Transformative experience and social connectedness mediate the mood-enhancing effects of psychedelic use in naturalistic settings

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Past research suggests that use of psychedelic substances such as LSD or psilocybin may have positive effects on mood and feelings of social connectedness. These psychological effects are thought to be highly sensitive to context, but robust and direct evidence for them in a naturalistic setting is scarce. In a series of field studies involving over 1,200 participants across six multiday mass gatherings in the United States and the United Kingdom, we investigated the effects of psychedelic substance use on transformative experience, social connectedness, and positive mood. This approach allowed us to test preregistered hypotheses with high ecological validity and statistical precision. Controlling for a host of demographic variables and the use of other psychoactive substances, we found that psychedelic substance use was significantly associated with positive mood—an effect sequentially mediated by self-reported transformative experience and increased social connectedness. These effects were particularly pronounced for those who had taken psychedelic substances within the last 24 h (compared to the last week). Overall, this research provides robust evidence for positive affective and social consequences of psychedelic substance use in naturalistic settings.

psychedelic substances | transformative experiences | social connectedness | mood

Research into the therapeutic potential of psychedelic substances (such as psilocybin, LSD, and mescaline) has come into renewed focus after several decades of relatively scant attention (1). Recent clinical studies attest to the relative safety and tolerability of these substances (2), in terms of both physical (3) and mental health (4), and contemporary research suggests that serotonergic psychedelics can have a variety of decidedly positive effects when used in therapeutic settings. Specifically, clinical researchers have begun investigating the potential of psychedelics in the treatment of mental health disorders, including affective disorders (5), anxiety-related disorders (6), and substance abuse disorders (7). For example, recent findings indicate that a single dose of psilocybin, the primary active component in mushrooms of the *Psilocybe* genus, can meaningfully attenuate depressive symptoms in patients with treatment resistant depression for up to 3 mo postadministration (5). Similar studies have been conducted—or are ongoing—for other serotonergic psychedelic substances such as LSD (8) or N,*N*-dimethyltryptamine (found in ayahuasca) (9).

Researchers have also begun investigating the acute and chronic effects of psychedelic substances on healthy individuals. They found, for example, that serotonergic psychedelics administered in the laboratory have noticeable acute effects on the affective processing of negative stimuli (10), feelings of social exclusion (11), as well as moral (12) and social decision-making (13). Other research endeavors have used large-scale surveys to query members of the general public about their substance use history and found that past psychedelic substance use positively predicted mental well-being (4) and proenvironmental behavior (14), while being negatively related to suicidality (4).

Yet, existing research on the psychological effects of psychedelics has several important limitations. On one hand, laboratory-based approaches, which allow for causal inferences through randomization, typically suffer from low sample sizes due to financial costs and logistical demands. In addition, they can be affected by sampling bias, in that people may sign up for a study with the explicit desire to have a psychedelic experience, or fail to capture the effects of spontaneous substance use. Laboratory settings also rarely resemble settings in which people typically use psychedelic substances—an especially important limitation given that the effects of these substances are notoriously affected by situational variables (2). The classic notions of "set and setting" emphasize the degree to which intrapersonal and environmental variables can affect the psychedelic experience (15, 16). For this reason, while existing laboratory research undoubtedly provides important insights into the psychological consequences of psychedelic substance use, this work leaves open the crucial question of how such consequences manifest in naturalistic settings. Finally, despite

Significance

For millennia, naturally occurring psychedelic substances have been used by indigenous cultures in medicinal or spiritual contexts. Recent scientific investigations hint at the potential for these substances in the treatment of affective disorders, yet scientific inquiries into their psychological effects remain scarce. Here we present findings from a large field study of mood-related effects of recent psychedelic substance use in naturalistic settings. We found that recent use of psychedelics was associated with increased positive mood through experience of personal transformation and feelings of connectedness to others. Our findings validate recent reports of mood-enhancing effects of psychedelic substances in laboratory settings and suggest that these effects manifest at least in part through changes in the experience of social relationships.

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being placebo-controlled, participants in laboratory studies are aware of the fact they partake in a study investigating the effects of psychedelic substances, which may affect their responses to questionnaires or tasks due to preconceived notions they might have about these substances.

On the other hand, large-scale survey studies, often obtained via online sampling, are an efficient way to collect data from a large number of participants about past psychedelic substance use and its psychological consequences. However, interpretation of these data is complicated by the fact that many participants in these studies were not recently under the influence of the respective substances at the time of data collection, thereby rendering their reports subject to the vagaries of personal recollection (since participants are often relying on memories of past experiences), and are hence potentially unreliable. Research of this nature also suffers from demand and suggestibility effects as participants are again usually aware they are taking part in a study about psychedelics. For these reasons, existing research represents a valuable but incomplete picture of the psychological consequences of psychedelic substance use.

The Present Research

We aimed to address these limitations by conducting a large-scale field study involving more than 1,200 participants at six multiday mass gatherings across the United States and the United Kingdom. Substance use at mass gatherings such as music and arts festivals is known to be a common occurrence (17, 18). There are several advantages to our field study approach. First, the large sample size afforded a greater degree of statistical precision than that obtained in previous research. Second, because the investigation took place on site, it allowed us to test participants within (on average) 72 h of substance consumption, thereby enabling a more fine-grained analysis of the temporal dynamics of psychedelic substance use while the experiences were still salient. Specifically, comparing people who took psychedelics at different points in time determines how the recency of a psychedelic experience relates to its effects and further allows us to rule out the possibility that any effect on our outcome variables are explained by a general willingness to use psychedelics (which may be confounded with personality traits and demographics that separately predict those outcome variables). Finally, the recreational setting provided the opportunity to conduct observations in a context more typical of substance use. Through this method, we hoped to isolate the unique, acute psychological effects of psychedelic substance use.

Our investigation focused on three key outcome variables. Our primary question concerned whether psychedelic substance use was associated with increased positive mood. This was based on past findings suggesting that psychedelic substance use can elicit pronounced and lasting changes in healthy individuals' subjective well-being (19), as well as clinical research indicating that single doses of psilocybin can alleviate depressive symptoms of patients whose condition was previously classified as treatment-resistant (5). We therefore sought to confirm in our field sample the association between psychedelic substance use and positive mood.

