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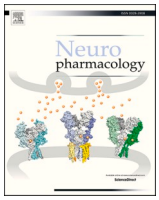

Cognitive and subjective effects of psilocybin microdosing: Results from two double-blind placebo-controlled longitudinal trials☆

Luisa Prochazkova [a,1,*], Josephine Marschall [a], Dominique Patrick Lippelt [a], Neil R. Schon [a], Martin Kuchař [b,c], Bernhard Hommel [a,2]

[a] Institute of Psychology, Leiden University, Wassenaarseweg 52, 2333 AK, Leiden, the Netherlands
[b] Forensic Laboratory of Biologically Active Substances, Department of Chemistry of Natural Compounds, University of Chemistry and Technology Prague, Technická 5, Praha 6, 166 28, Czech Republic
[c] Department of Experimental Neurobiology, National Institute of Mental Health, Topolová 748, 250 67, Klecany, Czech Republic

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ABSTRACT

Objective: Microdosing psychedelics has been widely reported to enhance focus and problem-solving, sparking interest in its potential to treat attentional disorders such as ADHD. However, existing studies largely rely on anecdotal evidence and lack adequate placebo control.
Methods: This study contributes to the literature by examining the longitudinal effects of microdosing psilocybin truffles in two randomized, double-blind, placebo-controlled trials conducted in semi-naturalistic settings. We assessed multiple domains, including cognitive control, memory, social cognition, subjective well-being and subjective experiences using a mix of quantitative and qualitative methods.
Results: Contrary to expectations, microdosing did not significantly affect behavioral or subjective measures compared to placebo. While some initial effects were observed in social cognition, mood, and self-reported cognitive flexibility, these did not remain significant after correcting for multiple comparisons. Regardless of condition, participants predominantly reported their subjective experiences as positive yet negative bodily feelings were enhanced in the active condition. Notably, participants remained effectively blinded throughout the trials.
Discussion: In conclusion, our findings do not support the idea that microdosing psilocybin reliably enhances cognitive or emotional functioning beyond placebo. Future research should explore individual differences in response to microdosing and examine whether specific populations might benefit from targeted microdosing interventions.

1. Introduction

1.1. Background

The practice of consuming small doses of psychedelics - commonly referred to as *microdosing* has grown rapidly in popularity in the past decade (Fadiman and Korb, 2019). Typical (or "classical") psychedelics—such as psilocybin, LSD, DMT, and mescaline—are compounds known for inducing altered states of perception, cognition, and emotion (Nichols et al., 2017). Chemically, they primarily exert their effects by activating the serotonin 2 A (5-HT2A) receptors in the brain, leading to changes in sensory processing, self-awareness, and neural connectivity

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* Corresponding author. iden University, Faculty of Social and Behavioural Sciences, Cognitive Psychology Unit Wassenaarseweg 52, 2333 AK Leiden, the Netherlands.
E-mail address: luiska.prochazkova@gmail.com (L. Prochazkova).
[1] Present address: Interdisciplinary Center for the Study of Human Performance (CIPER), Faculty of Human Kinetics, University of Lisbon, Estrada da Costa, 1495-751 Cruz Quebrada, Portugal.
[2] Present address: Faculty of Psychology, Shandong Normal University. Shandong Provincial Key Laboratory of Brain Science and Mental Health. No. 88 East Wenhua Road. Jinan, 250014, Shandong Province, China.

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(Carhart-Harris et al., 2014). Unlike full doses that induce pronounced alterations in consciousness, microdosing typically involves consuming 1/10th to 1/20th of a full psychoactive dose every few days (Fadiman and Korb, 2017) eliciting subtle changes in cognition and mood. Although widely popularized in the media as a "productivity hack" (Glatter, 2015), the scientific evidence supporting these claims has until recently relied largely on self-reports and observational studies.

Observational research reported large scope of benefits including improvements in attention, social cognition, mood, creativity, and well-being (Anderson et al., 2019; Lea et al., 2020a,b; Polito and Stevenson, 2019; Prochazkova et al., 2018). However, these findings stem primarily from prospective and retrospective research that lack placebo control and are therefore highly susceptible to expectancy effects (Althubaiti, 2016). Moreover, theoretical models of cognitive control suggest that pharmacological interventions often tradeoff between processing styles. For instance, gains in focus or persistence may reduce flexibility, or serial processing may impair parallel thinking (Hommel, 2015; Dreisbach and Goschke, 2004). Given this, the wide-ranging benefits often attributed to microdosing—spanning attention, creativity, and mood—seem unlikely without a clear mechanistic explanation, pointing to a possible influence of placebo effects.

1.1.1. Placebo-controlled trials

Indeed, although open-label studies suggest cognitive benefits of psychedelic microdosing, placebo-controlled evidence has yielded only a few specific effects. For example, Yanakieva et al. (2018) demonstrated that microdoses of LSD (5–20 μg) significantly altered interval timing: participants systematically over-reproduced time intervals, indicating microdosing can influence basic perceptual-cognitive processes. In a dose-finding trial, Hutten et al. (2020) observed that LSD microdoses (5–20 μg) reduced attentional lapses on sustained attention tasks, consistent with improved vigilance, while also increasing arousal and positive mood. Specifically, at 5 μg and 20 μg, participants exhibited fewer lapses than under placebo, suggesting that microdoses may help maintain attentional focus, possibly via heightened arousal or alertness. Other studies report null or inconsistent results. Cavanna et al. (2022) tested a single psilocybin microdose (0.5 g dried mushrooms) in a within-subject crossover design and found robust subjective effects and reduced theta power in EEG, yet no cognitive improvements: working memory (digit span), executive function (set-shifting), and divergent thinking were unaffected, while Stroop accuracy and convergent thinking showed modest decrements. In a neuroimaging study, Glatter (2015) reported that a single 13 μg dose of LSD increased reward-related brain activity during a monetary incentive task, reflecting acute modulation of reward processing but without behavioral improvements. van Elk et al. (2021) administered a seven-dose psilocybin regimen (~3 weeks) and found increases in awe and aesthetic appreciation, but these effects diminished after correcting for unblinding. Finally, in four-week self-blinding study, Szigeti et al. (2021) reported initial significant improvements in well-being, mindfulness, and convergent thinking (Remote Associates Test), but all effects disappeared once expectancy and blinding were modeled, leaving no reliable differences from placebo. Other single-dose or cumulative placebo-controlled studies failed to show any acute changes in cognition or mood related questionnaires (Bershad et al., 2019; Family et al., 2020; Marschall et al., 2022; Molla et al., 2023; Murphy et al., 2024).

The inconsistencies observed across placebo-controlled trials may reflect the domain-specificity of microdosing effects, but they also underscore persistent methodological challenges. Most existing studies rely on small samples, heterogeneous dosing protocols, and outcome measures that differ in sensitivity. Crucially, the absence of a unifying theoretical framework has led to highly variable task selection: some trials have targeted basic perceptual indices such as time reproduction, others have focused on emotional processing or sustained attention, while still others have examined neural activity through EEG. This broad, exploratory strategy is valuable in a new field where potential effects are unknown, yet the current resulting evidence base remains fragmented and hard to interpret. The few significant findings are scattered across disparate domains, making it difficult to identify consistent mechanisms of action. Interpretation is further complicated by differences in substances used, dose sizes and dosing durations. This gap underscores the need for further exploration, particularly in the context of longitudinal microdosing protocols, which mirror common use in the field (Fadiman and Korb, 2019, for review see Polito and Liknaitzky, 2024).

Moreover, a broad theoretical framework can serve useful in interpreting dispersed finding and generate more precise predictions regarding when and how psychedelics might shift balance in cognitive processing. More specifically, here we focus on models of cognitive control that provide a stronger base to test mechanistic hypotheses of microdosing mechanisms of action.

1.1.2. Metacontrol state models (MSM)

Dual Mechanisms of Control and Metacontrol state models (MSM) (Braver, 2012; Dreisbach and Goschke, 2004; Hommel, 2015, Hommel and Colzato, 2017) provide the central theoretical framework for the study and task interpretation. According to the MSM, human cognition reflects a dynamic balance between persistence and flexibility. Persistence denotes a focused, goal-shielded processing style that prioritizes stability and resistance to distraction, whereas flexibility reflects an open, inclusive style that facilitates adaptation, exploration, and divergent problem-solving.

Bias towards high persistence supports tasks requiring sustained attention and inhibition of irrelevant information and support serial processing while high flexibility is advantageous for tasks requiring parallel processing, novelty detection, exploration, social attunement, or creative thought (Hommel, 2015; Hommel and Colzato, 2017; Dreisbach and Goschke, 2004). This framework also highlights that the balance between stability and flexibility is dynamically shaped by mood states and reward contingencies: positive mood and heightened motivation tend to promote cognitive flexibility, whereas negative mood favors cognitive stability (Dreisbach and Goschke, 2004; Fröber and Dreisbach, 2014, 2016; Chiew and Braver, 2011, 2014; Locke and Braver, 2008; Shen and Chun, 2011).

Psychedelic microdosing has been hypothesized to tilt this balance toward flexibility, potentially enhancing flexibility at the cost of persistence and as a biproduct correlate with positive mood while at the same time reducing persistence (Prochazkova et al., 2018; Sayalı and Barrett, 2023; Bălăeț, 2022).

1.1.3. Current study

In the present work, we aim to continue in exploratory research assessing subjective experience, social cognition and mental health outcomes across two double blind placebo controlled longitudinal trials. Task selection and outcome prediction was based on Metacontrol State Model to evaluate impact of microdosing on broader cognition. As such we applied a set of paradigms previously suggested to be sensitive to shift in control policies and thus to test whether psychedelic microdosing biases cognitive functioning toward flexibility at the expense of persistence.

In Experiment 1, the AX-Continuous Performance Task (AX-CPT) was included to assess the balance between proactive (persistence-driven) and reactive (flexibility-driven) control, with the prediction that microdosing would shift performance toward reactive responding, reflected in reduced AY but increased BX errors (Gonthier et al., 2016). To capture the exploration–exploitation trade-off, we employed the Multi-Armed Bandit (MAB) task, expecting a bias toward exploration, expressed as greater choice variability and faster adaptation to changes in reward contingencies (Brown et al., 2022). Working memory updating was measured using the Reference-Back task, where we hypothesized that microdosing would facilitate flexible updating (reduced switch costs) but potentially at the expense of stability in non-update

trials, consistent with the metacontrol framework linking positive mood and altered neurochemistry to enhanced updating and reduced maintenance (Dreisbach and Goschke, 2004; Hommel, 2015; Hommel and Colzato, 2017). Long-term memory was probed with the Remember–Know task, where we anticipated a relative increase in familiarity-based "Know" responses over precise recollective "Remember" responses, in line with evidence that flexible processing styles promote gist-based memory retrieval (Yonelinas, 2002). Finally, social cognition was assessed using the Reading the Mind in the Eyes Test (RMET), where we predicted that increased cognitive flexibility would manifest as improved accuracy in decoding subtle social cues, given prior findings that psychedelics can enhance empathy and perspective taking (Mason et al., 2019).

