Drug and Alcohol Dependence 114 (2011) 61–67

Contents lists available at ScienceDirect

Drug and Alcohol Dependence

journal homepage: www.elsevier.com/locate/drugalcdep

Abnormal visual experiences in individuals with histories of hallucinogen use: A web-based questionnaire☆

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ARTICLE INFO

Article history:
Received 12 February 2010
Received in revised form
20 September 2010
Accepted 21 September 2010
Available online 28 October 2010

Keywords:
Hallucinogen Persisting Perception Disorder
Flashbacks
Hallucinogens
LSD
Toxicity
Adverse reactions

ABSTRACT

Despite longstanding reports of prolonged or reoccurring perceptual changes in a subset of hallucinogen users, very little is known about Hallucinogen Persisting Perception Disorder and related visual abnormalities in hallucinogen users. We used an online questionnaire to document the symptoms and relationship to drug use of unusual visual phenomena in hallucinogen users. 16,192 individuals viewed the information sheet and 2679 were included in the study. Of these, 224 reported having unrelated diagnoses associated with unusual visual experiences and were excluded from main analyses. Most (60.6%) of the remaining 2455 participants reported having experienced drug-free visual experiences that resembled hallucinogen effects. Probability of experiencing constant or near-constant symptoms was predicted by greater past exposure to specific hallucinogens, including lysergic acid diethylamide (LSD). Although symptoms were common, few (104, or 4.2% of the sample) found them distressing or impairing enough to consider seeking treatment. Visual changes in hallucinogen users may be more common than previously suspected and are worthy of further study.

1. Introduction

Hallucinogen use is widespread. In the United States, 16.9% of young adults report having used hallucinogens (Johnston et al., 2008). Although most hallucinogen use apparently occurs without adverse events, there have long been reports of prolonged or reoccurring perceptual changes in a subset of hallucinogen users (Asher, 1971; Rosenthal, 1964; Smart and Bateman, 1967). The DSM-IV-TR recognizes this syndrome as Hallucinogen Persisting Perception Disorder (Flashbacks) (HPPD) (American Psychiatric Association, 2000). Despite many case reports (Espiard et al., 2005; Favazza and Domino, 1969; Gaillard and Borruat, 2003; Kawasaki and Purvin, 1996; Lerner et al., 2000, 2001, 2002a,b, 2003; Sunness, 2004), very few studies have examined HPPD in a large group of users. We sought to use an online questionnaire as a first step towards documenting the symptoms, prevalence, and relationship to drug use of persisting visual abnormalities in hallucinogen users.

HPPD has been associated with a broader range of drugs than only hallucinogens, which primarily produce effects resembling those of lysergic acid diethylamide (LSD) through serotonergic 5-HT_{2A} receptors (Nichols, 2004). For example, cannabis (Annis and Smart, 1973; Gaillard and Borruat, 2003) and 3,4-methylenedioxymethamphetamine (MDMA, 'Ecstasy') (Creighton et al., 1991; McGuire and Fahy, 1992; McGuire et al., 1994) have been associated with HPPD-like syndromes. The DSM-IV-TR states that HPPD includes any perceptual symptoms reminiscent of acute hallucinogen effects (American Psychiatric Association, 2000). However, case reports rarely describe any hallucinogen-like effects except visual disturbances. These commonly involve geometric imagery, motion-perception deficits, halos, afterimages, and flashes of color (Abraham, 1983; Creighton et al., 1991; Espiard et al., 2005; Favazza and Domino, 1969; Gaillard and Borruat, 2003; Kawasaki and Purvin, 1996; Lerner et al., 2000, 2001, 2002a,b, 2003; McGuire and Fahy, 1992; McGuire et al., 1994). To meet DSM-IV-TR criteria for HPPD, symptoms must cause clinically significant impairment or distress, and must not be explainable by other medical conditions. Symptoms may be intermittent or constant and have been reported in some individuals to occur on a daily basis for years (e.g., 9.7 ± 7.7 years in Abraham and Duffy, 2001). The duration of symptoms is one distinction between HPPD and the common conception of a 'flashback,' which is usually described as an infrequent, intermittent phenomenon. Although persisting in popular culture, the concept of 'flashback' is no longer considered a useful diagnostic entity (Halpern and Pope, 2003).

