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Effects of Ayahuasca on Gratitude and Relationships with Nature: A Prospective, Naturalistic Study

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ABSTRACT

Qualitative studies and anecdotal reports suggest that experiences with ayahuasca, a psychedelic brew found in Central and South America, may be followed by individuals enduringly feeling more grateful and connected to nature. Yet, to date, these changes have been understudied. Here, participants ($N = 54$) completed validated surveys related to gratitude, nature relatedness, and nature appreciation one-week before, one-week after, and one-month after attending an ayahuasca retreat center. Compared to baseline, there was a significant increase in gratitude, nature relatedness, and nature appreciation at the one-week and one-month follow-ups. Ratings of mystical-type experiences and awe, but not ego dissolution, during participants' ayahuasca sessions were weakly-to-moderately correlated with these increases. The number of ayahuasca ceremonies attended at the retreat was not related to change in outcomes, underscoring the importance of the quality rather than the quantity of the experiences in post-acute change. Lastly, participant age was negatively related to the occurrence of mystical-type experiences and awe, supporting literature indicating blunted psychedelic effects with increased age. In the context of study limitations, the results suggest that mystical-type experiences and awe occasioned by ayahuasca may be linked to prosocial changes in gratitude and relationships with nature that may be beneficial to mental health.

Introduction

Classic psychedelic drugs include serotonin 5-HT2A receptor agonists such as lysergic acid diethylamide (LSD), psilocybin, mescaline, and N,N-dimethyltryptamine (DMT). DMT can be directly administered, but also is the primary psychoactive component in ayahuasca, a psychedelic brew that is found in regions of Central and South America (Riba et al. 2003). Psychedelics are currently of high scientific, public, and regulatory interest because of the promising therapeutic effects that have been demonstrated in clinical trials when the drugs are paired with psychotherapeutic support (Aday, Carhart-Harris, and Woolley 2023; Anderson et al. 2020; Carhart-Harris et al. 2021). Indeed, recent studies of so-called "psychedelic therapy" have demonstrated positive clinical outcomes in patients with depression (Davis et al. 2021; Palhano-Fontes et al. 2019), substance misuse (Bogenschutz et al. 2022), and end-of-life distress (Griffiths et al. 2016) as well as prosocial changes, such as increased openness to experience and feelings of

connection (Aday et al. 2020). However, there are many areas of social functioning and personality, such as gratitude and relationships with nature, that have been reported to be altered as a result of psychedelic experiences, but have been as of yet under examined. The current study was designed to assess potential changes in these aspects of personality following the administration of ayahuasca in a retreat setting.

Ayahuasca is a psychedelic, plant-based tea used in Central and South America that most often includes the leaves of Psychotria viridis, which contain the potent psychedelic compound N, N-Dimethyltryptamine (DMT), and the vines of Banisteriopsis caapi, which contain monoamine oxidase inhibitors (MAOIs; Guimarães, Fernando Tófoli, and Sussulini 2021). Ayahuasca "analogs" utilizing other sources of DMT and MAOIs are used in some regions as well (Kaasik et al. 2021). MAOIs prevent the oxidation of DMT in the stomach when ingested orally, enabling the psychoactive compound to continue into the

bloodstream and ultimately attach to serotonin 2A receptors in the cortex (Valle et al. 2016). Its use was first established in the scientific literature approximately 150 years ago (Spruce 1873), but anthropological evidence suggests it has been used shamanistically among Amazonian groups for millenia (Ruffell et al. 2023). Ayahuasca is usually administered in a ceremonial context and its psychoactive effects continue for approximately 4–5 hours after ingestion (Riba et al. 2001). It is not uncommon for users to purge or experience digestive discomfort during the onset of the drug, and some consider these effects to be essential aspects of the healing/cleansing process (Bouso et al. 2022; Osório et al., 2015).

Converging lines of evidence suggest that individuals may feel more grateful after ayahuasca and other psychedelic experiences (Agin-Liebes et al. 2021; Noorani et al. 2018; Griffiths et al. 2018). First, there is direct anecdotal and qualitative evidence suggesting individuals experience increased gratitude after psychedelic experiences (Agin-Liebes et al. 2021). For example, in a psilocybin study for smoking cessation, one participant remarked "I've learned how to be more grateful, which is probably the biggest thing" (Noorani et al. 2018). There is also tentative empirical evidence that psychedelic experiences may increase gratitude from Griffiths et al. (2018), who gave two high doses of psilocybin to healthy volunteers and assessed changes in gratitude using the six-question *Gratitude Questionnaire* (*GQ-6*). At the 6-month follow-up, they found that gratitude was increased in their two high-dose psilocybin groups, but not in the low-dose control group. The degree to which one had a mystical-type experience (i.e., characterized by strong feelings of connection, positive mood, ineffability, and transcendence of time and space) during dosing sessions was related to increases in gratitude in the high-dose groups. Yet, discussion of these findings was limited given that gratitude wasn't the primary outcome measure, and it is still unclear which facets of gratitude may be affected given the general nature of the *GQ-6*. It is also unknown the degree to which other drug effects may account for these changes. In particular, experiences of awe have been noted with psychedelic substances (Hendricks 2018; van Mulukom, Patterson, and van Elk 2020), and linked to increased gratitude in other contexts (Yaden et al. 2019).

