Altered States of Consciousness During Ceremonial San Pedro Use

Arne Bohn, Michiel H. H. Kiggen, Malin V. Uthaug, Kim I. M. van Oorsouw, Johannes G. Ramaekers & Hein T. van Schie

View supplementary material 🗗

Published online: 05 Dec 2022.

Submit your article to this journal 🗗

View related articles 🗗

View Crossmark data 🗗

This article has been awarded the Centre for Open Science 'Open Data' badge.

This article has been awarded the Centre for Open Science 'Open Materials' badge.

This article has been awarded the Centre for Open Science 'Preregistered' badge.

Routledge
Taylor & Francis Group

🔓 OPEN ACCESS ⊕ Check for updates

Altered States of Consciousness During Ceremonial San Pedro Use

Arne Bohn [ID][a]*, Michiel H. H. Kiggen [ID][a,b]*, Malin V. Uthaug [ID][c,d], Kim I. M. van Oorsouw [ID][d], Johannes G. Ramaekers [ID][e], and Hein T. van Schie [ID][a]

[a]Behavioural Science Institute, Radboud University, Nijmegen, The Netherlands; [b]Stevig Specialized and Forensic Care for People with Intellectual Disabilities, Dichterbij, Oostrum, The Netherlands; [c]The Centre for Psychedelic Research, Department of Brain Sciences, Faculty of Medicine, Imperial College, London, UK; [d]Department of Clinical Psychological Science, Faculty of Psychology and Neuroscience, Maastricht University, Maastricht, The Netherlands; [e]Department of Neuropsychology and Psychopharmacology, Faculty of Psychology and Neuroscience, Maastricht University, Maastricht, The Netherlands

ABSTRACT

San Pedro, a mescaline containing cactus, has been used for thousands of years and is currently popular as a psychedelic substance in ceremonial retreats in Europe. The current research investigates the consciousness altering effects of San Pedro. Forty-two participants who joined ceremonial psychedelic retreats in the Netherlands were investigated with questionnaires probing 11 dimensions of altered states of consciousness (11D-ASC), ego-dissolution, mystical experiences, and challenging experiences. Results tentatively demonstrate the status of San Pedro as a psychedelic, revealing deviations from normal waking consciousness on all 11 subscales of the 11D-ASC, moderate scores of ego-dissolution, and a complete mystical experience in two thirds of the participants. Furthermore, a consciousness profile of San Pedro was constructed, which revealed that spiritual experiences are strongly expressed in ceremonial San Pedro use. Furthermore, the San Pedro experience is characterized by low levels of disembodiment, anxiety, impaired control and cognition, transcendence of space, and relatively higher levels of physical distress and grief in case of (incidental) challenging experiences. Finally, graph network analysis indicated two separate networks of positive and negative altered states of consciousness. Possible interpretations of these findings are discussed in relation to the ceremonial setting, sympathomimetic effects of San Pedro's alkaloids and variations in affective valence.

San Pedro, Huachuma, or Echinopsis pachanoi is a psychoactive psychedelic plant from the family of Cactaceae. Native to the South American Andes, San Pedro has a long history of being harvested by indigenous societies, to be consumed as a medical plant sacrament during ceremonial rituals (Jay, 2019). Anno 2022, ceremonial San Pedro use has spread to western countries, where local ceremony providers offer San Pedro to participants for its healing potential, among other reasons (Uthaug, Davis et al., 2021). From research with other psychedelic drugs, we know that the altered states of consciousness generated by psychedelics offer a growing range of therapeutic applications (Garcia-Romeu et al., 2016), as well as psychological risks (Carbonaro et al., 2016). However, to this date, no research has exclusively investigated the psychological effects of ceremonial San Pedro use. In order to fill this hiatus in the literature and to aid the development of psychedelic assisted therapies, the current

---

study presents a first observational attempt to describe the effects of ceremonial San Pedro use on human consciousness.

San Pedro, originally called Huachuma, originates in the highlands of the Andes and has been used ceremonially for religious reasons as well as healing purposes. Archaeologists found evidence for extensive ceremonial use as a holy plant, as well as stone carvings from around 1300 BCE in ruins of the Peruvian *Chavin* culture, which depict humanoid figures holding a San Pedro Cactus (Jay, 2019). In 1571, Spanish administrators noted the consumption of San Pedro by the natives under guidance of a local shaman, and the accompanying Christian missionaries called Huachuma "the plant with which the devil deceived the Indians of Peru in their paganism" (Jay, 2019, p. 25). Nonetheless, after Christianization of South America, ritual consumption has been incorporated into the local Christian belief systems and Huachuma was renamed after "Saint Peter, who holds the keys to heaven" and is "suggestive of the plant's power to open the gates between the visible and invisible worlds" (Heaven, 2010, p. 52). As an integrated part of some modern-day Peruvian subcultures, markets in Peruvian cities like Casma and Trujillo have dedicated sections for selling San Pedro cacti (Jay, 2019). As such, the tradition of ceremonial practice is continued into the present day, and according to Schultes et al. (1992, p. 166f), may be used "to cure sickness, including alcoholism and insanity, for divination, to undo love witchcraft, to counter all kinds of sorcery, and to ensure success in personal ventures." For similar reasons, San Pedro ceremonies are also held throughout European countries such as the Netherlands, Poland, Austria, and Spain, as indicated by websites yielded from top google search queries (for instance see Retreat.guru; Acsauhaya.com; madretierraamor.com). These ceremonies are usually provided by local facilitators who have adapted their own method of guidance, although often inspired by indigenous traditions (Scuro & Rodd, 2015). Surprisingly, even though the history and ritualistic implementation of San Pedro has been studied by anthropologists and ethnobotanists (Dobkin, 1968; Gottlieb, 1977; Heaven, 2010, 2012; Jay, 2019; Schultes et al., 1992), San Pedro has received virtually no exclusive attention in psychological research.

Like other psychoactive cacti, San Pedro cacti contain many alkaloids, most prominent among them is the psychotropic phenylethylamine *Mescaline* (Jones, 2005; Ogunbodede et al., 2010). Mescaline belongs to the class of classical serotonergic psychedelics, whose best-known representatives are LSD, Psilocybin and DMT (Nichols & Barker, 2016). Psychedelic substances can be hallucinogenic and induce so-called altered states of consciousness (ASC), which are typified by changes in the perception of sensory input, reality, sense of self, mood, thoughts, space, and time (Preller & Vollenweider, 2016). Psychedelic-induced ASC may also lead to mystical-type experiences and dissolution of the ego, which may be perceived as transcendental, similar to "peak experiences" (Barrett & Griffiths, 2017; Johnson et al., 2019). There is evidence that psychedelics administered during psychotherapy yield promising results in the treatment of OCD, smoking cessation, alcohol abuse, anxiety concerned with life threatening illness, PTSD, and treatment-resistant depression (Garcia-Romeu et al., 2016). Even in healthy individuals who consume psychedelic substances, there is evidence for positive mental effects (Elsey, 2017; Griffiths et al., 2011; Schmid & Liechti, 2018; Uthaug et al., 2018; Van Oorsouw et al., 2021). Evidence for similar positive effects associated with mescaline use is starting to mount (Agin-Liebes et al., 2021; Uthaug, Davis et al., 2021). The underlying mechanisms are not yet fully understood, but it has been proposed that the temporary alterations in consciousness, specifically the mystical-type experience, may be driving the therapeutic effects (Garcia-Romeu et al., 2014; Johnson et al., 2019; Majić et al., 2015; Van Oorsouw et al., 2022).

Apart from any beneficial or pleasant connotations of ASC induced by psychedelics, a psychedelic experience may also be challenging, due to for example intense bouts of negative affective and somatic states, potentially leading to what is colloquially called a *bad trip* (Barrett et al., 2016; Bienemann et al., 2020; Guthrie, 2021). Challenging experiences can have a traumatic impact and lead to enduring mental illness symptoms, prompting users to seek therapeutic assistance (Carbonaro et al., 2016; Rubin-Kahana et al., 2021). Support and guidance by psychedelic guides (i.e., ceremony facilitators, such as shamans, ceremony leaders or guides) are therefore considered essential in helping participants navigate through personal crises that might surface and prevent the occurrence of prolonged

negative states and adverse mental health effects post-experience (Bravo & Grob, 1989; Winkelman, 2007). In addition to the support provided by the ceremonial framework (or *setting)* also the mind-set (i.e., *set*) of an individual (e.g., personality, history of negative life events, and current mood) is believed to play a central role in the psychedelic experience (Carhart-Harris et al., 2018; Hartogsohn, 2017; Studerus et al., 2011). While the psychedelic guides are part of and shape the setting of the psychedelic experience, they may also influence the set of the participant through mentally preparing them for the experience. As psychedelics are explored for their auxiliary potential to psychotherapy (Davis et al., 2021; Doss et al., 2021; Garcia-Romeu et al., 2016), it is of importance to gain insight to which degree positive and negative experiences are mutually exclusive, and whether certain features of a psychedelic experience could be associated with adverse reactions. Therefore, the current study will include measurements of self-reported adverse reactions during ceremonial consumption of San Pedro and will investigate whether certain induced mental states are associated with adverse reactions.

Although mescaline, has similar identifiable psychological effects as other classical psychedelics such as psilocybin, LSD and DMT (Nichols & Barker, 2016), there is evidence that different psyche-delic drugs induce different physiological responses (Holze et al., 2022; Isbell, 1959), and possibly different ASC (Hirschfeld & Schmidt, 2020; Studerus et al., 2010). While the psychedelic effects in humans are primarily mediated via 5-HT2A receptors (Holze et al., 2021; Preller et al., 2017; Vollenweider et al., 1998), different psychedelic substances show additional unique receptor-binding profiles (Ray & Manzoni, 2010; Rickli et al., 2016; Zamberlan et al., 2018). Mescaline, for instance, has been found to also act on 5HT2C receptors, as well as on adrenergic, cholinergic, and dopaminergic neurotransmitter systems (Cassels & Sáez-Briones, 2018; Dinis-Oliveira et al., 2019; Kovacic & Somanathan, 2009; Nichols, 2004; Trulson et al., 1983). The effects of mescaline typically range between 8 and 12 hours (Uthaug, Davis et al., 2021) and are therefore longer lasting than tryptamines such as Psilocybin and (5-MEO-)DMT (Araújo et al., 2015). Differential pharmacological properties of mescaline may support anecdotal user reports claiming unique subjective effects of mescaline in a supposedly more gentle, euphoric, and bodily/tactile experience (Erowid, n.d; .; PsychonautWiki, n.d.; Sociodelic, 2017), some even reporting it to be a more social psychedelic due to the induction of a sense of confidence, extroversion, and eagerness to talk (Guttmann, 1936; Tripsitter, 2021). While there are several other mescaline containing cacti like Peyote and the Peruvian Torch, San Pedro has the highest mescaline content of up to 5% (Ogunbodede et al., 2010) and the most common form of mescaline consumption (Uthaug, Davis et al., 2021). Furthermore, there is evidence for more (psychoactive) alkaloids in San Pedro, such as tyramine, hordenine, 3−methoxytyramine, lophophine, lobivine, MDPEA, and DMPEA (Bruhn et al., 2008; Gottlieb, 1977), some of which are known to interact with the function of dopamine (Khan & Nawaz, 2016; Miller, 2011; Sotnikova et al., 2010), adrenaline and noradrenaline (Hapke & Strathmann, 1995), and as such could potentially impact various mental functions (Iversen & Iversen, 2007; Wise, 2004). Conversely, through the catechola-minergic activity of both mescaline and other alkaloids, San Pedro may also induce a range of so-called sympathomimetic effects that are typical of phenethylamines, including agitation, alertness, increased heart rate and respiration, and talkativeness (Winstock et al., 2011). Lophophine, lobivine and MDPEA are psychoactive phenethylamines with entactogenic effects (Bruhn et al., 2008) and DMPEA is an inhibitor of monoamine oxidase (Keller & Ferguson, 1977), known to affect mood (Akindele et al., 1970). San Pedro's additional psychoactive alkaloids may explain why anecdotal user reports even claim subjective differences between mescaline-containing cacti (Sociodelic, 2017; Turner, 1994; Zamnesia, n.d.). However, beyond suggestive evidence from neurochemistry and anecdotal reports, there is very little data available on the consciousness altering effects of San Pedro.