☆ Supplementary data are available with the online version of this article at doi:10.1016/j.drugalcdep.2010.09.006... See Appendix A.

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doi:10.1016/j.drugalcdep.2010.09.006

Prevalence of HPPD is considered low (Halpern and Pope, 2003). Most studies providing estimates of visual changes in hallucinogen users predate the HPPD diagnosis, complicating interpretation. Robbins et al. (1967) reviewed 34 LSD-related psychiatric admissions and found 11 (32%) with "spontaneous return of perceptual distortions or feelings of depersonalization similar to those experienced under the influence of LSD." However, they also note that at least 8 patients in the case series had a history of psychosis predating LSD use, and they do not specify to what extent these subgroups overlapped. A 10-year follow-up study of 247 individuals who received LSD as part of research ($N = 123$) or psychotherapy ($N = 124$) identified five (2%) who described "major perceptual changes" (McGlothlin and Arnold, 1971). This included "recurring undulation of visual field" in an unspecified number, suggesting possible HPPD; however, auditory hallucinations were also described in an unspecified number, suggesting possible psychosis. Cohen (1960) collected information about 'hallucinogen-related complications' from 44 investigators who had studied the effects of LSD or mescaline in a total of 5000 individuals (including both patients and healthy volunteers). While symptoms of HPPD were not explicitly included in the questionnaire, investigators were asked to describe major complications. 'Fleeting afterimages' were reported in four subjects who had received mescaline, while no cases were reported for LSD. However, 22 investigators did not respond to the questionnaire and some adverse events may not have been reported (Novak, 1997). Together, these studies suggest HPPD is very rare, and raise the question of whether some apparent cases may represent misdiagnosis of other disorders, such as psychosis, seizure disorders, migraine aura without headache, or stroke (Manford and Andermann, 1998; Relja et al., 2005; San-Juan and Zermeno, 2007).

On the other hand, a limited number of publications suggest that chronic visual changes may be relatively common in hallucinogen users. Abraham and colleagues have reported evidence of visual changes not only in HPPD patients, but also in HPPD-free hallucinogen users (Abraham, 1982); published studies include changes in EEG coherence, color perception, and flicker fusion frequency (Abraham, 1982, 1983; Abraham and Duffy, 1996, 2001; Abraham and Wolf, 1988). In an unusual animal report, two of four squirrel monkeys developed deficits in size discrimination after prolonged exposure to a high-dose regimen of LSD (10–40 μg/kg daily for four to six months) (Sharpe et al., 1967). These accounts suggest that HPPD may be a severe form of a relatively common syndrome of drug-induced visual changes.

There are no recognized risk factors for HPPD (Halpern and Pope, 2003). Although some have reported a relationship between risk of visual changes (or flashbacks) and number of drug exposures (Abraham, 1983; McGlothlin and Arnold, 1971), others have not (Horowitz, 1969; Matefy et al., 1978; Stanton and Bardoni, 1972), possibly due to small sample sizes.

Because web questionnaires can be effective in recruiting relatively large samples of difficult-to-reach populations, we conducted a study to identify prevalence and characteristics of self-report visual experiences in hallucinogen users and to find relationships with drug use. Given the paucity of information on HPPD, a web questionnaire seemed appropriate for a first attempt to delineate the types of visual phenomena that this population experiences, despite the obvious limitations of anonymous self-report questionnaires.