We further focused on two psychological processes that we predicted would explain the relationship between psychedelic substance use and positive mood. The first was people's sense of having had a transformative experience (TE). TEs, also called self-transcendent (20) or quantum change (21) experiences, are defined in philosophy as experiences characterized by an epistemic shift that is so profound it causes a substantial change in one's personal values and priorities that is practically impossible to accurately imagine in advance (22). Such profound changes to a person's values, beliefs, or morals may in turn result from a mystical-type experience (23), a key element of the psychedelic experience (24), that is characterized, for example, by feelings of internal and external unity, transcendence of time and space, a sense of awe or sacredness, and a distinct noetic quality pertaining to one's understanding of reality. For example, in a placebo-controlled psilocybin study conducted in a laboratory setting, 22 of 36 participants reported having had such an experience after taking psilocybin (23), which 21 participants considered one of the top five most personally meaningful experiences in their lives (25). These experiences have been found to produce lasting, positive effects on subjective well-being (25), openness to experience (26), perceived meaning in life (25), and prosocial attitudes and behaviors (19). Importantly, past research found the beneficial effects of psychedelic substance use on subjective well-being depended on the strength of mystical-type experience reported by participants during the experimental sessions, with more pronounced experiences predicting greater long-term positive outcomes (27). Therefore, we predicted that people's reported degree of TE as a function of their use of psychedelics would be positively associated with positive mood.

Second, we investigated people's sense of connectedness to others. Past research suggests that psychedelics often engender a feeling of ego dissolution (24), a compromised sense of self most likely attributable to attenuated neural connectivity in the brain's default mode network (28). The reduced activity in these brain areas, known to be critical for accurate self-processing, is believed to be responsible for perceptually blurring the lines between self and outside world (29, 30), causing feelings of oceanic boundlessness or external unity during the psychedelic state, and thereby fostering a sense of connectedness with external objects or entities (31). As put by one of the participants in Griffiths et al.'s study, "[I experienced a] feeling of no boundaries, where I didn't know where I ended and where my surroundings began. Somehow I was able to comprehend what oneness is" (ref. 25, p. 629). In psychological terms, feelings of unity with other living entities can be described as an increased inclusion of others in the self—a self-construal incorporating other human beings that is considered a crucial element of close relationships (32)—or a heightened sense of social connectedness. Past studies found a sense of social disconnectedness to be a key feature of depression (33), while feelings of connectedness between oneself and others were associated with reduced depressive symptoms (31). In the domain of psychedelic research, it has therefore been theorized that increases in social connectedness may be responsible for the positive effects psilocybin use can have on mental well-being (34), and it was empirically validated that psilocybin administration has specific, dose-dependent effects on people's tendency to incorporate others in their self-construal (19). Thus, we predicted that greater degree of social connectedness would be associated with more positive mood after substance use.

Overall, then, we tested whether recent psychedelic substance use in naturalistic, nonclinical settings would predict positive mood as a function of TEs and/or a heightened sense of connectedness to other human beings.

Method

Participants and Design. Over the course of 3 y, we collected data from 1,242 attendees of six different multiday mass gatherings in the United States and the United Kingdom (*SI Appendix*, SOM I, Table 1). Of those participants, 17 were excluded from data analyses for indicating on an attention/sobriety check item embedded in the questionnaire that they have had one or multiple fatal(!) heart attacks, leaving a final sample of 1,225 participants.* All participants provided informed consent and completed a questionnaire comprising several different scales, tasks, and demographic questions. Although the questionnaires for the different events were for the most part identical, certain tasks, scales, or items were added or modified over the course of data collection (see footnotes †, ‡, and §). Participants were given

*Due to a data entry error, responses to the exclusion item are missing for 156 participants at event 2. Due to the generally low number of participants failing this check, we decided to include these participants in our data analyses.

the choice of several prizes preselected to be valuable to attendees (e.g., glow sticks, scarves, sunscreen, earplugs, and fans) as compensation for their participation. To prevent repeat participation and incidental duplicate data entries, as well as to allow for anonymized post hoc identification of a participant's data, we asked participants to provide an individual identification code composed of the first three letters of the first road on which they ever lived, the two-digit calendar day of their birthday, and the last two letters of their mother's maiden name. The research protocol was approved by the University of Oxford Central University Research Ethics Committee (MS-IDREC-C1-2015-134).

Materials and Procedure. Data were collected at events between 2015 and 2017 (35). For on-site data collection, teams of 5 to 10 experimenters recruited attendees from a booth set up in well-trafficked areas with a sign labeled "Play Games for Science." After granting their consent, participants either were handed a tablet computer to work on the survey (at events 4 to 6) or received a paper-and-pencil version of the questionnaires (at events 1 to 3).

Psychoactive substances. As our primary predictor variables for the present analyses, we assessed people's recent use of various psychoactive substances. Specifically, we asked people to indicate whether they had taken any substance of a given class of psychoactive substances within the past 24 h or at some point during the week prior. We further asked them whether they were under the influence of any substance belonging to the respective class when filling out the questionnaire, as well as whether they had taken substances belonging to this class for the first time that week.

One challenge for assessing substance use in naturalistic settings is the possibility that participants might refuse to answer questions about substance use affirmatively for fear of legal repercussions. To overcome this challenge, for each class of substances in the survey, we made sure to include one example of a legal substance (i.e., salvia, Kratom, hemp oil, or pharmaceutical medications). This was made explicitly clear to participants in the survey to reassure them that affirmative responses would not incriminate them in any way.

Participants were asked to indicate their recent use of alcohol, nicotine, cannabis products (e.g., weed, THC, CBD, and hemp oil), hallucinogens (e.g., psilocybin, LSD, salvia, mescaline, and DMT), euphorics (e.g., MDMA, Molly, and Kratom), stimulants (e.g., cocaine, methamphetamine, and ephedrine), narcotic analgesics (e.g., morphine, heroin, and oxycodone), benzodiazepines (e.g., Valium and Alprazolam [Xanax]), inhalants (poppers, whip-its, nitrous oxide, and glue), and other substances (*SI Appendix*, SOM IV).

