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Microdosing psychedelics: Demographics, practices, and psychiatric comorbidities

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Daniel Rosenbaum[1], Cory Weissman[1], Thomas Anderson[2], Rotem Petranker[3], Le-Anh Dinh-Williams[4], Katrina Hui[1] and Emma Hapke[1]

Abstract

Rationale: Microdosing psychedelics – the practice of consuming small, sub-hallucinogenic doses of substances such as LSD or psilocybin – is gaining attention in popular media but remains poorly characterized. Contemporary studies of psychedelic microdosing have yet to report the basic psychiatric descriptors of psychedelic microdosers.

Objectives: To examine the practices and demographics of a population of psychedelic microdosers – including their psychiatric diagnoses, prescription medications, and recreational substance use patterns – to develop a foundation on which to conduct future clinical research.

Methods: Participants (n = 909; M_{age} = 26.9, SD = 8.6; male = 83.2%; White/European = 79.1%) recruited primarily from the online forum Reddit completed an anonymous online survey. Respondents who reported using LSD, psilocybin, or both for microdosing were grouped and compared with non-microdosing respondents using exploratory odds ratio testing on demographic variables, rates of psychiatric diagnoses, and past-year recreational substance use.

Results: Of microdosers, most reported using LSD (59.3%; M_{dose} = 13 mcg, or 11.3% of one tab) or psilocybin (25.9%; M_{dose} = 0.3 g of dried psilocybin mushrooms) on a one-day-on, two-days-off schedule. Compared with non-microdosers, microdosers were significantly less likely to report a history of substance use disorders (SUDs; OR = 0.17 (95% CI: 0.05–0.56)) or anxiety disorders (OR = 0.61 (95% CI: 0.41–0.91)). Microdosers were also more likely to report recent recreational substance use compared with non-microdosers (OR = 5.2 (95% CI: 2.7–10.8)).

Conclusions: Well-designed randomized controlled trials are needed to evaluate the safety and tolerability of this practice in clinical populations and to test claims about potential benefits.

Keywords

Psychedelics, microdosing, psilocybin, LSD, substance use

Introduction

Microdosing refers to the use of a low, typically sub-perceptual dose of a pharmacological substance. In the context of the use of classic psychedelic drugs – for example lysergic acid diethylamide (LSD) and psilocybin (psilocin) – microdosing refers to ingesting sub-hallucinogenic amounts of the substance, approximately 1/10th of what would be considered a standard psychoactive dose (Fadiman, 2011; Kuypers et al., 2019). The classic psychedelics are a group of compounds that share 5-HT2A receptor agonist properties, and which, at higher doses, induce profound alterations in thought, perception, and emotion (Halberstadt, 2015; Nichols, 2016; Rickli et al., 2016), along with experiences of ego dissolution (Letheby and Gerrans, 2017; Milliere, 2017), and/or mystical-type experiences (Griffiths et al., 2011; Liechti et al., 2017). Various studies have demonstrated the safety and low addiction potential of psychedelics in healthy and clinical populations (Johnson et al., 2018; Nichols, 2016). In addition, recent studies have reported the potential efficacy of psychedelic-assisted psychotherapy for patients with anxiety associated with advanced cancer and other life-threatening illnesses (Gasser et al., 2014; Griffiths et al., 2016; Grob et al., 2011; Ross et al., 2016), alcohol use disorder (Bogenschutz et al., 2015), tobacco use disorder (Johnson et al., 2014), and major depressive disorder (Carhart-Harris et al., 2016).

Coverage of microdosing in popular media in recent years – including features in *Rolling Stone* (2015), *Wired* (2016), and *The New York Times* (2017) – has described some purported benefits of microdosing psychedelics, such as alleviating depression, migraines, and chronic-fatigue syndrome; improving concentration and reducing anxiety; and enhancing creativity (Leonard, 2015; Solon, 2016; Waldman, 2017a). In addition, anecdotal reports suggest that microdosing may improve cognitive performance (Waldman, 2017b; Wong, 2017). Despite these reports, there remains a dearth of academic research describing the practice of microdosing, including the specific substances consumed, doses and dosing schedules, and relevant demographic data of microdosers. Few scientific articles on microdosing among human subjects have been published, including two by our group

[1]Psychiatry, University of Toronto Faculty of Medicine, Toronto, Canada
[2]Psychology, University of Toronto, Toronto, Canada
[3]Psychology, York University, Toronto, Canada
[4]Clinical Science, University of Toronto, Scarborough, Canada

Corresponding author:
Daniel Rosenbaum, Psychiatry, University of Toronto Faculty of Medicine, 250 College Street, 8th Floor, Toronto, ON M5T 1R8, Canada.
Email: daniel.rosenbaum@mail.utoronto.ca

(Anderson et al., 2018, 2019). Where relevant to our findings, these studies are discussed in greater detail below. There have yet to be controlled clinical studies of psychedelic microdosing, and while this growing literature provides a valuable base from which to conduct future studies, it does not yet address the important relationships between participants' microdosing practices and their psychiatric diagnoses, prescription medications, and recreational substance use patterns.

Here we report on results of a cross-sectional observational study describing the characteristics and practices of a sentinel population of psychedelic drug microdosers identified through an anonymous online survey. The primary aim of this study is to describe the demographics, practices, and basic psychiatric descriptors of a large group of English-speaking adult microdosers. This report is part of a broader examination of survey response data that included testing of pre-registered hypotheses about microdosing and personality variables (Anderson et al., 2018), which showed that current and former microdosers scored lower on measures of dysfunctional attitudes and negative emotionality and higher on wisdom, open-mindedness, and creativity when compared with non-microdosing respondents. A qualitative analysis of open-ended survey responses pertaining to microdosing benefits and drawbacks was also performed, which found that improved mood and focus were the most commonly-reported beneficial outcomes, whereas physiolgical discomfort and increased anxiety were most commonly reported as challenging outcomes (Anderson et al., 2019).