In addition to cognitive paradigms, Experiment 1 included several standardized questionnaires to capture subjective and affective outcomes relevant to the persistence–flexibility framework. The Multidimensional Psychological Flexibility Inventory (MPFI; Rolffs et al., 2018) was used to assess individuals' capacity to adaptively shift cognitive and emotional states, where we hypothesized that microdosing would increase psychological flexibility scores, reflecting enhanced adaptability. To evaluate general well-being, we administered the Warwick–Edinburgh Mental Well-being Scale (WEMWBS; Tennant et al., 2007), predicting improvements in positive mental health indicators, consistent with anecdotal and field reports of microdosing (Fadiman and Korb, 2019; Rootman et al., 2021). Finally, participants completed the Affect Grid as a measure of momentary mood, where we expected higher ratings of positive affect and arousal, in line with evidence linking positive affect to increased cognitive flexibility (Isen, 2008; Dreisbach and Goschke, 2004).

In Experiment 2, we extended the scope of assessment to additional paradigms designed to probe attentional dynamics, working memory, and social cognition in a prolonged dosing protocol with a higher dose. The Attentional Blink task was included to index temporal attention and the capacity to flexibly reallocate resources between rapidly presented stimuli. We hypothesized that microdosing would reduce the attentional blink, reflecting enhanced flexibility in temporal attentional deployment (Slagter et al., 2007). Working memory was assessed using the N-back task with event-related potentials, where we predicted that microdosing might impair maintenance under high load, consistent with reduced persistence, but could facilitate more flexible updating processes (Braver, 2012). To examine social cognition, participants completed the Inclusion of Self in the Other (IOS) scale, where we expected increased ratings of closeness and self–other overlap, reflecting enhanced social attunement reported in psychedelic states (Forstmann et al., 2020). Finally, the Trust Game was used to evaluate interpersonal decision-making, where we predicted that microdosing would increase trusting behavior, in line with evidence that psychedelics promote prosociality and openness (Dolder et al., 2016; Preller and Vollenweider, 2018).

In addition to behavioral paradigms, Experiment 2 employed a set of standardized questionnaires to capture subjective aspects of cognitive-emotional functioning that align with the persistence–flexibility framework. The Cognitive Flexibility Inventory (CFI; Dennis and Vander Wal, 2010) was included to assess individuals perceived capacity to generate alternative strategies and adapt to challenging situations, where we predicted higher flexibility scores following microdosing. Mindfulness was assessed using the Freiburg Mindfulness Inventory (FMI; Walach et al., 2006), with the expectation that microdosing would enhance present-moment awareness and nonjudgmental acceptance, both of which are linked to flexible cognitive processing (Moore and Malinowski, 2009). The Self-Compassion Scale (SCS; Neff, 2003) was administered to measure the ability to respond to difficulties with kindness rather than self-criticism, with the hypothesis that microdosing would increase self-compassion as part of a broader shift toward openness. Finally, affective states were captured by the Positive and Negative Affect Schedule (PANAS; Watson et al., 1988), where we expected higher positive affect and reduced negative affect in the microdosing condition, consistent with evidence that positive mood is associated with greater cognitive flexibility (Dreisbach and Goschke, 2004).

Further methodological details and justification for task selection are provided in the Supplementary Materials.

2. Methodology

2.1. Study design overview

We conducted two randomized, double-blind, placebo-controlled, longitudinal trials at Leiden University (Experiment 1 and Experiment 2), following a similar structure. Baseline assessments were administered one week prior to the start of each trial. Participants were then invited to a microdosing workshop, where they received either an active or placebo capsule, which they self-administered according to a standardized schedule.

Each experiment included three assessment time points: Acute 1, Acute 2, and a Post-Acute measure (administered online ~2 days after the final dose). Both studies used a between-subjects design, with participants randomly assigned to either a psilocybin microdose group or a placebo group. Measures included cognitive control, working memory, social cognition, and self-reported well-being.

The primary differences between the experiments were dose and duration. In Experiment 1, participants received 0.65 g of fresh truffles over approximately four weeks. In Experiment 2, participants received 1 g of fresh truffles over the same duration. Study timelines are depicted in Fig. 1A. All protocols were approved by the Leiden University Ethics Committee. Truffles were legally self-administered in the Netherlands. Protocols were in accordance with the Declaration of Helsinki (1975, revised 2008).

2.2. General procedure

The trials were conducted in collaboration with the Microdosing Institute (MI) and the Psychedelic Society of the Netherlands (PSN), who organized the workshops. PSN screened participants for mental health issues, excluding those with personal or familial histories of psychosis, schizophrenia, mania, or borderline personality disorder. Leiden researchers conducted additional screenings, including baseline mental health assessments.

Baseline testing occurred at Leiden University's Faculty of Social and Behavioral Sciences (FSW), followed by participation in the workshop. Participants first attended an introductory lecture on psychedelics, after which they prepared their own active doses. Subsequently, 50 % of these doses were covertly swapped for placebos by PSN staff in a separate room. Participants then ingested their first capsule. Placebo capsules matched active ones in appearance and weight but contained inert cellulose (Experiment 1) or non-psychedelic mushrooms (Experiment 2). No deception was used—participants were informed they could receive either active or placebo pills.

Participants followed a microdosing schedule with a dose every three days, as recommended by Fadiman and Korb (2019). MI and PSN sent online reminders, and participants recorded any deviations. Dosing logs were collected at the end of the trial. Both participants and researchers remained blind to group allocation until after data analysis.

Participants completed lab-based testing sessions under acute psilocybin effects at two time points (Acute 1 and Acute 2), approximately 1 h after dosing, when peak effects occur (Tylš et al., 2014). Sessions were scheduled at consistent times to control for diurnal variations in arousal. Each session lasted up to 1 h and 45 min, with optional breaks to prevent fatigue.

We used standardized tasks, questionnaire data and collected quantitative and qualitative reports regarding microdosing experiences, including perceived group assignment to evaluate blinding integrity. More specifically, participants were during *Acute 1* and *Acute 2* testing

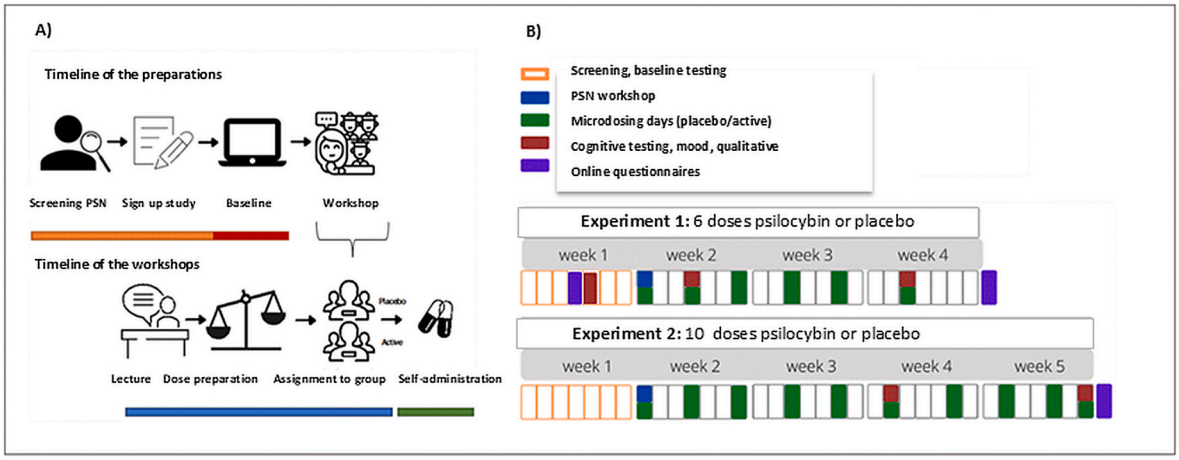

Fig. 1. Panel A shows the pre-trial preparation and randomization timeline; Panel B outlines the dosing schedule and assessment points for both experiments.

whether they believe to be in active or placebo condition (options were: *active, placebo, not sure*). Participants were also asked whether they were currently experiencing any state changes, compared to baseline, that they attributed to their microdosing experience. A final online assessment was administered a few days after the last dose to assess potential longer-term effects. For more details regarding the test battery and general procedure please see Supplement. The data presented here were collected as part of a broader investigation by Prochazkova et al. (2018), which primarily focused on the effects of microdosing on creativity. Given the distinct theoretical and methodological focus and the limited scope of the current paper, we present these findings independently.

2.3. Apparatus

Cognitive tasks were presented on a 60 Hz monitor (800 × 600 resolution), using E-Prime 2.0 (Psychology Software Tools, Sharpsburg, PA, USA) on Windows computers. Subjective measures were collected via Qualtrics (Qualtrics, Provo, UT). Data preprocessing was performed

