Journal of Psychoactive Drugs
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/ujpd20

Enhancement of Creative Expression and Entoptic Phenomena as After-Effects of Repeated Ayahuasca Ceremonies

Ede Frecska M.D. Ph.D. [a], Csaba E. Móré M.D. [b], András Vargha Ph.D. [c] & Luis E. Luna Ph.D. [d]

[a] Chairman, Department of Psychiatry, University of Debrecen, Debrecen, Hungary
[b] General Director, Sántha Kálmán Hospital and Mental Health Center, Nagykálló, Hungary
[c] Chairman, Department of Psychology, Károli Gáspár University of Reformed Church, Budapest, Hungary
[d] Director, Wasiwaska Research Center, Florianópolis, Brazil
Version of record first published: 02 Aug 2012.

To cite this article: Ede Frecska M.D. Ph.D. , Csaba E. Móré M.D. , András Vargha Ph.D. & Luis E. Luna Ph.D. (2012): Enhancement of Creative Expression and Entoptic Phenomena as After-Effects of Repeated Ayahuasca Ceremonies, Journal of Psychoactive Drugs, 44:3, 191-199

To link to this article: http://dx.doi.org/10.1080/02791072.2012.703099

Journal of Psychoactive Drugs, 44 (3), 191–199, 2012

ISSN: 0279-1072 print / 2159-9777 online
DOI: 10.1080/02791072.2012.703099

Routledge
Taylor & Francis Group

Enhancement of Creative Expression and Entoptic Phenomena as After-Effects of Repeated Ayahuasca Ceremonies

Ede Frecska, M.D., Ph.D.[a]; Csaba E. Móré, M.D.[b]; András Vargha, Ph.D.[c] & Luis E. Luna, Ph.D.[d]

Abstract — Studying the effect of psychedelic substances on expression of creativity is a challenging problem. Our primary objective was to study the psychometric measures of creativity after a series of ayahuasca ceremonies at a time when the acute effects have subsided. The secondary objective was to investigate how entoptic phenomena emerge during expression of creativity. Forty individuals who were self-motivated participants of ayahuasca rituals in Brazil completed the visual components of the Torrance Tests of Creative Thinking before and the second day after the end of a two-week long ceremony series. Twenty-one comparison subjects who did not participate in recent psychedelic use also took the Torrance tests twice, two weeks apart. Repeated ingestion of ayahuasca in the ritual setting significantly increased the number of highly original solutions and phosphenic responses. However, participants in the *ayahuasca* ceremonies exhibited more phosphenic solutions already at the baseline, probably due to the fact that they had more psychedelic experiences within six months prior to the study than the comparison subjects did. This naturalistic study supports the notion that some measures of visual creativity may increase after ritual use of ayahuasca, when the acute psychoactive effects are receded. It also demonstrates an increased entoptic activity after repeated ayahuasca ingestion.

Keywords — creativity, dimethyltryptamine, hallucinogens, phosphenes, psychedelics

Creativity has been defined as a mental process involving the generation of new ideas or concepts or new associations between existing ideas or concepts (Sessa 2008). Creative thinking requires more than just general intelligence or the use of specific knowledge to achieve a single, correct solution to a problem (convergent thinking). The creative process also entails the ability to develop multiple, alternative solutions to a single question (divergent thinking) (Guilford 1966).

The effect of psychedelic (hallucinogenic) substances on creative expression is a controversial issue, debated or ignored in professional literature, and often reflected with

The authors would like to thank Ilona Barkóczi, Eszter Ács, Vivien Magyar and Réka Zeley for their help in test evaluations and Frederick Rawski for editing assistance and making valuable comments on the manuscript. This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

[a]Chairman, Department of Psychiatry, University of Debrecen, Debrecen, Hungary.

[b]General Director, Sántha Kálmán Hospital and Mental Health Center, Nagykálló, Hungary.

[c]Chairman, Department of Psychology, Károli Gáspár University of Reformed Church, Budapest, Hungary.

[d]Director, Wasiwaska Research Center, Florianópolis, Brazil.

Please address correspondence to Dr. Ede Frecska, Chairman, Department of Psychiatry, Medical and Health Science Center, University of Debrecen, Nagyerdei krt. 98., 4012 Debrecen, Hungary; phone: +36-52-255-240; email: efrecska@hotmail.com

an emotional and sometimes judgmental tone in the popular media (Life Magazine 1966: 66)[1]. There are a significant number of often-cited anecdotal accounts about increased creative capacity as perceived by artists, writers, designers, computer programmers, and other users who self-administered psychedelic substances. Furthermore, there are publications from the anthropological field that relate the possible use of vision-inducing plants and techniques to artistic activity (Lewis-Williams 1997). Pieces of prehistoric art discovered all around the world suggest that optical illusions or entoptic phenomena may have been part of the artistic experience of our ancestors. The possible link between certain forms of prehistoric art and the use of psychedelic agents has been well described in the literature (Dronfield 1995; Lewin 1991; Dikov 1971; Howard 1957).