2. Methods

The study was approved by the University of California IRB. Participants were recruited from the drug information website erowid.org, which receives approximately 60,000 unique visitors per day. For 80 days, a link on the site invited hallucinogen-experienced individuals to complete a 'visual experiences survey.' Subjects who clicked on the link were shown a study information sheet, which did not indicate that chronic visual changes were a focus of the research. Those interested in participating clicked on a link at the bottom of the information sheet and began the questionnaire. Anonymity was maintained by using an encrypted hypertext communication protocol and storing encrypted computer network (IP) addresses.

2.1. Questionnaire

The survey first obtained participants' self-reports of drug-use history as well as past and present psychiatric and neurological diagnoses. It then requested detailed information about participants' visual experiences. Depending on the number of symptoms endorsed, there were 40–188 questions. The survey took a median of 10.6 min to complete.

2.1.1. Drug-use history. Questions explicitly asked participants for their number of exposures to 14 specific psychoactives from six pharmacological classes:

1. *classical serotonergic hallucinogens*, including LSD; psilocybin-containing mushrooms; dimethyltryptamine (DMT); 2,5-dimethoxy-4-ethylphenethylamine (2C-E); 2,5-dimethoxy-4-iodophenethylamine (2C-I); 5-methoxy-alpha-methyltryptamine (5-MEO-AMT); alpha-methyltryptamine (AMT); dipropyltryptamine (DPT); and lysergic acid amide (LSA; found in Hawaiian Baby Woodrose seeds)
2. *NMDA antagonists*, including ketamine and high-dose (defined as over 150 mg) dextromethorphan (DXM)
3. MDMA (3,4-methylenedioxymethamphetamine)
4. anticholinergic-containing Datura plants
5. cannabis
6. the kappa opioid agonist-containing plant *Salvia divinorum* (Salvia)

We selected these drugs based on both anecdotal reports of lasting visual changes and whether we had evidence that the population being recruited was likely to have interest in, and thus possible exposure to, the drugs in question.

In addition, to help ensure the validity of responses, we asked participants about their experience with a fictional drug called "kaopectamine." Those who reported using this drug were excluded from further analysis.

2.1.2. Psychiatric and neurological history. Participants were explicitly asked about past diagnoses (seizure disorders, migraine, schizophrenia or other psychotic disorders, visual impairments) that are sometimes associated with visual abnormalities. Additional free-response questions allowed descriptions of other diagnosed psychiatric, neurological, or visual difficulties. Four Likert-Scale questions (Zimmerman and Mattia, 1999), seeking to identify those with psychotic ideation, asked whether respondents had ever (1) been convinced that other people were watching, talking about, or spying on them; (2) thought they were in danger because someone was plotting to hurt them; (3) thought they had special powers other people did not have; or (4) thought some outside force or power was controlling their body or mind.

2.1.3. Visual experiences. Respondents were asked about unusual visual experiences with the following question: "Not counting times when (1) you were inebriated or under the influence of any strong psychoactive; or (2) you had taken any of these substances within the last 3 days; or (3) you were in a trance, falling

asleep, waking up, or had not slept in a long time, have you had a period in your life when you experienced any of the following visual effects/disturbances?" This question was repeated at the top of each new screen to reduce risk that participants would forget these constraints and answer for other circumstances. The listed visual changes were: "Halos or auras around things" (HALOS); "Stationary things appear to move, breathe, grow, or shrink" (MOVEMENT); "Things that are moving appear to be not moving" (STILL); "Things that are moving leave afterimages behind" (TRAILS); "Colors increase in brightness or intensity" (COLORS); "You see with open eyes patterns or textures that are not really there" (PATTERNS); "You see with open eyes things or objects that are not really there" (THINGS); "Oscillations or flashing light sources, as in TVs or fluorescent lights, bother you more than other times in your life" (OSCILL); "Grids, gratings or closely spaced lines bother you more than other times in your life" (GRIDS).

Respondents who endorsed any of the first seven listed visual experiences were asked further Likert-Scale questions about the frequency and phenomenology of these experiences. They were also asked for a free-text description of a specific time when the most vivid one had occurred. In addition, these respondents were asked whether these visual experiences overall had been so troublesome, or had made social, work, school, or other activities so difficult that they considered getting professional treatment.