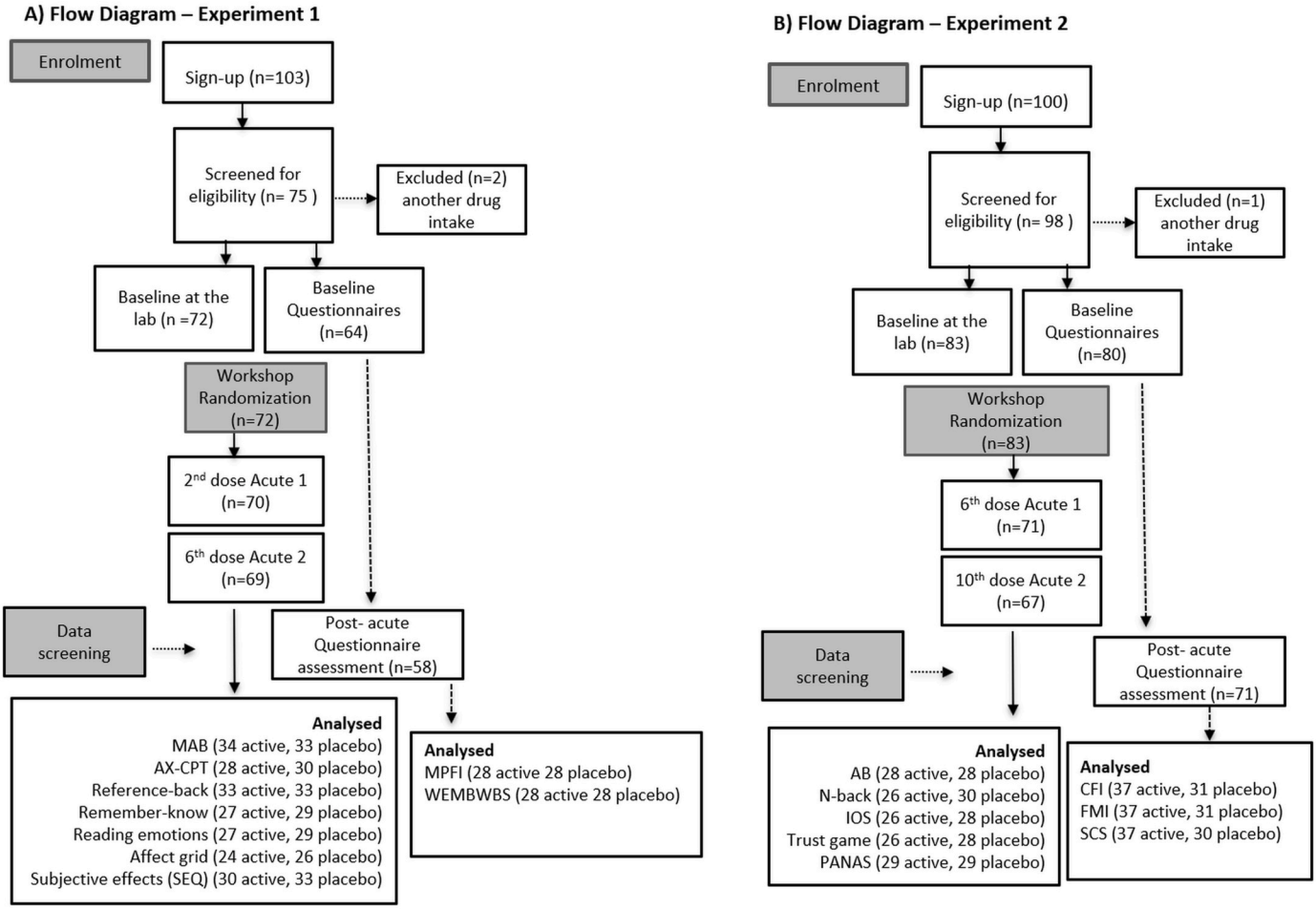

Fig. 2. Shows flow diagram depicting the progression of participants through Experiment 1 and Experiment 2.

in IBM SPSS Statistics 24, and final analyses in JASP Version 0.14.1.

2.4. Truffle dosage

Participants received Psilocybe galindoii truffles, donated by MagicTruffles.com (Netherlands). The strain and brand were identical across participants, and all received the same dose regardless of body weight. In Experiment 1 participants took 0.65 g of fresh truffles (~1/15 of a recreational dose) and in Experiment 2 participants took 1.00 g of fresh truffles (~1/10 of a recreational dose). Post-hoc chemical analyses were conducted by the University of Chemistry and Technology in Prague to verify alkaloid content. Further details on dosage and compound analysis can be found in the Supplementary Materials.

3. Experiment 1

3.1. Materials and methods

Experiment 1 aimed to examine the effects of psychedelic microdosing on cognitive control, working memory, and subjective measures of well-being and mood. This between-subject, longitudinal trial spanned approximately four weeks, including a two-week active microdosing period. Participants took six microdoses in total. Data were collected at five time points: online baseline, lab baseline, Acute 1 (after the 2nd microdose), Acute 2 (after the 6th microdose), and a Post-Acute online follow-up two days after the final dose (see Fig. 2).

3.2. Behavioral measures

Participants completed five computer-based tasks designed to assess various aspects of cognitive control and memory. The *AX-Continuous Performance Task* (AX-CPT; Servan-Schreiber et al., 1996) was used to evaluate proactive versus reactive control, while the *Multi-Armed Bandit Task* (MAB; Mekern et al., 2019) assessed the balance between exploration and exploitation strategies. The *Reference-Back Task* (Rac-Lubashevsky and Kessler, 2016) measured the ability to update information in working memory, and the *Remember-Know Task* (Tulving and Annis, 1985) was used to probe long-term memory processes. In addition, participants completed the *Reading the Mind in the Eyes Task* (RMET), which assessed social-cognitive abilities, particularly the capacity to interpret subtle emotional expressions. An overview of all behavioral indexes with further details on task procedures and preprocessing is available in Table 1.

3.3. Subjective measures and control measures

In terms of subjective outcomes, three primary measures were administered. Cognitive flexibility was assessed using the Multidimensional Psychological Flexibility Inventory (MPFI; Rolffs et al., 2018), overall well-being was measured by the Warwick-Edinburgh Mental Well-being Scale (WEMWBS; Tennant et al., 2007), and mood and arousal were evaluated using the Affect Grid (Russell et al., 1989). To capture microdosing-specific effects, participants also completed the Subjective Microdosing Experience Questionnaire (SMEQ), an in-house measure developed for this study. This questionnaire included items such as "Under the influence of a microdose, I have been feeling distracted," with responses made on a 7-point sliding scale ranging from 1 ("exceptionally less than normal") to 7 ("exceptionally more than normal"), where 4 represented "no change."

To evaluate blinding integrity and perceived drug effects, participants were asked to rate the intensity of the microdose experience at each test session on a scale from 0 ("no effect") to 100 ("extremely strong psychedelic effect"). They were also asked to guess their group allocation—whether they believed they had received an active psilocybin dose, were unsure, or had received a placebo. Detailed information about each measure is provided in Supplement.

3.4. Participants

A total of 103 participants signed up for the psychedelic workshop via social media and through contact with the Microdosing Institute (MI) and the Psychedelic Society of the Netherlands (PSN). Of these, 75 participants completed the initial screening. At baseline, lab data were collected from 72 participants, and 64 completed the online baseline assessment. Seventy participants attended the Acute 1 session, 69 attended Acute 2, and 58 completed the post-acute online assessment. Two participants were excluded from all analyses due to either taking other substances during the study or missing more than two doses. Additionally, further exclusions were made during data screening, based on standard preprocessing procedures specific to each measure.

The final sample sizes for each task were as follows: 67 participants for the Multi-Armed Bandit Task (MAB; 33 in the placebo group, 34 in the experimental group), 58 for the AX-Continuous Performance Task (AX-CPT; 30 placebo, 28 experimental), 66 for the Reference-Back Task (33 placebo, 33 experimental), and 56 for the Remember-Know Task (29 placebo, 27 experimental). The Reading the Mind in the Eyes Task (RMET) was completed by 59 participants (30 placebo, 29 experimental). For the subjective measures, the final sample sizes were: 56 participants for both the Multidimensional Psychological Flexibility

Table 1
Overview of experimental measures, subscales, and assessment timepoints in Experiments 1.

Measure (Domain)	Sample size	Baseline	Acute 1	Acute 2	Post-acute	Subscales/Trial types
Experiment 1 – Behavioral tasks						
AX-CPT (RT, ER)	58	✓	✓	✓	–	AX, AY, BX, BY
Remember–Know (ER)	56	✓	✓	✓	–	Incorrect new, Incorrect old
Reference-Back (RT, ER)	66	✓	✓	✓	–	Comp. Switch, Comp. No switch, Ref. Switch, Ref. No switch, Updating cost, Switch cost, Gate opening/closing
Multi-Armed Bandit (MAB)	67	✓	✓	✓	–	Stay, Win–stay, Switch, Lose–switch, Lose–stay
RMET (ER)	59	✓	✓	✓	–	Easy, Difficult
Experiment 1– Subjective measures						
MPFI	56	✓	–	–	✓	Acceptance, Self-as-context, Diffusion, Experiential avoidance, Present moment, Self-as-content, Fusion, Values, Inaction
WEMWBS	56	✓	–	–	✓	Total score
Affect Grid	50	–	✓	✓	–	Arousal, Pleasure
SMEQ	63	–	✓	✓	–	Subjective intensity
Group estimation	67	–	✓	✓	–	Allocation guess
Perceived microdosing intensity	67	–	✓	✓	–	1-100 scale

Note. RMET = Reading the Mind in the Eyes Test; MPFI = Multidimensional Psychological Flexibility Inventory; WEMWBS = Warwick–Edinburgh Mental Well-being Scale; SMEQ = Subjective Microdosing Experience Questionnaire; RT = reaction time; ER = error rate.

Inventory (MPFI) and the Warwick-Edinburgh Mental Well-being Scale (WEMWBS; 28 per group), with all participants completing both baseline and post-acute assessments. The Affect Grid (Russell et al., 1989) was completed by 50 participants (24 active, 26 placebo). The Subjective Microdosing Experience Questionnaire (SMEQ) included data from 63 participants (30 active, 33 placebo), all of whom completed both acute sessions. Please see Supplement for more details regarding screening and pre-processing.

3.5. Statistical analyses

Baseline demographic differences were assessed using independent samples *t*-tests and χ^2 tests. Perceived microdosing strength was analyzed using a mixed-design repeated-measures ANOVA (rmANOVA) with session (workshop, Acute 1, Acute 2) as the within-subject factor and group (placebo vs. active) as the between-subject factor. Group allocation guesses were analyzed using χ^2 tests at each session.

Behavioral task data were analyzed using mixed-design rmANOVAs with group (placebo vs. active) as a between-subject factor and session (baseline, Acute 1, Acute 2) as a within-subject factor. Task-specific within-subject factors (e.g., trial type, difficulty) were included as appropriate. Please see detailed analyses steps for each task in Supplement. Violations of sphericity were corrected using Greenhouse-Geisser or Huynh-Feldt adjustments. Non-parametric alternatives were applied where assumptions were violated. Significant interactions were followed up with corrected post hoc tests.

Subjective measures were analyzed using mixed-design rmANOVAs, including domain-level factors where applicable (e.g., flexibility/inflexibility domains in MPFI, pleasure/arousal in the Affect Grid). Group differences in the SMEQ were examined using independent samples *t*-tests per session.

All task-specific models, preprocessing steps, and correction procedures are detailed in the Supplementary Materials.

4. Results

4.1. Sample characteristics and drug manipulation

Randomization was successful, with no significant differences between the placebo and active microdosing groups on demographic variables (Table 2). The mean age was 23.7 years (SD = 5.22) in the placebo group and 23.9 years (SD = 4.83) in the active group. Gender distribution was comparable (placebo: 16 female, 15 male, 1 non-binary; active: 17 female, 15 male, 0 non-binary), as was the frequency of prior psychedelic experience (placebo: 16 yes, 13 no; active: 19 yes, 9 no). All comparisons were non-significant ($ps > 0.42$).