In sum, despite a long history of San Pedro use in South America and its recent spread to western countries, there is little research on the effects of San Pedro consumption. The present study presents an observative attempt at describing the consciousness altering effects of San Pedro. Detailing the effects of San Pedro would inform both a large sample of users (Krebs & Johansen, 2013) about the potential subjective and adverse effects of San Pedro in a ceremonial context, and guide future studies interested in comparing subjective effects between psychedelics, which could ultimately benefit clinical

research that is investigating the potential benefits of different psychedelic substances (Johnson et al., 2019).

In the current paper, we report the results of an observational study investigating the effects of ceremonial San Pedro use. Our first aim was to investigate if ceremonial San Pedro consumption induces ASC that differ significantly from what is considered normal waking (i.e. sober) consciousness. Our second aim was to construct a consciousness profile of ceremonial San Pedro use, by determining which of the San Pedro-induced ASC are comparable or different in terms of their average relative strength (for instance, do users of San Pedro report stronger elementary imagery than complex imagery?). Our third aim was to investigate which ASC are co-occurring (i.e. patterns of correlations) during San Pedro-induced psychedelic experiences (for instance, if users of San Pedro report strong experiences of elementary imagery, does this then come with stronger complex imagery?). Given that San Pedro has a long history of consumption with the intent to induce mind-altering effects, we expected that San Pedro would exert strong effects on human consciousness similar to other classical psychedelics. With regard to the second and third aim, we had no specific expectations and analyzed the data to construct a consciousness profile of San Pedro in terms of strength and co-occurrence of ASC.

Methods

Participants

Data were collected as part of a research project (including measurements at baseline, post-ceremony and follow-up at 4 weeks) to investigate psychological and affect changes in association with San Pedro consumption. For the current study only data describing experiences during the ceremony (measured post-ceremony) were analyzed. Over a timespan ranging from July 2019 until March 2020, we collected as many participants as possible who joined a San Pedro ceremony provided by one of four organizations facilitating ceremonies throughout the Netherlands. Participation was voluntary and no incentives were offered for joining the ceremony. Exclusion criteria as implemented by the ceremony facilitators were psychopharmacological medication intake (e.g. SSRI antidepressants or ADHD stimulants), psychopathological afflictions prone to psychotic breaks or delusional thoughts (e.g. bi-polar disorder, schizophrenia or borderline personality disorder), acute drug addiction (e.g. to cocaine or heroin), pregnancy, high or low blood pressure, a history with epileptic seizures, allergic reactions to mescaline cacti, addiction, kidney or/and intestine diseases and diabetes. Exclusion criteria as implemented by the researchers were non-fluency in Dutch, and being less than 18 years of age. To incentivize finishing the follow-up measurement, two 50-euro vouchers were raffled at the end of the follow-up survey. The study was approved by the standing Ethics Review Committee Psychology and Neuroscience of Maastricht University.

A total of 54 people signed up for the study of which 42 participants completed the post-ceremony survey. As some participants skipped the baseline measurements, we collected demographic information for 36 of 42 participants, that was evenly divided over 18 women ($M.age$ = 44.78; $range$ = 31–57; SD = 8.66) and 18 men ($M.age$ = 44.56; $range$ = 32–64, SD = 9.5), all of whom were Dutch residents and selected Europe as their place of origin. Looking at the attained educational degrees of the participants, 14% finished high school (n = 5), 17% got a vocational education degree (n = 6), 45% graduated from a university of applied sciences (n = 16) and 25% obtained a university degree or higher (n = 9). 22% reported to be struggling with affective problems (n = 8; i.e. symptoms of depression or/and anxiety). As for reasons to participate, 19% indicated "Solving problems" (n = 7) as their main motivation, while 61% reported "Insight into oneself" (n = 22) and 19% reported "Other reasons" (n = 7). Furthermore, 94% had previous experience with entheogens (n = 34), of which 11% had exclusively used some form of marihuana (n = 4), while the remaining people had previously used classical psychedelics at least once. Lastly, 67% of the participants reported having no previous experience with San Pedro (n = 24),

compared to 33% who acknowledged having used San Pedro on a previous occasion (n = 12; range = 1–52, median = 1).

Study procedure

Participants first, independently of this study, signed up for a ceremony with one of four participating organizations in the Netherlands that provide guided plant medicine (healing) ceremonies with San Pedro. Subsequently, the organization presented participants with a recruitment letter from the authors, inquiring whether they would, in addition to their ceremony, also like to participate in our study. Upon agreement, interested participants allowed organizations to transfer contact information to the researchers. Consequently, 7 days prior to the ceremony, participants meeting the inclusion criteria were sent a letter of invitation, including a briefing on the goals and methods of this study, and a link to the baseline survey inquiring, among others, about the previously detailed demographics (duration approx. 10 min). Before all surveys, participants were asked informed consent for anonymous collection, processing, and storage of the provided data. Directly after the ceremony, participants received a link to the post-ceremony survey containing a test-battery (see section *Materials*) inquiring, among others, on their experiences during the ceremony (duration approx. 10–20 min). Participants were instructed to fill in the post-ceremony survey as soon as possible, preferably within a 24 h time frame. Debriefing followed after successfully finishing the follow-up measurement at 4 weeks. The set-up of the ceremonies differed between organizations, and sometimes per session (see *Ceremonial context*). The researchers were not involved in the organization of the San Pedro ceremonies.

Materials

Survey data was collected via the online Qualtrics platform (https://www.qualtrics.com). Demographic and background information, as detailed in the participants section, were collected on age, sex, continent of origin, education, previous experience with San Pedro and/or other hallucinogenic substances (including marijuana), motivation for ceremony participation and current psychopathological afflictions. Four psychometric scales were used to explore the effects of San Pedro on human consciousness. Detailed information for each scale is presented in the next paragraphs. All scales were translated from the original English versions to non-validated Dutch versions. Translations were done by one author and double-checked by another author. Scale reliability of each scale was checked by calculating the internal consistency (i.e. Cronbach's alpha or α). For all scales, items are added to a mean total and subscale scores.

The Altered States of Consciousness Rating Scale (11D-ASC)

The 11D-ASC is a 42-item questionnaire investigating alterations in consciousness via 11 subscales. The 11D-ASC is a revised questionnaire which originated in the 5D-ASC (94-items; Dittrich, 1998), and reached its current form after revalidating research using substances with psychedelic properties by Studerus et al. (2010). Items contain statements (e.g. "I felt I was in a wonderful other world"), which can be answered on a continuous scale ranging from "No, not more than usually" (0) to "Yes, much more than usually" (100), where 0 is considered to resemble a sober state. The internal consistency of the subscales ranged from sufficient to excellent: Unity (5 items; α = .90), Spirituality (2 items; α = .88 after removal of 1 of 3 items belong to the scale was, in hindsight, found to incorrectly translated), Blissfulness (3 items; α = .83), Insightfulness (3 items; α = .64), Disembodiment (3 items; α = .82), Impaired control and cognition (7 items; α = .85), Anxiety (6 items; α = .77), Complex Imagery (3 items; α = .76), Elementary Imagery (3 items; α = .85), Audio-visual synesthesia (3 items; α = .87) and Changed Meaning of Percepts (3 items; α = .68).

The Ego-Dissolution Inventory (EDI)

The EDI (Nour et al., 2016) is an 8-item questionnaire, which investigates ego-dissolution, a key characteristic of peak experiences. Items contain statements (e.g. "I experienced a dissolution of my 'self' or 'ego'") that can be answered on a continuous scale ranging from "No, not more than usually" (1) to "Yes, I experience this completely/entirely" (100). The internal consistency was excellent ($\alpha = .90$).

The Challenging Experience Questionnaire (CEQ)

The CEQ by Barrett et al. (2016) is a 26-item questionnaire, consisting of a main scale and 7 subscales, which investigates whether an experience was perceived as challenging, as a measure of adverse reactions toward psychedelics, both in affect and cognition. Items contain statements (e.g. "Isolation and loneliness") that can be answered on a six-point Likert scale ranging from "None; not at all" (0) to "Extreme (more than any other time in my life)" (5). Challenging experience scores were calculated according to the instructions, by dividing the aggregated score of all items by 125 (e.g. the sum score that would be obtained if all items were answered with "Extreme"). Subscales were calculated similarly, by dividing the obtained score by the maximum score. The internal consistency of the (sub)scales was excellent: Challenging experience (25 items; $\alpha = .96$; 1 item was not included in the survey due to a programming mistake), Grief (6 items; $\alpha = .90$), Fear (4 items; $\alpha = .90$; missing item belonged also to this subscale), Death (2 items; $\alpha = .91$), Insanity (3 items; $\alpha = .74$), Isolation (3 items; $\alpha = .82$), Physical distress (5 items; $\alpha = .85$), Paranoia (2 items; $\alpha = .90$).

The Mystical Experience Questionnaire (MEQ)

The MEQ (MacLean et al., 2012) is a 30-item questionnaire, consisting of a main scale and four subscales. The main scale investigates the occurrence of a mystical-type experience, an important predictor that is hypothesized to be one of the responsible mechanisms for the clinical outcomes of psychedelics (Yaden & Griffiths, 2020). Items contain statements (e.g. "Experience of oneness or unity with objects and/or persons perceived in your surroundings"), which can be answered on a six-point Likert scale ranging from "None; not at all" (0) to "Extreme (more than any other time in my life)" (5). Mystical Experiences were calculated according to the instructions, by dividing the aggregated score of all items by 30, so that the sum scores can be interpreted on the original scale. Subscales were calculated similarly, by dividing the obtained score by the number of items in the scale. The internal consistency of the (sub)scales was excellent: Mystical Experience (30 items; $\alpha = .97$), Mysticality (15 items; $\alpha = .96$), Positive mood (6 items; $\alpha = .91$), Transcendence of time and space (6 items; $\alpha = .90$) and Ineffability (3 items; $\alpha = .87$).

Ceremonial context

The following information was not systematically collected and is based on personal observations of one of the researchers who visited multiple data collection sites (2019–2021). The set-up of the ceremonies (e.g. location, group size, presence and style of music, rituals, preparatory activities etc.) and the proceedings (screenings, briefings, instructions, preparatory recommendations, etc.) varied over the participating organizations, but could also differ within organizations. We nevertheless deemed an elaborate and detailed description of the context in which San Pedro was consumed relevant. Firstly, to convey a better understanding of what constitutes a San Pedro ceremony. Secondly, to provide insight into how different factors within and surrounding that what is considered a ceremony could be at play.

The four participating organizations facilitated recruitment, including precautionary screening, and a supportive ceremonial setting within a safe and restricted indoor or outdoor area. All participants were screened before participating, as they were required to fill in questionnaires provided by the organization, inquiring, among others, on previous and/or acute mental health issues, medical conditions, and reasons for participating. Facilitators were allied with medical experts (e.g., general

practitioner) to consult on potential contraindications hazardous to physical and/or mental well-being, as to ensure safety of the participants.

In the weeks and days prior to the ceremony, participants were recommended to prepare for the psychedelic journey by restricting diet (e.g. fasting, vegan diets, minimizing consumption of processed food, or salt and sugar intake) and refraining from sex, digital media (e.g., television, social media, web browsing) and drug consumption (incl. alcohol and certain psychopharmacological medication), and to engage more in reclusive activities such as reading, walking in nature and meditation.