Methods

Participants

An anonymous online survey was distributed to participants recruited via social media (e.g., Facebook, Twitter) and through posts on the online forum Reddit. Links were posted under the username/u/oredna on the following subreddits (i.e., forums dedicated to a specific topic): Microdosing, Nootropics, Psychonaut, RationalPsychonaut, Tryptonaut, Drugs, LSD, shrooms, DMT, researchchemicals, and SampleSize. Participants with and without experience microdosing psychedelics were recruited for this study. Study advertisements did not define either "microdosing" or "psychedelic" but indicated that researchers were interested in substance and dose regimens, as well as the benefits and drawbacks of microdosing psychedelics. Specifically, advertisements used the following language:

> We are interested in substance and dose regimens as well as benefits and drawbacks of microdosing psychedelics. Whether you have tried microdosing psychedelics, are microdosing right now, or are interested but have not microdosed yet, we want to hear from you! In fact, we even want to hear from you if you are not interested in microdosing as we need a control group!

There were no exclusion criteria. Participants were not remunerated. The survey was in English and was made internationally available. Ethical approval was received from the University of Toronto Social Sciences, Humanities, and Education Research Ethics Board.

Design and questionnaires

After informed consent, participants completed online computer-based questionnaires, including questions pertaining to demographics (see Table 1 for complete demographic characteristics of the sample), microdosing regimen (substance, frequency, dosage), substance use and mental health history, dispositional personality variables (wisdom, open-mindedness, negative emotionality, dysfunctional attitudes), and a creativity task. A complete list of survey questions is available at https://osf.io/jmcrh/. For brevity, methods reported here focus on variables analyzed in this paper.

Regarding substance(s) used for microdosing, participants were asked, "What substance do you use for microdosing?" Participants were then able to select either "LSD," "Psilocybin-containing 'magic' mushrooms," or "Other," which they were then asked to identify via free text. For dose, participants were instructed, "If you have a way of estimating your dose please report it here."

Regarding dose schedule, participants were asked, "How many days (approximately) do you space between microdoses?" and were then able to select from a list of 14 time-based intervals (i.e., ranging from "0: I microdose every single day" to "60: I microdose once every two months").

Regarding psychiatric diagnoses, participants were asked, "Have you ever been diagnosed by a doctor or health care professional (e.g., psychiatrist, psychologist) with any of the following diagnoses?" and were then able to select from a list of 11 diagnostic categories (see Table 2 for details).

Regarding prescription medications, participants were asked, "Are you currently taking any prescription drugs as prescribed by a doctor or health care professional?" and were then able to specify via free text.

Finally, regarding recreational substance use, participants were instructed, "Please indicate which of the following substances you have used for recreational purposes (e.g., for fun, with friends, for experimenting) by selecting the column that represents the most recent time you used this substance recreationally." Participants were then able to select one or more substances from a list of 13 categories across four time points (past month, past year, ever used, never used); see section entitled Recreational substance use and Table 3 for details.

Flow through the survey proceeded according to experience with microdosing; that is, individuals who reported never having microdosed were not presented with questions related to "history of microdosing" or "benefits and drawbacks of microdosing," and so forth. Participants were free to leave the survey at any time, and missing data were treated by available-case analysis (Gelman and Hill, 2007); that is, percentages are reported below based on the number of respondents for a given question, with the result that different subsets of data are not numerically consistent. The complete dataset is available at https://osf.io/jmcrh/.

Statistical analyses

Preliminary Wilcoxon signed-rank tests were performed to compare differences in age between grouped microdosers and non-microdosers, as this variable was non-normally distributed. For all other demographic variables, chi-squared testing was completed prior to follow-up odds ratio testing to examine specific demographic differences between grouped microdosers and

Table 1. Demographic characteristics of respondents by microdosing category (LSD and psilocybin microdosers only).

Characteristics		Currently microdosing	Not currently microdosing, but have microdosed in the past	Have not microdosed, but am interested in microdosing	Not interested in microdosing	Total
Age (years)	Mean (SD)	30.5 (9.9)	27.6 (9.1)	26.2 (8.0)	27 (5.3)	27.1 (8.8)
	Total					
Gender	*n* (%)					
	Male	161 (83.0)	188 (85.5)	207 (81.5)	19 (61.3)	575
	Female	24 (12.4)	24 (10.9)	43 (16.9)	11 (35.5)	102
	Neither/non-binary	7 (3.6)	4 (1.8)	1 (0.4)	1 (3.2)	13
	Prefer not to answer	1 (1.0)	4 (1.8)	3 (1.2)	0	8
	Total	193	220	254	31	698
Sexual orientation	*n* (%)					
	Heterosexual	156 (80.8)	179 (81.4)	213 (83.9)	25 (80.6)	
	Non-heterosexual (e.g., homosexual, bisexual/multisexual, asexual)	33 (17.1)	37 (16.8)	35 (13.8)	12 (19.4)	
	Prefer not to answer	4 (2.1)	4 (1.8)	6 (2.4)	0	
	Total	193	220	254	31	698
Ethnic heritage	*n* (%)					
	White/European	152 (78.8)	185 (84.1)	190 (74.8)	21 (67.7)	548 (78.5)
	Black	1 (0.5)	1 (0.5)	2 (0.8)	0	4
	East or South Asian	6 (3.1)	6 (2.7)	18 (7.1)	1 (3.2)	
	Middle Eastern	6 (3.1)	1 (0.5)	4 (1.6)	4 (12.9)	
	Hispanic or Latino	10 (5.2)	7 (3.2)	14 (5.5)	0	
	Mixed	11 (5.7)	9 (4.1)	14 (5.5)	1 (3.2)	
	Other	4 (2.1)	6 (2.7)	7 (2.8)	2 (6.5)	
	Prefer not to answer	3 (1.6)	5 (2.3)	5 (2.0)	2 (6.5)	
	Total	193	220	254	31	698
Religious affiliation	*n* (%)					
	Non-religious, atheist, or agnostic	117 (60.6)	112 (50.9)	130 (51.4)	16 (51.6)	
	Judaism	5 (2.6)	5 (2.3)	5 (2.0)	9 (29.0)	
	Christianity	6 (3.1)	11 (5.0)	35 (13.8)	2 (6.5)	
	Islam	0	0	3 (1.2)	0	
	Hinduism	0	1 (0.5)	2 (0.8)	1 (3.2)	
	Buddhism	5 (2.6)	8 (3.6)	8 (3.6)	0	
	Sikhism	0	0	1 (0.4)	0	
	Other religious affiliation	12 (6.2)	4 (1.8)	5 (2.0)	0	
	Spiritual but non-religious	47 (24.4)	75 (34.1)	55 (21.7)	1 (3.2)	
	Prefer not to answer	1 (0.5)	4 (1.8)	9 (3.6)	2 (6.5)	
	Total	193	220	253	31	
Social class	*n* (%)					
	Upper to upper-middle class	39 (20.2)	45 (20.5)	60 (23.6)	7 (22.6)	
	Middle to lower-middle class	116 (60.1)	133 (60.5)	129 (50.8)	22 (71.0)	
	Working class	23 (11.9)	30 (13.6)	41 (16.1)	1 (3.2)	
	Non-working class (casual workers, pensioners, or dependents)	10 (5.2)	6 (2.7)	11 (4.3)	1 (3.2)	
	Prefer not to answer	5 (2.6)	6 (2.7)	13 (5.1)	0	
	Total	193	220	254	31	698
Highest completed formal education	*n* (%)					
	Postgraduate degree	22 (11.4)	26 (11.9)	31 (12.2)	8 (25.8)	
	Bachelor or equivalent	75 (38.9)	73 (33.3)	74 (29.1)	14 (45.2)	
	Associate degree, diploma, certificate, or equivalent	51 (26.4)	49 (22.4)	49 (27.2)	4 (12.9)	
	High school or less	41 (21.2)	60 (27.4)	67 (26.4)	5 (16.1)	
	Prefer not to answer	4 (2.1)	11 (5.0)	13 (5.1)	0	
	Total	193	219	254	31	697