In addition to gratitude, another prosocial change that has been linked to psychedelics is alterations in one's relationships with nature. Forstmann and Sagioglou (2017) found that lifetime experience with psychedelics predicted greater pro-environmental behavior and these differences were mediated through increases in nature relatedness (i.e., how connected one feels with nature; Capaldi et al. 2014). Carhart-Harris et al. (2018) administered psilocybin to patients with treatment-resistant depression in an open-label trial and found that participants exhibited increases in nature relatedness that were maintained at the 7–12-month follow-ups. Another study examined individuals planning to use a psychedelic in a naturalistic setting and found that compared to the week before administration, participants showed increased nature relatedness at the 2-week, 4-week, and 2-year follow-ups (Kettner et al. 2019). Further, increases in nature relatedness were related to enhanced wellbeing and predicted by the extent to which participants experienced ego dissolution during their psychedelic experience. However, there has been limited research with ayahuasca specifically (Ruffell et al. 2023). A related, but psychometrically distinct, concept to nature relatedness is nature appreciation (i.e., the extent to which individuals value experiences with and in nature; Kaiser et al. 2013, 2014), but measures of this construct have not been included in any psychedelic study to-date.

Lastly, a systematic review by Aday et al. (2021) found that baseline traits, such as age, past history of psychedelic use, and personality variables, could be used to predict acute reactions to psychedelics. In particular, this review found that older age and increased previous experience using psychedelics were both related to generally less intense effects with the drugs. Further study into these relationships is needed to identify which individuals are likely to benefit from psychedelic use as well as informing risk assessments and dosage selection.

The current study was designed to inform the aforementioned gaps in the psychedelic literature. Detailed measures of gratitude, nature relatedness, and nature appreciation were given to participants one-week before (T1), one-week after (T2), and one-month after (T3) attending an ayahuasca retreat in Costa Rica. We also administered scales assessing the extent to which participants endorsed feelings of awe, ego dissolution, and mystical-type experiences during their most intense ayahuasca session to identify potential variables related to post-acute change and collected demographics to explore baseline variables related to acute drug effects.

Methods

Participants

Participants were recruited from Soltara Healing Center in Puntarenas Province, Gigante, Costa Rica (www.soltara.co). Soltara is an all-inclusive ayahuasca retreat center where attendees pay to participate in ayahuasca ceremonies with indigenous Shipibo

curanderos (i.e., "healers" specializing in plant medicine) from Peru. All meals, sleep accommodations, and transportation were provided by the center. The setting was located in a biodiverse region that included beaches and hiking trails on the grounds as well as various yoga and meditation classes on-site for recreation. The retreat required that attendees be at least 18 years old and that they complete a medical intake form confirming that they did not have contraindicated psychiatric disorders (e.g., schizophrenia, bipolar disorder) medications (e.g., lithium), or medical conditions (e.g., heart ailments; Schlag et al. 2022). All participants at the retreat were eligible to enroll in the study. Participants were compensated via a drawing to win one of five prizes ($100.00 USD each). Participants were recruited through e-mail after registering for the retreat as well as a posting on the retreat's website. All participants provided informed consent and the study was approved by the Central Michigan University Institutional Review Board.

Measures

The following demographic variables were collected during the first survey session: age, gender identity, highest level of education completed, annual household income, ethnoracial identity, country of permanent residence, range of lifetime history of psychedelic use (Never, Once only, 2–5 times, 6–10 times, 11–15 times, 16–25 times, 26–50 times, 51–100 times, >100 times), and an exact estimate of the number of times they have used psychedelics. Details for the rest of the measures included in the study are summarized in Table 1.

Procedure

Participants stayed at the center for 5–12 nights and participated in 2–7 ayahuasca ceremonies during their retreat ($M = 3.67$ $SD = 0.85$). Following enrollment in

the study, participants were emailed a link to the first survey session one week before their retreat was scheduled to begin to collect informed consent and baseline measures (T1). Surveys were administered using Qualtrics (Douglas et al. 2023) and participants could complete them using a computer or mobile device. During the first survey session, the following measures were collected: demographics, Appreciation Scale (AS), Nature Relatedness Scale (NR-6), and the Appreciation of Nature (APR) Scale.

Next, participants traveled to Soltara to attend the ayahuasca retreat. Procedural details of the ayahuasca ceremonies are described by Aday et al. (in press). The day after the participants' retreat had ended, they were emailed a link to the second survey session and asked to complete it within one week (T2). The second survey session included the same measures as the first session (except demographics) as well as the Mystical Experience Questionnaire (MEQ30), Awe Experience Scale (AWE-S), and the Ego Dissolution Inventory (EDI), which indexed the extent to which participants endorsed mystical-type experiences, awe, and ego dissolution, respectively. Participants were instructed to answer questions in the MEQ30, AWE-S, and EDI in reference to their most intense ayahuasca experience during the retreat. One month after the participants' retreat ended, they completed the same measures as the first survey session (except demographics) and had one week to complete the survey (T3). After completing the third survey, participants were debriefed on the nature of the study.

Data analysis

A 3×8 repeated-measures analysis of variance (ANOVA) was run on AS total scores with three levels of Time (T1, T2, and T3) and eight levels of Facet ("have focus," awe, ritual, present moment, self/social comparison, gratitude, loss adversity, interpersonal), and planned pairwise comparisons were used to evaluate the effect of Time. NR-6 and APR total scores were analyzed using two separate one-way

Table 1. Summary of study measures.