Participants' subjective guesses regarding group allocation did not differ significantly between conditions at either the Acute 1 (χ^2 (2, 62) = 2.18, $p = .337$) or Acute 2 (χ^2 (2, 62) = 4.88, $p = .087$) sessions, indicating that blinding was preserved. Similarly, there were no significant group differences in perceived psychoactive strength (F (1, 60) = 0.70, $p = .407$, $\eta^2 = 0.007$). However, a significant main effect of time was observed (F (2, 120) = 5.13, $p = .007$, $\eta^2 = 0.030$), reflecting a general decline in perceived intensity across sessions. This reduction may reflect increased physiological tolerance or a decrease in expectation-driven effects, as the pattern was consistent in both groups.

Table 2
Descriptive statistics for the two group conditions: Active (microdosing psilocybin) and control (placebo).

	Placebo Mean (SD)	Active Mean (SD)	t/χ^2	*p*	*Cohen's d/ Cramer's V*
Age (years)	23.7 (5.22)	23.9 (4.83)	−0.21	0.838,	−0.05
Weight (kg)	70.59 (14.75)	68.71 (10.92)	0.58	0.565	0.14
BMI	22.33 (3.32)	22.53 (2.52)	−0.27	0.786	0.07
	Frequency	Frequency			
Gender (F/M/ non-binary)	16/15/1	17/15/0	1.03	0.597	0.13
Previous experience (Yes/No)	16/13	19/9	0.65	0.421	0.11

4.2. Behavioral tasks

AX-CPT: For error rate, there was a significant main effect of time (F (1.36, 76.06) = 4.21, $p = .032$, $\eta^2 = 0.015$) and trial type (F (2.12, 118.63) = 56.38, $p < .001$, $\eta^2 = 0.185$), consistent with task-related learning. However, no significant interaction was found between time, trial type, and condition (F (3.84, 214.98) = 0.50, $p = .725$, $\eta^2 = 0.002$), suggesting no differential effect of microdosing. Reaction time analyses mirrored these findings, with significant main effects of time and trial type but no group interactions. The descriptive statistics are presented in Table 3. For all tasks the full F statistics are presented in Supplement B.

Remember-Know Task: A significant main effect of time on error rates (F (1.98, 107.07) = 16.33, $p < .001$, $\eta^2 = 0.058$) suggested performance improved across sessions. However, no significant interaction between time, condition, and trial type (old vs. new) was observed (F (1.97, 106.46) = 4.69, $p = .352$, $\eta^2 = 0.003$), indicating no group difference in long-term memory performance.

Reference-Back Task: Analyses revealed significant main effects of time and trial type on both error rate and reaction time, as well as expected interactions between trial type and switch condition—supporting successful task manipulation. Crucially, there were no significant interactions involving time and condition across any primary or subprocess measures, with the sole exception of a small effect for gate-closing error rates (F (1.82, 108.97) = 3.55, $p = .036$, $\eta^2 = 0.032$). However, post-hoc tests indicated this difference was already present at baseline and thus likely due to random group allocation.

Multi-Armed Bandit Task (MAB): Across all trial types (stay, win-stay, switch, lose-switch, lose-stay), there were significant main effects of time (F (1.67, 108.25) = 19.86, $p < .001$, $\eta^2 = 0.147$), suggesting learning or strategy adjustment. However, no significant time × condition interactions emerged, indicating microdosing had no discernible effect on exploration-exploitation behavior.

Reading the Mind in the Eyes Task (RMET): A robust main effect of item difficulty confirmed that accuracy was higher for easy than difficult items (F (1, 57) = 66.25, $p < .001$, $\eta^2 = 0.538$). Most relevantly, although there was no main effect of session, a significant three-way interaction (item difficulty × session × group) emerged (F (2, 114) = 3.92, $p = .023$, $\eta^2 = 0.064$). Follow-up analyses showed this interaction was driven by the experimental group: they improved in recognizing emotions in difficult items from baseline to both Acute 1 ($p = .04$) and Acute 2 ($p < .01$). No such effect was observed in the placebo group. Crucially, this result was not explained by participants' expectations, as no significant three-way interaction was found when expected group assignment was used as a between-subjects factor (F (2, 72) = 1.46, $p = .24$, $\eta^2 = 0.04$).

4.3. Subjective measures

Well-being (WEMWBS): Baseline well-being scores did not differ significantly between groups, t (61) = −1.05, $p = .296$. A repeated-measures ANOVA revealed no main effect of session, F (1, 54) = 0.35, $p = .556$, $\eta_p^2 = .006$, and no significant interaction between session and group, F (1, 54) = 0.06, $p = .801$, $\eta_p^2 = .001$. As no significant effects were observed, post-hoc analyses were not conducted. Means and standard deviations are reported in Table 4.

Psychological Flexibility (MPFI): At baseline, groups differed significantly on three subscales of psychological flexibility ($t \leq 2.44$, $p \geq .017$) and three subscales of psychological inflexibility ($t \leq 2.29$, $p \geq .025$). Group differences were also found for the total flexibility and

Table 3
Mean (SD) for behavioral measures in Experiment 1.

Measure (Domain)	Condition	Baseline		Acute 1		Acute 2	
AX-CPT		ER (SD)	RT (SD)	ER (SD)	RT (SD)	ER (SD)	RT (SD)
AX	placebo	5.90 (9.66)	354.30 (73.51)	5.27 (7.00)	346.85 (68.12)	9.67 (19.8)	370.42 (69.17)
	active	4.11 (5.17)	340.62 (58.56)	4.11 (3.92)	327.74 (44.42)	6.64 (8.7)	346.97 (36.64)
AY	placebo	22.13 (15.57)	492.54 (85.19)	16.93 (13.11)	490.83 (112.36)	24.7 (19.5)	507.64 (90.86)
	active	22.57 (16.48)	450.81 (65.47)	17.79 (16.49)	443.64 (49.57)	23.0 (22.2)	474.85 (73.07)
BX	placebo	16.57 (22.91)	336.34 (112.41)	6.83 (7.31)	346.71 (95.35)	9.13 (16.0)	390.87 (112.24)
	active	10.36 (16.94)	339.18 (98.31)	5.89 (7.16)	327.96 (93.12)	8.86 (15.2)	393.03 (146.80)
BY	placebo	3.97 (10.15)	340.74 (81.14)	1.37 (3.83)	326.98 (100.74)	6.10 (19.5)	403.35 (143.04)
	active	3.54 (8.27)	322.76 (68.12)	1.43 (3.12)	320.21 (62.94)	6.54 (16.1)	372.55 (108.64)
Ref-back		ER (SD)	RT (SD)	ER (SD)	RT (SD)	ER (SD)	RT (SD)
Comparison switch	placebo	0.72 (0.23)	803.72 (144.44)	0.82 (0.18)	657.60 (200.96)	0.81 (0.18)	611.25 (198.77)
	active	0.82 (0.16)	710.31 (310.02)	0.84 (0.17)	669.86 (262.70)	0.86 (0.15)	562.16 (186.93)
Comparison no switch	placebo	0.72 (0.23)	615.08 (211.45)	0.76 (0.19)	561.28 (168.89)	0.79 (0.19)	502.22 (175.23)
	active	0.73 (0.21)	580.19 (193.20)	0.80 (0.17)	554.52 (161.56)	0.84 (0.18)	479.56 (138.56)
Reference switch	placebo	0.77 (0.18)	828.82 (310.21)	0.80 (0.16)	760.42 (262.33)	0.81 (0.17)	639.22 (259.02)
	active	0.76 (0.15)	765.02 (345.02)	0.81 (0.16)	737.56 (427.90)	0.84 (0.13)	601.86 (223.90)
Reference no switch	placebo	0.83 (0.14)	769.68 (317.96)	0.88 (0.14)	675.47 (220.46)	0.84 (0.16)	638.98 (211.60)
	active	0.83 (0.18)	695.53 (235.56)	0.86 (0.13)	653.06 (262.49)	0.90 (0.08)	572.13 (183.80)
Updating cost	placebo	−0.09 (0.20)	113.25 (158.81)	−0.06 (0.14)	94.70 (143.02)	−0.02 (0.14)	74.47 (77.76)
	active	−0.02 (0.12)	69.81 (149.96)	−0.01 (0.12)	69.39 (196.33)	−0.02 (0.10)	58.34 (72.65)
Updating cost no switch	placebo	−0.12 (0.22)	154.60 (213.67)	−0.12 (0.20)	114.18 (215.97)	−0.04 (0.14)	136.77 (92.27)
	active	−0.10 (0.19)	115.34 (142.84)	−0.05 (0.18)	98.55 (161.72)	−0.06 (0.15)	92.56 (104.05)
Switch cost	placebo	0.04 (0.10)	108.10 (211.27)	0.01 (0.12)	87.15 (122.56)	0.01 (0.09)	46.15 (62.66)
	active	−0.01 (0.10)	104.88 (165.93)	0.01 (0.10)	91.36 (187.36)	0.03 (0.07)	53.17 (72.73)
Gate opening	placebo	0.06 (0.14)	59.13 (169.05)	0.08 (0.17)	84.95 (167.39)	0.03 (0.10)	0.23 (122.20)
	active	0.06 (0.17)	69.48 (218.32)	0.05 (0.16)	84.50 (268.79)	0.06 (0.12)	29.73 (96.05)
Gate closing	placebo	−0.01 (0.15)	188.63 (344.9) *	−0.05 (0.13)	96.32 (136.36)	−0.02 (0.11)	109.03 (74.89)
	active	−0.09 (0.13)	130.13 (181.3)	−0.04 (0.10)	115.34 (157.43)	−0.02 (0.11)	82.59 (98.89)
REMT		PE (SD)		PE (SD)		PE (SD)	
Difficult	placebo	0.67 (0.14)		0.66 (0.16)		0.68 (0.17)	
	active	0.69 (0.11)		0.73 (0.12) *		0.75 (0.10) *	
Easy	placebo	0.77 (0.13)		0.79 (0.14)		0.81 (0.14)	
	active	0.83 (0.08)		0.82 (0.12)		0.83 (0.10)	
Rem-know		ER (SD)		ER (SD)		ER (SD)	
Incorrect new	placebo	11.21 (9.17)		8.69 (7.53)		10.21 (8.24)	
	active	12.68 (8.45)		8.83 (8.45)		7.84 (7.27)	
Incorrect old	placebo	12.33 (9.16)		6.37 (6.60)		7.16 (8.01)	
	active	11.40 (8.30)		6.41 (6.83)		6.70 (6.00)	
MAB		RT (SD)		RT (SD)		RT (SD)	
Stay	placebo	0.65 (0.17)		0.80 (0.10)		0.78 (0.10)	
	active	0.70 (0.14)		0.80 (0.16)		0.78 (0.10)	
Win stay	placebo	0.30 (0.08)		0.40 (0.06)		0.37 (0.05)	
	active	0.32 (0.07)		0.39 (0.09)		0.37 (0.06)	
Switch	placebo	0.35 (0.17)		0.20 (0.10)		0.22 (0.10)	
	active	0.30 (0.14)		0.21 (0.16)		0.22 (0.10)	
Lose switch	placebo	0.17 (0.09)		0.09 (0.05)		0.10 (0.06)	
	active	0.14 (0.07)		0.10 (0.09)		0.10 (0.05)	
Lose stay	placebo	0.83 (0.09)		0.91 (0.05)		0.90 (0.06)	
	active	0.86 (0.07)		0.90 (0.09)		0.90 (0.05)	