Suggestions that psychedelics increase creativity are not restricted to the visionary field. Jeremy Narby (2001) interviewed three molecular biologists who reported that they acquired relevant information and insight about their research during their first ayahuasca experiences in the Peruvian Amazon. Benny Shanon (2000) has also documented intellectual-philosophical insights attained by ayahuasca drinkers without prior formal education. Ayahuasca is a tea-like decoction made of plants (such as *Banisteriopsis caapi* and *Psychotria viridis* or *Diplopterys cabrerana*) indigenous to the Amazon and Orinoco river basins of South America (McKenna, Towers & Abbott 1984). Its psychoactive ingredients include harmine and dimethyltryptamine (DMT). Phenomenologically, the effects of ayahuasca are diverse and include hallucinatory effects in all perceptual modalities, intellectual conceptualizations, psychological insights, spiritual experiences, moral contemplations, and philosophical ideas. Some of these resemble thoughts encountered in works of classical philosophers.

In his anecdotal report, Shanon (2000) emphasizes that significant improvements in creative performance are most likely to be encountered in domains where the user has special competence. Artists and other professionals in the creative field are likely to have special qualities and characteristics distinguishing them from the general population. Findings have shown that a high percentage of artists exhibit intuitive and introverted personality traits (Barron 1965). It may be that psychedelics help to manifest the creative potential already present in such individuals rather than give birth to creativity. For instance, the scientific information and imagery appearing in the ayahuasca visions of the three molecular biologists documented by Narby (2001) clearly drew upon information and images already present in their minds. Many artists feel that psychedelic drugs spark a higher degree of richness of imagery, appreciation for beauty, or induce spectacular sensory experiences as opposed to increasing artistic skills. Indeed, psychedelics were reported having negative effects on concentration and motor performance, especially in drug-naive subjects (Abramson et al. 1955).

Objective support for the notion that psychedelic use increases the creative potential based on controlled trials using psychometric tests of creativity is rare. The limited information that is currently available comes from poorly structured measurements with questionable validity and sensitivity resulting in inconclusive findings. Thus far, there have only been a handful of such research efforts.

In 1960, Zoltán Böszörményi – coworker of Stephen Szára, the Hungarian physician who first administered synthesized DMT to human subjects in an experimental setting (Szára 1956) – examined the effects of diethyltryptamine (a synthetic analogue of DMT) on brainwaves. He observed that five of 38 normal volunteers became inspired in their professional activity as incidental aftereffects of their research participation (Böszörményi 1960). The study itself did not involve formal testing of creativity. Böszörményi described his subjects as experiencing a "rather passive state of accumulating impressions prior to creative work."

Stanley Krippner (1990) surveyed 91 major artists, who admitted having had at least one psychedelic experience. The most frequently used psychedelics were lysergic acid diethylamide (LSD), DMT, mescaline, morning glory seeds, and psilocybin. Eighty-one percent reported that their work had been affected by psychedelic use—with the inspirational influence occurring sometimes during and sometimes after the experience. Notably, some of the artists participating in the survey acknowledged that the work that they had crafted under the influence of psychedelics was not always of the same quality as work inspired by but created after the experience.

In a placebo-controlled study, William McGlothlin and associates (McGlothlin, Cohen & McGlothlin 1967) gave 200 μg of LSD to 72 graduate students. Long-term follow-up of this cohort of nonartistic subjects showed a greater appreciation of music and the arts within the experimental group, but no actual increase in creative ability was noted.

With a better design specifically aimed at measuring effects on creativity, Leonard Zegans and his coworkers studied 19 graduate students, each of whom was given one of three varying doses of LSD, alongside 11 subjects receiving a placebo (Zegans, Pollard & Brown 1967). A range of psychometric data was collected at baseline, during, and after intoxication by using the Mednick Association Test, the Modified Word Association Test, the Mosaic Design Test, and the Free Association Test. Apparently insufficient attention was paid to set and setting since the study took place in the unnatural setting of a clinical research unit. The subjects were not selected for their creative abilities, and were not aware that psychotropic drugs would be administered to them until the morning of the study. The researchers provided little information about the aims of the study. Although most of the test results

were not statistically significant (with the exception of an increase in the originality of word association), there was an overall trend for favoring the LSD group. It was noted that LSD "increased the accessibility of remote or unique ideas and associations to their conscious awareness" for certain subjects with particular "creative personality traits." However, the authors concluded that "the administration of LSD-25 to a relatively unselected group of people, for the purpose of enhancing their creative ability, is not likely to be successful."