Participants reporting drug-free visual phenomena were asked if they thought a specific event triggered these symptoms or made them significantly worse. Those affirming a triggering event were asked to describe the event, their age at the time, and whether the symptoms occurring after the event had also occurred prior. They were also asked several questions about the week preceding the triggering event, including drugs used, new or changed doses of prescription medications, and whether they had experienced loss of consciousness, sickness or inflammation, or decreased visual ability.

2.2. Inclusion/exclusion criteria

Responses were excluded from analysis if (1) they were unfinished; (2) multiple submissions came rapidly (less than 10 min apart) from a single IP address; (3) respondents reported they were not fluent in English or had difficulty understanding the questions; (4) respondents reported use of the fictional drug "kaopectamine"; (5) respondents reported no past hallucinogen use; or (6) free-response or catch answers suggested submission was not serious or that the respondent was describing acute drug effects. Respondents who appeared to consistently describe acute drug effects when asked to provide an example of a visual symptom were excluded.

2.3. Data analysis

Because estimated numbers of exposures to each drug were not normally distributed, numbers were $\log_{10}$ transformed for analysis. Medians were reported when continuous variables were skewed. Categorical variables were analyzed using Fisher's Exact Test with odds ratios (OR) and 95% confidence intervals (CI) calculated. Analyses focused on three main measures: number of unusual visual experiences endorsed (NUMSYMPT); and number of constantly (or nearly constantly) occurring visual symptoms reported (NUMCONSTANT). NUMSYMPT was selected to liberally include even brief or single unusual experiences, while NUMCONSTANT attempted to identify individuals with truly abnormal visual experiences. To determine variables independently associated with these measures, multiple logistic regressions were conducted using Poisson models to predict number of symptoms or binomial models to predict presence of symptoms. Backwards elimination of variables was used to remove those variables not significantly predictive of outcome. Chi-squared tests were used to identify significant models. All analyses were conducted using R (R Development Core Team, 2007).

Table 1
Reported drug use history in full sample ($N = 2679$).

Drug	Percent using	Reported number of exposures among those using		
		25th percentile	Median	75th percentile
Cannabis	98.7%	100	500	1000
Mushrooms	82.7%	3	6	15
Salvia	61.1%	2	4	7
LSD	58.7%	2	5	20
MDMA	58.0%	3	8	25
DXM	49.5%	2	4	10
LSA	32.4%	1	2	4
Ketamine	22.1%	1	3	10
DMT	15.4%	1	2	6
2C-I	15.2%	1	3	5
2C-E	6.9%	1	2	5
Datura	6.5%	1	1	3
AMT	5.7%	1	2	5
5-MEO-AMT	5.3%	1	2	6
DPT	3.6%	1	3	6

3. Results

3.1. Respondents

3139 responses were collected over an 80-day period, representing 19.4% of the 16,192 who viewed the information sheet. 2679, or 85.3%, of these responses met inclusion criteria. Reasons for exclusion were as follows: unfinished responses (283, or 9%); duplicate responses (126, or 4%, in all cases an artifact that resulted from participants hitting the submit button twice); reported difficulty understanding the questionnaire (31, or 1%); appeared to be describing acute drug effects (17, or 0.5%), and reported no history of hallucinogen use (three, or 0.1%). No participants of the 2679 were excluded for apparently unserious submissions.

Respondents were 89.5% male, aged 21.6 ± 3.7 years (range: 13–77). Most lived in the United States (68.9%), with lower numbers residing in Canada (9.0%), the United Kingdom (5.8%), and other countries (16.3%). Respondents had extensive drug histories (Table 1), reporting a median of 5 different drugs used (out of 15 listed). 224 respondents (8.4%) of 2679 reported having at least one diagnosis associated with unusual visual experiences. These individuals were excluded from analyses, other than those with history of psychosis, who were analyzed in Section 3.6.