Control variables. We preregistered a set of control variables, which we included in all analyses performed with the present dataset. We selected these covariates based on previous research that found that users and nonusers of psychedelic substances significantly differ on certain demographic variables (14, 36). We tried to include as many relevant demographic variables as possible, without overfitting the models or reducing their interpretability. As a result, we ultimately decided to control for participants' age, gender (male, female, or other/both/none; dummy-coded)[†], educational attainment (high school, some college, 2-y degree, 4-y degree, or postgraduate or professional degree; dummy-coded), religious belief (on a seven-point Likert-type scale ranging from not religious to very religious), and political orientation (on a seven-point scale from extremely liberal to extremely conservative).[‡]

TEs. As our first criterion, we assessed on a single seven-point Likert-type item ranging from not at all to absolutely whether participants reported having had a TE while attending the event ("Have you had a transformative experience while at <event>?").

Additionally, we were interested in whether participants had a special kind of TE, referred to as an epistemically ET (ETE). Specifically, we gave participants a definition of ETEs based on Paul (22): "We are curious about a special kind of transformative experience: an experience that changes you so profoundly that you come out of the experience radically different than you were before the experience. This transformation may have been so profound that you could not have known what the experience or change would be like before going through it" (*SI Appendix*, SOM IV). Following this description, we again asked participants to indicate whether they have had such an experience using the same scale we used for the initial question on TEs.

To gain more insight into these experiences, using seven-point Likert-type scales, we then asked participants to indicate the extent of their TE (minimal to complete), how good it felt (not at all to extremely), how bad it felt (not at all to extremely), whether they expected such a transformation (not at all to absolutely), whether they desired it (not at all to absolutely), and whether it caused them to significantly change their moral values (not at all to absolutely). We had no a priori hypotheses with regard to the quality of people's experiences. Yet we still decided to analyze people's responses exploratorily, in order to find out how the expectation and desire of having a TE factored into their actual experience, as well as to gain insight into the nature of TEs experienced as a result of substance use.

Similarly, for ETEs, we asked some participants whether they were glad that they had this experience (not at all to very much) and whether this experience affected their moral values (not at all to definitely). A subset of participants provided answers about whether they expected (not at all to definitely) or desired (not at all to definitely) an ETE.

Social connectedness. To assess this construct, we presented participants with a modified version of the "inclusion of others in the self" scale—originally designed to assess how strongly people include their romantic partners in their self-construal. The scale comprises seven images, each displaying two equally sized circles with varying degrees of overlap, ranging from full separation of the two circles to nearly full overlap (32). For the present purposes, the two circles were labeled "self" and "other." Participants were asked to "circle the image that best describes [their] current relationship with other human beings, in general" (*SI Appendix*, SOM IV). As such, higher values on this measure indicate greater social connectedness.

Positive mood. To test the hypothesis that recent use of psychedelic substances would predict participants' positive mood, we assessed people's current affective state using a single pictorial item (*SI Appendix*, SOM IV). Specifically, participants were presented with six faces with different facial expressions, ranging from a very joyful expression to a sad, crying expression. Participants were asked to "circle the image that best represents [their] current mood." We coded this measure so that higher values indicate a more positive affective state.

Preregistered hypotheses. Before analyzing the data, we preregistered a set of hypotheses based on previous empirical findings and theoretical arguments from the literature (https://osf.io/q8xvd). Specifically, among other hypotheses, we predicted that recent use of psychedelic substances (i.e., during the past 24 h or during the past week) would positively predict self-reported TEs and feelings of social connectedness. We further predicted a positive relationship between psychedelic substance use and participants' mood, mediated by their reports of having had a TE. In other words, we hypothesized that recent use of psychedelic substances would lead to a greater chance of having had a TE, which should in turn positively predict participants' affective state.

Past research has shown that use of various kinds of psychoactive substances is highly intercorrelated (14). In order to account for these intercorrelations, for all of our hypothesis tests and exploratory analyses, we predicted that use of psychedelic substances would predict the respective outcome variables when statistically controlling for the use of all other types of psychoactive substances assessed. This approach allowed us to investigate the unique predictive power of psychedelic substance use regardless of people's general propensity to consume mind-altering substances or their simultaneous use of other, nonpsychedelic substances.

Further, we specified in our preregistration that in addition to using aggregate scores representing use of psychedelics at any point during the week prior, we would test our hypotheses by exclusively analyzing very recent use of psychoactive substances (i.e., participants currently under the influence or who used the substances in the last 24 h). Results for these analyses can be found in *SI Appendix*, SOM I. Instead, we chose to include a more sophisticated, nonpreregistered set of analyses in the main manuscript, in which we disentangled whether very recent or moderately recent use of psychedelics (i.e., during the week prior) would be more predictive of the outcome variables, by simultaneously entering both variables into the respective regression models. Likewise, we included a nonpreregistered structural equation model to exploratorily consolidate our findings.

All data discussed in the paper are available at https://osf.io/avdrc.

Results

Sample Characteristics. The sample was mostly composed of younger (M = 32.39, SD = 11.37), educated adults (median education: 4-y college degree), with low to medium levels of religiosity (M = 2.31, SD = 1.63, on a seven-point scale), moderately liberal

[†]At event 1, participants indicated their gender on an open response item. Their responses were later coded to match the data collected at the other events.

[‡]At two events, event 1 and event 4, participants were asked two individual questions about social and economic conservatism. To include data from these two events, we merged the two variables to create a single liberalism–conservatism index; $r(231) = 0.45$, $P < 0.001$.