Table 2. Psychiatric diagnoses of survey respondents. Have you ever been diagnosed by a doctor or health care professional (e.g., psychiatrist, psychologist) with any of the following diagnoses?

	Microdosers *n* (%)	Non-microdosers *n* (%)	OR (95% CI)
ADHD	67 (20.5)	26 (15.7)	1.39 (0.84–2.28)
ASD	10 (3.1)	5 (3.0)	1.02 (0.34–3.02)
Anxiety (GAD, PD, SAD, SP)	87 (26.6)	62 (3.73)	**0.61** (0.41–0.91)
OCD	8 (2.4)	9 (5.4)	0.44 (0.17–1.16)
PTSD	20 (6.1)	10 (6.0)	1.02 (0.46–2.22)
Mood Disorder	82 (25.1)	49 (29.5)	0.8 (0.53–1.21)
DID	7 (2.1)	0	N/A
Eating Disorder	3 (0.9)	2 (1.2)	0.76 (0.13–4.59)
Schizophrenia spectrum disorder	6 (1.8)	2 (1.2)	1.53 (0.31–7.68)
SUD	4 (1.2)	11 (6.6)	**0.17** (0.05–0.56)
None of the above	173 (52.9)	76 (45.8)	1.33 (0.91–1.93)

ADHD: attention-deficit/hyperactivity disorder; ANXIETY: Anxiety (generalized anxiety disorder, panic disorder, social phobia, specific phobia); ASD: autism spectrum disorder; DID: dissociative identity disorder; ED: eating disorder (anorexia, bulimia, binge eating disorder); MOOD: mood disorder (major depression, bipolar disorder, dysthymia/persistent depressive disorder, treatment-resistant depression); OCD: obsessive compulsive disorder; PTSD: posttraumatic stress disorder; schizophrenia spectrum disorder (schizophrenia, schizoaffective, schizotypal, brief psychotic disorder); SUD: substance use disorder.
Odds ratios represent differences in rates of diagnosis among LSD- and psilocybin-only microdosers (current or past) compared with non-microdosers (interested or not interested); bold denotes statistical significance.

Table 3. Recent recreational substance use among LSD and/or psilocybin microdosers.

Substance	*n* (%)		**Bold** denotes statistical significance
	Microdosers	Non-microdosers	OR (95% CI)
Classic hallucinogens at full dose (LSD, psilocybin mushrooms, DMT, ayahuasca, mescaline)	276 (45.5)	40 (16.3)	**5.49** (3.6–8.38)
Research chemical (2C-B, 2C-E, 2C-I, 25I-NBOMe)	75 (18.5)	15 (8.2)	**2.42** (1.39–4.2)
MDxx (MDMA, MDA, MDE, "ecstasy," "molly")	148 (31.1)	52 (23.9)	**1.8** (1.22–2.67)
Cannabis	286 (46.5)	120 (41.8)	**2.61** (1.64–4.15)
Alcohol	291 (47.0)	142 (46.0)	1.38 (0.8–2.39)
Stimulants (cocaine, crack, amphetamines, methamphetamine)	130 (28.3)	63 (27.5)	1.07 (0.73–1.57)
Opioids	63 (16.1)	34 (17.0)	0.92 (0.58–1.47)
Dissociatives (ketamine, PCP, DXM, cough syrup)	86 (20.7)	23 (12.2)	**2.2** (1.33–3.64)
Sedatives (GHB, barbiturates)	40 (10.9)	8 (4.6)	**2.73** (1.24–5.97)
Inhalants (nitrous, paint thinners, gasoline, contact cement)	52 (13.6)	15 (8.3)	**1.89** (1.03–3.47)
Caffeine	308 (48.4)	154 (48.0)	1.24 (0.6–2.54)
Nootropics (L-theanine, Bacopa monnieri, Ashwagandha, racetams)	136 (29.3)	55 (24.7)	1.46 (0.99–2.15)
Psychiatric prescription drugs for recreational purposes	103 (23.8)	47 (22.1)	1.15 (0.76–1.73)

n (%) = proportion of respondents using each substance in the past year (includes "past month" and "past year" responses).
OR values (95% CI): **bold** denotes statistical significance.

non-microdosers. Odds ratio testing between grouped microdosers and non-microdosers was also performed to compare rates of specific DSM-5 diagnoses and "recent" (i.e., past year) recreational substance use between the two groups.

While the initial aim of this study was exploratory and participants were free to indicate all substances used for microdosing, we focused our analyses on participants who reported using LSD, psilocybin, or both (i.e., the classic psychedelics). This was done to facilitate interpretation of results in the context of current basic and clinical research into classic psychedelics per se. As such, results from "microdosers" reported below include only those who reported using LSD, psilocybin, or both.