3.2. Prevalence of visual experiences

1487 (60.6%) of the remaining 2455 individuals reported at least one of the nine visual experiences that were included in the questionnaire. 587 (23.9%) endorsed at least one experience on a constant or near-constant basis (Table 2). In a free-text response, 278 (11.3%) reported at least one experience in addition to the nine experiences included in the questionnaire (see online Appendix 1, Table 5).

3.3. Relationship between visual experiences and drug use

In order to test for relationships between self-reported visual experiences and drug use, we began by assessing number of types of reported visual experiences (NUMSYMPT). A Poisson regression model predicting NUMSYMPT from $\log_{10}$-transformed exposures to individual drugs was statistically significant (chi-squared = 392.38, df = 8, $p < 0.001$). Log_{10} exposures to LSD, LSA,

Table 2
Symptoms among those without complicating diagnoses ($N = 2455$).

	Ever occurred	Constantly occurs	Example description
MOVEMENT	833 (33.9%)	212 (8.6%)	"I had taken a large amount of mushrooms throughout a day. Afterwards for about a week I would get times where objects appeared to be breathing and objects seemed to slowly move."
COLORS	635 (25.9%)	199 (8.1%)	"Sometimes a color-shift will occur; and certain objects/colors will become very intense – standing out from the background."
PATTERNS	594 (24.2%)	216 (8.8%)	"Stayed up all night on MDMA and started seeing yellow hexagons on a white wall. I was admiring this the next day too when someone told me the wall was blank. I still see yellow hexagons on any blank surface."
OSCILL	549 (22.4%)	NA (NA)	NA
TRAIL	543 (22.1%)	227 (9.2%)	"When you wave your hand in front of your face or in your field of vision you will appear to have many hands following your hand."
HALOS	503 (20.5%)	178 (7.3%)	"This happens often when I am watching people from far away. They appear to have halos over their heads and their body parts also leave impressions as they move."
GRIDS	444 (18.1%)	NA (NA)	NA
STILL	186 (7.6%)	37 (1.5%)	"Traffic appears like comic book images – cartoon-like; frame by frame with dynamic illustration of velocity."
THINGS	154 (6.3%)	29 (1.2%)	"The week before I had taken 2 grams of mushrooms; 1 blotter hit of acid; about 10 grams of marijuana; and about 2 grams of DXM powder. The most vivid of the things to happen after the effects had worn off happened in my bedroom one morning about 1 week after. Gigantic transparent spiders were in my bed; standing in my bedroom. They didn't move but stayed in the same place. I left the room and went into my bathroom and everything was normal; but going back into my bedroom they were still there."

mushrooms, DXM, ketamine, 2C-E, DPT, and Salvia were significant predictors of NUMSYMPT. Estimates were similar for most hallucinogens, and ranged from 0.795 for DPT to 1.23 for LSD. In other words, for example, each $\log_{10}$-unit increase in LSD exposures led to an expected increase of 1.23 additional types of experiences.

We hypothesized that reporting constant or nearly constant changes might be a more reliable indication of truly abnormal visual changes than simply having ever had a given experience. Therefore, we made a Poisson regression predicting the number of constantly or near-constantly occurring experiences (NUMCONSTANT) from $\log_{10}$-transformed exposures to individual drugs (chi-squared 394.34, df = 5, $p < 0.001$). Log_{10}-transformed exposures to 2C-E, LSD, DXM, LSA, and AMT were significant predictors of NUMCONSTANT. Each $\log_{10}$-unit increase in drug exposure was predicted to increase the number of constant experiences by 1.79 for 2C-E, 1.53 for LSD, 1.51 for DXM, 1.33 for LSA, and 0.67 for AMT (see online Appendix 1, Fig. 1). Similarly, we constructed binomial models to predict the presence or absence of any experience with number of drug exposures. Table 3 summarizes significant predictor drugs and estimated odds ratios.