Each organization had its own way of preparing San Pedro, varying from boiling dried San Pedro chips with water into a concoction, offering powdered San Pedro on the spot to be mixed with apple juice or by cooking the meat of fresh cacti into a liquid substance. Dosages were determined by the ceremony leader and varied per person; often initial dosages were equal among all participants, but as the ceremony went along the leader offered voluntary additional dosages as deemed adequate. Initial effects were noticeable after 1 to 2 hours, although this may have varied per participant. The complete length of intoxication varied between 10 and 17 hours, depending on consumption of additional doses.

Organizations were represented at the ceremony through teams consisting of a ceremony leader and one or more guides, depending on the number of participants in the ceremony. Group sizes ranged from 7 to 20 people. During the ceremony the organizations took care of comfort (e.g., comfortable chairs/couches), entertainment (e.g., recorded, or live music, including instruments to be played with), guidance (e.g., emotional support), food (e.g., fruit, nuts, chocolate) and beverages (tea and water). Additionally, some organizations also offered people to participate in shamanic rituals during the ceremony, such as smoking the *Mapacho* tobacco leaf (see Sharrock, 2018) or ritualized blowing of *Rapé snuff* (Stanfill et al., 2015) up the nostril cavities, which can supposedly help people move forward from difficult phases in their psychedelic journey. All organizations set up a fire in a pit or stove and an altar in the middle of the ceremonial space, containing shamanic ornaments (e.g., rattles, feathers, incense) and items with spiritual and/or sacramental meaning (e.g., incense, candles, mineral stones). Participants could also position meaningful personal items (e.g., a picture of a loved one) at the altar.

Directly before San Pedro servings were shared, some ceremony leaders described the effects of San Pedro, and the energy of San Pedro as The Grandfather, a masculine energy that may include animal spirits, such as the Spirit of the Jaguar, the Kolibri and the Condor. In terms of physical effects, ceremony leaders indicated that San Pedro generally (but not always) allows the user to be more active, physically, and socially, through engaging in, for example, dance, talks and music making, as compared to other psychedelics. Moreover, the ceremony leaders claimed that the intensity of effects of San Pedro comes in waves slightly digressing over time, accordingly, giving the impression at times that one is sobering up and the most significant part of the experience has waned, whereas in fact psychedelic effects may resurface, drawing people back into intense alterations of consciousness. Furthermore, the ceremony leaders noted that some adverse effects could come up, such as nausea, vomiting (purging), tremors, heart palpitations, sweating, headaches, and sudden bouts of feeling very cold or warm. They also warned that at the end of the ceremony while the effects of San Pedro are wearing off, sleeping could be difficult, because of restlessness, anxiety, visual hallucinations, or intense dreaming. Participants were also told that they might experience slight headaches during this period.

Data-analysis

First, to investigate our aims, we aggregated the data for all four questionnaires into the according subscales. Four CEQ item responses were missing and accounted for in the average subscale scores of the respective participants. No other missing values were present in the data set.

To investigate the first aim, whether ceremonial San Pedro consumption induces ASC that differ significantly from normal waking consciousness, we conducted one sample *t*-tests for the subscales of the 11D-ASC and EDI to test whether they differ from 0, as both questionnaires assume 0 to be the sober state. We did not include CEQ and MEQ values here, as the phrasing of these questions did not

ask participants to compare it against a sober state. Then, to answer our second aim, to construct a consciousness profile of San Pedro-induced ASC, we ran an ANOVA to compare the scores of the 11D-ASC subscales by pairwise comparison and applied Bonferroni adjustments to correct the *p*-values for multiple comparisons. We included the EDI in this analysis, as it utilizes the same range of scores as the 11D-ASC. Similar separate analyses were run for the CEQ and MEQ scores. Finally, to answer our third aim to determine which ASC co-occur during San Pedro-induced psychedelic experiences, we conducted a correlation analysis including sum scores of ASC, EDI, CEQ and MEQ subscales using pairwise complete observations and calculated Pearson's correlation coefficients, also with a Bonferroni correction applied for multiple comparisons. Subsequently, the correlations were visualized via a matrix using the *corrplot* function (version 0.90; Wei & Simko, 2021) in R (version 4.1.1; R Core Team, 2020) and via a Network Analysis using MATLAB's *graph* function in MATLAB R2017a (MATLAB, 2017). The matrix plot allows identifying significance and magnitude and orders the variables in rows and columns based upon hierarchical clustering. The network analysis plots graphs with undirected edges, and graphically groups them based on a matrix of significant correlations. The network analysis visualizes the significant correlations between subscales as solid lines connecting scales and spatially arranges scales based on the pattern of correlations between each individual scale and all other scales. Scales that have the largest number of significant correlations with other scales are placed centrally in the cluster. A cluster refers to a group of points in the network analysis graph that is connected in the form of a network structure. These clusters do not necessarily indicate a causal network, as is sometimes the case in genetics or clinical psychology (Borsboom & Cramer, 2013), but reflect a measure of interrelations between the different subscales that were used to describe the San Pedro experience.

Results

The effect of San Pedro on human consciousness

To answer our first aim, whether ceremonial San Pedro consumption induces ASC that differ significantly from normal waking consciousness, we report the results of one sample *t*-tests for the 11D-ASC and the EDI. Furthermore, we report the descriptives of the MEQ, and CEQ.

11D-ASC

All mean scores on the 11 subscales of the 11D-ASC differed significantly from zero (See Table 1), which indicates that participants experienced ASC for each of the 11 dimensions included in the 11D-ASC questionnaire (see Figure 1).

Table 1. Descriptive information and results of one-sample t-test of the 11D-ASC and EDI (N = 42).

Scale	M	SD	t-value	p-value*	skew.se2**	Min-max
11D-ASC						
Experience of unity	53.64	31.07	11.19	<.001	−.05	1-100
Spiritual experience	63.13	33.00	12.40	<.001	−.93	1.5-100
Blissful state	50.98	30.03	11.00	<.001	−.36	0–99.6
Insightfulness	51.72	26.06	12.86	<.001	−.30	1-100
Disembodiment	22.60	24.19	6.05	<.001	1.20	0–76.33
Impaired Control and Cognition	21.83	20.43	6.92	<.001	1.45	0-80
Anxiety	10.86	13.99	5.03	<.001	2.63	0–56.67
Complex Imagery	45.24	30.95	9.47	<.001	.24	0-100
Elementary Imagery	43.75	33.86	8.38	<.001	.09	0-100
Audio-visual synesthesia	36.69	32.56	7.30	<.001	.60	0–96.67
Changed meaning of percepts	45.94	28.44	10.47	<.001	−.79	1-100
Ego-dissolution Inventory	47.85	26.17	11.85	<.001	−.77	2.38–98.62

* This *p*-value displays the significant difference from zero, obtained by a one-sample *t*-test.
** skew.2se values above 1 or below −1 signify abnormality of the distribution due to outliers.
The table presents an overview of the results from one-sample *t*-tests, including means (M), standard deviations (SD), *t*-values, significance values (*p*-value), skewness of distribution (skew.se2), minimum and maximum obtained values (Min-Max). In Table S1 (see supplementary online materials), we report the data of the 11D-ASC scale in a different format, namely the 5D-ASC and 3D-OAV scales that collapse the information in the 11D-ASC in five and three factors, respectively.
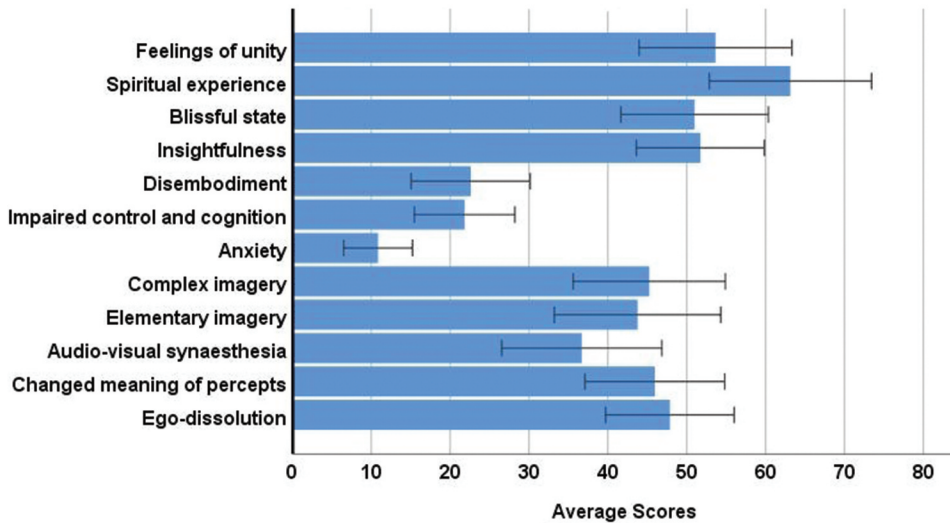
Figure 1. Altered states of consciousness as measured with the 11D-ASC and EDI associated with ceremonial San Pedro use. Horizontal bar chart of mean scores of the 11D-ASC subscales and EDI scale revealing significant differences from the sober state (first study aim; all 11D-ASC subscales and the EDI were statistically different from 0, i.e. the sober state) and the consciousness profile of ceremonial San Pedro use (second study aim; see the main text for the statistical differences between subscales). Error bars indicate the 95% confidence interval. Figure S1 in the online supplementary materials displays a radar chart of the same 11D-ASC subscales without Ego-dissolution. Radar graphs have been used in other research on ASC and allow for quick visual comparison between different substances.

EDI

Participants' average scores on the EDI were found to be significantly different from zero (see Table 1), indicating that participants' self-reported level of ego-dissolution during the ceremony was significantly higher than during normal waking consciousness. On average, the San Pedro experience appears to be characterized by a medium level of ego-dissolution ($M = 47.85$, $SD = 26.17$).

MEQ

Twenty-six Participants (62% of the total sample) were classified with a "complete mystical experience," by having a total score higher than 3.0 (60% of the maximum score; cf. Griffiths et al., 2006). See *Table 2* for the descriptive information on the MEQ scores and the CEQ scores.

Table 2. Descriptive information of the MEQ and the CEQ (N = 42).

Scale	M	SD	skew.2se*	Min-Max
Challenging Experience Questionnaire	.20	.19	2.32	0-.90
Fear	.15	.23	2.70	0-1
Grief	.29	.26	1.42	0-1
Physical distress	.28	.23	1.21	0-.92
Insanity	.11	.18	3.25	0-.87
Isolation	.16	.20	2.05	0-.087
Death	.10	.24	3.51	0-1
Paranoia	.08	.18	3.82	0-.8
Mystical Experience Questionnaire	3.15	1.14	−.87	.23-4.8
Mystical	3.29	1.25	−1.18	0-5
Positive mood	3.25	.126	−1.15	0-5
Transcendence of space and time	2.58	1.31	.066	0.5-5
Ineffability	3.37	1.29	−.917	0-5

* skew.2se values above 1 or below −1 signify abnormality of the distribution due to outliers
The table presents an overview of the descriptive information from the Challenging Experience Questionnaire and Mystical Experience Questionnaire, including means (M), standard deviations (SD), skewness of distribution (skew.2se), minimum and maximum obtained values (Min-Max).

CEQ

San Pedro evoked a relatively low overall rating of "challenging experience," when taking the mean score and the maximum scale scores in consideration. Furthermore, on a participant level, four participants had scores that indicated a slight to moderately "challenging experience." Moreover, one participant had a moderate to strong challenging experience, and one participant was found to have experienced a strong to extremely challenging experience (see Figure S3).