Oscar Janiger facilitated LSD sessions in his home for nearly 1,000 people with a variety of professional backgrounds in the 1950s and 1960s. His project was unique because it was largely unguided and took place in a naturalistic setting. The participants' experiences varied widely, but the majority of them described the outcome as valuable and sustaining with very rare incidence of adverse reactions. During the course of this work, two types of effects were typically reported: profound spiritual experiences and a boost in the subjects' creative potential. These observations lead Janiger to conduct a further study examining the effects of LSD on creativity in a controlled setting (Dobkin de Rios & Janiger 2003). He gave LSD to a group of 60 visual artists and asked them to draw before and after the sessions. The participants produced about 250 drawings that were subsequently analyzed by an art professional. In this naturalistic study, the drug appeared to enhance certain aspects of the artists' work, such as expressionistic design, color sharpening, and syntactical organization. Less adherence to prescribed mental sets was also observed.

Willis Harman's study is among the best conducted to date (Harman et al. 1966) despite its lack of placebo control and double blind design. After an extensive screening and preparation for how psychedelics might affect creativity, 27 creative professionals (engineers, architects, designers, physicists, and theoretical mathematicians) volunteered to receive doses of mescaline followed by workshops requiring creative problem solving, and individual psychological testing. During the orientation a positive mind-set was purposefully encouraged by the researchers. The subjects were told that the mescaline would enhance their creativity and help them to work more productively. The applied psychometric tests included the Purdue Creativity Test, the Millar Object Visualization Test and the Witkin Embedded Figures Test. One week after the mescaline session subjects submitted a written account of their experience. Eight weeks later personal interviews with the researchers took place and subjects were asked whether the drug session resulted in impairment, no change, or improvement in their creative activity and work performance.

The study concluded that the psychedelic drug significantly enhanced the creative process, as assessed by psychological testing, subjective reports, and the practical applicability of the solutions participants came up during the experiment. Participants denied feeling any form of impairment. Similar to Böszörményi's findings, there seemed to be an after-effect of enhanced creativity lasting at least eight weeks after the sessions. It is suggested that a psychedelic agent may have an increased effect on the creative process when subjects have a positive attitude and a specific question or problem upon which to focus their creative thinking.

One recent study (Jones, Blagrove & Parrott 2009) tested links between chronic cannabis or Ecstasy use and objective and subjective measures of creativity. These researchers administered the Consequences Test of divergent thinking, which is a recognized measure of verbal creativity. They found no significant differences in the fluency of responses between the groups. Cannabis users produced significantly more "rare-creative" responses than controls did as evaluated by the objective frequency method. However, when judges rated originality based on subjective impression, no significant differences in creative response emerged between the groups. Despite this discrepancy, the authors describe their overall findings as positive.

This brief review of previous studies suggests that the effect of psychedelics on creativity may vary depending on the experimental context and participants' expectations. Personal mindset and environmental setting—pertinent factors in the psychedelic experience (Faillace & Szára 1968)—are particularly important. For both experimental and practical reasons, these factors should be controlled as much as it is possible.

Even less experimental data is available on the relationship between psychometric measures of creative expression and the occurrence of phosphenic effects after hallucinogen use. A phosphene is a visual sensation of perceiving light at a time when no light is entering the retina. It is an entoptic phenomenon, meaning that its source lies within the eye or visual system itself. Typically it can be induced by direct mechanical, magnetic or electrical stimulation of the eye. Phosphenes can occur spontaneously as a result of visual deprivation, and can be provoked in a number of ways. Heinrich Klüver (1942) outlined 13 conditions (including drug administration) under which entoptic phenomena can be generated. Psychedelics such as mescaline, psilocybin and LSD often evoke phosphenes of abstract design, even at low doses. Indeed, entoptic phenomena appear to be a significant feature of hallucinogen inebriation. Furthermore, these effects are long-term, and may last up to six months (Oster 1970).

Perception of phosphenes should not be confused with visual hallucinations, "flashbacks," and hallucinogen persisting perception disorder while entoptic phenomena can be part of them. Phosphene visions involve flickering light, glowing dots, pulsating waves, and simple geometric figures. Knoll and colleagues (1963) identified 15 types of entoptic imagery and classified them into a number of groups. One class of phosphenes that were frequently reported includes lattice, fretwork, filigree, honeycomb,

and chessboard images. A second group consists of cobwebs and swirls, and the third of tunnels, funnels, cones, and spirals. Many of these images can be seen in the artwork of many different cultures dating back to the prehistorical period. "Flashbacks" are spontaneous, repeated, and at times continuous recurrences of one or more of the sensory, cognitive, or emotional symptoms of the psychedelic experience after an intervening drug-free period (Frecska 2007). Visual alterations of the hallucinogen persisting perception disorder include seeing halos or auras surrounding objects, trails attached to moving objects, perceiving false motion on the edges of the visual field, and distortions in the color or dimensions of a perceived item.

The quality and design of the studies outlined in this introduction do not meet modern research standards. In a recent article, Ben Sessa (2008) argued that the possible connection between psychedelic drug use and creativity needs to be revisited. With growing interest in cognition-enhancing drugs and the current renaissance in psychedelic research the time has arrived to replicate these studies with improved research methods. With this in mind, our primary goal was to study the psychometric measures of creativity in a naturalistic setting, after a series of ayahuasca ceremonials at a time when the acute intoxication subsided. In addition to studying the measures of creativity, a secondary goal was to investigate the occurrence of phosphenic solutions during the visual tasks used for testing creative expression.