3.4. Treatment-seeking participants

104 of 2455 (4.2%) said their visual experiences were initially or currently sufficiently troublesome to have prompted thoughts of treatment. Of these, 70 participants reported considering treatment during the first 2 months after symptom onset, 14 reported considering treatment during the 2 months prior to the questionnaire, and 20 reported considering treatment during both periods. Only 27 of 2455 (1.1%) had actually sought treatment.

Constant symptoms increased likelihood of a participant considering or actually seeking treatment from a healthcare provider (OR 9.76, 95%CI: 6.18–15.82, $p < 0.001$); however, only 76 (12.9%) of the 587 participants reporting constant symptoms considered treatment. Thus, these perceptual experiences, even when constant, may not have been considered problematic. Some participants indicated this, for example commenting that, it was "[n]ot really a negative thing; kind of neutral. It's become normal. Actually, the low-light patterning hallucinations are quite beautiful and enjoyable." Similarly, another participant wrote that "visuals of drugs are present when I am not tripping now because I notice how things change more or how light is formed of different ways. It makes me feel like a kid again because I enjoy the simple things in life, like light patterns."

Table 3
Results of models predicting any constant symptom.

Predictor	OR	95% CI	p-value
Log LSD	1.63	1.41–1.88	<0.001
Log DXM	1.59	1.34–1.88	<0.001
Log 2C-E	2.17	1.30–3.66	0.003
Log DPT	0.415	0.20–0.83	0.016
Log LSA	1.53	1.14–2.06	0.004

3.5. Endorsement of a precipitating episode that began visual changes

13.9% (262 of 1487) of participants who reported visual experiences and lacked complicating diagnoses felt that their experiences were triggered by a specific episode (that is, their experiences had a sudden onset). Most of these individuals (191 of 262, or 72.1%) reported they had never experienced these visual change(s) on any previous occasion. Of those reporting triggering episodes, 45 (17.2%) considered or actually sought treatment. Six of these 45 (13.3%) reported non-drug events in the week before onset, such as illness or loss of consciousness. When asked to recall anything unusual about the triggering episode, free-text responses by participants mentioned an unusually high dose or strong effects (45 of 262, or 17.2%), an acute dysphoric response to the drug (26, or 9.9%), or first exposure to the specific drug (22, or 8.4%). Thus, visual experiences appear not to be uniquely associated with any of these factors. Table 4 summarizes drugs reported to have been used in the week before the experience.

3.6. Comparison of HPPD-like participants and participants with psychosis

Reported history of psychosis was associated with increased likelihood of experiencing at least one constant symptom. (45% vs. 24%, OR 2.64, 95%CI 1.23–5.58, $p = 0.007$) compared to those without any past diagnoses. We therefore compared age, drug exposures, paranoid ideation, and visual experiences between the 45 HPPD-like participants (i.e., reported sudden symptom

Table 4
Drugs used in the week before 262 episodes of sudden symptom onset.

	Number of episodes	% of episodes
LSD	81	31%
Psilocybin	64	24%
MDMA	41	16%
DXM	35	13%
Salvia	13	5%
2C-I	13	5%
LSA	12	5%
AMT	7	3%
Ketamine	6	2%
DMT	6	2%
2C-E	5	2%
5-MEO-AMT	4	2%
Datura	3	1%
DPT	2	1%