Results

Demographics

Between September and November 2017, 1390 people began the survey; 475 exited before responding, 3 requested that their responses be removed, and 3 were excluded for careless/

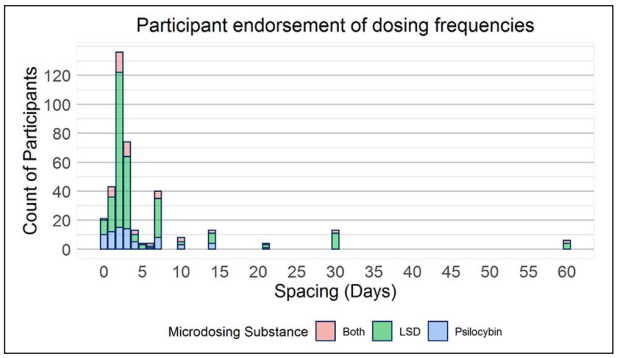

Figure 1. Microdosing schedule: count of participants (*n*) vs. spacing (frequency).
Spacing (Days) refers to the number of days between doses, that is, 0: I microdose every single day; 1: I microdose every other day; 2: I microdose one-day-on, two-days-off; 7: I microdose once per week; and so on.

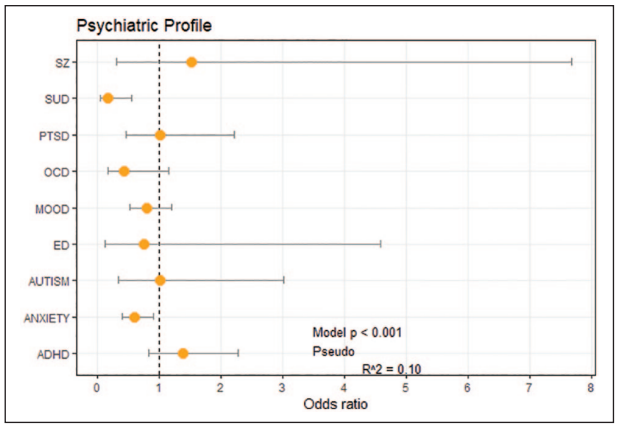

Figure 2. Psychiatric diagnoses.
Have you ever been diagnosed by a doctor or health care professional (e.g., psychiatrist, psychologist) with any of the following diagnoses?
ADHD: attention-deficit/hyperactivity disorder; ANXIETY: anxiety (generalized anxiety disorder, panic disorder, social phobia, specific phobia); AUTISM: autism spectrum disorder; ED: eating disorder (anorexia, bulimia, binge eating disorder); MOOD: mood disorder (major depression, bipolar disorder, dysthymia/persistent depressive disorder, treatment-resistant depression); OCD: obsessive compulsive disorder; PTSD: posttraumatic stress disorder; SUD: substance use disorder; SZ: schizophrenia spectrum disorder (schizophrenia, schizoaffective, schizotypal, brief psychotic disorder).
Odds ratios represent differences in rates of diagnosis among LSD- and psilocybin-only microdosers (current or past) compared with non-microdosers (interested or not interested).

disingenuous responding. The final sample comprised 729 respondents, $n = 414$ who reported microdosing with either LSD, psilocybin, or both, and $n = 315$ non-microdosers. Respondents who reported using other substances for microdosing were removed. Participants were divided into four distinct categories based on their microdosing history: currently microdosing (26.6%, $n = 194$); past microdosing (30.2%, $n = 220$); not microdosing but interested (37.7%, $n = 275$); not interested in microdosing (5.5%, $n = 40$).

Of the 729 respondents who provided their country of origin, just over half (50.1%, $n = 365$) were from the United States. Other significant nation contributors to the survey included Canada (12.2%, $n = 86$) and Norway (5.1%, $n = 36$). In total, respondents from 45 countries responded to the survey. Of the total sample, over three-quarters (82.4%, $n = 575$) were male, the average age was 27.1 years (SD = 8.8, range = 16–70 years), and over two-thirds (69.3%) identified their ethnicity as White/European. See Table 1 for complete demographic characteristics of the sample.

Exploratory analyses on demographic variables were performed in order to distinguish traits that were more characteristic of microdosers compared with non-microdosers. There were no significant differences between these groups in age, $Z = -0.526$, $p > 0.05$, $r = 0.020$; sexual orientation, χ^2 (4) = 1.02, $p > .05$; ethnic heritage, χ^2 (9) = 13.6, $p > .05$; social class, $\chi^2(7) = 7.1$, $p > .05$; or highest completed formal education, χ^2 (9) = 4.6, $p > .05$. We did find significant differences in religion, χ^2 (9) = 42.7, $p < .001$; and gender, χ^2 (4) = 11.8, $p = .02$. Post hoc odds ratio tests demonstrated significantly lower odds of reporting religious affiliation in microdosers compared with non-microdosers, OR = 0.46 (95% CI: 0.33–0.66), and near-significantly higher odds of being male, OR = 1.47 (95% CI: 0.98–2.19).

Microdosing regimen

Of all microdosers, 59.3% reported using LSD ($n = 385$) and 25.9% reported using psilocybin ($n = 168$), with reported median doses of 13 mcg of LSD (or 11.3% of one tab, assumed for our report to be tabs of the LSD tartrate salt, though the question did not specify) and 0.3 g of psilocybin mushrooms (assumed for our report to be dried mushrooms, though the question did not specify). Complete details of substance coding and of less commonly reported substances are available in Supplementary Table 1.

With respect to dosing schedule, a multimodal distribution of microdosing frequency emerged (Figure 1), with a large mode centered around brief intervals between doses, including microdosing (a) one-day-on, two-days-off (35.9% of microdosers, $n = 136$), (b) one-day-on, three-days-off (19.5% of microdosers, $n = 74$), and (c) one-day-on, one-day-off (11.3% of microdosers, $n = 43$). Other peaks included more distant intervals, that is, on a weekly basis (10.6% of microdosers, $n = 40$) or more than 2 weeks apart (9.5% of microdosers, $n = 36$). The median monthly cost of microdosing was USD 6.92.

Psychiatric comorbidities

Self-reported psychiatric diagnoses among LSD and/or psilocybin microdosers are displayed in Table 2. Five-hundred nine participants provided details about psychiatric diagnoses; 47.1% of microdosers ($n = 154$) and 54% of non-microdosers ($n = 90$) reported a history of receiving one or more psychiatric diagnoses from a mental health professional during their lifetime. The most commonly reported diagnoses were as follows (microdosers vs. non-microdosers): anxiety disorders (26.1% vs. 35.2%), followed by mood disorders (24.6% vs. 27.8%), and attention-deficit hyperactivity disorder (ADHD; 20.1% vs. 14.8%). See Table 2 for complete details.

