proposed by [@patriat_improved_2017]. All resamplings can be performed with *a single interpolation step* by composing all the pertinent transformations (i.e. head-motion transform matrices, susceptibility distortion correction when available, and co-registrations to anatomical and output spaces). Gridded (volumetric) resamplings were performed using `nitransforms`, configured with cubic B-spline interpolation.

Supplementary Results

Below, we provide the complete statistical results of the ROI analysis, including all regions and outcomes regardless of statistical significance. These details complement the main manuscript, where only the significant interaction effects are described.

Anterior cingulate cortex

No significant effects were observed in the anterior cingulate cortex. Neither the main effect of Emotional condition ($F = 1.88$; $p = 0.135$), Group ($F = 1.40$; $p = 0.242$), nor the Group × Emotional condition interaction ($F = 0.59$; $p = 0.617$) reached statistical significance.

Frontal pole

A significant main effect of Emotional condition was found in the frontal pole ($F = 6.32$, $p < 0.001$), with all emotion conditions associated with negative beta values (deactivation relative to baseline). Deactivation was significantly greater for both Angry ($t = –2.91$, $p = 0.030$) and Fearful ($t = –3.85$, $p = 0.002$) faces compared to Neutral, and for Fearful faces compared to Happy faces ($t = –2.98$, $p = 0.024$). Neither the main effect of Group ($F = 0.59$, $p = 0.444$) nor the Group × Emotional condition interaction ($F = 1.59$, $p = 0.196$) reached statistical significance.

Left amygdala

No significant effects were detected in the left amygdala. Neither the main effect of Emotional condition ($F = 0.61$, $p = 0.603$), Group ($F = 0.06$, $p = 0.804$), nor the Group × Emotional condition interaction ($F = 0.84$, $p = 0.468$) reached statistical significance.

Right amygdala

A significant main effect of Emotional condition was observed in the right amygdala ($F = 3.13$, $p = 0.028$). Post hoc comparisons revealed that activation was significantly higher during the perception of Fearful faces compared to Happy faces ($t = 2.87$, $p = 0.033$), with no other pairwise comparisons reaching statistical significance after correction. Neither the main effect of Group ($F = 0.04$, $p = 0.835$) nor the Group × Emotional condition interaction ($F = 1.00$, $p = 0.392$) was significant.

Fusiform gyrus

A significant main effect of Emotional condition was found ($F = 2.98$, $p = 0.036$). Post hoc comparisons demonstrated that activation was higher for Fearful compared to Neutral faces ($t = 2.88$, $p = 0.032$). No other contrasts reached significance after correction. Neither the main effect of Group ($F = 0.67$, $p = 0.417$) nor the Group × Emotional condition interaction ($F = 0.14$, $p = 0.925$) were significant.