onset after drug exposure and were treatment-seeking) and the 33 otherwise-excluded individuals with a reported history of psychosis (and no other complicating diagnoses). Age and drug exposures were not significantly different between the two subgroups. Those with a past diagnosis of psychosis were significantly more likely to endorse three of four questions designed to measure psychotic ideation: having felt they were being spied on (79% vs. 44%, OR 4.97, 95%CI 1.66–16.56, $p = 0.002$), possessed special powers (64% vs. 27%, OR 4.70, 95%CI 1.65–14.24, $p = 0.001$), or being influenced by an outside force (54% vs. 22%, OR 4.12 4.70, 95%CI 1.42–12.65, $p = 0.004$). A fourth question, feeling in danger due to plots by others, did not achieve significance, but the effects were in the same direction ($p = 0.088$). Regarding visual experiences, those with psychosis were significantly less likely to report MOVEMENT (42% vs. 73%, OR 0.27 95%CI 0.092–0.77, $p = 0.0096$). When constant or nearly constant experiences were examined, those with psychosis were found to be less likely to experience constant HALOS (18% vs. 44%, OR 0.28, 95%CI 0.0794–0.881, $p = 0.017$) or PATTERNS (18% vs. 40%, OR 0.338, 95%CI 0.0946–1.06, $p = 0.049$).

4. Discussion

We used a web-based questionnaire to collect self-report data on unusual drug-free visual experiences in hallucinogen users. In the absence of objective testing and a drug-free comparison group, we cannot determine the proportion of participants in whom these symptoms represent objective visual abnormality (as opposed to attention to normal-but-subtle visual phenomena) or how much this proportion is elevated beyond what would be seen in the general drug-free population. Nonetheless, unusual drug-free visual experiences were strikingly common in our sample. 61.7% of included respondents reported seemingly hallucinogen-like visual experiences occurring when they had not used a drug within three days. While some participants made it clear that they were not distressed by their visual experiences, 4.2% indicated significant distress or impairment.

We attempted to determine presence of distress by asking whether the visual experiences were sufficiently troublesome or interfering with life activities that the individual considered or actually sought professional treatment. We designed this question to approximate the DSM-IV TR criterion that HPPD must involve clinically significant distress or impairment. Keeping in mind the limitations of the self-report dataset, responses to this question revealed 4.2% who appeared HPPD-like in their self-description. Even if this group is conservatively limited to the 45 who reported a clear temporal relationship between drug use and symptom onset, HPPD-like abnormal visual symptoms still occurred in at least 1.7% of participants, and at least 0.28% of those who had the opportunity to participate but did not (i.e., they viewed the introductory information sheet). We find these numbers strikingly high, particularly considering the lack of research on the phenomenon (Halpern and Pope, 2003). However because this is not a random sampling of the population, we cannot conclude that HPPD-like visual abnormalities are truly this common. What can be concluded is that drug-related visual complaints are sufficiently prevalent to warrant further study.

Relationships were seen between number of drug exposures and both number of experiences (of any frequency) and number of constant or near-constant experiences. Several investigators (Horowitz, 1969; Matefy et al., 1978; Stanton and Bardoni, 1972) have failed to detect such a relationship, possibly due to the smaller sample sizes and the larger proportion of participants with clinically significant changes in their samples. Our results, in contrast, suggest an increased likelihood of unusual visual experiences as individuals increase their drug exposures.

Several specific drugs were statistically associated with unusual visual experiences in our sample. LSD appeared to be the most robust predictor, consistent with its prominence in case reports of HPPD (Halpern and Pope, 2003; Hermle et al., 2008). For the 1,016 respondents who reported no LSD use, the prevalence of any constant or near-constant visual experience was 18.1%, and this number approximately doubled to 34.5% in the 525 individuals who had used LSD 10 or more times. In addition to LSD, some less prevalent drugs were statistically associated with unusual visual experience. However, the reliability of predictions is questionable for drugs with low prevalence of use in this sample.

One potential limitation to this statistical analysis is that individuals are likely to stop using drugs at the onset of worrisome symptoms, while asymptomatic individuals will continue to use, thus obscuring a relationship. Because of this, we also collected data on reported temporal relationships between drug use and symptoms with sudden onset. Temporally coincident drugs were most commonly LSD, psilocybin, high-dose DXM, and MDMA. With the exception of DXM, these have been previously associated with HPPD-like changes in case reports (Creighton et al., 1991; Espiard et al., 2005; McGuire and Fahy, 1992; McGuire et al., 1994; Pierrot et al., 2000; Sunness, 2004). These drugs involve a variety of pharmacological mechanisms, suggesting that some forms of HPPD-like visual changes may be due to some individual vulnerability that can be triggered by drug exposure. Given the extensive drug use reported by our sample, we cannot discount the possibility that the temporal relationship between drug use and symptom onset may have been coincidental in some cases. Nonetheless, free-text responses describing experiences that first developed during drug intoxication and then lingered for days, weeks, or longer suggest that the relationship cannot be attributed solely to chance.