Measure	Author(s) (Year)	Pre/Post (P) or Acute (A)	Construct of Interest	Number of Facets	Cronbach's α	Example Item
Appreciation Scale (AS)	Adler and Fagley (2005)	P	Gratitude	8	0.96	'I am content with what I have.'
Nature Relatedness Scale (NR-6)	Nisbet and Zelenski (2013)	P	Nature Relatedness	1	0.89	'I feel very connected to all living things and the earth.'
Appreciation of Nature Scale (APR)	Bogner (2018b)	P	Nature Appreciation	1	0.84	'I consciously watch or listen to birds.'
Mystical Experience Questionnaire (MEQ30)	MacLean et al. (2012)	A	Mystical-type Experiences	4	0.97	"Sense of reverence."
Awe Experience Scale (AWE-S)	Yaden et al. (2019)	A	Awe	5	0.97	'I felt in the presence of greatness.'
Ego Dissolution Inventory (EDI)	Nour et al. (2016)	A	Ego Dissolution	1	0.95	'All notion of self and identity dissolved away.'

repeated measures ANOVAs with three levels of Time (T1, T2, and T3). Scores on the *MEQ30*, *AWE-S*, and *EDI* were correlated with one-week and one-month changes (Δ) in *AS*, *NR-6*, and *APR* total scores with two-way Pearson correlations. One-week change scores (Δ_1) for the *AS*, *NR-6*, and *APR* were calculated by subtracting baseline (T1) total scores from one-week post-retreat (T2) total scores for each respective measure (e.g., T2-T1 =Δ_1). One-month change scores (Δ_2) for the *AS*, *NR-6*, and *APR* were each calculated by subtracting baseline (T1) total scores from one-month post-retreat (T3) total scores for each respective measure (e.g., T3-T1 = Δ_2). Lastly, two-way Pearson correlations were used to assess if the number of ayahuasca ceremonies attended was related to changes in gratitude.

Results

Participants

The sample began with 77 participants who completed baseline (T1). Of these, 65 participants (84% of initial sample) completed Survey 2 one-week post-retreat (T2) and 55 (71% of initial sample) completed Survey 3 one-month post-retreat (T3). One participant who indicated that they did not partake in any ayahuasca ceremonies while at the retreat was removed from analyses, leaving a final sample of $N = 54$ ($M_{age} = 41.17$, $SD = 11.24$; female = 24). The sample was highly educated (88.9% college degree or higher), had generally high incomes (38.9% > $125,000/year), and was predominantly non-Hispanic white (74.1%). There was a wide range of previous experience with psychedelics, with 18.5% reporting "never" having used a psychedelic drug, 29.6% 1–5 uses, 13% 6–10 uses, 9.3% 11–15 uses, 7.4% 16–25 uses, 13% 26–50 uses, 3.7% 51–100 uses, and 5.6% >100 uses.

Gratitude

To assess changes in overall gratitude as well as which facets were altered, the individual facets of the *AS* were analyzed with a 3 × 8 repeated-measures ANOVA. The main effect of Time was significant ($F(1, 53) = 34.97$, $p < .001$, $eta_p^2 = 0.40$). Planned pairwise comparisons revealed one-week (T2) and one-month (T3) post-retreat *AS* total scores were significantly higher than scores at baseline (T1); one-week (T2) and one-month (T3) post-retreat AS scores did not differ from one another ($p > .05$; Figure 1). The main effect of Facet was significant ($F(1, 53) = 709.19$, $p < .001$, $eta_p^2 = .93$. Every facet increased at the one-week and one-month follow-ups compared to baseline and there were no significant differences between the one-week and one-month follow-ups for any facet (Table 2). The Time ×
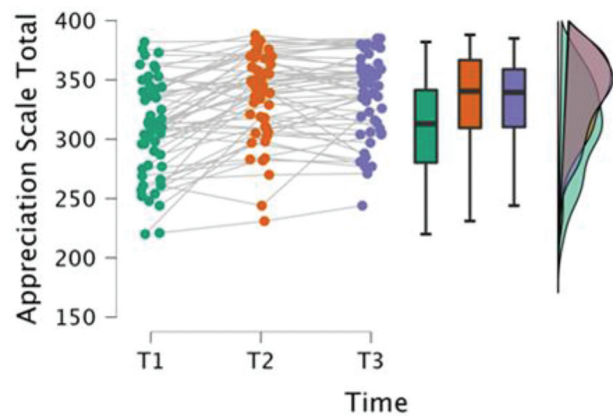

Figure 1. Effects of ayahuasca on gratitude. Compared to baseline, there was a significant increase in AS scores one week and one month after attending the ayahuasca retreat.

Facet interaction was significant, $F(1, 53) = 5.68$, $p < .001$, $eta_p^2 = 0.10$, such that the ritual facet and interpersonal facet were significantly different at the one-week ($p = .014$) and one-month follow-ups ($p < .001$), but not at baseline. Changes in gratitude at the one-week ($r = .04$, $p = .80$) and one-month follow-ups ($r = -.05$, $p = .70$) did not correlate with the number of ayahuasca sessions attended at the retreat. Scores on the *AWE-S* and *MEQ30*, but not the *EDI*, were weakly-to-moderately correlated with one-week ($AS\Delta_1$) and one-month ($AS\Delta_2$) changes in *AS* total scores (Table 3).

Nature relatedness and nature appreciation

NR-6 and *APR* total scores were analyzed using two separate one-way repeated measures ANOVAs. For the *NR-6*, the effect of Time was significant ($F(1, 53) = 26.27$, $p < .001$, $eta_p^2 = 0.33$), such that one-week (T2) and one-month (T3) post-retreat *NR-6* scores were significantly higher than baseline (T1) scores (Figure 2a); one-week (T2) and one-month (T3) post-retreat *NR-6* scores did not differ from one another ($p > .05$). For the *APR*, the effect of Time was significant ($F(1, 53) = 31.79$, $p < .001$, $eta_p^2 = 0.38$), such that one-week (T2) and one-

Table 2. Average scores of *AS* facets across each timepoint.