Exploratory odds ratio testing revealed that microdosers were not more likely to report a psychiatric history compared with non-microdosers, OR = 0.75 (95% CI: 0.52–1.09). When examining specific diagnostic categories, exploratory odds ratio testing

revealed that microdosers were significantly less likely to report a history of SUDs, OR = 0.17 (95% CI: 0.05–0.56), or anxiety disorders, OR = 0.61 (95% CI: 0.41–0.91), compared with non-microdosers. There were no other significant differences in risk between groups (see Table 2 and Figure 2).

Prescription medications

Four-hundred ninety-six respondents provided details about their current prescription medications, 329 of whom were current or past microdosers of LSD, psilocybin, or both. After non-psychotropic medications (i.e., medications for non-psychiatric illnesses, such as antihypertensives), the most commonly reported prescription medications among microdosers were the dopamine and norepinephrine reuptake inhibitor and releasing agents (e.g., methylphenidate- and amphetamine-based psychostimulants; 6.4% of microdosers, n = 21), benzodiazepine receptor agonists (e.g., lorazepam and other benzodiazepines, as well as sedative-hypnotic agents such as zopiclone; 3.3%, n = 11), and bupropion (an agent with primary noradrenergic and dopaminergic activity; 3.0%, n = 10). In addition, 2.7% of microdosers (n = 9) reported current prescription of medications with serotonin reuptake inhibition properties (i.e., SSRIs or SNRIs). For further details of prescription medications, please refer to the complete dataset available at https://osf.io/jmcrh/.

Recreational substance use

Participants reported their use of various substances for recreational purposes across four time categories: past month, past year, ever used, or never used. Participants were able to select one or more substances from a list of 13 substance classes (see Table 3 for details). "Recent" substance use was examined by combining past month and past year responses. Complete results are presented in Table 3.

Aside from caffeine (48.4% of microdosers) and alcohol (47.0% of microdosers), the most commonly reported substances used in the past year for recreational purposes among LSD and/or psilocybin microdosers were cannabis (46.5%, n = 286), classic psychedelics at full dose (45.5%, n = 276), and the MDxx family (31.1%, n = 148). Exploratory odds ratio tests indicated that microdosers were approximately 5 times more likely to report recent substance use (excluding caffeine, alcohol, nootropics, and prescription medications) compared with non-microdosers, OR = 5.2 (95% CI: 2.7–10.8). Specifically, microdosing status was associated with significantly higher odds of reporting the use of classic psychedelics at full dose, OR = 5.49 (95% CI: 3.60–8.38); sedatives, OR = 2.73 (95% CI: 1.24–5.97); cannabis, OR = 2.61 (95% CI: 1.64–4.15); research chemical hallucinogens, OR = 2.42 (95% CI:1.39–4.2); dissociatives, OR = 2.20 (95% CI: 1.33–3.64); inhalants, OR = 1.89 (95% CI: 1.03–3.47); and the MDxx family, OR = 1.80 (95% CI: 1.22–2.67). There were no significant differences between microdosers and non-microdosers in recent use of all other substances. Regarding substance use more generally, microdosers were also 1.5 times more likely to report having used recreational substances in the past (ever used) – excluding caffeine, alcohol, nootropics, and prescription medications for recreational purposes – compared with non-microdosers, OR = 1.48 (95% CI: 1.02–2.15).

Discussion

This study is one of the largest scientific observational studies on the phenomenon of psychedelic microdosing, consisting of an international sample of 909 respondents. Our objectives for this study were to explore the following: the substances, doses, and dose schedules used by microdosers; the basic psychiatric descriptors of microdosers; the concomitant use of prescription medications; and the recreational substance use patterns of microdosers. In the following section, we review these findings in detail and discuss their relevance to the field of psychedelic science and future studies of psychedelic microdosing.

Microdosing regimen

The two most commonly reported substances used for microdosing among our sample were LSD (median dose 13 mcg LSD; 11.3% of one tab) and psilocybin (median dose 0.3 g of psilocybin mushrooms, presumed to be dried). The psilocybin content of dried *Psilocybe cubensis*, a common strain of psilocybin-containing mushroom, has been shown to be in the range of 0.37–1.30% of the whole mushroom (Tsujikawa et al., 2003). Taking a value of 1% psilocybin per gram of dried mushroom, we estimate a mean psilocybin dose of approximately 3 mg reported by our sample.

The most commonly reported microdosing schedule was to dose every 3 days (i.e., one-day-on, two-days-off), with nearly half of all microdosers spacing fewer than 3 days between doses (Figure 1). Our findings are broadly consistent with the recent work of Hutten et al. (2019), who also completed an online questionnaire of adult microdosers (n = 1116) and found that LSD (mean dose 10 mcg) and psilocybin mushrooms (mean dose 0.5 g) were most commonly used, at a frequency of 2–4 times per week.

This regimen (i.e., one-day-on, two-days-off) may have its basis in Fadiman's (2011) work, *The Psychedelic Explorer's Guide: Safe, Therapeutic, and Sacred Journeys*, which describes anecdotal evidence of the benefits of microdosing LSD and psilocybin-containing mushrooms in a case-series of self-reports, and which has become a popular microdosing reference. In this work, LSD microdoses are suggested on average to be 10–20 mcg per dose and are taken every 3 days, and psilocybin microdoses may take the form of two medium-sized mushrooms, equivalent to 1 g of dried mushrooms (or approximately 10 mg of psilocybin), with the suggestion that they can be taken daily without development of tolerance (Fadiman, 2011). The one-day-on, two-days-off dosing schedule appears to have some rationale in neurophysiology, where tachyphylaxis related to 5-HT2A receptor downregulation results in a near-complete loss of sensitivity to acute effects of LSD by Day 4 of repeated administration (Belleville et al., 1956; Cholden et al., 1955). Cross-tolerance between psilocybin and LSD has been shown to occur in humans (Isbell et al., 1961), and one may therefore expect that tachyphylaxis would also occur in the context of repeated psilocybin ingestion. The question of what dosing regimen may optimize potential clinical benefits is one that warrants further study; we report elsewhere that we did not find a relationship between microdosing schedule and certain personality variables (Anderson et al., 2018).