It has been suggested or implied that apparent cases of HPPD may sometimes represent misdiagnosis of psychosis. Although often associated with auditory hallucinations, visual symptoms may be described in prodromal and first-episode psychosis (Gouzoulis et al., 1994; Klosterkotter et al., 2001), possibly relating to perceptual hypersensitivity and dysfunction in the magnocellular visual pathway (Keri and Benedek, 2007). For example, Klosterkotter et al. (2001) reported that the presence of self-reported visual perception anomalies predicted eventual development of first-episode psychosis with a sensitivity of 0.46 and a specificity of 0.85. Furthermore, many of our participants were young adults in the age range when first episodes of psychosis are most likely to occur (Kirkbride et al., 2006). Nonetheless, the differences in visual experiences and paranoid ideation between those who reported signs of psychosis and those with HPPD-like complaints argue against undiagnosed or prodromal psychosis explaining the majority of the HPPD-like experiences in our sample.

The major limitation of this study is that it relied entirely on self-report data from a convenience sample. The subset of Erowid website users who completed the questionnaire is not likely to be representative of hallucinogen users in general. Although the information sheet referred nonspecifically to visual experiences and did not indicate an interest in persisting changes, individuals with such changes may have been biased to complete the questionnaire. The self-report nature of the study also ensures that we cannot diagnose any participants with HPPD, or any other syndrome for that matter. Distinguishing between HPPD and, for example, persistent migrainous visual aura without headache would likely be difficult even with a detailed examination (Relja et al., 2005; San-Juan and Zermeno, 2007). Although the length of the questionnaire and our various data-integrity checks likely minimized unserious responses, key data—such as drug intake, visual experiences, and past diagnoses—may have been inaccurately reported even by those making good-faith attempts to give accurate data. Nevertheless, given the limited knowledge of the frequency and character of HPPD in drug users, the present findings are a first approximation, and the results invite more research into this phenomenon.

In conclusion, we collected self-report data indicating that seemingly unusual drug-free visual experiences reminiscent of acute drug effects are common in hallucinogen users. More extensive use of LSD and several other hallucinogens significantly, if modestly, increased the probability of reporting unusual visual experiences. Although preliminary, this suggests that HPPD may be an unusually severe form of a relatively common syndrome of post-hallucinogen visual changes. The range of pharmacological classes associated with these changes additionally suggests HPPD and less severe changes may be better explained by individual vulnerability rather than specific pharmacological mechanisms. Together, these results indicate that more objective testing of visual functioning in hallucinogen-using populations is warranted and could clarify mechanisms of HPPD and the effects of these drugs on the visual system.

Role of funding source

M.J.B. was supported by the Beckley Foundation. L.R.C. is supported by NIH grant #EY016975 and a Merit grant from the Veterans Administration. Neither organization had any role in study design; in the collection, analysis and interpretation of data; in the writing of the report; or in submitting the paper for publication.

Contributors

All authors contributed to the protocol and study design. M.J.B. and J.R.C. completed the statistical analysis, and M.J.B. wrote the first draft of the manuscript. All authors contributed to and have approved the final manuscript.

Conflict of interest

None.

Acknowledgements

We acknowledge: John Mendelson, Gantt Galloway, and David Presti for helpful discussions; Danielle Hubbard for assistance with editing and review of the manuscript; the volunteers and staff of Erowid for assistance with the survey; and the participants for sharing their experiences.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.drugalcdep.2010.09.006.

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