Note. AX-CPT: AX-Continuous Performance Task, Rem-know: Remember-Know Task, Ref-back: Reference-Back Task, MAB: Multi-Armed Bandit Task. In the MAB, the stay and lose stay were left out for simplicity, as they are direct opposites of the switch and lose switch conditions. (*p < .05).

inflexibility scores ($t \leq 2.26$, $p \geq .027$). Given the randomized design and absence of demographic imbalance, these differences are likely attributable to chance. The repeated-measures ANOVA revealed no significant main effect of session for the total flexibility score, $F(1, 54) = 3.61$, $p = .073$, $\eta_p^2 = .063$, but a significant main effect was found for inflexibility, $F(1, 54) = 6.02$, $p = .017$, $\eta_p^2 = .100$, indicating an overall decrease in inflexibility over time. Crucially, there was no significant three-way interaction between session, dimension, and group for either flexibility, $F(1, 54) = 0.74$, $p = .616$, $\eta_p^2 = .014$, or inflexibility, $F(1, 54) = 0.84$, $p = .543$, $\eta_p^2 = .015$. These findings suggest no reliable effect of microdosing on psychological flexibility or inflexibility.

Mood and Arousal (Affect Grid): At baseline, ratings of pleasure ($t(53) = 0.87$, $p = .385$) and arousal ($t(53) = 0.20$, $p = .844$) did not differ between groups. Across the testing period, there were no significant main effects of session on pleasure, $F(1, 51) = 3.14$, $p = .083$, $\eta_p^2 = .058$, or arousal, $F(1, 51) = 0.93$, $p = .339$, $\eta_p^2 = .018$. The session × group interaction was also non-significant for both pleasure, $F(1, 51) = 0.70$, $p = .498$, $\eta_p^2 = .014$, and arousal, $F(1, 51) = 0.69$, $p = .505$, $\eta_p^2 = .013$. Although exploratory comparisons indicated a reduction in pleasure in the placebo group over time ($p = .042$), this effect did not survive correction for multiple comparisons.

Subjective Microdosing Experience (SMQ): During the first acute session, no significant group differences were found across any of the nine SMQ dimensions ($t \leq 1.55$, $p \geq .190$). In the second session, eight of the nine dimensions also showed no significant differences ($t \leq 1.32$, $p \geq .126$). One significant effect was observed for the dimension of visual clarity, with the microdosing group reporting higher ratings, $t(68) = 2.54$, $p = .013$, $d = 0.617$. However, this effect did not survive correction for multiple comparisons and should be interpreted with caution.

Table 4
Mean (SD) for outcomes of subjective ratings in Experiment 1.

Measure (Domain)	Group	Assessment time-point						
		Pre intervention		Post intervention				
WEMWBS		**Mean**	**SD**	**Mean**	**SD**	**Mean (Post-Pre)**		
Mental wellbeing	Placebo	50.929	7.428	51.143	7.697		0.214	
Mental wellbeing	Psilocybin	50.107	7.524	49.857	7.291		−0.25	
MPFI								
Acceptance	Psilocybin	4.007	0.86	3.871	0.946		−0.136	
Acceptance	Placebo	3.543	1.008	3.65	0.828		0.107	
Committed action	Psilocybin	4.293	0.944	4.05	0.961		−0.243	
Committed action	Placebo	3.714	0.793	3.657	0.72		−0.057	
Diffusion	Psilocybin	3.386	1.025	3.729	0.991		0.343	
Diffusion	Placebo	3.229	0.767	3.471	0.856		0.242	
Present moment awareness	Psilocybin	4.193	1.099	4.243	1.029		0.05	
Present moment awareness	Psilocybin	3.986	0.824	3.957	0.757		−0.029	
Self as context	Placebo	4.307	0.91	4.279	0.854		−0.028	
Self as context	Psilocybin	4.007	0.936	4	0.881		−0.007	
Values	Placebo	4.293	1.151	4.15	1.236		−0.143	
Values	Psilocybin	3.586	1.109	3.657	0.888		0.071	
Psychological Flexibility (total)	Placebo	4.08	0.872	4.054	0.852		−0.026	
Psychological Flexibility (total)	Psilocybin	3.677	0.679	3.732	0.634		0.055	
Experiential avoidance	Psilocybin	2.807	0.817	2.9	0.885		0.093	
Experiential avoidance	Placebo	3.329	0.982	3.079	0.959		−0.25	
Fusion	Psilocybin	2.5	0.788	2.514	0.971		0.014	
Fusion	Placebo	2.807	0.784	2.614	0.998		−0.193	
Inaction	Psilocybin	2.107	0.7	2.264	0.99		0.157	
Inaction	Placebo	2.564	0.952	2.471	1.032		−0.093	
Lack of contact with values	Psilocybin	2.129	0.718	2.207	0.981		0.078	
Lack of contact with values	Psilocybin	2.971	1.213	2.657	1.082		−0.314	
Lack of contact in present moment	Placebo	2.271	0.802	2.307	0.894		0.036	
Lack of contact in present moment	Psilocybin	2.686	1.023	2.807	0.908		0.121	
Self as content	Placebo	2.15	0.679	2.229	0.82		0.079	
Self as content	Psilocybin	2.657	1.14	2.236	0.996		−0.421	
Psychological Inflexibility (total)	Placebo	2.327	0.548	2.404	0.71		0.077	
Psychological Inflexibility (total)	Psilocybin	2.836	0.663	2.644	0.699		−0.192	
		Baseline		**Acute 1**		**Acute 2**		
Affect grid	Placebo	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**(Ac2-Base)**
Pleasure	Psilocybin	5.667	1.711	5.25	1.726	4.833	1.579	−0.834*
Pleasure	Placebo	5.966	1.401	6.034	1.721	5.621	1.568	−0.345
Arousal	Psilocybin	4.875	1.918	4.958	1.732	4.417	1.792	−0.458
Arousal	Placebo	4.897	1.589	5.586	1.57	4.828	1.754	−0.069
				Acute 1		**Acute 2**		
SMQ				**Mean**	**SD**	**Mean**	**SD**	**(Ac2-Ac1)**
Mood swings	Placebo			3.806	0.889	3.559	0.991	−0.247
Mood swings	Psilocybin			4.03	1.075	3.912	0.996	−0.118
How anxious	Placebo			3.389	0.766	3.5	0.896	0.111
How anxious	Psilocybin			3.515	1.176	3.647	1.041	0.132
Thinking clear	Placebo			4.278	0.779	4.176	0.797	−0.102
Thinking clear	Psilocybin			4.273	1.008	4.265	0.963	−0.008
Distracted	Placebo			3.889	0.979	3.735	0.994	−0.154
Distracted	Psilocybin			3.879	1.269	4.118	1.038	0.239
Disoriented	Placebo			3.944	0.715	4.088	0.753	0.144
Disoriented	Psilocybin			3.788	0.893	3.794	0.946	0.006
Depth perception	Placebo			4.222	0.54	4.118	0.327	−0.104
Depth perception	Psilocybin			4.394	0.998	4.265	0.448	−0.129
Color change	Placebo			4.222	0.591	4.088	0.288	−0.134
Color change	Psilocybin			4.303	0.847	4.235	0.699	−0.068
Visual clarity	Placebo			4.361	0.639	3.941*	0.547	−0.42
Visual clarity	Psilocybin			4.152	1.004	4.324*	0.684	0.172
Self-confidence	Placebo			4.694	0.786	4.529	0.788	−0.165
Self-confidence	Psilocybin			4.394	1.088	4.382	0.779	−0.012
Subjective microdosing effects:		**Baseline**		**Acute 1**		**Acute 2**	**(Ac2-Bc)**	
Microdosing intensity	Active	30.34	25.83	20.75	17.3	15.02	15.02	−15.32***
Microdosing intensity	Placebo	27.26	23.75	19.53	20.6	14.88	17.97	−12.38***

Note: MPFI: Multidimensional Psychological Flexibility Inventory; WEMWBS: Warnick Edinburgh Mental Well Being Scale; SMEQ: Inhouse Subjective microdosing experience. Asterisks indicate α level (*p < .05, **p < .01, ***p < .001).

5. Experiment 2

5.1. Materials and methods

Experiment 2 followed a similar conceptual framework as Experiment 1 but introduced several key modifications to address potential limitations related to task sensitivity, dose, and duration. To rule out the possibility that null effects in Experiment 1 were due to task selection, a different set of behavioral tasks targeting cognitive control, working memory, and well-being was used. Additionally, two measures of social cognition—the Trust Game and the Inclusion of Other in the Self (IOS) scale—were added to expand the scope of social assessment.

To explore possible dose-dependent effects, the microdosing dose was increased from 0.65 g to 1 g of fresh truffles. The active dosing period was also extended to four weeks, in line with Fadiman and Korb (2019) original protocol, and the overall trial duration spanned approximately eight weeks. These changes were made to align more closely with widely used community protocols and prior research suggesting that extended schedules may be necessary to detect microdosing benefits (Fadiman and Korb, 2017).

Experiment 2 retained a randomized, double-blind, placebo-controlled, between-subject, longitudinal design. As in Experiment 1, data were collected at five time points: baseline (online and lab), Acute 1, Acute 2, and a post-acute follow-up. Unlike Experiment 1, however, the Acute 1 assessment was conducted under the influence of the 6th microdose and Acute 2 under the 10th, to better capture potential cumulative or delayed effects of microdosing (see Fig. 2).