Table 1. Sample demographics

Sample characteristics (n = 1,225)	Frequency (percentages)
Gender	
Male	630 (51.4%)
Female	563 (46.0%)
Other (both/neither/fluid)	22 (1.8%)
Age	
18 to 30	676 (55.2%)
31 to 40	285 (23.3%)
41 to 50	103 (8.4%)
51 to 60	89 (7.3%)
>60	33 (2.7%)
Religiosity: 1 (very low) to 7 (very high)	
Low (1 and 2)	802 (65.5%)
Medium (3 to 5)	350 (28.6%)
High (6 and 7)	58 (4.7%)
Education (highest)	
High school	75 (6.1%)
Some college	276 (22.5%)
2-y degree	169 (13.8%)
4-y degree	459 (37.5%)
Postgraduate or professional degree	233 (19.0%)
Political orientation: 1 (strongly liberal) to 7 (strongly conservative)	
Liberal (1 and 2)	580 (47.3%)
Moderate (3 to 5)	550 (44.9%)
Conservative (6 and 7)	18 (1.5%)

political views (M = 2.67, SD = 1.19, on a seven-point scale) (Table 1), and a median annual income of $26,000 to $35,000.

With regard to the use of psychoactive substances among the attendees, we found that use of alcohol was the most widespread (80.0% of all attendees), followed by cannabis products (50.9%) and nicotine (35.9%). Psychedelic substances were used by 26.6% of the sample, with similar values for euphorics (24.8%) and stimulants (21.6%). Substances from the remaining classes were all used to a substantially lesser degree (≤7.1% each; Fig. 1); 12.3% of all attendees reported having taken no substance.

Statistical Analyses. We used the lavaan package (version 0.5-23.1097; ref. 37) for R to run our regression analyses. In all models, parameter estimates were obtained through normal maximum likelihood estimation (using the biased sample covariance matrix), with SEs based on the observed information matrices. Missing values were estimated using a full information maximum likelihood procedure (38). In all analyses, we regressed the outcome variables on all variables representing use of a certain class of psychoactive substance as well as on all control variables. Deviations from this approach are noted.

For each class of psychoactive substance, we created a binary score indicating whether participants used any of the included substances throughout the past week. Participants who reported having taken a substance in the last 24 h or during the week prior or who were currently under the influence of the substance were coded 1, while the remaining participants were coded 0. In each analysis, we predicted the outcome variable with all substance classes and covariates.

Prediction of Individual Outcome Variables: (Epistemically) TEs, Positive Mood, and Social Connectedness.

TEs. As hypothesized, use of psychedelic substance positively predicted TEs: $b = 0.79$ ($\beta = 0.17$), SE = 0.15, $P < 0.001$, 95% CI = [0.49; 1.09]. Thus, people who recently took psychedelic substances were indeed more likely to report having had a TE than were people who did not take any of these substances, regardless of their use of other psychoactive substances or associated demographic variables.

There remains, however, the possibility that people who planned on using psychedelics at the respective events had a greater desire to have a TE or were more likely to expect having such an experience. As such, it could be the case that these desires were partly responsible for having a TE in the first place (in that people were more open to experiencing transformation or more likely to seek out situations that would enable transformation; cf. a self-fulfilling prophecy (39)) or that expectations and desires caused participants to retroactively conceptualize certain experiences as being transformative (cf. confirmation bias (40)). However, entering both desire for and expectations about TEs into the model speaks against this possibility. While both desires, $b = 0.23$ ($\beta = 0.23$), SE = 0.04, $P < 0.001$, 95% CI = [0.15; 0.30], and expectations, $b = 0.17$ ($\beta = 0.15$), SE = 0.04, $P < 0.001$, 95% CI = [0.09; 0.24], predicted self-reported TEs, use of psychedelics still predicted TEs over and above these effects: $b = 0.67$ ($\beta = 0.14$), SE = 0.14, $P < 0.001$, 95% CI = [0.39; 0.95].

ETEs. Having an ETE was a more rare occurrence ($M = 2.79$, SD = 1.97) than having an unspecified TE ($M = 4.10$, SD = 2.07): $t(1,196) = 26.83$, $P < 0.001$. In line with our hypotheses, and similar to unspecified TEs, use of psychedelic substances positively predicted having had an ETE: $b = 0.46$ ($\beta = 0.10$), SE = 0.15, $P = 0.002$, 95% CI = [0.17; 0.75]. Controlling for people's desire or expectation of having an unspecified TE did not meaningfully affect the association between psychedelic substance use and ETEs: $b = 0.38$ ($\beta = 0.09$), SE = 0.14, $P = 0.008$, 95% CI = [0.10; 0.66].[§]

Quality of TEs. Participants at the various events were asked additional questions about the quality of their TEs, if they had one, which we analyzed exploratorily. Among the people who had a

[§]Specific desire for (n = 100) and expectation of having (n = 227) an ETE (as opposed to a regular TE) were only assessed at one and two events, respectively. Inclusion of these variables likewise did not affect statistical significance of the association between psychedelic substance use and self-reported ETEs; $b = 0.54$ ($\beta = 0.12$), SE = 0.15, $P < 0.001$, 95% CI = [0.25; 0.84].

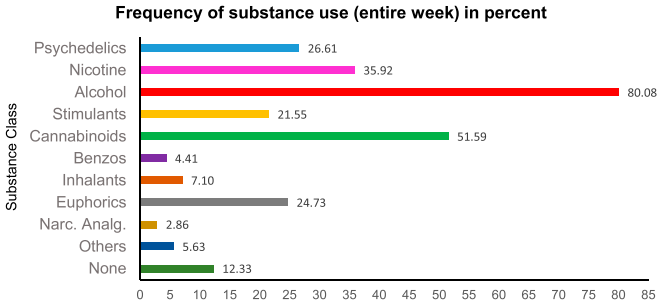

Fig. 1. Use of different classes of psychoactive substances across all events. Numbers indicate the percentage of people who took any substance of the respective class at some point during the week prior to data collection.

self-reported TE, those who took psychedelic substances rated their experience to be more positive ($M = 5.44$, SD = 1.49) than those who had such an experience without taking psychedelic substances ($M = 4.87$, SD = 1.64), $t(544.5) = 5.04$, $P < 0.001$, but rated them as equally negative, $t(508.71) = 0.40$, $P = 0.691$. They further described the extent of their experience as having been greater ($M = 4.05$, SD = 1.58) than did nonusers of psychedelics ($M = 3.24$, SD = 1.77), $t(540.78) = 6.83$, $P < 0.001$, and were more likely to state that their moral values were changed as a result of this experience ($M = 3.19$, SD = 1.92) than were people who had these experiences without having taken psychedelics ($M = 2.62$, SD = 1.86): $t(554.05) = 4.59$, $P < 0.001$. Descriptive information regarding the quality of ETEs is provided in *SI Appendix*, SOM I.