With respect to dose, the Global Drug Survey (GDS) 2017 Key Findings Report cites a GDS mini-survey conducted in 2016

in which 655 participants reported having microdosed with LSD (10–30 mcg) at least once. Nearly two-thirds of these respondents (64.3%) reported that their dosing involved "guess work," generally via fractions of LSD tabs obtained via illegal online markets (Winstock et al., 2017). This guess work was cited by many of our respondents as a significant drawback of microdosing (Anderson et al., 2019). We expect this issue to be present with psilocybin as well, as microdosers generally consume fractions of dried psilocybin mushrooms. Psilocybin content is likely to vary by mushroom species, and the psilocybin content of dried mushroom caps may be greater than in stems (Tsujikawa et al., 2003). This speaks to the importance of dose standardization and the necessity of controlled clinical trials to test the safety and potential benefits of microdosing psychedelics.

In a recent open-label experimental trial involving 20 healthy adults (Bershad et al., 2019), subjects were provided with either placebo or four varying low doses of LSD (6.5 mcg, 13 mcg, and 26 mcg) in weekly intervals. In this study, LSD produced dose-related subjective effects, and at the 26 mcg dose participants reported increased ratings of "vigor" and decreased positivity ratings of images with positive emotional content. The authors suggested that a "threshold dose" of 13 mcg of LSD could be considered safe in future investigations of LSD microdosing involving repeated administration (Bershad et al., 2019); this suggested dose is identical to the median dose reported by our sample of LSD microdosers.

The median dose of psilocybin mushrooms reported by our sample (approximately 0.3 g) is significantly lower than that suggested by Fadiman (approximately 1.0 g; Fadiman, 2011). Notably, both these doses could be expected to produce significant and potentially intense effects. Psilocybin doses as low as 5 mg/70 kg have been shown to produce significant subjective and observer-rated effects (Griffiths et al., 2011). In addition, in their study of psilocybin for the treatment of depression and anxiety in patients with life-threatening cancer, Griffiths et al. (2016) used a "low-dose" control condition psilocybin dose of 1 or 3 mg/70 kg, compared with a "high-dose" experimental condition (22 mg/70 kg). In sessions involving the low-dose condition, 12% of participants reported physiological discomfort and 15% reported an episode of anxiety. Furthermore, 24% of participants rated the low-dose session as one of the top five most meaningful experiences of their life, and 24% also rated the session as one of the top five most spiritually significant experiences of their life (Griffiths et al., 2016). The role of expectancy in this study is important to mention here, given that participants were blinded to dose and encouraged to try to "attain maximal therapeutic and personal benefit from each session." Indeed, the subjective effects of psychedelics in general have been shown elsewhere to be affected greatly by expectancy (Metzner et al., 1965). Nevertheless, given these findings, and that the aim of microdosing is to avoid significant perceptual disturbances or alterations of consciousness, it is likely that at doses reported by our sample and suggested by Fadiman (2011), users may experience undesired, significant acute drug effects, especially considering the guess work and resultant dose variability discussed above.

We suggest that clinical trials involving microdosing psychedelics could be designed to test a range of doses and schedules to compare both acute drug effects and longer-term outcomes. Weight-based dosing, as implemented in some high-dose psychedelic studies, could also be considered. Ultimately, potential benefits of microdosing psychedelics should be tested via randomized controlled trials against inactive placebo.

Psychiatric comorbidities

The most commonly reported diagnoses among current or past LSD and/or psilocybin microdosers were anxiety disorders, mood disorders, and ADHD (Table 2). However, the only significant differences between grouped microdosers and non-microdosers were in rates of SUDs and anxiety disorders; in both cases, microdosers had significantly lower odds of reporting these diagnoses compared with non-microdosers.

By combining our data for the DSM-V diagnoses of PTSD, OCD, and anxiety disorders, we can attempt broad comparisons – without tests of statistical significance – with DSM-IV data from the National Comorbidity Survey Replication (NCS-R), a household survey representative of the US population conducted in 2001 (Kessler et al., 2004). In the present study, over a quarter of LSD and/or psilocybin microdosers (26.6%, $n = 87$) reported any anxiety disorder as described in DSM-IV, which is a lower rate than that reported in the NCS-R (33.7% lifetime prevalence of any anxiety disorder; Kessler et al., 2012). Our sample of LSD and/or psilocybin microdosers reported a much higher prevalence of ADHD than the general US population (20.5% vs. 4.4%, respectively; Kessler et al., 2006). This is an intriguing finding, and one which may also have its basis in the work of Fadiman, who has described microdosing psychedelics as "an extremely healthy alternative to Adderall" (Leonard, 2015). The potential role of psychedelic microdosing in improving attention, concentration, or other domains of cognitive performance fits with anecdotes reported in popular media, and was also reported as beneficial by respondents in our companion study of microdosing benefits and drawbacks (Anderson et al., 2019). These claims warrant further study using well-designed placebo-controlled trials.

Our sample of LSD and/or psilocybin microdosers unexpectedly reported a lower prevalence of SUDs (1.2%) than both our non-microdosing respondent group (6.6%, a statistically significant result) and the general US population as reported in the NCS-R (5.9% prevalence of current SUD; Coccaro et al., 2017). While the self-reporting nature of our study could have led to underreporting of SUDs, this finding remains noteworthy given the suggestion that psychedelics at high doses may have efficacy for the treatment of various SUDs (Bogenschutz et al., 2015; Johnson et al., 2014). Of note, the lower reported rate of SUDs among our sample of microdosers appears discordant with our finding of significantly higher reported rates of recent substance use among microdosers relative to non-microdosing respondents (see Table 3). Considering our finding that microdosers score significantly higher compared with non-microdosers on measures of the personality domain of openness (Anderson et al., 2018), we hypothesize that those who engage in an experimental practice of psychedelic microdosing may be less likely to consider recreational substance use problematic, and may therefore be less likely to seek care and receive a diagnosis of SUD. Furthermore, Webb et al. (2019) recently published results of semi-structured interviews with 30 psychedelic microdosers, which aimed to explore personal narratives of people who microdose in order to understand the factors shaping their use. These participants were noted

to view themselves as "conventional people" who were concerned about and chose to microdose to enhance their health and wellness. Participant narratives appeared to normalize their drug use and emphasized their connection to "conventional citizens who embrace middle-class values" (Webb et al., 2019). These results may also shed light on the low rate of self-reported SUDs among our population of psychedelic microdosers. Ultimately, the potential role of psychedelic microdosing in the setting of SUDs also warrants further study using well-designed, randomized controlled trials.