METHODS AND MATERIALS

Subjects

Data was obtained from 40 individuals who were participating in ayahuasca ceremonials held in Florianópolis, Brazil between April 8, 2004 and January 29, 2008 and volunteered for the creativity tests. Brazil was chosen as the study site for the reason that drinking ayahuasca is permitted in the country for religious use. Enrolled volunteers took the decoctum for religious-spiritual purposes and not for participation in the study. The principal investigator (E.F.) had no role in the organization of the ayahuasca sessions. A separate group of the research staff was involved in the administration of the brew and test materials (supervised by L.E.L.). Other team members blind to the identifying and grouping data evaluated the tests (supervised by E.F.). A third party (A.V.) performed the statistical analysis. The investigators obtained written informed consent from participants for the creativity tests prior to the ingestion of the psychoactive brew, conforming to the guidelines set forth by the Ethical Principles and Guidelines for the Protection of Human Subjects of Research (National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research 1979). The use of the test had clearance from the review board at the National Institute of Neurology and Psychiatry, Budapest for use within broad range of subjects. All participants were fully debriefed and were assured of confidentiality.

Originally, 48 candidates were expected to complete the figural components of the Torrance Tests of Creative Thinking (TTCT). Eight were not eligible to be included in the analysis because they had a dose below the required range, had a suboptimal subjective experience, or did not take part in sessions as long or on as many occasions as required by the inclusion criteria. The final experimental group included 17 males and 23 females with a mean ($\pm$SD) age of 30.9 ($\pm$7.7) years.

Inclusion criteria for experimental subjects were: (1) being experienced in psychedelic use (having it on at least three previous life-time occasions); (2) having the intention to stay for two weeks at the center, and (3) planning to ingest a minimum of 50 ml of ayahuasca in at least four of the sessions.

Exclusion criteria for experimental subjects were: (1) personal history of psychiatric or neurological disorder and/or use of psychotropic medication for a nonpsychiatric condition (e.g. antidepressant for chronic pain, psychostimulant for weight loss); (2) head injury leading to loss of consciousness for more than five minutes; (3) alcohol or illicit drug use in the past two weeks; (4) lifetime history of substance dependence as diagnosed by DSM-IV-TR (APA 2000); (5) body mass index <18.5 or >30 kg/m^2; (6) history of cardiac or endocrine illness; (8) lack or mild degree of ayahuasca experience during the sessions resulting less than four moderate or strong experiences during the two-week study period based on five-point Lickert scale ratings (see below).

A further sample of 21 undergraduate international students and staff members recruited from the Swedish School of Economy in Helsinki and Károli Gáspár University in Budapest provided control data for test-retest measures of the TTCT without ingesting ayahuasca. The comparison group included ten males and eleven females with a mean ($\pm$SD) age of 27.1 ($\pm$8.6) years.

Ayahuasca Sessions

Participants maintained a salt-, sugar-, red meat-, and alcohol-free diet for two weeks while partaking in the ceremonies organized in Florianópolis, Brazil, which involved drinking the brew on every second or third day within a two-week timeframe (for a total of four or five times). The provided traditional diet did not include fermented or smoked food, aged/dried/cured meat products, and beverages known to have high tyramine content. On the day of the ayahuasca ceremonies, subjects avoided solid food for 12 hours starting from 2:00 p.m. At 8:00 p.m. they ingested a self-chosen dose of ayahuasca (provided by one of the Brazilian syncretic churches) of at least 50 ml. During the two-week session participants drank a total amount of 583 $\pm$ 315.8 ml (mean $\pm$ SD). The alkaloid

concentrations of the beverage from the same source were analyzed and reported formerly (Frecska, White & Luna 2004). For four hours following ingestion, subjects rested supine with lights turned off. Based on participants' previous psychedelic experiences, the global subjective experience induced by the brew was rated on a five-point Lickert scale ranging from zero to four (none, mild, moderate, strong, very strong) in the morning following the ritual.

Creativity Tests

Volunteers completed the creativity tests between 90 and 180 minutes before the start of the first ayahuasca session and had the tests repeated at the end of the two-week session, 24 to 48 hours after the last ayahuasca administration when they were free of the acute effects of the decoction. A standardized form of TTCT (Barkóczi & Zétényi 1981) was applied to participants. It consists of five parts: the first task is meant to serve as a warm-up and followed by two subsets of verbal and two of the figural tasks. For the purpose of this study, since subjects did not share the same native tongue only the figural tasks were scored, since those are not dependent on the use of language. There was a time limit set for each task, and the participants were not allowed to go back to previous tasks. The figural tasks (blank circle use and figure completion) were based on the TTCT (Torrance 1966). Responders were asked to draw as many pictures as they could, starting from the shape of 35 circles, and to finish ten abstract shapes (lines and curves) in a creative manner. These tasks lasted eight and ten minutes respectively.