Positive mood. We further predicted that recent use of psychedelic substances would predict user's positive mood and that this increase in positive mood would be mediated by self-reported TEs. In line with this hypothesis, use of psychedelics predicted participant's positive mood: $b = 0.14$ ($\beta = 0.08$), SE = 0.06, $P = 0.019$, 95% CI = [0.02; 0.26].

Next, we investigated the hypothesized mediating role of TEs in the relationship between substance use and positive mood. As predicted, having had a TE predicted people's positive mood: $b = 0.08$ ($\beta = 0.21$), SE = 0.01, $P < 0.001$, 95% CI = [0.06; 0.10]. As a result, the indirect effect of psychedelic substance use on positive mood via TEs was statistically significant, $b = 0.05$ ($\beta = 0.03$), SE = 0.01, $P < 0.001$, 95% CI = [0.03; 0.08], and rendered the formerly significant direct effect of psychedelics use on positive mood (see above) nonsignificant: $b = 0.08$ ($\beta = 0.05$), SE = 0.06, $P = 0.181$, 95% CI = [−0.04; 0.20]. In other words, the relationship between recent use of psychedelic substances and positive mood was indeed statistically mediated by self-reported TEs.

Social connectedness. In line with our preregistered hypotheses, we found that—controlling for the use of other substances and demographic variables—recent use of psychedelic substances significantly and positively predicted social connectedness: $b = 0.36$ ($\beta = 0.10$), SE = 0.12, $P = 0.003$, 95% CI = [0.12; 0.60]. It therefore seems as if psychedelic substance use may indeed uniquely contribute to an increased perception of oneness or connectedness with other human beings, regardless of the use of other types of substances. While we did not preregister that social connectedness would mediate the effects of psychedelic substance use on mood, we decided to explore this possibility in a mediation analysis similar to the one we employed for TEs. We found that social connectedness indeed predicted people's positive mood: $b = 0.11$ ($\beta = 0.23$), SE = 0.01, $P < 0.001$, 95% CI = [0.09; 0.14]. In addition, the indirect effect of psychedelic substance use on positive mood via social connectedness turned out statistically significant, $b = 0.04$ ($\beta = 0.02$), SE = 0.01, $P = 0.007$, 95% CI = [0.01; 0.07], and reduced the direct effect to marginal significance: $b = 0.10$ ($\beta = 0.06$), SE = 0.06, $P = 0.089$, 95% CI = [−0.02; 0.22]. Based on these findings, we decided to further explore the relationship between the various outcome variables in the structural equation model below.

Very Recent vs. Moderately Recent Use of Psychedelics. Our questionnaire allowed us to differentiate between very recent (last 24 h) and moderately recent (the week prior) use of the various substances. Of all users of psychedelic substances at the events ($n = 326$), only 2.8% ($n = 9$) took a psychedelic substance both within the past 24 h and in the week prior. A total of 69.6% ($n = 227$) only took them in the last 24 h, while 27.6% ($n = 90$) only took them in the week prior.

In order to get more insight into how the recency of psychedelic experience moderated the observed psychological effects of psychedelic substance use, we reran the analyses reported above with a modification: instead of a single item indicating general recent use of psychedelic substances, we included two variables (both binary coded) representing very recent (i.e., in the past 24 h or current) or moderately recent (i.e., in the week prior) use of psychedelic substances. This allowed us to test whether more recent use of psychedelic substances would have stronger psychological effects. Crucially, this analysis controls for potential effects of a general willingness to take psychedelic substances on our outcome variables. In other words, dispositional willingness to ingest these substances may be associated with greater propensity to report TEs, greater social connectedness, or more positive mood. One way we can account for this is by ensuring that the results remain robust when controlling for expectations and desires for TE (see above). However, an even stronger approach is to examine the temporal differences in these effects within the substance-using population. This was possible because the nature of our data collection procedure meant that participants completed our survey at a relatively random time point after their psychedelic experience. This design therefore enabled us to investigate the temporal dynamics of the psychological effects of psychedelic substance use, that is, how the temporal proximity (or salience) of such experiences factors into how their effects unfold.

Overall, we found that very recent use of psychedelic substances, as compared to moderately recent use in the week prior, was primarily responsible for predicting scores on the outcome variables for which we found an association with general recent psychedelic substance use. That is, self-reported TEs (with and without controlling for expectations and desires), ETEs, and psychological well-being were all significantly predicted by use of psychedelic substances in the last 24 h, yet not uniquely predicted by use of psychedelic substances in the week prior (*SI Appendix*, SOM II, and Fig. 2). Comparing the predictive power of moderately recent versus very recent use of psychedelic substances on these outcome variables, we found significantly larger predictive power of 24 h use of psychedelics for self-reported TEs, $\Delta b = 0.58$ ($\beta = 0.13$), SE = 0.24, $P = 0.017$, 95% CI = [0.10; 1.06] (when controlling for expectations and desires, $\Delta b = 0.49$ ($\beta = 0.11$), SE = 0.31, $P = 0.031$, 95% CI = [0.05; 0.94]), for ETEs, $\Delta b = 0.49$ ($\beta = 0.10$), SE = 0.23, $P = 0.035$, 95% CI = [0.03; 0.97] (when controlling for expectations and desires, $\Delta b = 0.42$ ($\beta = 0.09$), SE = 0.23, $P = 0.063$, 95% CI = [−0.02; 0.87]), as well as for positive mood, $\Delta b = 0.27$ ($\beta = 0.13$), SE = 0.10, $P = 0.005$, 95% CI = [0.08; 0.46] (Fig. 2). Although we found that only very recent (as opposed to moderately recent) use of psychedelics predicted feelings of social connectedness, there was no significant difference in predictive power between the two predictors. Detailed results for these and all other analyses can be found in *SI Appendix*, SOM II.