5.2. Behavioral measures

In Experiment 2, participants completed two cognitive tasks targeting visual attention and working memory: the Attentional Blink task (Raymond et al., 1992), which assesses temporal attention and has been linked to cognitive flexibility (e.g., Colzato et al., 2013), and the N-back task (Jonides et al., 1997) assessing working memory load. Two tasks assessed social cognition: the Trust Game (Bershad et al., 2019) measured interpersonal trust, and the Inclusion of Other in the Self (IOS) scale (Aron et al., 1992) assessed perceived social closeness. An overview of outcome measures is presented in Table 5. Full task descriptions and preprocessing procedures are provided in the Supplement.

5.3. Subjective and control measures

Subjective outcomes in Experiment 2 were assessed using several standardized self-report questionnaires (Table 5). The Cognitive Flexibility Inventory (CFI) measured cognitive adaptability, the Freiburg Mindfulness Inventory (FMI; Walach et al., 2006) assessed present-moment awareness, and the Self-Compassion Scale (SCS) evaluated participants' capacity for self-kindness and acceptance. These measures were administered at baseline and again two days after the final microdose.

Mood was measured using the Positive and Negative Affect Schedule (PANAS), collected at baseline and during both acute sessions. In line with procedures from Experiment 1, participants were also asked to provide open-ended written responses describing any experienced effects of microdosing and to rate the perceived intensity of their dose. At each session, participants guessed their group assignment to assess the effectiveness of blinding. Full details, including scoring procedures, are included in the Supplement.

5.4. Participants

A total of 100 healthy individuals passed the initial PSN screening, of whom 98 agreed to participate in the associated research. Eighty-three participants completed the lab-based baseline session, 80 completed the online baseline, 71 attended the Acute 1 session, 67 attended Acute 2, and 71 completed the post-acute online questionnaire. Following standard data preprocessing and exclusions based on task completeness, final sample sizes varied by task.

The final sample included: 56 participants for the Attentional Blink task (28 per group), 56 for the N-back task (30 placebo, 26 active), 54 for the Trust Game (28 placebo, 26 active), and 47 for the IOS scale (25 placebo, 22 active). For self-report questionnaires: 68 participants completed the CFI and FMI (31 placebo, 37 active), 67 completed the Self-Compassion Scale (30 placebo, 37 active), and 58 completed the PANAS (29 per group). Additionally, 70 participants provided open-text responses during at least one acute session. For qualitative analysis, text data were collapsed across experiments and acute sessions, yielding a final sample of 178 responses (93 placebo, 85 active).

5.5. Statistical analyses

Baseline group equivalence was assessed using independent samples *t*-tests and chi-square tests on demographic variables. To evaluate the integrity of the blinding, the same analytic approach as in Experiment 1 was applied: χ^2 tests were used for group allocation guesses, and a mixed-design repeated-measures ANOVA (rmANOVA) was conducted on participants' subjective ratings of perceived microdosing strength, with session as the within-subject factor and group as the between-subject factor.

Behavioral task data were analyzed using mixed-design rmANOVAs. Group (placebo vs. active) was entered as a between-subject factor, and

Table 5
Overview of experimental measures, subscales, and assessment timepoints in Experiment 2.

Measure (Domain)	Sample size	Baseline	Acute 1	Acute 2	Post-acute	Subscales/Trial types
Experiment 2 – Behavioral tasks						
Attentional Blink Task (ER)	56	✓	✓	✓	–	Lag 100 ms, Lag 300 ms, Lag 800 ms
N-back (ER)	56	✓	✓	✓	–	Hit 0/1/3-back, CR 1/3-back, d′ 0/1/3-back
IOS	47	✓	✓	✓	–	Inclusion of self in the other
Trust Game	57	✓	✓	✓	–	Trust decisions
Experiment 2 – Subjective measures						
CFI	69	✓	–	–	✓	Cognitive flexibility
FMI	68	✓	–	–	✓	Mindfulness
SCS	67	✓	–	–	✓	Self-kindness, Self-judgment, Common humanity, Isolation, Mindfulness, Overidentification
PANAS	58	✓	✓	✓	–	Positive affect, Negative affect
Group estimation	70	–	✓	✓	–	Allocation guess
Perceived microdosing intensity	67	–	✓	✓	–	1-100 scale

Note. Hit = correct response to target; CR = correct rejection of non-target; IOS = Inclusion of Self in the Other Scale; CFI = Cognitive Flexibility Inventory; FMI = Freiburg Mindfulness Inventory; SCS = Self-Compassion Scale; PANAS = Positive and Negative Affect Scale.

session (baseline, Acute 1, Acute 2) was entered as a within-subject factor. Where applicable, an additional within-subject factors were included. For instance the Attentional Blink task was analyzed using a 2 (group) × 3 (session) × 3 (lag: 100, 300, 800 ms) rmANOVA on T2|T1 accuracy as the dependent variable. For the N-back task, three 2 × 3 × 3 rmANOVAs were conducted for hits, correct rejections (CR), and *d'* scores, with session and memory load (0-, 1-, 3-back) as within-subject factors. The Trust Game and IOS scale were each analyzed using 2 × 3 rmANOVAs, with session as a within-subject factor and group as a between-subject factor. Assumptions of normality and sphericity were tested, and Greenhouse-Geisser or Huynh-Feldt corrections were applied when appropriate. Non-parametric alternatives were used if assumptions were violated.

Subjective measures were analyzed using mixed-design rmANOVAs, including domain-level factors where applicable. The Cognitive Flexibility Inventory (CFI) was analyzed with session (pre vs. post) and subscale (control vs. alternatives) as within-subject factors. The Freiburg Mindfulness Inventory (FMI), being a single-scale measure, was analyzed using a 2 × 2 rmANOVA. The Self-Compassion Scale (SCS), which includes six subscales, was analyzed with session and subscale entered as within-subject factors. For the Positive and Negative Affect Schedule (PANAS), separate rmANOVAs were conducted for positive and negative affect, with session (baseline, Acute 1, Acute 2) as the within-subject factor. Where applicable, post hoc tests were planned with correction for multiple comparisons. All task-specific models, preprocessing steps, and statistical corrections are detailed in the Supplementary Materials.

6. Results

Randomization was successful, with no significant differences between the placebo and active microdosing groups on any demographic variables (Table 6). The mean age was 28.4 years (SD = 5.70) in the placebo group and 26.3 years (SD = 6.54) in the active group, t (75) = 1.47, p = .145. Body weight and BMI were also comparable between groups (Weight: t (74) = 0.11, p = .913; BMI: t (74) = 0.03, p = .898). Gender distribution did not differ significantly (placebo: 21 female, 17 male; active: 19 female, 20 male), χ^2 (1) = 0.33, p = .565. Prior psychedelic experience was similarly balanced (placebo: 32 yes, 2 no, 4 missing; active: 30 yes, 2 no, 5 missing), χ^2 (2) = 0.83, p = .661. All comparisons were non-significant (*ps* > 0.14).

Participants' subjective guesses regarding group allocation did not differ significantly between conditions at either the Acute 1 (χ^2 (2, 71) = 3.24, p = .198) or Acute 2 (χ^2 (2, 66) = 1.92, p = .383) session, indicating that blinding was preserved. Likewise, perceived microdosing strength did not differ between groups, as reflected in a non-significant group × time interaction (F (1, 63) = 0.01, p = .942, η^2 = 0.000). However, a significant main effect of time was observed (F (2, 126) = 27.49, p < .001, η^2 = 0.127), indicating a general decline in perceived intensity over sessions. This pattern may reflect increasing tolerance or waning expectation effects, consistent with findings from Experiment 1.

Table 6
Descriptive statistics for the two group conditions: Active (microdosing psilocybin) and control (placebo).

	Placebo	Active	t/χ^2	p	*Cohen's d/ Cramer's V*
	Mean (SD)	Mean (SD)			
Age (years)	28.4 (5.70)	26.3 (6.54)	1.47	0.145	0.34
Weight (kg)	70.47 (11.03)	70.18 (12.35)	0.11	0.913	0.03
BMI	23.16 (3.24)	23.26 (3.65)	0.03	0.898	−0.03
	Frequency	Frequency			
Gender (F/M/non-binary)	21/17/0	19/20/0	0.33	0.565	0.07
Previous experience (Yes/No/Missing)	32/2/4	30/2/5	0.83	0.661	0.10

6.1. Behavioral task results

Attentional Blink (AB): Analysis of T2|T1 accuracy revealed a significant main effect of time, F (2.01, 108.43) = 15.12, p < .001, η^2 = 0.014, indicating general improvement across sessions. A robust main effect of lag was observed, F (1.35, 72.71) = 57.19, p < .001, η^2 = 0.274, confirming that the AB effect was reliably elicited. A significant time × lag interaction, F (3.81, 205.74) = 7.04, p < .001, η^2 = 0.009, further supports successful task manipulation. However, the critical three-way interaction (time × lag × group) was not significant, F (3.81, 205.74) = 0.43, p = .780, η^2 < 0.001, indicating that microdosing did not influence attentional blink performance. Descriptive statistics are provided in Table 7.

N-back Task: For hit rates, there was a strong main effect of memory load, F (1.23, 66.53) = 95.14, p < .001, η^2 = 0.345, and a significant time × load interaction, F (3.03, 1734.53) = 4.88, p = .002, η^2 = 0.007. A small but significant time × group interaction was also observed, F (1.71, 92.43) = 3.49, p = .042, η^2 = 0.007; however, the three-way interaction (time × load × group) was not significant, F (23.03, 1734.53) = 0.20, p = .910, η^2 < 0.001. For correct rejections (CR), there was a significant main effect of load, F (1.27, 68.41) = 40.28, p < .001,

Table 7
Mean (SD) for outcome measures of behavioral tasks in Experiment 2.