Standardized administration, normalized scoring procedures, and continuous development with reevaluations have made the TTCT remarkably useful for identifying individuals with creative potentials (Davis & Rimm 1994). The figural components of the TTCT have had more than three decades of extensive evaluation (Millar 2002). This subset of TTCT has large norming samples, with valuable longitudinal validations (Davis 1997) and high predictive validity over a very wide age range (Cropley 2000). "The TTCT-Figural can be fair in terms of gender, race, and community status, as well as for persons with a different language background, socioeconomic status, and culture . . ." (Kim 2006). Such robustness is essential for a study like this one with participants of different nationalities (Cramond 1993; Torrance 1977). However, according to the TTCT manuals (Torrance 1974, 1966), the test-retest reliability is not high with coefficients ranging from .50 to .93. Ellis Torrance (1974) indicated that motivational conditions may affect the measurement of creative skills, which could explain the modest test-retest reliability. Donald Treffinger (1985) concluded that, given the complexity of creative thinking, the use of TTCT is questionable for routine assessment of individuals but reliable for group and research applications.

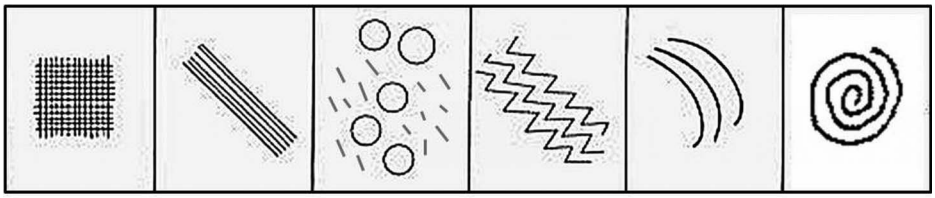
Measures of Creativity

The scoring of the standardized creativity test was carried out in accordance with the process specified by Barkóczi and Zétényi (1981). Each task (35 blank circle use and ten figure completion) of the TTCT was scored by two blind raters, who were unaware of the subjects' group membership, for three measures of creativity (fluency, flexibility, and originality) as defined by John Baer (1993), and the scores (interrater Cronbach's alphas > 0.77) were summed up. As result, tasks of the test received creativity scores independently: a fluency score, a flexibility score (except for figure completion), and an originality score. The fluency score equaled the number of responses given, while the flexibility score reflected the number of categories the subjects selected their answers from. The categories were set up in the course of the standardization procedure by Barkóczi and Zétényi (1981). The originality score was assigned on the basis of a list containing an index calculated from the statistical frequency of the given response (Barkóczi & Zétényi 1981). Originality scores of different items varied from 0.01 to 0.99 points (high points representing rare responses with high originality), while flexibility and creative fluency scores of each response were worth one point.

Albert and Kormos (2004) demonstrated that in this scoring system the creative fluency score (the number of responses the subject produces) significantly influences both the flexibility and originality scores and this usually results in high intercorrelations between the three subscores of the test. Since a similar scoring method is applied for the flexibility scores (each new category is rewarded with one point without considering the total number or responses), they can be affected by fluency to a great extent as well. For this reason, the establishment of fluency free scores was important as these could provide information about other facets of the subjects' creativity, regardless of the number of responses they produced. In order to achieve this, the relative flexibility (the ratio of summed flexibility scores over summed fluency scores) and the relative originality (the ratio of summed originality scores over summed fluency scores) were also calculated, in line with the procedure specified in the test (Barkóczi & Zétényi 1981). In this way the fluency score can be used to measure creative fluency, the relative flexibility score to measure flexibility and the relative originality score to measure originality as defined above.

Apart from these creativity scores, the number of highly original solutions (with originality scores above 0.90) was also calculated and considered as the most reliable index of creativity. A few very original ideas can make a person creative; pooling those together with every solution can weaken the effect and mask real potentials. For example, if a person produces two highly original ideas worth the maximum score 0.99 point each and two more common solutions worth of 0.45, his total originality score

FIGURE 1
Six Categories of Entoptic Phenomena Taken From Lewis-Williams and Dowson (1988)



will be 2.88 points (resulting in a relative originality score of 0.72) for the given task. If, however, another individual produces four statistically less original responses worth 0.75 point each, his/her total and relative originality scores (3.0 and 0.75, respectively) will be higher than those of his/her somewhat less consistent peer. Without the analysis of the highly original solutions a skewed picture is drawn about the two persons' (or groups') true creative capacity.