Facet	T1M (SE)	T2M (SE)	T3M (SE)
"Have focus"	48.56(1.02)	52.94(0.83)***	52.65(0.91)***
Awe	34.44(0.83)	37.43(0.71)***	37.26(0.68)***
Ritual	29.50(1.04)	34.07(0.91)***	34.70(0.81)***
Present Moment	39.41(0.88)	43.44(0.64)***	43.35(0.59)***
Self/Social	25.44(0.72)	26.93(0.79)*	27.13(0.80)*
Gratitude	62.56(0.74)	64.94(0.66)**	64.56(0.64)**
Loss/Adversity	41.44(1.04)	44.39(1.02)**	45.43(1.03)**
Interpersonal	29.17(5.55)	31.46(0.43)***	31.10(0.46)***
Total	310.52(5.51)	335.61(4.89)***	336.17(4.76)***

Asterisks indicate a significant difference from T1.
(*p<.05,**p<.01,***p<.0001).

Table 3. Relationships among acute effects and post-acute change.

|		MEQ30	AWE-S	EDI	$AS\Delta_1$	$AS\Delta_2$	$NR\text{-}6\Delta_1$	$NR\text{-}6\Delta_2$	$APR\Delta_1$	$APR\Delta_2$
MEQ30										
	Pearson's *r*									
	p-value									
AWE-S										
	Pearson's *r*	0.86								
	p-value	<.001								
EDI										
	Pearson's *r*	0.79	0.73							
	p-value	<.001	<.001							
ASΔ_1										
	Pearson's *r*	0.31	0.41	0.15						
	p-value	<.05	<.01	0.28						
ASΔ_2										
	Pearson's *r*	0.15	0.30	0.19	0.76					
	p-value	.28	<.05	.17	<.001					
NR-6Δ_1										
	Pearson's *r*	0.22	0.24	0.16	0.46	0.31				
	p-value	.11	.08	.26	<.001	<.05				
NR-6Δ_2										
	Pearson's *r*	0.29	0.34	0.26	0.49	0.43	0.87			
	p-value	<.05	<.05	.06	<.001	<.01	<.001			
APRΔ_1										
	Pearson's *r*	0.32	0.34	0.20	0.48	0.38	0.37	0.37		
	p-value	<.05	<.05	.14	<.001	<.01	<.01	<.01		
APRΔ_2										
	Pearson's *r*	0.23	0.30	0.23	0.26	0.34	−0.06	0.11	0.63	
	p-value	.10	<.05	.10	0.06	<.05	.65	.43	<.001	
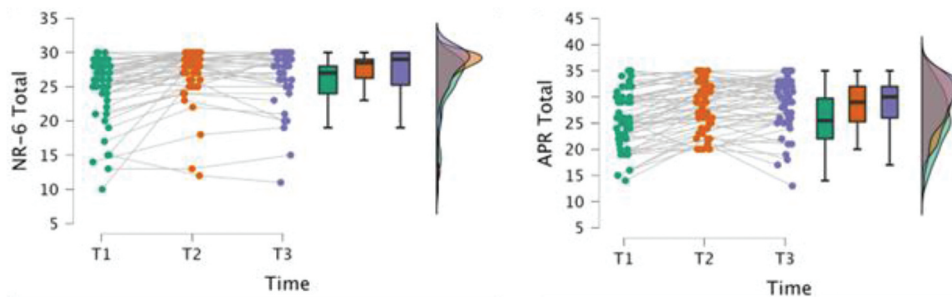
Figure 2. Effects of ayahuasca on nature relatedness and appreciation of nature. Figure shows that, compared to baseline, there was a significant increase in *NR-6* and *APR* scores one week and one month after attending the ayahuasca retreat.

month (T3) post-retreat *APR* scores were significantly higher than baseline (T1) scores (Figure 2b); one-week (T2) and one-month (T3) post-retreat *APR* scores did not differ from one another ($p > .05$). Scores on the *AWE-S* and *MEQ30*, but not the *EDI*, were weakly correlated with one-week (T2) and one-month (T3) changes (Δ) in *NR-6* and *APR* total scores (Table 3)

Mystical-type experiences

Previous research has established the frequency and impact of mystical-type experiences in psilocybin sessions (e.g., Griffiths et al. 2018), but the literature is unclear regarding ayahuasca. Barrett et al. (2015) defined "complete mystical experiences" as scoring 60% or higher on all four subscales of the *MEQ30*. To examine what proportion of our sample met this criterion, a percentage score was calculated for each facet of the *MEQ30* for each participant. We found that 37/54 (68.52%) of participants met the criterion for a complete mystical-type experience. This is in-line with Griffiths et al. (2018), who found that across two groups administered two high doses of psilocybin in a controlled setting, 61% and 64% of participants met this same criterion. The slightly higher proportion reporting a complete mystical-type experience in this study is likely due to having more chances to experience an intense effect (i.e., participants here took ayahuasca on average 3–4 times over their retreat and completed the *MEQ30* in reference to their most intense session).

Baseline predictors

To explore the relationships between baseline variables and acute drug effects in the current study, we ran planned two-tailed Pearson correlations between baseline variables (e.g., age and past history of psychedelic use) and measures of acute effects (e.g., *MEQ30*, *AWE-S*, and *EDI*). In line with Aday et al. (2021), we found that age was negatively related to intensity of acute effects as measured by the *MEQ30* ($r = -.34$, $p = .010$) and *AWE-S* ($r = -.39$, $p = .004$), but this relationship was not significant with the *EDI* ($r = -.18$, $p = .140$). Contrasting with Aday et al. (2021), past history of psychedelic use was not related to acute effects as measured by the *MEQ30* ($r = .11$, $p = .424$), *AWE-S* ($r = .05$, $p = .703$), nor *EDI* ($r = .11$, $p = .388$).