Constructing a consciousness profile of San Pedro induced ASC

Our second aim was to construct a consciousness profile of San Pedro-induced ASC, via within-subjects ANOVA Bonferroni corrected pairwise comparisons of the scores on the 11D-ASC subscales.

11D-ASC and EDI

Within-subjects ANOVA ($F(11, 31) = 10.156$, $p < .001$, $\eta_p^2 = .783$) indicated that there were significant differences among the ASC subscales and the EDI. Subsequent pairwise comparisons are presented in supplementary Table S3. Participants' scores were highest for *Spiritual experience* (above 63), see Figure 1. A group of subscales with medium scores (between 43 and 54) was found to include *Experience of unity*, *Blissful state*, *Insightfulness*, *Complex imagery*, *Elementary imagery*, *Changed meaning of percepts* and *Ego-dissolution*. Scores on these latter subscales were not statistically different from each other. Scores on *Spiritual experiences* however differed from a selection of subscales in this latter group, in particular *Complex imagery* and *Changed meaning of percepts*. A second group of subscales with low scores (ranging between 10 and 23) was found including *Disembodiment*, *Impaired control and cognition* and *Anxiety*. Scores on the subscales in this latter group were found to differ statistically from all subscales in the previously described group with medium scores. Within the group with low scores, *Anxiety* was scored significantly lower than *Impaired control and cognition*. Finally, scores on the *Audio-visual Synesthesia* subscale (37) were found to be somewhere in between the two groups. *Audio-visual synesthesia* scores were significantly higher than all subscales in the group with low scores, but significantly lower than a selection of subscales in the group with medium scores, in particular *Experience of Unity* and *Insightfulness*.

MEQ

Repeated-measures ANOVA ($F(3, 39) = 7.786$, $p < .001$, $\eta_p^2 = .375$) indicated that there were significant differences between the four MEQ subscales. Pairwise comparisons are presented in supplementary Table S3. Transcendence in time and space was found to be significantly different from all other scales, but no further differences between pairs of scales were found to be significant.

CEQ

Repeated-measures ANOVA ($F(6, 36) = 11.603$, $p < .001$, $\eta_p^2 = .659$) indicated significant differences between the 7 subscales of the CEQ. Pairwise comparisons between CEQ subscales are presented in supplementary Table S4. *Grief* and *Physical distress* were most pronounced and significantly different from the rest, but not from each other. *Fear, Insanity, Isolation, Death* and *Paranoia* were not significantly different from each other.

Co-occurrence of ASC during San Pedro-induced psychedelic experiences

Our third aim was to determine which ASC are co-occurring during San Pedro-induced psychedelic experiences. To this end we constructed a correlation matrix including all correlations between subscales and conducted a Network Analysis. In both analyses we identified two clearly separate clusters in the San Pedro Experience (see Figures 2 and S3). The first cluster consisted of the four subscales of the Mystical Experience Questionnaire (*Mysticality; Positive mood; Transcendence of time and space; Ineffability*), the EDI, and several ASC subscales (*Experience of unity*, *Spirituality*,
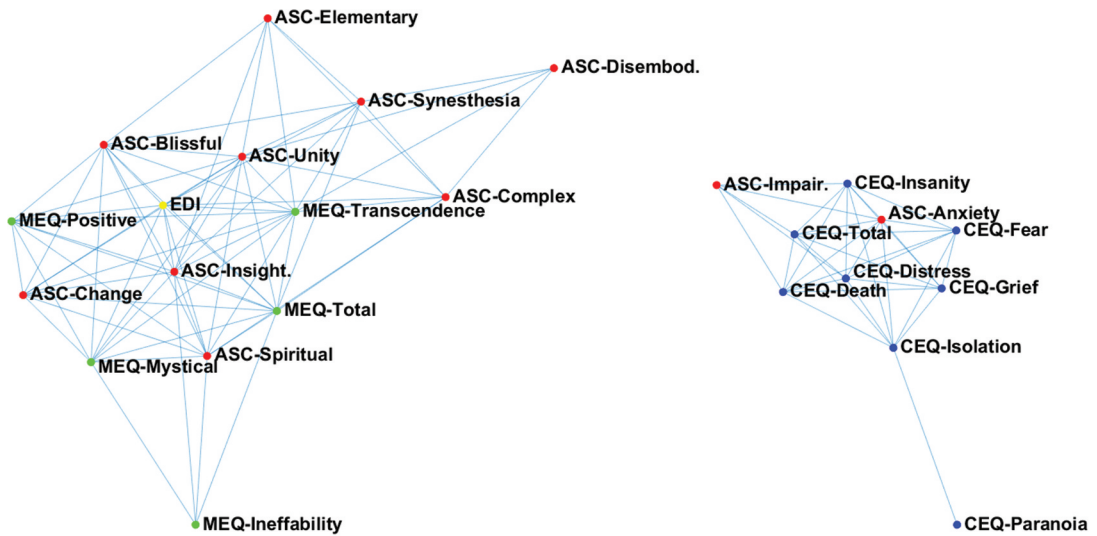
Figure 2. Network analysis graph. The graphical result of the network analysis. Each node represents either a subscale or total score of our measurements (Red = 11D-ASC, yellow = EDI, green = MEQ, blue = CEQ). Lines represent significant correlations corrected for multiple comparisons. No information can be deduced from distance and angle between two nodes. For further explanation see method and result section. Some variables were abbreviated among the 11D-ASC (Unity = Feelings of Unity; Spiritual = Spiritual Experience; Blissful = Blissful state; Insight. = Insightfulness; Disembod. = Disembodiment; Impair. = Impaired control and cognition; Elementary = Elementary Imagery; Complex = Complex Imagery; Synesthesia = Audio-visual synesthesia; Change = Changed meaning of percepts) and the MEQ (Positive = Positive Mood; Transcendence = Transcendence in time and space) and the CEQ (Distress = Physical distress).

Blissfulness, *Insightfulness*, *Disembodiment*, *Elementary imagery*, *Audio-visual synesthesia*, *Complex imagery* and *Changed meaning of percepts*). The other cluster consisted of all CEQ subscales and a selection of ASC subscales (*Anxiety*, *Impaired control and cognition*). There were no significant correlations between nodes in the separate clusters following correction for multiple comparisons.

Discussion

The current study investigated the effects of ceremonial San Pedro use on participants' self-reported states of consciousness as reflected in 11 dimensions of ASC, ego-dissolution, mystical experiences, and challenging experiences. In the consecutive discussion, we will first discuss the results of the analyses for each of the three successive aims. Subsequently, we will discuss the potential influence of the ceremonial setting, and limitations and directions for future research, before reaching a conclusion.

The effect of San Pedro on human consciousness

The first aim of this study was to investigate whether consumption of San Pedro induces any changes in consciousness beyond normal waking consciousness as measured with the four instruments, 11D-ASC, EDI, MEQ and CEQ.

11D-ASC

Results showed that all 11D-ASC subscales differed from zero, indicating that participants' self-reported state of consciousness was significantly altered following ceremonial San Pedro use and clearly distinct from the sober state. This finding suggests that ceremonial San Pedro use

tends to affect users' consciousness in a broad manner, by impacting multiple phenomenological aspects of consciousness. This property is shared by many psychedelics (Carhart-Harris et al., 2016; Holze et al., 2021, 2022; Liechti et al., 2017; Studerus et al., 2010) and supports the classification of San Pedro as a psychedelic plant. It should be noted, however, that the current observational study design does not allow us to separate the influence of the ceremony from the consciousness altering effects (see *The potential influence of the ceremonial setting* for a more extensive discussion).

EDI

Ego-dissolution was significantly different from zero in a one sample *t*-test, indicating that the ceremonial San Pedro experience was characterized by a state of ego-dissolution that differs from the normal, sober state of mind in most participants. Comparable findings were reported by Uthaug, Davis et al. (2021; M = 48; SD = 26)[1] in a large-scale retrospective survey study (N = 452) investigating naturalistic use of mescaline, including (but not limited to), ceremonial San Pedro consumption. The findings on the EDI further corroborate the classification of San Pedro as a psychedelic substance and suggest that San Pedro presents no exception to the close relationship that has been noted between the consumption of psychedelics and the state of ego-dissolution (Barrett & Griffiths, 2017; Letheby & Gerrans, 2017; Nour et al., 2016). Again, it should be noted that these conclusions require further confirmation by experimental studies that control for the possible influence of the ceremonial setting.

MEQ

Analysis of the MEQ indicated that roughly two out of three participants (62%) satisfied the criteria for a complete mystical experience (60% of the total score), demonstrating the mystical character of a San Pedro experience in a ceremonial setting. Of interest to note, although bound to the same limitations as mentioned in the previous two paragraphs, Uthaug, Davis et al. (2021) also reported near similar results for mescaline and San Pedro (M = 3.2 SD = 1.1), corroborating the potency of (ceremonial) San Pedro use to induce a complete mystical experience.

CEQ

We also investigated to what degree the ceremonial consumption of San Pedro evokes challenging experiences. Our findings suggested relatively low levels of challenging experiences for the average participant in the current study, as the mean value of .20 (SD = .19) represents an average response of "so slight I cannot decide" across all items included in the CEQ questionnaire. At the level of individual participants, we found that two out of 42 participants felt more than moderately challenged during the San Pedro ceremony, with one participant scoring between "moderate" and "strong" on the CEQ, and another participant scoring between "strong" and "extreme (more than ever before in my life)". These findings suggest that for most participants (95%) in the current sample the San Pedro experience was not particularly challenging, but that a small percentage of participants experienced moderate to extreme negative effects. Uthaug, Davis et al. (2021) also included measures of challenging experiences for mescaline in general (M = 0.12; SD = 0.12) and for San Pedro specifically (M = 0.14; SD = 0.14).[2] The current results further add to the evidence that mescaline consumption (here in the form of San Pedro, in the context of a ceremony) entails a low prevalence of challenging experiences.

Although the current observational findings are subject to various limitations, the results discussed above provide first tentative evidence that San Pedro used in the context of a ceremony induces widespread altered states of consciousness, ego-dissolution, and mystical states, at levels comparable with other mescaline containing psychedelics (e.g. Uthaug, Davis et al., 2021). Furthermore, like other psychedelics (Carbonaro et al., 2016; Schlag et al., 2022), a small proportion of participants report negative emotional experiences to be part of San Pedro's consciousness altering effect.

---

[1]Adjusted for scale differences.
[2]Adjusted for scale differences.

A consciousness profile of the San Pedro experience

The second aim of this study was to construct a consciousness profile of the San Pedro experience by quantifying and comparing the average scores across subscales of the 11D-ASC and EDI, as well as the MEQ and CEQ.

11D-ASC and EDI

The dimension of the 11D-ASC that was most strongly altered was *Spiritual experience*. In agreement with this finding, archeological records from the Andes region (Carod-Artal & Vazquez-Cabrera, 2006; Samorini, 2019; Torres, 1995), suggest that San Pedro may have functioned as a historical catalyst among the native inhabitants of Peru, effectuating the start of institutionalized religious worship of deities (De Rios, 1977; Glass-Coffin, 2010; Millière et al., 2018). Today's users of psychedelics also seem more likely to develop spiritual interests following mystical experiences induced by psychedelics (Aday et al., 2020; Móró et al., 2011). However, it should be considered that the current findings were obtained in the context of a ceremonial setting, which included various spiritual elements (See *Ceremonial context* under Methods) that may have contributed to the relatively high scores on the spirituality dimension of the 11D-ASC. In accordance with this view, research has found that contextual factors such as set and setting, including individual expectations, intentions, and preparations prior to psychedelic consumption, as well as the physical, social, and cultural setting in which the consumption takes place, may exert strong influences on individual experiences accompanying drug consumption (Hartogsohn, 2016). This is supported by findings of Uthaug, Mason et al. (2021) who did not find differences between their placebo and ayahuasca group in their reports of *Spiritual Experience*, suggesting that the ceremonial setting induced part of the ASC.