Phosphenic Responses

The analysis of phosphenic solutions does not belong to the TTCT, and drawing phosphenes is usually not considered to be a creative response *per se*. In the TTCT phosphenes can appear in a picture by itself (e.g., in a Torrance circle with dots inside) or as part of a complex figure (in the drawing of a leopard, for example). Although there are numerous entoptic forms, certain types recur. We have selected six of the most common types from the range established by neurologists and psychologists (Siegel 1977; Horowitz 1975; Eichmeier & Höfer 1974; Richards 1971; Oster 1970; Knoll & Kugler 1963; Klüver 1942). These are: (1) a basic grid and its development in a lattice or hexagonal pattern, (2) sets of parallel lines, (3) dots and short flecks, (4) zigzag lines (reported by some subjects as angular, by others as undulating), (5) nested catenary curves, and (6) filigrees or thin meandering lines (Figure 1). Because these phenomena are mercurial, we do not suppose our six categories to be as rigid as this list seems to imply. Nevertheless, we consider the six entoptic types to be fundamental because they were established by abstracting redundant elements from a large number of reports and seen as frequently used motifs in tribal art (Lewis-Williams & Dowson 1988). Each response belonging to any of the above categories was evaluated by two independent raters, given a score of one point and summed. The total score of the phosphenic responses had good interrater reliability (Cronbach's alpha = 0.81).

Statistical Analysis

The following variables were subject to statistical analysis: fluency in blank circle use, relative flexibility in blank circle use, relative originality in blank circle use, the number of highly original solutions in blank circle use, fluency in figure completion, relative originality in figure completion, the number of highly original solutions in figure completion, and the number of phosphenic responses. Repeated measures of ANOVA (IBM SPSS v19.0) were run with the variables for testing the after-effects of repeated ayahuasca use, and Bonferroni's *post hoc* comparisons were applied when the ANOVA indicated significant group-test interaction. Qualitative data and nonparametric variables were analyzed by Pearson's chi-square and Kolmogorov-Smirnov tests.

RESULTS

Descriptive Measures

Age was 27.1 ± 8.6 (mean ± SD) years for the comparison subjects (N = 21), and 30.9 ± 7.7 (t = 1.78, p V = 0.08) for the participants (N = 40). Sex distribution (male:female) was: comparison group = 10:11, ayahuasca group = 17:23 ($chi^2 = 0.14$; N.S.). Twenty-five participants had four and 15 participants had five sessions during the two-week period.

Measures of Creativity

Table 1 summarizes the results of creativity tests and entoptic activity. Repeated ingestion of ayahuasca had no effect on creativity measures such as fluency, relative flexibility, and relative originality. However, there was a significant increase in the number (mean ± SD) of highly original solutions both in blank circle use (F1,59 = 13.8, $p < 0.0005$; 0.7 ± 1.01 vs. 1.7 ± 1.04, $p < 0.0001$ by Bonferroni's test) and figure completion (F1,59 = 17.2, $p < 0.0005$; 1.1 ± 1.06 vs. 2.9 ± 1.88, $p < 0.0001$ by Bonferroni's test). Groups did not differ in baseline measures of creativity. Since the groups were not perfectly

TABLE 1
Results (Mean ± SD) of the Creativity Measures and Phosphenic Responses

	Comparison Group (N = 21)		Ayahuasca Group (N = 40)	
	Test 1	Test 2	Test 1	Test 2
Blank Circle Use				
Fluency	20.0 ± 10.18	20.0 ± 11.49	15.7 ± 9.73	19.5 ± 9.33
Relative Flexibility	0.3 ± 0.25	0.2 ± 0.27	0.3 ± 0.21	0.3 ± 0.23
Relative Originality	0.5 ± 0.16	0.5 ± 0.23	0.6 ± 0.24	0.7 ± 0.16
High Originality	0.8 ± 0.60	0.6 ± 0.59	0.7 ± 1.01***	1.7 ± 1.04***
Phosphenes	1.6 ± 2.16*	0.8 ± 1.12***	5.2 ± 5.86*,**	7.8 ± 6.90**,***
Figure Completion				
Fluency	9.7 ± 0.86	8.5 ± 1.91	9.4 ± 1.00	9.5 ± 1.11
Relative Originality	0.5 ± 0.08	0.6 ± 0.13	0.5 ± 0.12	0.7 ± 0.12
High Originality	1.1 ± 0.73	1.0 ± 0.80	1.1 ± 1.06***	2.9 ± 1.88***

Probabilities for Bonferroni's *post hoc* tests: *$p < 0.05$, **$p < 0.01$, ***$p < 0.0001$.

balanced for age (the comparison subjects had a tendency with $p = 0.08$ for lower age), we entered age as covariate into the same analyses; and the significant differences remained.