Discussion

Ayahuasca retreat centers have emerged as a popular method for individuals to experience psychedelics in a legal and controlled environment (Prayag et al. 2016). However, several drug effects that are anecdotally noted by psychedelic users remain understudied. Specifically, a renewed sense of general gratitude as well as increased interest and engagement with nature, linked to psychedelics in subjective reports, have received limited systematic study. We addressed this gap in the literature using a naturalistic, open-label, and within-subjects design at an ayahuasca retreat center. Compared to one-week before the retreat, participants reported greater levels of gratitude, nature relatedness, and nature appreciation at the one-week and one-month follow-ups. Measures of awe and mystical experience in response to ayahuasca were weakly-to-moderately correlated with increases across these domains, but ego dissolution was not.

Our findings are consistent with Griffiths et al. (2018), who found that mystical-type experiences during psilocybin dosing sessions were associated with increased gratitude at the six-month follow-up. Our results provide evidence that in addition to psilocybin, ayahuasca may lead to similar changes in gratitude as well, and indicate that changes in gratitude seem to be nonspecific, as every facet of the *AS* increased at both follow-ups (T2 and T3) compared to baseline (T1). Although awe has been linked to increases in gratitude in other contexts (Yaden et al. 2019), the current results support that psychedelic-induced awe may be linked to increased gratitude as well. This is unsurprising given that awe and mystical-type experiences in response to ayahuasca were strongly correlated in the current study ($r = .86$, $p < .001$). In terms of a mechanistic explanation,

experiences that provoke strong feelings of awe can lead to meaningful memories which may increase gratitude and buffer against emotional distress by serving as a powerful reminder of the positive aspects of life (Büssing et al. 2014). Overall, the results support the hypothesis that psychedelics can induce experiences that are associated with individuals feeling more grateful after the acute drug effects have worn off.

Participants also reported increased nature relatedness and appreciation of nature for at least one month after taking ayahuasca, and these changes correlated with acute mystical-type experiences and feelings of awe during ayahuasca consumption. The findings support a growing body of literature indicating psychedelic experiences can alter one's relationship with nature (Forstmann and Sagioglou 2017; Irvine et al. 2023; Kettner et al. 2019, Longo et al. 2023; Lyons and Carhart-Harris 2018; Ruffell et al. 2023) and indicate that these pro-environmental effects generalize to ayahuasca use specifically. Given the retreat setting involved in drug administration, it could be argued that non-pharmacological factors contributed to these effects. However, pro-environmental effects have also been documented when synthetically manufactured psychedelics are administered in modern research laboratories (Carhart-Harris et al. 2018), suggesting that these changes are likely driven, at least in-part, by direct drug effects. It remains to be seen how one's expectations for connecting with nature and motivations for usage contribute to changes in one's relationship with nature after taking a psychedelic. This may be an important point to note with ayahuasca in particular as Altman, Mian, and Earleywine (2020) found that in a sample of predominantly white, educated ayahuasca users, participants expected to connect with nature while under the influence of the drug more than with other psychedelics. Nonetheless, given the rapidly developing environmental crises and increasing disconnection many people have from nature in modern civilizations (Kesebir and Kesebir 2017), further exploration of the potential for psychedelics to strengthen an individual's connection to, and appreciation of, nature is an important area of future research.

Our study was limited by an open-label design that did not include a blinded placebo control condition. However, there is current debate about whether it is possible to design "double-blind" placebo-controlled studies with psychedelics given their intense and easily identifiable psychoactive effects (Muthukumaraswamy, Forsyth, and Lumley 2021). Open-label naturalistic studies focusing on mechanistic work may be a cost-effective alternative to traditional double-blind randomized control trials (Aday et al. 2022). A further

limitation is that participants were recruited from Soltara Healing Center, where attendees receive ayahuasca a variable number of times and its administration is embedded into a broader retreat context. Non-pharmacological factors, such as the retreat amenities (e.g., hiking trails, yoga/meditation classes.) and social relationships developed at the retreat with attendees and staff, could have contributed to the documented changes. However, many of these changes have been noted in qualitative reports when psychedelics are given in laboratory settings without these confounding factors. It remains to be seen if there are potential additive or synergistic effects from integrating psychedelics into retreat settings as compared to laboratory or hospital administration. In one test of non-pharmacological factors, Griffiths et al. (2018) found that there were not significant differences in gratitude between those administered a high dose of psilocybin with high support compared to standard support for spiritual practice, suggesting that direct drug effects and dose may be more pertinent in post-acute changes. Lastly, the homogenous background of the sample is a limitation to the generalizability of the results. This is pertinent given recent findings that race may be a moderator of therapeutic effects with psychedelics, with people of color experiencing diminished returns (Jones 2023; Jones and Nock 2022).

Future studies should expand upon our results by addressing these limitations as well as incorporating behavioral measures and ratings from outside observers. Doing so would provide more objective measures of these changes and reveal if individuals not only report feeling differently, but behave differently as well. Indeed, Tsang (2007) created a behavioral test of gratitude that could be incorporated into studies with psychedelics to this end. Behavioral measures of pro-environmental behavior have been developed as well and have already been shown to be sensitive to the effects of psychedelics (Forstmann and Sagioglou 2017). Additionally, future researchers should examine if the prosocial changes reported here (e.g., increased gratitude, nature relatedness) mediate clinical improvements documented with psychedelics given that strengthening gratitude and one's relationship with nature have been causally linked to positive mental health outcomes in other contexts (Grahn et al. 2017; Lambert, Fincham, and Stillman 2012). Another open question is how long changes in gratitude, nature relatedness, and nature appreciation are maintained. Griffiths et al. (2018) found that participants demonstrated increased levels of gratitude for at least six months after administration of psilocybin, but lengthier longitudinal designs are needed. In context of these limitations, it should be acknowledged that the study had strong participant retention, included multiple post-acute follow-ups, was high in ecological validity, utilized validated and multi-faceted measures of gratitude and relationships with nature, and identified variables that correlated with post-acute changes.