Measure (Domain)	Condition	Baseline	Acute 1	Acute 2
AB		**PC (SD)**	**PC (SD)**	**PC (SD)**
Lag 100 ms	placebo	0.96 (0.04)	0.96 (0.04)	0.96 (0.04)
*Lag*100 ms	active	0.94 (0.06)	0.96 (0.06)	0.94 (0.05)
*Lag*300 ms	placebo	0.73 (0.20)	0.85 (0.09)	0.79 (0.19)
*Lag*300 ms	active	0.78 (14)	0.81 (0.18)	0.84 (0.09)
*Lag*800 ms	placebo	0.90 (0.09)	0.93 (0.07)	0.92 (0.08)
*Lag*800 ms	active	0.92 (0.08)	0.94 (0.07)	0.92 (0.11)
N-back		PC (SD)	PC (SD)	PC (SD)
Hit_0-back	placebo	0.96 (0.07)	0.91 (0.19)	0.95 (0.07)
Hit_0-back	active	0.94 (0.18)	0.98 (0.03)	0.97 (0.03)
Hit_1-back	placebo	0.94 (0.06)	0.64 (0.28)	0.91 (0.12)
Hit_1-back	active	0.95 (0.06)	0.76 (16)	0.93 (0.07)
Hit_3-back	placebo	0.65 (0.24)	0.87 (0.22)	0.70 (0.27)
Hit_3-back	active	0.66 (0.16)	0.94 (0.08)	0.75 (0.19)
CR_0-back	placebo	0.95 (0.12)	0.93 (0.20)	0.96 (0.06)
CR_0-back	active	0.92 (0.21)	0.98 (0.04)	0.98 (0.03)
CR_1-back	placebo	, 96 (0.05)	0.94 (0.18)	0.95 (0.05)
CR_1-back	active	0.97 (0.04)	0.97 (0.08)	0.97 (0.04)
CR_3-back	placebo	0.75 (0.22)	0.80 (0.24)	0.86 (0.18)
CR_3-back	active	0.78 (0.12)	0.84 (0.12)	0.83 (0.13)
dprime_0-back	placebo	0.14 (10.18)	−0.36 (20.64)	−0.30 (20.33)
dprime_0-back	active	−0.16 (20.52)	0.41 (0.39)	0.34 (10.19)
dprime_1-back	placebo	−0.18 (10.95)	−0.29 (20.46)	−0.27 (20.17)
dprime_1-back	active	0.21 (10.64)	0.34 (10.01)	0.32 (10.49)
dprime_3-back	placebo	−0.09 (10.97)	−0.30 (20.20)	−0.03 (20.10)
dprime_3-back	active	0.10 (10.21)	0.35 (10.18)	0.04 (10.45)
Trust game				
Trust score	placebo	307 (147)	355 (148)	379 (134) **
Trust score	active	357 (145)	395 (137)	403 (133) **
IOS				
IOS score	placebo	3.52 (1.42)	3.84 (1.67)	3.92 (1.57) *
IOS score	active	2.95 (1.221)	3.455 (1.22)	3.31 (1.28) *

Note: Hit-correct response to target, CR - correct rejection to non-target. Asterisks in Trust game and IOS indicate α level (*p < .05, **p < .01) for within-group contrast (change from baseline).

$\eta^2 = 0.200$, and a significant time × load interaction, F (2.30, 123.92) = 4.58, p = .009, η^2 = 0.009. No significant three-way interaction was found, F (2.30, 123.92) = 1.47, p = .232, η^2 = 0.003. Similarly, for d' scores, no significant main or interaction effects involving group were observed ($ps > 0.05$), including non-significant three-way interaction, F (3.22, 174.12) = 1.17, p = .324, η^2 = 0.003.

Trust Game: Baseline trust scores did not differ significantly between groups, t (52) = 1.25, p = .217. A significant main effect of session was found, F (2, 104) = 6.11, p = .003, η^2 = 0.105, reflecting an overall increase in trust over time. However, neither the main effect of group, F (1, 52) = 1.36, p = .248, η^2 = 0.026, nor the session × group interaction, F (2, 104) = 0.27, p = .765, η^2 = 0.005, reached significance. This suggests that trust increased equally in both conditions.

Inclusion of Other in the Self (IOS): No significant group differences were observed at baseline, t (45) = 1.46, p = .152. A significant main effect of session emerged, F (2, 90) = 3.48, p = .035, η^2 = 0.072, indicating that participants reported greater closeness to others over time. The main effect of group, F (1, 45) = 2.06, p = .158, η^2 = 0.044, and the session × group interaction, F (2, 90) = 0.04, p = .961, η^2 < 0.001, were non-significant, suggesting that this increase was not specific to the microdosing condition. For full F statistics see Supplement.

6.2. Subjective measures

Cognitive Flexibility Inventory (CFI): A significant group difference was observed at baseline on the "alternatives" subscale (t (72) = −2.70, p = .008, d = −0.61), likely due to chance given random assignment. The main effects of session (F (1, 67) = 0.09, p = .761) and group (F (1, 67) = 3.43, p = .069) were not significant. However, a significant group × session × subscale interaction emerged (F (1, 67) = 11.70, p = .001, η_p^2 = .15), driven by a higher post-intervention score in the control subscale for the microdosing group (t (67) = 2.62, p = .011, d = 0.63). Given the number of comparisons, this isolated effect should be interpreted cautiously (Table 8).

Freiburg Mindfulness Inventory (FMI): No significant baseline difference was observed between groups (t (71) = 0.38, p = .705). Neither the main effect of session (F (1, 71) = 0.13, p = .718), group (F (1, 71) = 0.92, p = .339), nor the interaction (F (1, 71) = 0.13, p = .718) reached significance, indicating no detectable effect of microdosing on trait mindfulness.

Self-Compassion Scale (SCS): At baseline, group differences emerged for the subscales "common humanity" (t (71) = 3.69, p < .001, d = 0.86) and "isolation" (t (71) = 3.08, p = .003, d = 0.72), suggesting random allocation imbalances. However, no main effects of session (F (1, 65) = 2.37, p = .128) or group (F (1, 65) = 0.09, p = .771) were found, and the three-way interaction with subscales was not significant (F (6, 390) = 0.48, p = .823), indicating no evidence for microdosing-related changes.

Positive and Negative Affect Schedule (PANAS): Baseline differences in positive and negative affect were not significant ($ps \geq 0.135$). A significant main effect of session was observed (F (1, 65) = 3.31, p = .039), driven by a reduction in negative affect from baseline to Acute 1 across both groups. There were no significant main effects of group (F (1, 56) = 0.31, p = .579) or group × session × affect dimension interaction (F (1, 65) = 0.32, p = .727), indicating that mood improvements were not specific to the microdosing condition.

Table 8
Mean (SD) for outcomes of subjective ratings in Experiment 2.

Measure (Domain)	Group	Assessment time-point						
		Pre intervention				Post intervention		Mean (Post-Pre)
CFI		**Mean**	**SD**			**Mean**	**SD**	
Alternative	Active	62.333	11.404			65.389	9.166	3.056
Alternative	Placebo	66.778	7.112			64.848	11.172	−1.93
Control	Active	35.167	8.392			37.278 *	7.767	1.111
Control	Placebo	33.879	7.737			32.394 *	7.669	−1.485
FMI								
Acceptance	Active	11.973	3.296			11.081	2.42	−0.892
Acceptance	Placebo	12.433	2.269			11.767	2.75	−0.666
SCS								
Humanity	Active	14.919	2.203			14.378	2.046	−0.541
Humanity	Placebo	13.167	2.35			13.7	1.745	0.533
Identification	Active	12.108	2.025			11.378	1.891	−0.73
Identification	Placebo	12.967	1.938			12.067	2.067	−0.9
Isolation	Active	14	2.134			13.324	2.015	−0.676
Isolation	Placebo	12.533	1.925			13.033	1.671	0.5
Judgment	Active	15.676	3.334			15.27	2.653	−0.406
Judgment	Placebo	15.1	2.881			15.533	3.048	0.433
Kindness	Active	14.946	2.999			14.514	2.556	−0.432
Kindness	Placebo	15	2.678			15.067	2.753	0.067
Mindfulness	Active	11.973	3.296			11.081	2.42	−0.892
Mindfulness	Placebo	12.433	2.269			11.767	2.75	−0.666
Total	Active	78.054	7.028			78	5.364	−0.054
Total	Placebo	78	5.045			77.9	5.384	−0.1
		Baseline		**Acute1**		**Acute 2**		
		Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean (Ac2-Base)**
PANAS								
Positive	Placebo	32.448	6.317	33.931	5.757	33.241	5.449	0.793
Positive	Active	34.448	6.462	33.966	5.666	33.931	5.567	−0.517
Negative	Placebo	22.207	5.747	19.276	5.168	20.241	6.983	−1.966*
Negative	Active	20.517	7.458	17.414	4.468	18.414	6.242	−2.103*
Secondary effects:								
M. intensity	Active	37.85	33.305	20.027	27.199	17.059	22.28	−20.791***
M. intensity	Placebo	43.8	33.113	19.528	23.752	16.939	18.453	−26.861***

Note: FMI- Freidburg Mindfulness Inventory, SCS - Self-Compassion Scale, PNAS - Positive and Negative Affect Scale. M.Intensity – Subjective microdosing intensity reported. Asterisks in PNAS and M.intensity indicate α level (*p < .05, **p < .01) for within-group contrast (change from baseline) and asterisks in FMI indicate significant group differences (*p < .05).

7. Text analyses

7.1. Methods

Finally, qualitative data from both experiments were analyzed together to maximize sample size. In total, 178 open-ended responses were examined (85 in the active microdosing condition and 93 in the placebo condition). A thematic analysis was conducted using a deductive approach (Fereday and Muir-Cochrane, 2006). The data were pre-processed by two independent raters who scored responses according to three predetermined categories. Investigator triangulation was implemented by having both raters independently code the responses and identify potential themes that have emerged. Based on these themes, a coding framework was developed and systematically applied to all responses.

Specifically, the responses were evaluated based on: (1) the presence and strength of symptoms (i.e., absence, subtle, or clear presence); (2) the perceived change in emotional valence (i.e., positive, negative, mixed, or increased sensitivity); and (3) the presence of four qualitative effect categories (i.e., cognitive, emotional, bodily, and social), with the frequency of each category summed per participant. Categorical data were analyzed using χ^2 tests, and the frequency of qualitative effects was compared using independent-samples t-tests.

7.2. Results

There were no significant group differences in the likelihood of reporting any microdosing-related symptoms across the two experiments, χ^2 (2, 178) = 4.65, p = .098. Interestingly, most participants reported experiencing some form of symptom—even when unsure of their group allocation—suggesting a potential role of expectancy effects. Notably, two participants reported strong adverse reactions, including flashbacks, extreme insomnia, and intense emotional experiences both of which were in the placebo condition.

Regarding emotional valence (Fig. 3), 49 % of participants described their symptoms as purely positive, 14 % reported negative symptoms, and the remainder described either mixed emotional states or amplified sensory experiences. A chi-square test revealed a significant group difference in emotional valence: negative symptoms were more frequently reported in the active microdosing group than in the placebo group, χ^2 (1, 146) = 9.5, p = .023. Independent-samples t-tests showed that participants in the active microdosing group reported significantly more bodily awareness experiences, t (176) = 2.8, p = .006, d = 0.49. Conversely, pro-social symptoms were more frequently reported in the placebo group, t (176) = 2.2, p = .025, d = 0.32. Finally, exploratory analyses using text analysis software generated word clouds from participants' open-ended responses. Visual inspection revealed a higher prevalence of somatic descriptors (e.g., "body sensations," "alertness," "nausea") in the active group compared to the placebo group, consistent with prior findings on microdosing-related body awareness.