Phosphenic Responses

Phosphenic responses (mean ± SD) were much higher in the post-ayahuasca tests (7.8 ± 6.90) as compared to the pre-ayahuasca tests (5.2 ± 5.86) and the retest sample of the comparison subjects (0.8 ± 1.12; $F1,59 = 4.7$, $p < 0.05$). The use of Bonferroni's *post hoc* tests indicated significant differences between the mentioned cells (post-ayahuasca vs. pre-ayahuasca $p < 0.01$ and post-ayahuasca vs. controls' retest $p < 0.0005$). However, participants in the ayahuasca ceremonies exhibited more phosphenic solutions at the baseline (5.2 ± 5.86 vs. 1.6 ± 2.16; $p < 0.05$) as compared to controls. At the same time, our results show that they had more psychedelic experiences than the comparison subjects had during a six-month period preceding the study (1.1 ± 1.2 vs. 0.1 ± 0.4; $p < 0.005$ by Kolmogorov-Smirnov test).

DISCUSSION

This study is the first to address creativity in ayahuasca users by administering standardized tests with objective measures. Our results show that repeated ayahuasca intake in a ceremonial setting has a positive after-effect on originality as reflected in high scoring on the visual components of the TTCT, and induces long-lasting phosphenic activity as well. These findings are consistent with the findings of Jones and coworkers' study (2009). In that study no significant differences between groups were found in the fluency of responses, but cannabis users had significantly more "rare-creative" responses as measured by scores analogous to our number of highly original solutions. Similarly, while our study found no change in measures of creativity such as fluency or relative flexibility, it did find that there was a significant increase in the number of highly original solutions to the tasks.

One strength of this study is its application of a standardized creativity test to a group of individuals who underwent repeated psychedelic exposure within a preset time period. A weakness is the use of a mixture-compound, which is probably the most unreliable among psychedelics for being controlled and monitored by the dose and blood level of its active ingredients. The bioavailability of DMT is highly dependent on the pharmacokinetics and pharmacodynamics of the other admixture—harmine. Moreover, it is difficult to measure active transport of DMT through the blood-brain barrier—a unique feature in its class (Sangiah, Gomez & Domino 1979). Finally, the synaptic effects of DMT can be altered by the third ingredient of ayahuasca, which is the serotonin reuptake inhibitor tetrahydroharmine.

For a more optimal investigation, an ethnically comparable, placebo-controlled group should have gone through a two-week period with environment, diet, day-schedule, and ceremony sessions similar to those of the ayahuasca participants. Fulfilling those requirements would multiply the costs of the study. We hope that the current study will provide a foundation for future work. Since the control subjects did not participate in the same ceremonial processes as the ayahuasca participants we can only draw conclusions regarding the effects of ayahuasca in the context of ceremonies (the drug plus set and setting). Based on this study alone, it is not possible to disaggregate the specific role played by repeated ayahuasca administration (the drug itself) from environmental factors. Although this constraint may weaken the pharmacological significance of the study, its results should be of both pharmacological and ethnopharmacological interest to future researchers.

In the interpretation of the results, two possibilities have to be taken into consideration. It is tempting to postulate that repeated ayahuasca ceremonies enhance creative thinking. Another possibility is that creative individuals tend to seek out novelty, including psychoactive drug sessions like ayahuasca rituals. Both are consistent with the idea of Frank Barron (1965) cited in our introduction that psychedelics manifest potentials already present in an individual, rather than giving birth to creativity. However, the finding that baseline creativity scores did not differ between the two groups suggests that the ayahuasca group may not constitute a self-selected high creativity sample.

Neuropsychologically, it is unclear why ayahuasca users produced more original solutions. According to a three-factor speculative model of creative drive the frontal lobes are involved in the generation of ideas, the temporal lobes evaluate and edit the information and, finally, limbic structures participate in goal-oriented behavior (Flaherty 2005). The interaction between the three structures then results in an increase of creative performance. Indeed, ayahuasca is known to increase frontal and paralimbic blood flow (Riba et al. 2006). This activation pattern was found when the subjects were under the acute effect. However, it is unclear how long this activation pattern lasts. Current knowledge about the pharmacokinetics of exogenous DMT suggests that it may remain in the brain for at least one week after administration. In high concentrations, DMT is taken up by the serotonin transporter, stored in vesicles by the vesicle monoamine transporter, and ready to be released in response to appropriate stimuli (Vitale et al. 2011).

The phosphenic after-effects of psychedelic use are possibly related to long-lasting hyperexcitability of the lower visual system (Rhodium Archive 2009). Gerald Oster (1970) points out that studying entoptic phenomena after psychedelic use may be of some interest to art historians. He considers phosphenic effects as possible "intrinsic" source of inspiration for people of many different cultures—especially tribal societies. Following this line of argumentation, Lewis-Williams and Dowson (1988) constructed a neuropsychological model to explain the origin of shamanistic rock art including Upper Paleolithic cave paintings. They were able to show that this art was associated with entoptic phenomena, and speculated that it may have been based on experiences in altered states of consciousness. Their model implies an increase in three components of the artistic process: entoptic activity, creative urge, and original solutions. As of yet, there is no direct experimental support addressing all three factors simultaneously. Our study was not designed for this purpose, and was not able to detect creative urge since spontaneity was not part of the testing situation. However, our study did address and positively answered the question of whether an altered state of consciousness affects the other two components of the creative process. The spontaneous appearance of creative urge has been observed in Zoltán Böszörményi's study (1960).