Further, ceremonial San Pedro use appears to induce relatively little *Anxiety*, *Disembodiment* and *Impaired control and cognition*. While low anxiety mirrors the low incidence of challenging experience, reports of low disembodiment and impaired control and cognition could reflect the sympathomimetic effects that are characteristic of phenethylamines (Cassels & Sáez-Briones, 2018; Zamberlan et al., 2018) and San Pedro's adrenergic (Hapke & Strathmann, 1995) and entactogenic alkaloids (Bruhn et al., 2008) that stimulate arousal and bodily activation. This hypothesis fits with the observations that ceremony facilitators and attendees describe the San Pedro experience on multiple occasions as a gentle, physically grounding and a down-to-earth experience. Dinis-Oliveira et al. (2019, p. 190) report a comparable experience in a user who found him/herself "weighted down by some strange gravitational force". These observations are furthermore matched by websites that collect and summarize user reports of various psychedelics (Microdosinginstitute, n.d.; PsychonautWiki, n. d.) where the use of mescaline is associated with (a greater) emphasis on bodily and tactile sensations and sense of control.

Finally, San Pedro users rated ego-dissolution at medium levels of intensity. It is worth noting that ego-dissolution as a construct has been suggested to be broader than a simple unidimensional concept, as the loss of self-awareness can occur at multiple levels such as narrative self-loss, loss of body ownership, loss of bodily awareness and loss of self-location (Barrett & Griffiths, 2017; Letheby & Gerrans, 2017; Millière et al., 2018). Sympathetic nerve stimulation may therefore also constrain the loss of bodily self-representations, which is interesting considering that other phenethylamines such as MDMA and d-amphetamine have produced similar levels of ego-dissolution and disembodiment as San Pedro (Holze et al., 2020). However, it must be noted that the reported values of ego-dissolution following psychedelic consumption vary considerably between studies (Holze et al., 2020; Uthaug et al., 2018; Van Oorsouw et al., 2021), and were found not to differ from a placebo in one study (Uthaug, Mason et al., 2021). Thus, any comparison of ego-dissolution between substances should be considered preliminary before investigated in future research by appropriate designs, including direct comparisons among multiple substances, doses, and settings, to disentangle how sympathomimetic effects may influence psychedelic-induced ego-dissolution.

MEQ

Among the factors of a Mystical Experience, *Transcendence in time and space* was scored significantly lower than the factors *Mystical*, *Positive mood* and *Ineffability*. On closer scrutiny, we separated the items of the MEQ inquiring about time versus those inquiring about space. We found that in particular *Transcendence of space* was scored significantly lower than the other factors included in the MEQ. Considering that our experience of space depends on sensorimotor structures that are involved in the construction of body awareness (Millière et al., 2018), lower scores on *Transcendence of space* items may also be explained by the hypothesized sympathomimetic effects of San Pedro. More specifically, heightened physical awareness associated with San Pedro may root one's sense of presence in the current physical environment, preventing spatial self-transcendence.

CEQ

The pairwise comparisons between the different challenging experiences suggested that for those participants who encountered a challenging experience following San Pedro consumption, *Grief* and *Physical distress* were most prominent while *Fear, Insanity, Isolation, Death*, and *Paranoia* were less often reported. The reason why grief may be relatively pronounced in our sample may have to do with the therapeutic nature of the ceremonies and the way the ceremonial guides invite people to explore autobiographical experiences involving loss and emotional pain to find relief and spiritual healing (Gorman et al., 2021; Healy, 2021; Wolff, 2020). Although the other categories could similarly be featured in a therapeutic process, the items that make up *Grief* comprise a larger range of potentially distressing experiences (i.e., sadness, grief, despair, crying and emotional suffering). The *Grief* measurement as such seems to cover a greater portion of the negative human experience. The finding of relatively high *Physical distress* is interesting in the light of relatively low disembodiment, as both might be related to the sympathomimetic effects of some of San Pedro's alkaloids. Hordenine, for instance, may increase heart rate and respiration frequency (Dinis-Oliveira et al., 2019) and mescaline, as a phenylethylamine, is known for activating the sympathetic nervous system through adrenergic and dopaminergic pathways (Kovacic & Somanathan, 2009). Activation of the sympathetic nervous system heightens bodily awareness and could thereby enhance appraisal of physical reactions (Barile, 2019; Hoehn-Saric & McLeod, 1988; Schulz & Vögele, 2015).

Taken together, the consciousness profile of ceremonial San Pedro use seems to be characterized by relatively strong spiritual experiences, and low incidence of challenging experiences. Furthermore, we hypothesize that our results of relatively low disembodiment, low transcendence of space, medium ego-dissolution, a high retainment of control and cognition, and high physical distress in case of (incidental) challenging experiences, may reflect activation of the sympathetic nervous system that is known to accompany some of San Pedro's alkaloids.

Co-occurrence of ASC during San Pedro-induced psychedelic experiences.

The third aim of this study was to investigate to what extent induced ASC were co-occurring during the San Pedro ceremony. The resulting correlation matrix and network analysis revealed two clusters of altered states:

The first cluster, graphically centered around ego-dissolution (see Figure 2), was interpreted to represent desirable states that are often anticipated with the consumption of psychedelics (Olson et al., 2020). The centering of the cluster around ego-dissolution suggests that ego-dissolution was strongly associated with mystical experiences and desired altered states of consciousness during the ceremonial use of San Pedro. The finding that ego-dissolution seems to play a central role in the San-Pedro experience corroborates previous suggestions that ego-dissolution may be central to any psychedelic or mystical experience (Barrett & Griffiths, 2017; Letheby & Gerrans, 2017; Nour et al., 2016).

Next to the positively valenced cluster, a second cluster was found, which appears to reflect undesirable or unpleasant states evoked by ceremonial San Pedro use. Interestingly, the correlations in this network seem to suggest that the experience of a negatively valenced state increases the likelihood of experiencing more negative states. One possible way to look at this finding is that

individual differences in mood or affective valence during the ceremony may influence the type of experiences that individuals encounter and report (Russell, 2003). Negative mood may profoundly bias one's attention, perception, autobiographical memory and processing of social stimuli (Phelps, 2006), and influence one's judgment, reasoning, and decision making (Blanchette & Richards, 2010) in a negative direction. In other words, individuals who are in a negative mood may interpret various experiences during a ceremony more negatively. This may result in a downward spiral of negative thoughts and feelings.

Interestingly, there was no significant negative correlation between any of the positive and negative subscales across both clusters of the network analysis. It could have been the case, for instance, that the more anxiety-inducing an experience was, the less blissful it would have been perceived. However, this was not the case in our data. The separation between the two clusters (Figure 2) and a follow-up analysis to map the relationship between the occurrence of mystical (MEQ) and challenging (CEQ) experiences (see supplementary Figure S3) suggests that the two sides of the San Pedro experience, i.e., positively, and negatively valenced experiences, are not mutually exclusive in this sample. Future research may investigate how positive and negative experiences are expressed over time, considering that many psychedelic trips span over several hours.

The potential influence of the ceremonial setting on the reported effects

Beyond the mentioned potential influences of the ceremonial setting on our results, there are several additional factors that are worth considering. Especially the influence of the facilitator's practicing style and the structural properties of the ceremony, such as group size, interactions between participants and the preparatory and integrative activities surrounding the ceremony, deserve further elaboration (Carhart-Harris et al., 2018; Hartogsohn, 2017; Winkelman, 2007).

As this study measured the ASC during naturalistic ceremonial San Pedro consumption, ASC cannot solely be attributed to San Pedro but may additionally reflect influences of the ceremony on the mind-set of the participant. Hartogsohn (2016) suggests that the set & setting may induce placebo ASC and influence the psychedelic trip. Along the same lines, Olson et al. (2020) found that a small percentage of participants reported profound ASC following consumption of a placebo psychedelic. Furthermore, participants can experience ASC in religious, shamanic, or cultural ceremonies that do not involve psychedelics, through purposefully participating in chanting, dancing or drumming (Jilek, 1982; Polito et al., 2010; Thomason, 2010). Additionally, fewer mystical experiences were found in some controlled studies using an academic laboratory setting instead (Holze et al., 2022; Liechti et al., 2017). Consequently, it is hard to distinguish the drug effects from the contextual effects in the measurements of ASC as obtained by this study.

Likewise, previous research has found that ceremonial settings may have an influence on perceived challenges, as administering psychedelics in a structured, supportive and safe setting induced higher mystical experiences while generating lesser challenging experiences (Sepeda et al., 2020). Traditionally-led ceremonies conducted within indigenous societies may build upon preserved old cultural knowledge to reduce the risks and challenges associated with consumption of plant medicines (Fotiou, 2020). Such properties include preparation and integration strategies (Dorsen et al., 2019), social belongingness in group settings (Carhart-Harris et al., 2018; Kettner et al., 2021), and choice of music (Strickland et al., 2020). Similarly, ceremonies in the current study were led by experienced facilitators who helped participants to prepare their body and mind for the ceremony days in advance and supported participants in various ways (e.g. guidance, rituals, music, atmosphere, safety) throughout the ceremony, which may have helped participants to navigate through challenging phases and reach insights (e.g. Winkelman, 2007). More recent qualitative work among ayahuasca ceremony attendants has also shown the importance of setting elements, such as feeling comfortable in the group, leadership, and physical comfort, in helping to reduce challenging experiences and increasing mystical experiences (Pontual et al., 2022). Future research should further disentangle how the various elements of guided settings surrounding San Pedro use affect challenging and mystical experiences.

Further, San Pedro ceremonies in this study consisted of varying group sizes and often multiple guides. The effect of group size on the psychedelic ceremony plays partly into the experience of *communitas*, which is defined as a sense of intense togetherness and shared humanity (Haidt et al., 2008). Communitas has been shown to correlate with social connectedness and wellbeing after psychedelic experiences (Kettner et al., 2021). Hence, considering the social nature of ritual ceremonies (Watson-Jones & Legare, 2016), the social aspect of any ceremony and its effect on the subjective experience of participants, must not be underestimated.

Further limitations & future directions

Beyond the limitations mentioned earlier, several additional limitations can be pointed out that are concerned with the current observational study design. One limitation of the current study is that it did not include a placebo control condition with which to compare the ASC that accompany ceremonial San Pedro use. It should be noted though that the current study design asked participants to rate their mental state during the San Pedro ceremony relative to their normal (i.e. sober) waking consciousness. Other limitations of this study concern the sample size and the number of organizations included. Considering that our study is the first to systematically map the ASC that accompany ceremonial San Pedro use, replication in a larger sample and with a larger set of organizations is needed to draw more definite conclusions about the consciousness altering effects of ceremonial San Pedro use. Next, our results are limited by the fact that the dose (by bodyweight) of San Pedro consumed is unknown. The amount of mescaline and other alkaloids may vary between two cacti (Ogunbodede et al., 2010), and thus also between the brews and powders that were consumed throughout the ceremonies provided by the various organizations. Moreover, the amount of a specific brew or powder that was consumed may have varied across participants, as this was under the control of the facilitators and sometimes up to the preference of the individual participant. Hence, the question remains how changes in consciousness that accompany San Pedro consumption manifest when doses of mescaline and alkaloids are parametrically controlled. Finally, not all ceremonies were exclusive in terms of drugs that were consumed, signaling a potential *entourage effect* — the synergistic effect of polysubstance use on human consciousness (Ribeiro, 2018). One practitioner offered participants the opportunity to smoke *mapacho*, a nicotine-containing leaf which is used by some Amazonian tribes as a plant medicine in ceremonial context (Sharrock, 2018), while two organizations allowed for the ingestion of cannabis in addition to San Pedro when participants were familiar with the effects and had regularly used cannabis before. As cannabis is a substance which by itself is sometimes used for spiritual purposes and reaching peak-experiences (Ferrara, 2021; Johnstad, 2020), but may also cause states of intense negative affect comparable to a challenging experience (Cohen et al., 2019; Farmer et al., 2019), it complicates the degree to which the reported experiences and their relative frequencies may be attributable to San Pedro (Kuc et al., 2022), or to additional psychoactive substances consumed in the ceremony or their interaction.