Structural Equation Model. To consolidate the findings detailed above and to investigate in more detail the relationships between

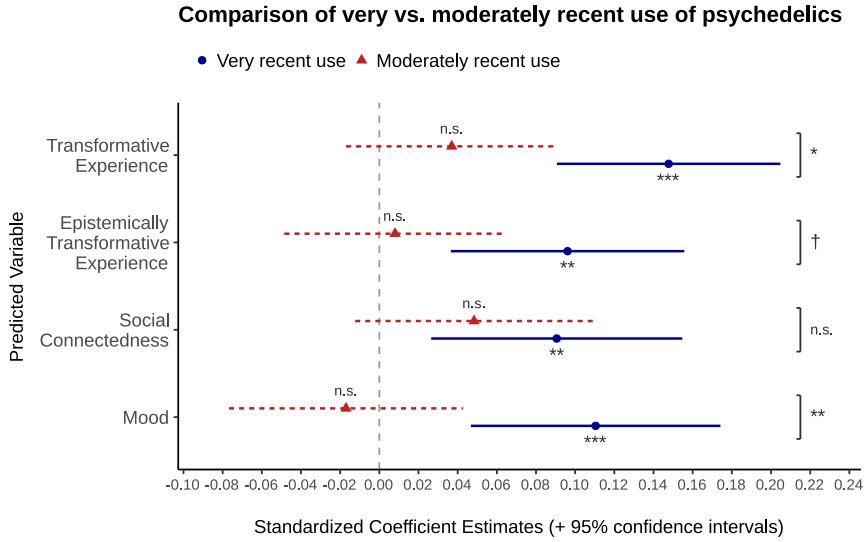

Fig. 2. Comparison of the effects of very recent vs. moderately recent use of psychedelics on the relevant outcome variables. All results control for the use of other classes of psychoactive substances and demographic variables. Results for TEs and ETEs further control for expectations and desires for TEs. Error bars represent 95% confidence intervals. Symbols above and below the coefficients indicate significant difference from zero; ***$P < 0.001$, **$P < 0.01$, *$P < 0.05$, †$P < 0.10$; n. s., not significant.

substance use and psychological variables, we entered all relevant variables into a structural equation model, testing for sequential mediation. More precisely, as predictors, we entered the full set of variables representing moderately recent and very recent use of each substance class, as well as the demographic variables age, gender, religiosity, education, and political orientation. We designed the model to test how very recent (vs. moderately recent) use of psychedelics would predict participants' positive mood via three indirect effects: (1) via TEs (controlling for expectations and desires), (2) via social connectedness alone, and (3) via TEs and connectedness in sequence (Fig. 3).

Data from all mass gatherings were included in this SEM, with missing values estimated using a full-information maximum likelihood procedure. Given the comparably few degrees of freedom, the model revealed good fit to the data; χ^2 (4, n = 1,225) = 2.59, $P = 0.628$, CFI = 1.00, RMSEA = < 0.01, 90% CI_{RMSEA} = [0.00; 0.04].

Very recent psychedelic substance use. Confirming our previous analyses, when controlling for expectations and desires, TEs were positively predicted by very recent psychedelic substance use: $b = 0.78$ ($\beta = 0.15$), SE = 0.15, $P < 0.001$, 95% CI = [0.48; 1.08]. Likewise, feelings of social connectedness were (marginally significantly) predicted by very recent psychedelic substance use, $b = 0.24$ ($\beta = 0.06$), SE = 0.13, $P = 0.073$, 95% CI = [−0.02; 0.50], yet more substantially by self-reported TEs, $b = 0.11$ (β = 0.14), SE = 0.02, $P < 0.001$, 95% CI = [0.07; 0.15], indicating that both variables may function as sequential mediators.

Moderately recent psychedelic substance use. Although descriptively pointing in the same direction, moderately recent psychedelic substance use did not significantly predict any of the variables included in the model. As we only found direct effects of very recent use of psychedelic substances (i.e., within the last 24 h), we focused on this variable for our mediation analyses.

Indirect effects/mediation. Focusing on our outcome variable of positive mood, TEs by themselves ($b = 0.07$ [$\beta = 0.18$], SE = 0.01, $P < 0.001$, 95% CI = [0.04; 0.09]) as well as social connectedness ($b = 0.10$ [$\beta = 0.21$], SE = 0.01, $P < 0.001$, 95% CI = [0.08; 0.13] both strongly predicted positive mood.

Testing for statistical mediation, three indirect effects of psychedelic substance use on positive mood emerged: via TEs, b = 0.05 ($\beta = 0.03$), SE = 0.01, $P < 0.001$, 95% CI = [0.03; 0.08]; via social connectedness, $b = 0.02$ ($\beta = 0.01$), SE = 0.01, $P = 0.081$, 95% CI = [0.00; 0.05]; and via both TEs and social connectedness in sequence, $b = 0.01$ ($\beta < 0.01$), SE < 0.01, $P = 0.002$, 95% CI = [0.00; 0.01] (combined indirect effects, $b = 0.09$ ($\beta = 0.04$), SE = 0.02, $P < 0.001$, 95% CI = [0.05; 0.13]). Controlling for these indirect effects reduced the total effect of very recent psychedelic substance use on psychological well-being ($b = 0.20$ [$\beta = 0.10$], SE = 0.07, $P = 0.002$, 95% CI = [0.07; 0.33]) to marginal significance: $b = 0.12$ ($\beta = 0.06$), SE = 0.06, $P = 0.067$, 95% CI = [−0.01; 0.24].