Notably, 1.8% of microdosers (n = 6) reported having been diagnosed with a schizophrenia spectrum disorder. This is a significant finding given that the presence of a personal or immediate family history of psychosis is a common exclusion criterion in contemporary studies of high-dose psychedelics (see for instance Carhart-Harris et al., 2016; Ross et al., 2016). These studies also tend to exclude individuals with a history of mania. The current study reports only on the presence of mood disorders and did not ask participants to specifically report a history of mania or bipolar disorder. It will be important to consider personal and/or immediate family histories of mania or hypomania in designing future clinical trials involving psychedelic microdosing given the potential for serotonergic agents to precipitate mania or hypomania in individuals with underlying bipolar illnesses (Goldberg and Truman, 2003). Ultimately, the risks of microdosing psychedelic drugs for individuals with risk factors for psychotic disorders or bipolar illnesses remain unclear in both acute and chronic settings, and safety studies are needed to inform the design of future clinical trials.

In sum, our results suggest that individuals with a history of substance use disorder(s) and anxiety disorders are less likely to engage in the practice of psychedelic microdosing. This suggests that individuals may be cautious about engaging in experimental substance use such as microdosing when (a) they have a history of problematic substance use, perhaps in an effort to minimize risk of relapse; and (b) if they may be vulnerable to anxious sensations and thoughts, and may therefore have difficulty tolerating the uncertainty associated with this experimental practice (e.g., potential effects, appropriate dosage, etc.) and/or potential physiologic discomfort or other potential drawbacks (see our companion paper of microdosing benefits and drawbacks for further discussion: Anderson et al., 2019).

Prescription medications

Psychotropic medication prescription is generally an exclusion criterion of contemporary studies involving high-dose psychedelics (see for instance Carhart-Harris et al., 2016; Ross et al., 2016). The rate and nature of psychotropic medication prescription reported by our microdosing sample are thus noteworthy, especially given the psychiatric comorbidities reported by our sample. Prescription with methylphenidate- and/or amphetamine-based psychostimulants was reported by 6.4% of microdosers (n = 21), which fits with the high reported rate of ADHD among this group. This class of medication primarily affects the dopamine and norepinephrine neurotransmitter systems (which is also the case for bupropion, reported by 3.0% of microdosers (n = 10)) and would not be expected to interact directly with the serotonergic psychedelics. Benzodiazepine receptor agonists such as lorazepam and zopiclone, which act primarily on the GABA system, were reported by 3.3% of microdosers (n = 11). In high-dose psychedelic studies, tranquilizing medications such as lorazepam (as well as risperidone, a potent dopamine D2 receptor antagonist) are made available if necessary to reduce the intensity of peak drug effects (see for instance Carhart-Harris et al., 2016). It is possible that concomitant use of benzodiazepines could attenuate the potential benefits of microdosing psychedelics through indirect mechanisms.

Agents with serotonin reuptake inhibition properties (i.e., SSRIs or SNRIs) were reported by 2.7% of microdosers (n = 9). Serotonergic antidepressants have been shown to attenuate psychedelic effects (Bonson et al., 1996), presumably via downregulation of 5-HT2A receptors, which is a property of many drugs used for the treatment of depression (Gray and Roth, 2001). In addition, combining serotonergic medications raises the theoretical risk of serotonin syndrome, a potentially dangerous reaction caused by excess serotonin (Boyer and Shannon, 2005). Whether this risk is theoretical or clinically significant remains to be determined. The design of future trials of psychedelic microdosing should carefully consider the relative potential benefits (e.g., mitigating any theoretical risk of serotonergic drug pharmacodynamic interactions; increasing reproducibility/internal validity of the trial) and drawbacks (e.g., risk of symptom worsening or harm to participants who may be benefiting to some degree from their SSRI; potentially limiting generalizability/external validity) of participants being tapered off their medications prior to study entry.

Recreational substance use

Our sample of LSD and/or psilocybin microdosers was approximately 5 times more likely to report a history of recent (i.e., past year) recreational substance use compared with non-microdosers. With respect to specific substances, microdosers had significantly greater odds of reporting recent use of classic psychedelics at full dose, research chemicals, the MDxx family, cannabis, dissociatives, sedatives, and inhalants (Table 3).

There are several possible interpretations of these results. First, previous experience with recreational substance use may reduce some of the barriers to engaging in psychedelic microdosing, such as anxiety about buying illegal substances and the likelihood of experiencing aversive effects (e.g., hallucinations, being "out of control", etc.). Previous experience with recreational substance use may also influence positive expectations about microdosing. Next, as discussed, our sample of microdosers reported a higher prevalence of ADHD compared with the general population as reported in the NCS-R, and showed a trend toward significantly higher odds of reporting a diagnosis of ADHD compared with non-microdosers (Table 2). Numerous studies have shown an association between ADHD and substance use, along with diagnoses of SUDs (see for instance Ameringer and Leventhal, 2013; Capusan et al., 2016; Kessler et al., 2006; Levy et al., 2014), a finding that may have its basis in the overlapping symptomatology of ADHD and SUDs, including "behavioural undercontrol," impulsivity, and disinhibition, along with possible shared neurobiological and etiological underpinnings in dopaminergic reward processing pathways (Luo and Levin, 2017). Interestingly, a 2015 meta-analysis involving 13 studies and 1271 patients with ADHD and comorbid substance use issues showed that treatment of ADHD may lead to improvements in

ADHD symptoms, but does not appear to be effective in leading to drug abstinence (Cunill et al., 2015). The potential role of psychedelics in the setting of ADHD, if shown to be effective in well-designed randomized controlled trials, may provide an interesting parsimonious treatment option for those with comorbid ADHD and SUDs, as there is promising evidence to suggest that psychedelics may be effective in treating various SUDs (Bogenschutz et al., 2015; Johnson et al., 2014).