Conclusion

The present study explored the effects of San Pedro consumption in a ceremonial setting on human consciousness. The findings summarized in this study include the following. First, although the observational design of the present study comes with several clear limitations, our findings suggest that the ceremonial use of San Pedro is associated with a broad set of prominent changes in consciousness which are akin to classical psychedelics. Second, our findings suggest that ceremonial San Pedro use is characterized by relatively high levels of spiritual experience, moderate levels of insightfulness, bliss, feelings of unity, ego-dissolution, changed meaning of percepts, complex and elementary imagery, and audio-visual integration, and relatively low levels of disembodiment, impaired control and cognition and anxiety, as compared to normal waking consciousness. Third, results indicated that positively valenced ASC tended to co-occur with other positively valenced ASC and that similar co-occurrence

occurred for negative ASC. We hope that these findings and the discussion of the hypothesized mechanisms will provide a starting point for future research on the physiology and psychology of San Pedro ASC and will contribute to the development of safe therapeutic applications of San Pedro in both ceremonial and clinical settings.

Acknowledgements

Author contributions

Arne Bohn: Conceptualization, Formal analysis, Software, Writing – Original Draft, Writing – Review & Editing, Visualization. Michiel Kiggen: Conceptualization, Methodology, Software, Formal analysis, Investigation, Data Curation, Writing – Original Draft, Writing – Review & Editing, Visualization. Malin Uthaug: Conceptualization, Methodology, Writing – Review & Editing. Kim van Oorsouw: Conceptualization, Methodology, Writing – Review & Editing. Johannes Ramaekers: Conceptualization, Writing – Review & Editing. Hein van Schie: Conceptualization, Methodology, Writing – Original Draft, Writing – Review & Editing, Supervision.

Disclosure statement

Funding

Data availability statement

All data, stimuli and analysis scripts belonging to this research are available through the APA repository in the Open Science Framework via the following link: https://doi.org/10.5281/zenodo.1212328.

Open Scholarship

This article has earned the Center for Open Science badges for Open Data, Open Materials and Preregistered. The data and materials are openly accessible at https://doi.org/10.5281/zenodo.1212328.

Ethical approval

The study was approved by the standing Ethics Review Committee Psychology and Neuroscience at Maastricht University.

Informed consent from participants

Participants were asked informed consent for anonymous collection, processing, and storage of the provided data.

ORCID

Arne Bohn http://orcid.org/0000-0002-2599-3489
Michiel H. H. Kiggen http://orcid.org/0000-0003-0900-0157

Malin V. Uthaug 🔘 http://orcid.org/0000-0001-7903-1325
Kim I. M. van Oorsouw 🔘 http://orcid.org/0000-0001-9148-5282
Johannes G. Ramaekers 🔘 http://orcid.org/0000-0003-4553-376X
Hein T. van Schie 🔘 http://orcid.org/0000-0002-1149-5198

References

Aday, J. S., Mitzkovitz, C. M., Bloesch, E. K., Davoli, C. C., & Davis, A. K. (2020). Long-term effects of psychedelic drugs: A systematic review. *Neuroscience & Biobehavioral Reviews*, 113, 179–189. https://doi.org/10.1016/j.neubiorev.2020.03.017

Agin-Liebes, G., Haas, T. F., Lancelotta, R., Uthaug, M. V., Ramaekers, J. G., & Davis, A. K. (2021). Naturalistic use of mescaline is associated with self-reported psychiatric improvements and enduring positive life changes. *ACS Pharmacology & Translational Science*, 4(2), 543–552. https://doi.org/10.1021/acsptsci.1c00018

Akindele, M. O., Evans, J. I., & Oswald, I. (1970). Mono-amine oxidase inhibitors, sleep and mood. *Electroencephalography and Clinical Neurophysiology*, 29(1), 47–56. https://doi.org/10.1016/0013-4694(70)90078-7

Araújo, A. M., Carvalho, F., de Lourdes Bastos, M., De Pinho, P. G., & Carvalho, M. (2015). The hallucinogenic world of tryptamines: An updated review. *Archives of Toxicology*, 89(8), 1151–1173. https://doi.org/10.1007/s00204-015-1513-x

Barile, F. A. (2019). *Barile's Clinical Toxicology: Principles and Mechanisms*. CRC Press.

Barrett, F. S., Bradstreet, M. P., Leoutsakos, J. M. S., Johnson, M. W., & Griffiths, R. R. (2016). The challenging experience questionnaire: Characterization of challenging experiences with psilocybin mushrooms. *Journal of Psychopharmacology*, 30(12), 1279–1295. https://doi.org/10.1177/0269881116678781

Barrett, F. S., & Griffiths, R. R. (2017). Classic hallucinogens and mystical experiences: Phenomenology and neural correlates. *Behavioral Neurobiology of Psychedelic Drugs*, 393–430. https://doi.org/10.1007/7854_2017_474

Bienemann, B., Ruschel, N. S., Campos, M. L., Negreiros, M. A., Mograbi, D. C., & Carrà, G. (2020). Self-reported negative outcomes of psilocybin users: A quantitative textual analysis. *PLoS One*, 15(2), e0229067. https://doi.org/10.1371/journal.pone.0229067

Blanchette, I., & Richards, A. (2010). The influence of affect on higher level cognition: A review of research on interpretation, judgement, decision making and reasoning. *Cognition & Emotion*, 24(4), 561–595. https://doi.org/10.1080/02699930903132496

Borsboom, D., & Cramer, A. O. (2013). Network analysis: An integrative approach to the structure of psychopathology. *Annual Review of Clinical Psychology*, 9(1), 91–121. https://doi.org/10.1146/annurev-clinpsy-050212-185608

Bravo, G., & Grob, C. (1989). Shamans, sacraments, and psychiatrists. *Journal of Psychoactive Drugs*, 21(1), 123–128. https://doi.org/10.1080/02791072.1989.10472149

Bruhn, J. G., Ei-Seedi, H. R., Stephanson, N., Beck, O., & Shulgin, A. T. (2008). Ecstasy analogues found in cacti. *Journal of Psychoactive Drugs*, 40(2), 219–222. https://doi.org/10.1080/02791072.2008.10400635

Carbonaro, T. M., Bradstreet, M. P., Barrett, F. S., MacLean, K. A., Jesse, R., Johnson, M. W., & Griffiths, R. R. (2016). Survey study of challenging experiences after ingesting psilocybin mushrooms: Acute and enduring positive and negative consequences. *Journal of Psychopharmacology*, 30(12), 1268–1278. https://doi.org/10.1177/0269881116662634

Carhart-Harris, R. L., Kaelen, M., Bolstridge, M., Williams, T. M., Williams, L. T., Underwood, R., Feilding, A., & Nutt, D. J. (2016). The paradoxical psychological effects of lysergic acid diethylamide (LSD). *Psychological Medicine*, 46(7), 1379–1390. https://doi.org/10.1017/S0033291715002901

Carhart-Harris, R. L., Roseman, L., Haijen, E., Erritzoe, D., Watts, R., Branchi, I., & Kaelen, M. (2018). Psychedelics and the essential importance of context. *Journal of Psychopharmacology*, 32(7), 725–731. https://doi.org/10.1177/0269881118754710

Carod-Artal, F. J., & Vazquez-Cabrera, C. B. (2006). Mescaline and the San Pedro cactus ritual: Archaeological and ethnographic evidence in northern Peru. *Revista de Neurologia*, 42(8), 489–498. PMID: 16625512. https://doi.org/10.33588/rn.4208.2006040

Cassels, B. K., & Sáez-Briones, P. (2018). Dark classics in chemical neuroscience: Mescaline. *ACS Chemical Neuroscience*, 9(10), 2448–2458. https://doi.org/10.1021/acschemneuro.8b00215

Cohen, K., Weizman, A., & Weinstein, A. (2019). Positive and negative effects of cannabis and cannabinoids on health. *Clinical Pharmacology & Therapeutics*, 105(5), 1139–1147. https://doi.org/10.1002/cpt.1381

Davis, A. K., Barrett, F. S., May, D. G., Cosimano, M. P., Sepeda, N. D., Johnson, M. W., Finan, P. H., & Griffiths, R. R. (2021). Effects of psilocybin-assisted therapy on major depressive disorder: A randomized clinical trial. *JAMA Psychiatry*, 78(5), 481–489. https://doi.org/10.1001/jamapsychiatry.2020.3285

De Rios, M. D. (1977). Plant hallucinogens and the religion of the Mochica—An ancient Peruvian people. *Economic Botany*, 31(2), 189–203. https://doi.org/10.1007/BF02866590

Dinis-Oliveira, R. J., Pereira, C. L., & da Silva, D. D. (2019). Pharmacokinetic and pharmacodynamic aspects of peyote and mescaline: Clinical and forensic repercussions. *Current Molecular Pharmacology*, 12(3), 184. https://doi.org/10.2174/1874467211666181010154139

Dittrich, A. (1998). The standardized psychometric assessment of altered states of consciousness (ASCs) in humans. *Pharmacopsychiatry*, *31*(S 2), 80–84. https://doi.org/10.1055/s-2007-979351

Dobkin, M. (1968). Trichocereus pachanoi: A mescaline cactus used in folk healing in Peru. *Economic Botany*, *22*(2), 191–194. https://doi.org/10.1007/BF02860562

Dorsen, C., Palamar, J., & Shedlin, M. G. (2019). Ceremonial 'Plant Medicine' use and its relationship to recreational drug use: An exploratory study. *Addiction Research & Theory*, *27*(2), 68–75. https://doi.org/10.1080/16066359.2018.1455187

Doss, M. K., Považan, M., Rosenberg, M. D., Sepeda, N. D., Davis, A. K., Finan, P. H., Smith, G. S., Pekar, J. J., Barker, P. B., Griffiths, R. R., & Barrett, F. S. (2021). Psilocybin therapy increases cognitive and neural flexibility in patients with major depressive disorder. *Translational Psychiatry*, *11*(1), 1–10. https://doi.org/10.1038/s41398-021-01706-y

Elsey, J. W. (2017). Psychedelic drug use in healthy individuals: A review of benefits, costs, and implications for drug policy. *Drug Science, Policy and Law*, *3*, 205032451772323. https://doi.org/10.1177/2050324517723232

Erowid. (n.d.) *Psychoactive Cacti*. Erowid. https://erowid.org/plants/cacti/

Farmer, S., Slavin, M. N., Loflin, M. J., Luba, R., & Earleywine, M. (2019). Aversiveness and meaningfulness of uncomfortable experiences with edible cannabis. *Journal of Psychoactive Drugs*, *51*(5), 413–420. https://doi.org/10.1080/02791072.2019.1645371

Ferrara, M. S. (2021). Peak-experience and the entheogenic use of cannabis in world religions. *Journal of Psychedelic Studies*, *4*(3), 179–191. https://doi.org/10.1556/2054.2020.00122

Fotiou, E. (2020). The role of indigenous knowledges in psychedelic science. *Journal of Psychedelic Studies*, *4*(1), 16–23. https://doi.org/10.1556/2054.2019.031

Garcia-Romeu, A., Griffiths, R., & Johnson, M. (2014). Psilocybin-occasioned mystical experiences in the treatment of tobacco addiction. *Current Drug Abuse Reviews*, *7*(3), 157–164. https://doi.org/10.2174/1874473708666150107121331

Garcia-Romeu, A., Kersgaard, B., & Addy, P. H. (2016). Clinical applications of hallucinogens: A review. *Experimental and Clinical Psychopharmacology*, *24*(4), 229. https://doi.org/10.1037/pha0000084

Glass-coffin, B. (2010). Shamanism and San Pedro through time: Some notes on the archaeology, history, and continued use of an entheogen in northern Peru. *Anthropology of Consciousness*, *21*(1), 58–82. https://doi.org/10.1111/j.1556-3537.2010.01021.x

Gorman, I., Nielson, E. M., Molinar, A., Cassidy, K., & Sabbagh, J. (2021). Psychedelic harm reduction and integration: A transtheoretical model for clinical practice. *Frontiers in Psychology*, *12*, 710. https://doi.org/10.3389/fpsyg.2021.645246

Gottlieb, A. (1977). *Peyote and other psychoactive cacti*. Kistone Press.