To conclude, the current study supports that mystical experiences and awe induced by ayahuasca are linked with sustained increases in gratitude, nature relatedness, and nature appreciation. Given the relationships between these constructs and positive mental health outcomes, these results could have important implications for clinical populations and society more broadly. Although future randomized controlled trials are needed to address limitations of the study, our findings support anecdotal and qualitative reports regarding several post-acute effects of ayahuasca and suggest preliminary mechanisms associated with these changes.

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Data availability statement

Due to the nature of this research, participants of this study did not agree for their data to be shared publicly, so supporting data is not available.

References

Aday, J., E. Bloesch, A. K. Davis, S. Domoff, K. C. Scherr, and J. Woolley. in press. Increases in aesthetic experience following ayahuasca use: An open-label, naturalistic study. *Journal of Humanistic Psychology*.

Aday, J. S., R. L. Carhart-Harris, and J. D. Woolley. 2023. Emerging challenges for psychedelic therapy. *JAMA Psychiatry* 80 (6):533–34. doi:10.1001/jamapsychiatry.2023.0549.

Aday, J. S., A. K. Davis, C. M. Mitzkovitz, E. K. Bloesch, and C. C. Davoli. 2021. Predicting reactions to psychedelic drugs: A systematic review of states and traits related to acute drug effects. *ACS Pharmacology and Translational Science* 4 (2):424–35. doi:10.1021/acsptsci.1c00014.

Aday, J. S., B. D. Heifets, S. D. Pratscher, E. Bradley, R. Rosen, and J. D. Woolley. 2022. Great expectations: Recommendations for improving the methodological rigor of psychedelic clinical trials. *Psychopharmacology* 239 (6):1989–2010. doi:10.1007/s00213-022-06123-7.

Aday, J. S., C. M. Mitzkovitz, E. K. Bloesch, C. C. Davoli, and A. K. Davis. 2020. Long-term effects of psychedelic drugs: A systematic review. *Neuroscience & Biobehavioral Reviews* 113:179–89. doi:10.1016/j.neubiorev.2020.03.017.

Adler, M. G., and N. S. Fagley. 2005. Appreciation: Individual differences in finding value and meaning as a unique predictor of subjective well-being. *Journal of Personality* 73 (1):79–114. doi:10.1111/j.1467-6494.2004.00305.x.

Agin-Liebes, G., E. Ekman, B. Anderson, M. Malloy, A. Haas, and J. Woolley. 2021. Participant reports of mindfulness, posttraumatic growth, and social connectedness in psilocybin-assisted group therapy: An interpretive phenomenological analysis. *Journal of Humanistic Psychology*. doi:10.1177/00221678211022949.

Altman, B. R., M. N. Mian, and M. Earleywine. 2020. The novelty of ayahuasca scale and the prediction of intentions to use. *Journal of Psychedelic Studies* 4 (2):93–103. doi:10.1556/2054.2020.00117.

Anderson, B. T., A. Danforth, R. Daroff, C. Stauffer, E. Ekman, G. Agin-Liebes, A. Trope, et al. 2020. Psilocybin-assisted group therapy for demoralized older long-term AIDS survivor men: An open-label safety and feasibility pilot study. *EClinicalMedicine* 27. doi:10.1016/j.eclinm.2020.100538.

Barrett, F. S., M. W. Johnson, and R. R. Griffiths. 2015. Validation of the revised mystical experience questionnaire in experimental sessions with psilocybin. *Journal of Psychopharmacology* 29 (11):1182–90. doi:10.1177/0269881115609019.

Bogenschutz, M. P., S. Ross, S. Bhatt, T. Baron, A. A. Forcehimes, E. Laska, S. E. Mennenga, et al. 2022. Percentage of heavy drinking days following psilocybin-assisted psychotherapy vs placebo in the treatment of adult patients with alcohol use disorder: A randomized clinical trial. *JAMA Psychiatry* 79 (10):953–62. doi:10.1001/jamapsychiatry.2022.2096.

Bogner, F. X. 2018b. Environmental values (2-MEV) and appreciation of nature. *Sustainability* 10 (2):350. doi:10.3390/su10020350.

Bouso, J. C., Ó. Andión, J. J. Sarris, M. Scheidegger, L. Fernando Tófoli, E. Sátiro Opaleye, V. Schubert, and D. Perkins. 2022. Adverse effects of ayahuasca: Results from the Global Ayahuasca Survey. *PLOS Global Public Health* 2 (11):e0000438.

Büssing, A., A. G. Wirth, F. Reiser, A. Zahn, K. Humbroich, K. Gerbershagen, and S. Schimrigk, M. Haupts, N. Hvidt, K. Baumann. 2014. Experience of gratitude, awe and beauty in life among patients with multiple sclerosis and psychiatric disorders. *Health and Quality of Life Outcomes* 12 (1):1–11. doi:10.1186/1477-7525-12-63.

Capaldi, C. A., R. L. Dopko, and J. M. Zelenski. 2014. The relationship between nature connectedness and happiness: A meta-analysis. *Frontiers in Psychology* 5:976. doi:10.3389/fpsyg.2014.00976.

Carhart-Harris, R., L. David Erritzoe, E. C. H. M. Haijen, M. Kaelen, and R. Watts. 2018. Psychedelics and connectedness. *Psychopharmacology* 235:547–50. doi:10.1056/NEJMoa2032994.