In sum, we found that very recent use of psychedelic substances uniquely and positively predicted positive mood. These associations were predominantly explained by participants' self-reported TEs and were robust to controlling for their expectations and desires for these experiences. To a lesser extent, these associations were also explained by increased feelings of social connectedness, both as a function of TEs or via other, unknown processes.[¶] As such, results indicate that the relationship between psychedelic substance use and psychological well-being is indeed statistically mediated by two processes in sequence: TEs and feelings of social connectedness.

Acute vs. Postacute Effects of Substances. One concern arising from the present results is the possibility that the analyses we ran confounded acute and postacute effects of psychedelic substance use. In other words, while the acute subjective effects of psychedelics taken more than 24 h ago (i.e., in the week prior) were likely to have subsided by the time of data collection, certain effects of some substances taken within the past 24 h (such as those of LSD) may still have affected participants. This is due to differences in absorption rates, half-lives, and subjective effects of different psychedelic substances, as well as the exact time when participants used them.

Therefore, when designing our study, we implemented several measures to minimize the chances that any current (residual)

[¶]Results for the SEM including the sum scores for substance use can be found in *SI Appendix*, SOM II. Including ETEs instead of TEs in the model produced highly similar (and equally significant) results.

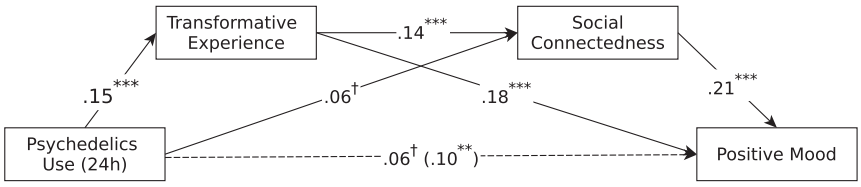

Fig. 3. Full structural equation model. Not displayed are control variables and other substance class predictors. Values represent standardized beta coefficients. The stroke path represents the direct effects, with the value in parentheses indicating the total effect. ***$P < 0.001$, **$P < 0.01$, †$P < 0.10$.

intoxication would noticeably affect participants' responses to our questionnaire. First, we instructed experimenters to take special care to only approach subjects who were not noticeably intoxicated. Second, we collected data between 10 AM and 1 PM, reducing the likelihood that participants were under substantial influence of a substance. Third, we embedded a sobriety/attention check item in our questionnaire (see above) and excluded participants who failed this check.

Finally, to validate that we indeed captured postacute, rather than acute effects of psychedelic substances, we replicated our main findings, excluding all participants ($n = 47$) who reported being currently under the (residual) influence of a psychedelic substance when completing the questionnaire. This conservative test revealed effect sizes largely identical to the full sample (see *SI Appendix*, SOM I and II, for detailed results). In addition, although we were primarily concerned with making sure to analyze postacute effects of psychedelic substances in particular, we ran a second set of analyses excluding every participant who was, at the time of data collection, under the influence of any substance (except for nicotine, as specified in our preregistration). These analyses, too, revealed results similar to the main analyses, indicating that (residual) intoxication did indeed not play a major role in responses to our questionnaire items.

TEs Due to Event Attendance Itself. Next, we considered the possibility that attending a multiday mass gathering may itself have effects on TE, social connectedness, and mood, regardless of substance use. This introduces a potential alternative explanation for our findings: if time spent at a mass gathering is associated with a higher likelihood of using psychedelics relative to other substance classes (for instance, because participants prefer to adjust to a new environment before taking psychedelics), and time spent at a mass gathering also predicts TE, social connectedness, and mood, this could produce a spurious relationship between psychedelic use and these outcome variables. We therefore reanalyzed our data including an additional covariate: the number of days participants already spent at the event prior to data collection (days at the event). On average, participants had already spent 3 d (median) at the respective event when completing the questionnaires (with duration of attendance ranging from 0 to 7 d). As suggested above, days at the event indeed significantly predicted psychedelic substance use, ($b = 0.04$ [$\beta = 0.15$], SE < 0.01, $P < 0.001$, 95% CI = [0.02; 0.05]), and this relationship was, in fact, about twice as strong as the corresponding relationship with alcohol use ($\Delta b = 0.02$ [$\beta = 0.09$], SE < 0.01, $P = 0.010$, 95% CI = [0.01; 0.04]), or cannabinoid use ($\Delta b = 0.02$ [$\beta = 0.08$], SE < 0.01, $P = 0.052$, 95% CI = [−0.00; 0.03]). Therefore, we tested whether this potential confound could indeed account for our findings. Controlling for days at the event in our main analyses produced similar results to the ones discussed above, with significant effects of (very) recent psychedelic substance use on TEs, ETEs, social connectedness, and mood. Controlling for days at the event in the mediations and the full SEM likewise produced results highly similar to the main analyses (see *SI Appendix*, SOM II, for details). As such, it seems as if event attendance itself does not explain the relationship between psychedelic substance use and TEs, social connectedness, or positive mood.

General Discussion

Data from a sample of more than 1,200 attendees across six mass gatherings in two countries indicate that recent use of psychedelic substances positively predicted self-reported TEs, social connectedness, and positive mood. Higher levels of self-reported TEs were not explained by a stronger desire for, or a greater expectation of having, such experiences. In addition, users of psychedelic substances considered their TEs to be more positive and intense and were more likely to report changes in their moral values as a consequence of these experiences, compared with nonusers of psychedelics. Further, TEs and social connectedness statistically mediated the effects of very recent (within 24 h) psychedelic substance use on positive mood. In all analyses, we controlled for the use of other types of psychoactive substances as well as a variety of demographic variables. Notably, use of euphorics (such as MDMA) did not meaningfully predict our outcome variables. Given that the effects of these substances are prototypically associated with constructs such as social connectedness (hence their common classification as empathogens) or positive mood, our findings with regard to psychedelics seem especially relevant (see *SI Appendix*, SOM II, for detailed results).