Griffiths, R. R., Johnson, M. W., Richards, W. A., Richards, B. D., McCann, U., & Jesse, R. (2011). Psilocybin occasioned mystical-type experiences: Immediate and persisting dose-related effects. *Psychopharmacology*, *218*(4), 649–665. https://doi.org/10.1007/s00213-011-2358-5

Griffiths, R. R., Richards, W. A., McCann, U., & Jesse, R. (2006). Psilocybin can occasion mystical-type experiences having substantial and sustained personal meaning and spiritual significance. *Psychopharmacology*, *187*(3), 268–283. https://doi.org/10.1007/s00213-006-0457-5

Guthrie, L. (2021). *A phenomenology of challenging psychedelic experiences: From relational trauma to relational healing* [Doctoral dissertation, Duquesne University]. https://dsc.duq.edu/etd/2011

Guttmann, E. (1936). Artificial psychoses produced by mescaline. *The Journal of Mental Science*, *82*(338), 203–221. https://doi.org/10.1192/bjp.82.338.203

Haidt, J., Patrick Seder, J., & Kesebir, S. (2008). Hive psychology, happiness, and public policy. *The Journal of Legal Studies*, *37*(S2), S133–156. https://doi.org/10.1086/529447

Hapke, H. J., & Strathmann, W. (1995). Pharmacological effects of hordenine. *DTW Deutsche Tierarztliche Wochenschrift*, *102*(6), 228–232. PMID: 8582256.

Hartogsohn, I. (2016). Set and setting, psychedelics and the placebo response: An extra-pharmacological perspective on psychopharmacology. *Journal of Psychopharmacology*, *30*(12), 1259–1267. https://doi.org/10.1177/0269881116677852

Hartogsohn, I. (2017). Constructing drug effects: A history of set and setting. *Drug Science, Policy and Law*, *3*, 2050324516683325. https://doi.org/10.1177/2050324516683325

Healy, C. J. (2021). The acute effects of classic psychedelics on memory in humans. *Psychopharmacology*, 1–15. https://doi.org/10.1007/s00213-020-05756-w

Heaven, R. (2010). *Hummingbirds journey to god: Perspective on san pedro, the cactus of vision & andean soul healing methods*. John Hunt Publishing.

Heaven, R. (2012). *Cactus of mystery: The shamanic powers of the Peruvian San Pedro cactus*. Simon and Schuster.

Hirschfeld, T., & Schmidt, T. T. (2020). How it feels to be on: LSD, Psilocybin, DMT or Ayahuasca (Version1). figshare. https://doi.org/10.6084/m9.figshare.13056104.v1

Hoehn-Saric, R., & McLeod, D. R. (1988). The peripheral sympathetic nervous system: Its role in normal and pathologic anxiety. *The Psychiatric Clinics of North America*, *11*(2), 375–386. https://doi.org/10.1016/S0193-953X(18)30504-5

Holze, F., Ley, L., Muller, F., Becker, A. M., Straumann, I., Vizeli, P., Kuehne, S. S., Roder, M. A., Duthaler, U., Kolaczynska, K., Varghese, N., Eckert, A., & Liechti, M. E. (2022). Direct comparison of the acute effects of lysergic acid diethylamide and psilocybin in a double-blind placebo-controlled study in healthy subjects. *Neuropsychopharmacology*, 47(6), 1180–1187. https://doi.org/10.1038/s41386-022-01297-2

Holze, F., Vizeli, P., Ley, L., Müller, F., Dolder, P., Stocker, M., Duthaler, U., Varghese, N., Eckert, A., Borgwardt, S., & Liechti, M. E. (2021). Acute dose-dependent effects of lysergic acid diethylamide in a double-blind placebo-controlled study in healthy subjects. *Neuropsychopharmacology*, 46(3), 537–544. https://doi.org/10.1038/s41386-020-00883-6

Holze, F., Vizeli, P., Müller, F., Ley, L., Duerig, R., Varghese, N., Eckert, A., Borgwardt, S., & Liechti, M. E. (2020). Distinct acute effects of LSD, MDMA, and D-amphetamine in healthy subjects. *Neuropsychopharmacology*, 45(3), 462–471. https://doi.org/10.1038/s41386-019-0569-3

Isbell, H. (1959). Comparison of the reactions induced by psilocybin and LSD-25 in man. *Psychopharmacologia*, 1(1), 29–38. https://doi.org/10.1007/BF00408109

Iversen, S. D., & Iversen, L. L. (2007). Dopamine: 50 years in perspective. *Trends in Neurosciences*, 30(5), 188–193. https://doi.org/10.1016/j.tins.2007.03.002

Jay, M. (2019). *Mescaline: A global history of the first psychedelic*. Yale University Press.

Jilek, W. G. (1982). Altered states of consciousness in North American Indian ceremonials. *Ethos*, 10(4), 326–343. https://doi.org/10.1525/eth.1982.10.4.02a00040

Johnson, M. W., Hendricks, P. S., Barrett, F. S., & Griffiths, R. R. (2019). Classic psychedelics: An integrative review of epidemiology, therapeutics, mystical experience, and brain network function. *Pharmacology & Therapeutics*, 197, 83–102. https://doi.org/10.1016/j.pharmthera.2018.11.010

Johnstad, P. G. (2020). Cannabis as entheogen: Survey and interview data on the spiritual use of cannabis. *Journal of Cannabis Research*, 2(1), 1–17. https://doi.org/10.1186/s42238-020-00032-2

Jones, P. N. (2005). The American Indian Church and its sacramental use of peyote: A review for professionals in the mental-health arena. *Mental Health, Religion & Culture*, 8(4), 277–290. https://doi.org/10.1080/13674670412331304348

Keller, W. J., & Ferguson, G. G. (1977). Effects of 3, 4-dimethoxyphenethylamine derivatives on monoamine oxidase. *Journal of Pharmaceutical Sciences*, 66(7), 1048–1050. https://doi.org/10.1002/jps.2600660741

Kettner, H., Rosas, F. E., Timmermann, C., Kärtner, L., Carhart-Harris, R. L., & Roseman, L. (2021). Psychedelic communitas: Intersubjective experience during psychedelic group sessions predicts enduring changes in psychological wellbeing and social connectedness. *Frontiers in Pharmacology*, 12, 234. https://doi.org/10.3389/fphar.2021.623985

Khan, M. Z., & Nawaz, W. (2016). The emerging roles of human trace amines and human trace amine-associated receptors (hTaars) in central nervous system. *Biomedecine & Pharmacotherapie*, 83, 439–449. https://doi.org/10.1016/j.biopha.2016.07.002

Kovacic, P., & Somanathan, R. (2009). Novel, unifying mechanism for mescaline in the central nervous system: Electrochemistry, catechol redox metabolite, receptor, cell signaling and structure activity relationships. *Oxidative Medicine and Cellular Longevity*, 2(4), 181–190. https://doi.org/10.4161/oxim.2.4.9380

Krebs, T. S., & Johansen, P. Ø. (2013). Over 30 million psychedelic users in the United States. *F1000Research*, 2. https://doi.org/10.12688/f1000research.2-98.v1

Kuc, J., Kettner, H., Rosas, F., Erritzoe, D., Haijen, E., Kaelen, M., Nutt, D., & Carhart-Harris, R. L. (2022). Psychedelic experience dose-dependently modulated by cannabis: Results of a prospective online survey. *Psychopharmacology*, 239(5), 1425–1440. https://doi.org/10.1007/s00213-021-05999-1

Letheby, C., & Gerrans, P. (2017). Self unbound: Ego dissolution in psychedelic experience. *Neuroscience of Consciousness*, 2017(1), nix016. https://doi.org/10.1093/nc/nix016

Liechti, M. E., Dolder, P. C., & Schmid, Y. (2017). Alterations of consciousness and mystical-type experiences after acute LSD in humans. *Psychopharmacology*, 234(9–10), 1499–1510. https://doi.org/10.1007/s00213-016-4453-0

MacLean, K. A., Leoutsakos, J. M. S., Johnson, M. W., & Griffiths, R. R. (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), 721–737. https://doi.org/10.1111/j.1468-5906.2012.01685.x

Majić, T., Schmidt, T. T., & Gallinat, J. (2015). Peak experiences and the afterglow phenomenon: When and how do therapeutic effects of hallucinogens depend on psychedelic experiences? *Journal of Psychopharmacology*, 29(3), 241–253. https://doi.org/10.1177/0269881114568040

MATLAB. (2017). *Version 9.2.0 (R2017a)*. The MathWorks Inc.

Microdosinginstitute. (n.d.) *Microdosing San Pedro (mescaline)*. Microdosinginstitute. https://microdosinginstitute.com/microdosing-101/substances/san-pedro-mescaline/

Miller, G. M. (2011). The emerging role of trace amine-associated receptor 1 in the functional regulation of monoamine transporters and dopaminergic activity. *Journal of Neurochemistry*, 116(2), 164–176. https://doi.org/10.1111/j.1471-4159.2010.07109.x

Millière, R., Carhart-Harris, R. L., Roseman, L., Trautwein, F. M., & Berkovich-Ohana, A. (2018). Psychedelics, meditation, and self-consciousness. *Frontiers in Psychology*, 9, 1475. https://doi.org/10.3389/fpsyg.2018.01475

Móró, L., Simon, K., Bárd, I., & Rácz, J. (2011). Voice of the psychonauts: Coping, life purpose, and spirituality in psychedelic drug users. *Journal of Psychoactive Drugs*, *43*(3), 188–198. https://doi.org/10.1080/02791072.2011.605661

Nichols, D. E. (2004). Hallucinogens. *Pharmacology & Therapeutics*, *101*(2), 131–181. https://doi.org/10.1016/j.pharmthera.2003.11.002

Nichols, D. E., & Barker, E. L. (2016). Psychedelics. *Pharmacological Reviews*, *68*(2), 264–355. https://doi.org/10.1124/pr.115.011478

Nour, M. M., Evans, L., Nutt, D., & Carhart-Harris, R. L. (2016). Ego-dissolution and psychedelics: Validation of the ego-dissolution inventory (EDI). *Frontiers in Human Neuroscience*, *10*, 269. https://doi.org/10.3389/fnhum.2016.00269

Ogunbodede, O., McCombs, D., Trout, K., Daley, P., & Terry, M. (2010). New mescaline concentrations from 14 taxa/cultivars of Echinopsis spp.(cactaceae)("san Pedro") and their relevance to shamanic practice. *Journal of Ethnopharmacology*, *131*(2), 356–362. https://doi.org/10.1016/j.jep.2010.07.021

Olson, J. A., Suissa-Rocheleau, L., Lifshitz, M., Raz, A., & Veissiere, S. P. (2020). Tripping on nothing: Placebo psychedelics and contextual factors. *Psychopharmacology*, *237*(5), 1371–1382. https://doi.org/10.1007/s00213-020-05464-5