It is also noteworthy that our sample of microdosers was nearly 5.5 times more likely to report recent use of classic psychedelics at full dose compared with non-microdosers. Given the sustained effects of high-dose psychedelic-assisted therapy reported in recent clinical trials (Gasser et al., 2014; Griffiths et al., 2016; Grob et al., 2011; Ross et al., 2016), recent use of psychedelics at high doses should be considered a significant confounding factor in any interpretation of reported benefits of microdosing psychedelics if not properly controlled for.

Validity and limitations of methods

To our knowledge, this report represents one of the largest global studies of psychedelic microdosers conducted to date. Our study sample included several online communities of microdosers, as well as participants with no microdosing experience. Online discussion forums such as Reddit offer a potentially rich source of data about microdosing, as the popularization and de-stigmatization of this practice has only begun in the past few years. Given the illegality of most substances used for microdosing across jurisdictions, Reddit and other Internet-based forums have likely provided safe and anonymous platforms through which microdosers share information about the nature of their practices. As such, our study sample, which was largely recruited via several psychedelics-oriented subreddits, likely represents a highly informed population of microdosers, potentially increasing the utility of our results.

Anonymous online surveys, such as the annual GDS (Barratt et al., 2017; Winstock et al., 2017), have been shown to be inexpensive and highly useful tools for the identification of novel substances of abuse or drug practices, as they allow for the rapid identification and assessment of a potentially large drug-using population (Winstock et al., 2014). The utility, validity, and limitations of the methods employed in the GDS – which employs similar online, anonymous, cross-sectional, opportunistic sampling of drug users as the sampling methods we employed – are discussed in Barratt et al., (2017). Specific limitations relevant to our study include the reliability of participant self-report, which is an inherent, general limitation of these methods. In addition, while this is one of the largest studies of microdosers ever conducted, our participants may not be representative of the wider microdosing population given the self-nominating nature of the sample, and given that our survey drew primarily from Reddit users recruited from microdosing- and/or psychedelics-oriented forums. Finally, as in all such studies, there is no way of validating the composition or dose of specific substances reported or consumed.

Despite these limitations, our findings should be considered a significant advance from media anecdotes of microdosing, a phenomenon which remains understudied in the academic literature. We hope that this study will serve as an important base from which to plan and conduct future research into microdosing psychedelics, and that our findings can inform those who choose to engage in this practice.

Microdosing psychedelics and clinical psychiatry

Contemporary, high-dose psychedelic therapy has been conceptualized as a distinct form of drug-assisted psychotherapy, as opposed to a traditional pharmacotherapy (Roseman et al., 2017). Importantly, a central mediator of change in this paradigm is the quality of the acute drug experience itself – a potentially profound, psychologically- and/or spiritually-transformative peak or mystical-type experience. The central import of the acute drug experience is evident in the emphasis in psychedelic literature on "set and setting," the concept that drug response is highly influenced by factors such as expectancy, preparation, and intention (set), and the physical/social environments (setting; Hartogsohn, 2016). Psychedelic microdosing, on the other hand, appears more akin to conventional pharmacotherapy: regular consumption of a substance for some intended benefit(s) without significant or disruptive life-interfering acute effects. As such, set and setting may be less important in microdosing psychedelic drugs, and designing clinical trials involving psychedelic microdosing is therefore likely to be more similar to trials of new pharmacotherapies than recent trials involving high-dose psychedelics. Furthermore, given that the aim of microdosing is to avoid significant perceptual disturbances or altered states of consciousness, blinding procedures should be easier to implement than in clinical trials involving high-dose psychedelics, where there remain significant challenges with and debate over blinding methods.

In our taxonomy of microdosing benefits and drawbacks (Anderson et al., 2019), we describe beneficial outcomes of microdosing as reported by our sample, including improved mood (26.6% of microdosers) and focus (14.8%), along with reduced anxiety (4.2%). Given the recent work examining the treatment of depression and anxiety with full-dose psychedelic-assisted therapy, as well as anecdotal reports of these and other benefits in popular media, we suggest that rigorously designed randomized controlled trials are needed to test hypotheses concerning the potential role of psychedelic microdosing in clinical populations. Clinical trials could be designed to isolate the potential effects of microdosing as pharmacotherapy alone, or microdosing could be combined with evidence-based treatments for mood and anxiety disorders in a manner similar to "psycholytic therapy" (Gasser, 1995). While high-dose psychedelics make engaging in formal, manualized therapies difficult because of the profound alterations in consciousness they produce, psychedelic microdosing may be better suited to combine with specific psychotherapies, including first-line psychotherapeutic treatments for depression and anxiety disorders, such as cognitive behavioral therapy (Rush and Beck, 1978). If microdosing psychedelic drugs produces beneficial effects on mood via increased openness (MacLean et al., 2011) or other personality domains, or via reductions in pessimism and rigid thinking, the pairing of this pharmacologic intervention with manualized psychotherapies for the treatment of depression or anxiety may be a fruitful area of future study. Indeed, 5-HT2A receptor-mediated signaling has been suggested to enhance plasticity and ultimately improve

abilities to adapt, learn, and change (i.e., "active coping" in the face of stress; Carhart-Harris and Nutt, 2017).

Conclusion

Psychedelics such as LSD and psilocybin are commonly reported substances used for microdosing, a method of psychedelic substance use that aims to avoid significant perceptual disturbances and alterations of consciousness associated with higher doses of these substances. Information provided by our international sample of 909 microdosers and non-microdosers, as reported in the present paper and in our companion articles (Anderson et al., 2018, 2019), can usefully guide future research involving psychedelic microdosing.

While the results of recent studies on psychedelic microdosing are promising and controlled experimental research is warranted, the current use of psychedelic microdosing for experimental self-treatment of mood, anxiety, or other mental health disorders is potentially concerning given both the absence of evidence for efficacy of this practice in treating these conditions as well as the potential for commonly used microdosing substances to interact with psychotropic medications. As this practice continues to gain attention and popularity, it is critical that well-designed scientific studies be conducted to examine the safety of microdosing and to test anecdotal claims about its benefits. We hope that insights from this work will serve as an important base from which to conduct future research into microdosing psychedelics.

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ORCID iDs

Daniel Rosenbaum https://orcid.org/0000-0002-4846-9380
Thomas Anderson https://orcid.org/0000-0002-2387-5219

Supplemental material

Supplemental material for this article is available online.

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