Our large dataset provides robust evidence that validates and extends findings from a growing literature on the mood-enhancing effects of psychoactive substances. Given that the psychedelic experience is notoriously affected by environmental variables (2), our laboratory-in-the-field approach allowed us to capture the psychological effects of psychedelic substances in a setting where people naturally use them. Collecting these data in the field also allowed us to observe psychological variables in the immediate aftermath of psychedelic substance use, in contrast to past studies surveying retrospective reports of past use. This allowed us to avoid relying on potentially incomplete or skewed recollections of psychedelic experiences. Because our questions about substance use were embedded within a larger questionnaire about social attitudes at mass gatherings, participants' responses were less likely to be affected by experimenter demand or preconceived notions about the psychological effects of psychedelic substances—a problem that can potentially arise in placebo-controlled studies in which participants notice that they received an active dose rather than a placebo or surveys that are explicitly described as studying the effects of psychedelics. Finally, given that participants completed our study at a relatively random time point after their psychedelic experience, the fact that very recent (past 24 h) psychedelic substance use had stronger psychological effects in our models hints at the importance of recency of an experience in the effects of these substances on reported TEs, feelings of social connectedness, and subsequent positive mood.

Although effects of moderately recent psychedelic substance use consistently pointed in the same direction as those of very recent use, they did not reach statistical significance. This is

potentially due to a lack of statistical power as moderately recent use (27.6%) was a less common occurrence among users of psychedelics than very recent use (69.6%) was. However, although they should be interpreted with caution, standardized effect sizes suggest a decline in the effects over time. In other words, feelings of transformation, social connectedness, or enhanced mood may have partly regressed back toward baseline in the days following the psychedelic experience, rather than disappear entirely. Although on a smaller timescale and not in a clinical population, such a trend would mirror the temporal effects of psychedelic substances on people suffering from affective disorders (5). Yet, an even larger sample or more sensitive measures would be necessary to make precise statements about such temporal effects in the present population.

Limitations

Our data have several limitations we should note. First, substance use was assessed via self report, which means we cannot verify with certainty that participants actually took the substances they indicated, nor can we pinpoint exactly which psychedelic substances might be responsible for the observed effects. In particular, participants may have been reluctant to disclose the use of psychedelics and other illegal substances. We can address this limitation in several ways. First, we designed our substance use survey to minimize participants' concerns about incriminating themselves with affirmative responses, by including a legal example in each substance category, and making this explicitly clear to participants as well as the fact that their survey responses were anonymous and confidential. Second, there is a common perception of widespread substance use at the events we studied, which reduces the possibility that participants would have felt they violated a norm by ingesting psychoactive substances. Finally, we note that our findings are highly consistent with placebo-controlled studies of the psychological effects of psychedelic substance use in laboratory settings (e.g., refs. 19, 25, 27, and 31).

In addition, it is possible that one or multiple unassessed variables that predict use of psychedelic but not other types of substances likewise predicted some of our outcome variables. That is, it is possible that a certain combination of personality variables predicted both the use of psychedelic substances, as well as the predisposition to have (or to report) TEs. To sidestep this limitation, we compared very recent and moderately recent use of psychedelic substances and found that effects on our psychological variables were more pronounced for very recent use. This shows that even among those participants who are generally willing to use psychedelic substances, the recency of the experience is a significant factor in predicting the respective positive outcomes. Yet, the question remains why, when differentiating moderately and very recent use of psychedelic substances, only very recent use significantly predicted our outcome variables, given that past research established long-lasting effects of psychedelics on similar variables (e.g., refs. 19 and 25). There are multiple potential reasons for this effect. First, moderately recent use of psychedelics was a considerably less common phenomenon (only 27.6% of psychedelics users took a substance in the week prior) than was very recent use, resulting in less statistical power to detect any effects on the dependent variables. Second, as the salience of any experience fades over time, one must expect a temporal decline in effects caused by a psychoactive substance and therefore also expect smaller effect sizes. Third, it is possible that—after an initial postacute effect that is relatively short-lived—it requires more time to fully integrate psychedelic experiences in order for them to unfold into their potential long-term effects. Elaborate follow-up studies will be necessary to fully explore this possibility. Longitudinal studies with event attendees, however, would likely require an even larger initial sample as one would need to account for a substantial number of dropouts in the follow-up analyses.

Further addressing the temporal dynamics of psychedelic substance use and TE, future studies should try to assess more precisely when psychedelic substance use and the experience of transformation took place (although the latter was perceived to be a rather gradual process by most participants; *SI Appendix*, SOM I). This would allow us to investigate potential delays between substance use and TE, as well as help further control for non–substance-induced TE due to the attendance of a mass gathering itself.

A third limitation concerns the generalizability of our observed effects. Attendees of certain cultural events, such as the events at which we collected our data, as well as people who are willing to use psychedelic substances in general, may be rather different from the average person in terms of personality, political attitudes, or sociodemographic variables. As such, while the results of our analyses may very well apply to the prototypical user of psychedelic substances, we cannot make definitive statements about how psychedelic substances affect the average person. However, we note that our findings survive controlling for a variety of demographic variables that past work has shown to predict a propensity to use psychedelic substances (14, 36).

Finally, we note the correlational nature of our findings. The methodology of the present research cannot entirely replace laboratory studies, as the lack of random assignment prevents causal inferences. Nevertheless, our data collection procedure allowed us to directly compare the effects of psychedelics taken in the past 24 h versus the past week. The fact that very recent psychedelic use had stronger effects on TE, social connectedness, and positive mood suggests that the causal arrow may run from substance use to affective outcomes, rather than the other way around. However, causality can only be established by means of experimental studies. Thus, in combination with placebo-controlled laboratory studies, laboratory-in-the-field studies have the potential to converge on a more complete account of how psychedelic substances affect mood and social relationships.

Conclusions

In sum, we provide evidence from a large sample that recent use of psychedelic substances in a naturalistic setting is associated with experiences of personal transformation, a sense of altered moral values, increased feelings of social connectedness, and a more positive mood. These effects were robust to controlling for the use of other substances, a host of demographic variables, and willingness to consume psychedelic substances in general. These findings confirm, in a larger sample and a naturalistic setting, previously observed positive effects of psychedelic substance use in placebo-controlled experimental investigations in the laboratory and may have important implications for future research into their therapeutic potential.

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