Phelps, E. A. (2006). Emotion and cognition: Insights from studies of the human amygdala. *Annual Review of Psychology*, *57*(1), 27–53. https://doi.org/10.1146/annurev.psych.56.091103.070234

Polito, V., Langdon, R., & Brown, J. (2010). The experience of altered states of consciousness in shamanic ritual: The role of pre-existing beliefs and affective factors. *Consciousness and Cognition*, *19*(4), 918–925. https://doi.org/10.1016/j.concog.2010.05.013

Pontual, A. A. D. D., Tófoli, L. F., Corradi-Webster, C. M., van Oorsouw, K., Delgado, A. R. O., & Ramaekers, J. G. (2022). The influence of ceremonial settings on mystical and challenging experiences occasioned by ayahuasca: A survey among ritualistic and religious ayahuasca users. *Frontiers in Psychology*, *4239*. https://doi.org/10.3389/fpsyg.2022.857372

Preller, K. H., Herdener, M., Pokorny, T., Planzer, A., Kraehenmann, R., Stämpfli, P., Liechti, M. E., Seifritz, E., & Vollenweider, F. X. (2017). The fabric of meaning and subjective effects in LSD-induced states depend on serotonin 2A receptor activation. *Current Biology*, *27*(3), 451–457. https://doi.org/10.1016/j.cub.2016.12.030

Preller, K. H., & Vollenweider, F. X. (2016). Phenomenology, structure, and dynamic of psychedelic states. *Behavioral Neurobiology of Psychedelic Drugs*, 221–256. https://doi.org/10.1007/7854_2017_477

PsychonautWiki. (n.d.) *Mescaline*. PsychonautWiki. https://psychonautwiki.org/wiki/Mescaline

Ray, T. S., & Manzoni, O. J. (2010). Psychedelics and the human receptorome. *PloS One*, *5*(2), e9019. https://doi.org/10.1371/journal.pone.0009019

R Core Team. (2020). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing. https://www.R-project.org/

Ribeiro, S. (2018). Whole organisms or pure compounds? Entourage effect versus drug specificity. In B. C. Labate & C. Cavnar (Eds.), *Plant medicines, healing and psychedelic science* (pp. 133–149). Springer.

Rickli, A., Moning, O. D., Hoener, M. C., & Liechti, M. E. (2016). Receptor interaction profiles of novel psychoactive tryptamines compared with classic hallucinogens. *European Neuropsychopharmacology*, *26*(8), 1327–1337. https://doi.org/10.1016/j.euroneuro.2016.05.001

Rubin-Kahana, D. S., Hassan, A. N., & Le Foll, B. (2021). Posttraumatic stress disorder after a psychedelic experience, a case report. *Journal of Addiction Medicine*, *15*(3), 248–251. https://doi.org/10.1097/ADM.0000000000000734

Russell, J. A. (2003). Core affect and the psychological construction of emotion. *Psychological Review*, *110*(1), 145. https://doi.org/10.1037/0033-295X.110.1.145

Samorini, G. (2019). The oldest archeological data evidencing the relationship of Homo sapiens with psychoactive plants: A worldwide overview. *Journal of Psychedelic Studies*, *3*(2), 63–80. https://doi.org/10.1556/2054.2019.008

Schlag, A. K., Aday, J., Salam, I., Neill, J. C., & Nutt, D. J. (2022). Adverse effects of psychedelics: From anecdotes and misinformation to systematic science. *Journal of Psychopharmacology*, *36*(3), 258–272. https://doi.org/10.1177/02698811211069100

Schmid, Y., & Liechti, M. E. (2018). Long-lasting subjective effects of LSD in normal subjects. *Psychopharmacology*, *235*(2), 535–545. https://doi.org/10.1007/s00213-017-4733-3

Schultes, R. E., Hofmann, A., & Rätsch, C. (1992). *Plants of the gods: Their sacred, healing, and hallucinogenic powers*. Healing Arts Press.

Schulz, A., & Vögele, C. (2015). Interoception and stress. *Frontiers in Psychology*, *6*, 993. https://doi.org/10.3389/fpsyg.2015.00993

Scuro, J., & Rodd, R. (2015). Neo-shamanism. In H. P. P. Gooren (Ed.), *Encyclopedia of Latin American religions* (pp. 1–6). Springer.

Sepeda, N. D., Clifton, J. M., Doyle, L. Y., Lancelotta, R., Griffiths, R. R., & Davis, A. K. (2020). Inhaled 5-methoxy-N, N-dimethyltryptamine: Supportive context associated with positive acute and enduring effects. *Journal of Psychedelic Studies*, *4*(2), 114–122. https://doi.org/10.1556/2054.2019.033

Sharrock, D. (2018, April). Smoky boundaries, permeable selves: Exploring the self in relationship with the Amazonian jungle tobacco, Mapacho. *Anthropological Forum*, 28(2), 146–157. Routledge. https://doi.org/10.1080/00664677.2018.1419934

Sociodelic. (2017). *What is peyote? (Mescaline)*. Sociodelic. https://www.sociedelic.com/what-is-peyote-mescaline/

Sotnikova, T. D., Beaulieu, J. M., Espinoza, S., Masri, B., Zhang, X., Salahpour, A., Barak, L. S., Caron, M. G., Gainetdinov, R. R., & Bartolomucci, A. (2010). The dopamine metabolite 3-methoxytyramine is a neuromodulator. *PloS One*, 5(10), e13452. https://doi.org/10.1371/journal.pone.0013452

Stanfill, S. B., da Silva, A. L. O., Lisko, J. G., Lawler, T. S., Kuklenyik, P., Tyx, R. E., Peuchen, E. H., Richter, P., & Watson, C. H. (2015). Comprehensive chemical characterization of Rapé tobacco products: Nicotine, un-ionized nicotine, tobacco-specific N′-nitrosamines, polycyclic aromatic hydrocarbons, and flavor constituents. *Food and Chemical Toxicology*, 82, 50–58. https://doi.org/10.1016/j.fct.2015.04.016

Strickland, J. C., Garcia-Romeu, A., & Johnson, M. W. (2020). Set and setting: A randomized study of different musical genres in supporting psychedelic therapy. *ACS Pharmacology & Translational Science*, 4(2), 472–478. https://doi.org/10.1021/acsptsci.0c00187

Studerus, E., Gamma, A., Vollenweider, F. X., & Bell, V. (2010). Psychometric evaluation of the altered states of consciousness rating scale (OAV). *PloS One*, 5(8), e12412. https://doi.org/10.1371/journal.pone.0012412

Studerus, E., Kometer, M., Hasler, F., & Vollenweider, F. X. (2011). Acute, subacute and long-term subjective effects of psilocybin in healthy humans: A pooled analysis of experimental studies. *Journal of Psychopharmacology*, 25(11), 1434–1452. https://doi.org/10.1177/0269881110382466

Thomason, T. C. (2010). The role of altered states of consciousness in Native American healing. *Journal of Rural Community Psychology*, E13(1), 1–11.

Torres, C. M. (1995). Archaeological evidence for the antiquity of psychoactive plant use in the Central Andes. *Annuli Dei Musei Civici Roverero*, 11, 291–326.

Tripsitter. (2021). *Mescaline: Peyote, San Pedro, & Peruvian Torch Cactus*. Tripsitter. https://tripsitter.com/mescaline/

Trulson, M. E., Crisp, T., & Henderson, L. J. (1983). Mescaline elicits behavioral effects in cats by an action at both serotonin and dopamine receptors. *European Journal of Pharmacology*, 96(1–2), 151–154. https://doi.org/10.1016/0014-2999(83)90544-7

Turner, D. M. (1994). *The essential psychedelic guide*. Panther Press.

Uthaug, M. V., Davis, A. K., Haas, T. F., Davis, D., Dolan, S. B., Lancelotta, R., Timmermann, C., & Ramaekers, J. G. (2021). The epidemiology of mescaline use: Pattern of use, motivations for consumption, and perceived consequences, benefits, and acute and enduring subjective effects. *Journal of Psychopharmacology*, 02698811211013583. https://doi.org/10.1177/02698811211013583

Uthaug, M. V., Mason, N. L., Toennes, S. W., Reckweg, J. T., de Sousa Fernandes Perna, E. B., Kuypers, K. P. C., van Oorsouw, K., Riba, J., & Ramaekers, J. G. (2021). A placebo-controlled study of the effects of ayahuasca, set and setting on mental health of participants in ayahuasca group retreats. *Psychopharmacology*, 238(7), 1899–1910. https://doi.org/10.1007/s00213-021-05817-8

Uthaug, M. V., Van Oorsouw, K., Kuypers, K. P. C., Van Boxtel, M., Broers, N. J., Mason, N. L., Toennes, S. W., Riba, J., & Ramaekers, J. G. (2018). Sub-acute and long-term effects of ayahuasca on affect and cognitive thinking style and their association with ego dissolution. *Psychopharmacology*, 235(10), 2979–2989. https://doi.org/10.1007/s00213-018-4988-3

Van Oorsouw, K. I., Toennes, S., & Ramaekers, J. G. (2022). Therapeutic effects of an ayahuasca analogue in clinically depressed patients: A longitudinal observational study. *Psychopharmacology*, 1–14.

Van Oorsouw, K. I., Uthaug, M. V., Mason, N. L., Broers, N. J., & Ramaekers, J. G. (2021). Sub-acute and long-term effects of ayahuasca on mental health and well-being in healthy ceremony attendants: A replication study. *Journal of Psychedelic Studies*, 5(2), 103–113. https://doi.org/10.1556/2054.2021.00174

Vollenweider, F. X., Vollenweider-Scherpenhuyzen, M. F., Babler, A., Vogel, H., & Hell, D. (1998). Psilocybin induces schizophrenia-like psychosis in humans via a serotonin-2 agonist action. *Neuroreport*, 9(17), 3897–3902. https://doi.org/10.1097/00001756-199812000-00024

Watson-Jones, R. E., & Legare, C. H. (2016). The social functions of group rituals. *Current Directions in Psychological Science*, 25(1), 42–46. https://doi.org/10.1177/0963721415618486

Wei, T., & Simko, V. (2021). *R package 'corrplot': Visualization of a correlation matrix*. (Version 0.90). https://github.com/taiyun/corrplot

Winkelman, M. J. (2007). *Shamanic guidelines for psychedelic medicine*. psychedelic medicine: New evidence for hallucinogenic substances as treatments (Vol. 2). Praeger/Greenwood Publishers.

Winstock, A., Mitcheson, L., Ramsey, J., Davies, S., Puchnarewicz, M., & Marsden, J. (2011). Mephedrone: Use, subjective effects and health risks. *Addiction*, 106(11), 1991–1996. https://doi.org/10.1111/j.1360-0443.2011.03502.x

Wise, R. A. (2004). Dopamine, learning and motivation. *Nature Reviews: Neuroscience*, 5(6), 483–494. https://doi.org/10.1038/nrn1406

Wolff, T. J. (2020). *The touristic use of Ayahuasca in Peru*. Springer Fachmedien Wiesbaden.

Yaden, D. B., & Griffiths, R. R. (2020). The subjective effects of psychedelics are necessary for their enduring therapeutic effects. *ACS Pharmacology & Translational Science*, *4*(2), 568–572. https://doi.org/10.1021/acsptsci.0c00194

Zamberlan, F., Sanz, C., Martínez Vivot, R., Pallavicini, C., Erowid, E., & Tagliazucchi, E. (2018). The varieties of the psychedelic experience: A preliminary study of the association between the reported subjective effects and the binding affinity profiles of substituted phenethylamines and tryptamines. *Frontiers in Integrative Neuroscience*, *12*, 54. https://doi.org/10.3389/fnint.2018.00054

Zamnesia. (n.d.) *The ultimate mescaline cactus guide*. Zamnesia. https://www.zamnesia.com/content/698-mescaline-cacti