Carhart-Harris, R. L., D. Erritzoe, E. Haijen, M. Kaelen, and R. Watts. 2018. Psychedelics and connectedness. *Psychopharmacology* 235 (2):547–50. doi:10.1007/s00213-017-4701-y.

Carhart-Harris, R., Giribaldi, B., Watts, R., Baker-Jones, M., Murphy-Beiner, A., Murphy, R., and Nutt, D. J. (2021). Trial of psilocybin versus escitalopram for depression. *New England Journal of Medicine*, 384(15), 1402–1411. doi:10.1056/NEJMoa2032994.

Davis, A. K., F. S. Barrett, D. G. May, M. P. Cosimano, N. D. Sepeda, M. W. Johnson, P. H. Finan, and R. R. Griffiths. 2021. Effects of psilocybin-assisted therapy on major depressive disorder: A randomized clinical trial. *JAMA Psychiatry* 78 (5):481–89.

Douglas, B. D., P. J. Ewell, M. Brauer, and J. S. Hallam. Data quality in online human-subjects research: Comparisons between MTurk, prolific, CloudResearch, Qualtrics, and SONA. *PLoS One* 18(3):2023 Mar 14 e0279720. doi:10.1371/journal.pone.0279720.

Forstmann, M., and C. Sagioglou. 2017. Lifetime experience with (classic) psychedelics predicts pro-environmental behavior through an increase in nature relatedness. *Journal of Psychopharmacology* 31 (8):975–88. doi:10.1177/0269881117714049.

Grahn, P., A. M. Pálsdóttir, J. Ottosson, and I. H. Jonsdottir 2017. Longer nature-based rehabilitation may contribute to a faster return to work in patients with reactions to severe stress and/or depression. *International Journal of Environmental Research and Public Health* 14 (11):1310. doi:10.3390/ijerph14111310.

Griffiths, R. R., M. W. Johnson, M. A. Carducci, A. Umbricht, W. A. Richards, B. D. Richards, M. P. Cosimano, and M. A. Klinedinst. 2016. Psilocybin produces substantial and sustained decreases in depression and anxiety in patients with life-threatening cancer: A randomized double-blind trial. *Journal of Psychopharmacology* 30 (12):1181–97. doi:10.1177/0269881116675513.

Griffiths, R. R., M. W. Johnson, W. A. Richards, B. D. Richards, R. Jesse, K. A. MacLean, F. S. Barrett, M. P. Cosimano, and M. A. Klinedinst. 2018. Psilocybin-occasioned mystical-type experience in combination with meditation and other spiritual practices produces enduring positive changes in psychological functioning and in trait measures of prosocial attitudes and behaviors. *Journal of Psychopharmacology* 32 (1):49–69. doi:10.1177/0269881117731279.

Guimarães, I. C., L. Fernando Tófoli, and A. Sussulini. 2021. Determination of the elemental composition of ayahuasca and assessments concerning consumer safety. *Biological Trace Element Research* 199:1179–84.

Hendricks, P. S. 2018. Awe: A putative mechanism underlying the effects of classic psychedelic-assisted psychotherapy. *International Review of Psychiatry* 30 (4):331–42. doi:10.1080/09540261.2018.1474185.

Irvine, A., D. Luke, F. Harrild, S. Gandy, and R. Watts. 2023. Transpersonal ecodelia: Surveying psychedelically induced biophilia. *Psychoactives* 2 (2):174–93. doi:10.3390/psychoactives2020012.

Jones, G. M. 2023. Race and ethnicity moderate the associations between lifetime psychedelic use (Mdma/ecstasy and psilocybin) and major depressive episodes. *Journal of Psychopharmacology* 37 (1):61–69. doi:10.1177/02698811221127304.

Jones, G. M., and M. K. Nock. Race and ethnicity moderate the associations between lifetime psychedelic use (MDMA and psilocybin) and psychological distress and suicidality. *Scientific Reports* 12(1):2022 Oct 10 16976. doi:10.1038/s41598-022-18645-3.

Kaasik, H., R. C. Souza, F. S. Zandonadi, L. F. Tófoli, and A. Sussulini. 2021. Chemical composition of traditional and analog ayahuasca. *Journal of Psychoactive Drugs* 53 (1):65–75. doi:10.1080/02791072.2020.1815911.

Kaiser, F. G., A. Brügger, T. Hartig, F. X. Bogner, and H. Gutscher. 2014. Appreciation of nature and appreciation of environmental protection: How stable are these attitudes and which comes first? *European Review of Applied Psychology* 64 (6):269–77. doi:10.1016/j.erap.2014.09.001.

Kaiser, F. G., T. Hartig, A. Brügger, and C. Duvier. 2013. Environmental protection and nature as distinct attitudinal objects: An application of the Campbell paradigm. *Environment & Behavior* 45 (3):369–98. doi:10.1177/0013916511422444.

Kesebir, S. and P. Kesebir 2017. A growing disconnection from nature is evident in cultural products. *Perspectives on Psychological Science* 12 (2):258–69. doi:10.1177/1745691616662473.

Kettner, H., S. Gandy, E. C. Haijen, and R. L. Carhart-Harris. 2019. From egoism to ecoism: Psychedelics increase nature relatedness in a state-mediated and context-dependent manner. *International Journal of Environmental Research and Public Health* 16 (24):5147. doi:10.3390/ijerph16245147.

Lambert, N. M., F. D. Fincham, and T. F. Stillman. 2012. Gratitude and depressive symptoms: The role of positive reframing and positive emotion. *Cognition & Emotion* 26 (4):615–33. doi:10.1080/02699931.2011.595393.

Longo, M. S., B. Bienemann, M. Multedo, M. A. Negreiros, E. Schenberg, and D. C. Mograbi. 2023. The association of classic serotonergic psychedelic use and intention of future use with nature relatedness. *Journal of Psychoactive Drugs* 1–9. doi:10.1080/02791072.2022.2112788.