8. General discussion

Across two double-blind, placebo-controlled longitudinal trials, we found no compelling evidence that psilocybin microdosing enhances cognitive performance or emotional well-being in healthy individuals. While participants tolerated the intervention well and blinding was successful, neither behavioral nor self-reported outcomes showed consistent group differences after correcting for multiple comparisons. These findings contribute to the growing number of placebo-controlled studies that report inconsistent findings regarding cognitive and emotional benefits (Polito and Stevenson, 2019; de Wit et al., 2022; Cavanna et al., 2022; Murphy et al., 2024).

8.1. Cognitive effects

More specifically, in both experiments, microdosing failed to improve performance across a broad range of behavioral tasks. In Experiment 1, no effects were observed on cognitive control (AX-CPT), decision-making (Multi-Armed Bandit), or selective attention and working memory (Reference-Back). Similarly, in Experiment 2, performance on the Attentional Blink, N-back, Trust Game, and Inclusion of Other in the Self scale (IOS) was unaffected by the active microdose.

The only notable exception emerged in Experiment 1: participants in the microdosing group performed better on difficult trials of the Reading the Mind in the Eyes Task (RMET), a measure of intuitive social

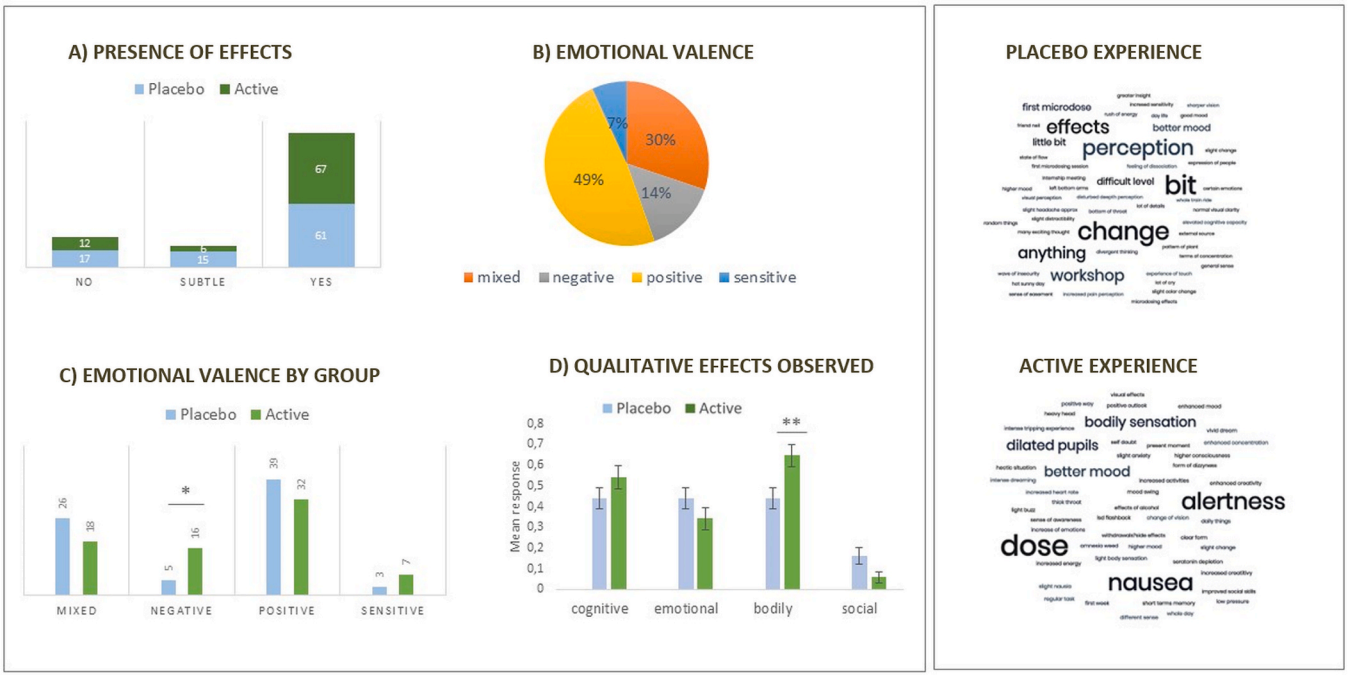

Fig. 3. Panel on the left shows frequency analyses of reported symptoms; Panel on the right shows generated word clouds.

cognition. This effect remained significant after controlling for expectation effects and was not driven by broken blinding—suggesting it may reflect a real, albeit subtle, enhancement in affective processing. However, given the high number of statistical tests conducted, this isolated result may represent a Type I error. Alternatively, it raises the possibility that microdosing selectively modulates intuitive or affective processes rather than deliberate higher order executive control.

These largely null behavioral findings converge with results from several placebo-controlled studies (for review see Polito and Stevenson, 2019). For example, Bershad et al. (2019), de Wit et al. (2022), Cavanna et al. (2022), and Murphy et al. (2024) found no benefits of microdosing across multiple traditional cognitive paradigms, even though differences in brain activity—measured via EEG and fMRI seed-based connectivity—were detected (Bershad et al., 2020; Cavanna et al., 2021).

On the other hand, several studies showed significant cognitive effects in microdosing. Yanakieva et al. (2018) found that LSD microdosing altered time perception. Hutten et al. (2020) reported a reduction in attentional lapses as compared to placebo and van Elk et al. (2021) showed that microdosing increased feelings of awe in response to emotionally evocative videos. Importantly, unlike previous naturalistic longitudinal studies (Szigeti et al., 2021; van Elk et al., 2021), participants in this study did not break the blinding, as they were no better than chance at guessing their experimental condition. This was further supported by the qualitative analyses of self-reported microdosing symptoms: among participants who reported feeling any symptoms, 48 % were actually in the placebo group.

In summary, microdosing psilocybin did not improve cognitive performance in this study but also did not impair cognition. Overall, the intervention was well-tolerated by healthy participants.

While consistent improvements in traditional cognitive paradigms have not been demonstrated here under controlled conditions, previous evidence suggests microdosing may influence perceptual or time-based judgments —a hypothesis warranting further investigation.

8.2. Subjective effects

Subjective self-report measures across both experiments similarly revealed no reliable benefits of microdosing. In Experiment 1, microdosing did not improve scores on well-being (WEMWBS), psychological flexibility (MPFI), or mood (Affect Grid). While psychological inflexibility decreased over time, this trend was observed across both groups, suggesting a general or expectancy-driven effect. A small, uncorrected difference in visual clarity was reported during the second session in the microdosing group but did not survive correction for multiple comparisons.

Experiment 2, mirrored these findings. No significant effects were observed on measures of mindfulness (FMI), self-compassion (SCS), or affective state (PANAS). A marginal increase in perceived cognitive control (CFI subscale) was observed in the microdosing group, but this likely reflects baseline imbalance rather than a true treatment effect. Decreases in negative affect were observed over time in both groups—again pointing to non-specific improvements that cannot be attributed to the active compound. These results are consistent with previous placebo-controlled trials showing little to no impact of microdosing on emotional well-being in healthy populations. Murphy et al. (2024), Marschall et al. (2022), and Cavanna et al. (2022) each found no significant changes in depression, anxiety, or stress symptoms following LSD or psilocybin microdosing.

In the qualitative text analyses, regardless of condition, participants predominantly reported positive experiences. Specifically, 49 % described their symptoms as positive (including those in the placebo group), 30 % reported mixed symptoms, and 14 % reported negative symptoms. These qualitative findings suggest that subjective experiences associated with microdosing are largely positive, even among participants in the placebo group, highlighting the potential influence of expectancy effects.

Notably, the majority (76 %) of those who reported negative symptoms were in the active microdosing group. The only significant difference between conditions was observed in the reporting of somatic symptoms. Participants in the active microdosing group were more likely to report changes in bodily awareness, such as elevated heart rate, altered body temperature, or nausea. The higher prevalence of negative symptoms in the active condition, particularly somatic discomfort, indicates that while microdosing may not impair cognition, it can produce subtle physiological effects that are not always experienced as pleasant. The fact that the only significant difference between groups emerged in bodily awareness reinforces previous findings that microdosing's most consistent effects may lie in interoceptive domains rather than cognitive enhancement.

8.3. Limitations and future directions

It is important to interpret our null findings considering the study's statistical power. Both trials were sufficiently powered to detect small-to-moderate effect sizes ($d = 0.3–0.5$), consistent with those reported in prior microdosing research and broader cognitive enhancement literature. The absence of significant effects across multiple cognitive and affective measures suggests that, if microdosing exerts any benefits in these domains, they are likely to be subtle and require higher statistical power. While our sample size was larger than in majority of prior microdosing studies, it may still have been underpowered to detect small cognitive and likely domain-specific effects.

Moreover, all the mentioned studies—including ours—targeted non-clinical samples, which may limit the potential for detecting improvements in mental health and cognitive indicators. For instance, Molla et al. (2023), found that participants with elevated depressive symptoms (measured via the Beck Depression Inventory) showed significant mood improvements following LSD microdosing, relative to placebo. This suggests that microdosing may have therapeutic potential in populations with clinically relevant symptomatology—where baseline impairment allows greater room for improvement.

Furthermore, our task battery—though comprehensive—may not have captured ecologically valid effects. Although traditional laboratory cognitive tasks (e.g., AX-CPT, N-back) afford experimental control, they often fail to mirror the complexity and demands of everyday life—and thus their ecological validity is limited. Performance under microdosing may manifest in complex ways (e.g. increased sensitivity, stress resilience, or creative problem-solving)—that are unlikely to be detected by sterile, isolated tasks. To bridge this gap, future research should incorporate more naturalistic and multimodal assessments in real-world environments.

Finally, while less of an issue in placebo-controlled settings, selection bias may have influenced the findings, as many participants had prior experience with psychedelics. For instance, the placebo effect itself might be stronger in a group that expects benefits from microdosing based on their prior experience, thereby raising placebo group scores and making it harder to detect true drug effects.

CRediT authorship contribution statement

Luisa Prochazkova: Writing – review & editing, Writing – original draft, Visualization, Supervision, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Josephine Marschall:** Writing – review & editing, Project administration, Methodology, Investigation, Conceptualization. **Dominique Patrick Lippelt:** Resources, Methodology, Investigation, Conceptualization. **Neil R. Schon:** Project administration, Investigation. **Martin Kuchař:** Validation, Formal analysis, Data curation. **Bernhard Hommel:** Writing – review & editing, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization.

Declaration of generative AI and AI-assisted technologies in the writing process

Statement: During the preparation of this work the author(s) used ChatGPT in order to improve grammar and readability. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published article.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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