Lyons, T. and R. L. Carhart-Harris. 2018. Increased nature relatedness and decreased authoritarian political views after psilocybin for treatment-resistant depression. *Journal of Psychopharmacology* 32 (7):811–19. doi:10.1177/0269881117748902.

MacLean, K. A., J. M. S. Leoutsakos, M. W. Johnson, and R. R. Griffiths. 2012. Factor analysis of the mystical experience questionnaire: A study of experiences occasioned by the hallucinogen psilocybin. *Journal for the Scientific Study of Religion* 51 (4):721–37. doi:10.1111/j.1468-5906.2012.01685.x.

Muthukumaraswamy, S. D., A. Forsyth, and T. Lumley. 2021. Blinding and expectancy confounds in psychedelic randomized controlled trials. *Expert Review of Clinical Pharmacology* 14 (9):1133–52. doi:10.1080/17512433.2021.1933434.

Nisbet, E. K., and J. M. Zelenski. 2013. The NR-6: A new brief measure of nature relatedness. *Frontiers in Psychology* 4:813. doi:10.3389/fpsyg.2013.00813.

Noorani, T., A. Garcia-Romeu, T. C. Swift, R. R. Griffiths, and M. W. Johnson. 2018. Psychedelic therapy for smoking cessation: Qualitative analysis of participant accounts. *Journal of Psychopharmacology* 32 (7):756–69 doi:10.1177/0269881118780612.

Nour, M. M., L. Evans, D. Nutt, and R. L. Carhart-Harris. 2016. Ego-dissolution and psychedelics: Validation of the ego-dissolution inventory (EDI). *Frontiers in Human Neuroscience* 269. doi:10.3389/fnhum.2016.00269.

Osório, F. D. L., R. F. Sanches, L. R. Macedo, R. G. Dos Santos, J. P. Maia-de-Oliveira, L. Wichert-Ana, and J. E. Hallak. 2015. Antidepressant effects of a single dose of ayahuasca in patients with recurrent depression: A preliminary report. *Brazilian Journal of Psychiatry* 37 (1):13–20. doi:10.1590/1516-4446-2014-1496.

Palhano-Fontes, F., D. Barreto, H. Onias, K. C. Andrade, M. M. Novaes, J. A. Pessoa, S. A. Mota-Rolim, et al. 2019. Rapid antidepressant effects of the psychedelic ayahuasca in treatment-resistant depression: A randomized placebo-controlled trial. *Psychological Medicine* 49 (4):655–63.

Prayag, G., P. Mura, C. Michael Hall, and J. Fontaine. 2016. Spirituality, drugs, and tourism: Tourists' and shamans' experiences of ayahuasca in Iquitos, Peru. *Tourism Recreation Research* 41 (3):314–25. doi:10.1080/02508281.2016.1192237.

Riba, J., A. Rodríguez-Fornells, G. Urbano, A. Morte, R. Antonijoan, M. Montero, J. C. Callaway, and M. J. Barbanoj. 2001. Subjective effects and tolerability of the South American psychoactive beverage Ayahuasca in healthy volunteers. *Psychopharmacology* 154:85–95.

Riba, J., M. Valle, G. Urbano, M. Yritia, A. Morte, & M. J. Barbanoj. 2003. Human pharmacology of ayahuasca: Subjective and cardiovascular effects, monoamine metabolite excretion, and pharmacokinetics. *Journal of Pharmacology and Experimental Therapeutics* 306 (1):73–83. https://doi.org/10.1124/jpet.103.049882.

Ruffell, S., N. Netzband, W. Tsang, S. Gandy, D. Perkins, A. Halman, D. McHerron, T. Kennedy, E. White, D. B. Terhune, et al. 2023. Ayahuasca–a review of historical, pharmacological, and therapeutic aspects. *Psychiatry and Clinical Neurosciences Reports* 2 (4). doi:10.1002/pcn5.146.

Schlag, A. K., J. Aday, I. Salam, J. C. Neill, and D. J. Nutt. 2022. Adverse effects of psychedelics: From anecdotes and

misinformation to systematic science. *Journal of Psychopharmacology* 36 (3):258–72. doi:10.1177/0269881121106910.

Spruce, R. 1873. On some remarkable narcotics of the amazon Valley and Orinoco. *August Geographic Review* 1 (55):184–93.

Tsang, J. A.2007. Gratitude for small and large favors: A behavioral test. *The Journal of Positive Psychology* 2 (3):157–67. doi:10.1080/17439760701229019.

Valle, M., A. E. Maqueda, M. Rabella, A. Rodríguez-Pujadas, R. M. Antonijoan, S. Romero, and J. Riba, M. À. Mañanas, S. Barker, P. Friedlander. 2016. Inhibition of alpha oscillations through serotonin-2A receptor activation underlies the visual effects of ayahuasca in humans. *European Neuropsychopharmacology* 26 (7):1161–75. doi:10.1016/j.euroneuro.2016.03.012.

van Mulukom, V., R. E. Patterson, and M. van Elk. 2020. Broadening your mind to include others: The relationship between serotonergic psychedelic experiences and maladaptive narcissism. *Psychopharmacology* 237:2725–37. doi:10.1007/s00213-020-05568-y.

Yaden, D. B., S. Barry Kaufman, E. Hyde, A. Chirico, A. Gaggioli, J. Wei Zhang, and D. Keltner. 2019. The development of the awe experience scale (AWE-S): A multifactorial measure for a complex emotion. *The Journal of Positive Psychology* 14 (4):474–88. doi:10.1080/17439760.2018.1484940.