Following a buoyant professional interest in psychedelics in the 1950s and 1960s, there has been an almost 40-year moratorium on psychedelic research. Psychedelic studies were abandoned prematurely for social—not scientific—reasons before their full therapeutic potential had been adequately addressed. The enhancement of creativity is one topic that may have potential benefits for extending our knowledge of mental processes, and therefore should be of interest to the re-emerging field of psychedelic research. Creative activity is an important human characteristic and a worthwhile subject of modern research methods—including the experimental administration of psychedelic substances.

NOTE

1. "For Brooklyn chemistry professor Dr. Gerald Oster, a single trip on LSD was all it took to launch him on an art career. 'It made a fabulous impression' he recalls. What struck him particularly was the 'stunning magnificence of phosphenes' those dancing dots, spirals, radial lines and other luminous images that one can see when the eyes are closed or the fingers are pressed against the lids."

REFERENCES

Abramson, H.A.; Jarvik, M.; Kaufman, M.; Kornetsky, C.; Levine, A. & Wagner, M. 1955. Lysergic acid diethylamide (LSD-25): Physiological and perceptual responses. *Journal of Psychology* 39: 3–60.

Albert, Á. & Kormos, J. 2004. Creativity and narrative task performance: An exploratory study. *Language Learning* 54 (2): 277–310.

American Psychiatric Association (APA) 2000. *Diagnostic and Statistical Manual of Mental Disorders. Fourth Edition-Text Revision*. Washington, DC: American Psychiatric Publishing.

Baer, J. 1993. *Creativity and Divergent Thinking: A Task Specific Approach*. Hillsdale: Lawrence Erlbaum Associates.

Barkóczi, I. & Zétényi, T. 1981. *A Kreativitás Vizsgálata [The Examination of Creativity]*. Budapest: Országos Pedagógiai Intézet.

Barron, F. 1965. The creative process and the psychedelic experience. *Explorations Magazine* (June-July). Available at http://www.druglibrary.org/schaffer/lsd/barron.htm.

Böszörményi, Z. 1960. Creative urge as an after effect of model psychoses. *Confinia Psychiatrica* 3: 117–26.

Cramond, B. 1993. The Torrance Tests of Creative Thinking: From design through establishment of predictive validity. In: R.F. Subotnik & K.D. Arnold (Eds.) *Beyond Terman: Contemporary Longitudinal Studies of Giftedness and Talent*. Norwood: Ablex Publishing.

Cropley, A.J. 2000. Defining and measuring creativity: Are creativity tests worth using? *Roeper Review* 23 (2): 72–79.

Davis, G.A. 1997. Identifying creative students and measuring creativity. In: N. Colangelo & G.A. Davis (Eds.) *Handbook of Gifted Education*. Needham Needham Heights: Viacom.

Davis, G.A. & Rimm, S.B. 1994. *Education of the Gifted and Talented. Third Ed*. Needham Heights: Simon & Schuster.

Dikov, N.N. 1971. *Naskalnuie Sagadki Drevniei Ciukotki: Pietroglifui Pegtimelia [Mysteries in the Rocks of Ancient Chukotka: Petroglyphs of Pegtymel]*. Moscow: Nauka.

Dobkin de Rios, M. & Janiger, O. 2003. *LSD, Spirituality and the Creative Process*. Rochester: Park Street Press.

Dronfield, J. 1995. Subjective visions and the source of Irish Megalithic art. *Antiquity* 69: 539–49.

Eichmeier, J. & Höfer, O. 1974. *Endogene Bildmuster*. Munich: Urban & Schwarzenberg.

Faillace, L.A. & Szára, S. 1968. Hallucinogenic drugs: Influence of mental set and setting. *Diseases of the Nervous System* 29 (2): 124–6.

Flaherty, A.W. 2005. Frontotemporal and dopaminergic control of idea generation and creative drive. *Journal of Comparative Neurology* 493 (1): 147–53.

Frecska, E. 2007. Therapeutic guidelines: Dangers and contra-indications in therapeutic applications of hallucinogens. In: T. Roberts & M. Winkelman (Eds.) *Psychedelic Medicine*. Westport: Praeger.

Frecska, E.; White, K.D. & Luna, L.E. 2004. Effects of ayahuasca on binocular rivalry with dichoptic stimulus alternation. *Psychopharmacology (Berlin)* 173 (1–2): 79–87.

Guilford, J.P. 1966. *Measurement and Creativity: Theory into Practice*. Mahwah: Lawrence Erlbaum Associates.

Harman, W.W.; McKim, R.H.; Mogar, R.E.; Fadiman, J. & Stolaroff, M.J. 1966. Psychedelic agents in creative problem solving: A pilot study. *Psychological Reports* 19 (1): 211–27.

Horowitz, M.J. 1975. Hallucinations: An information-processing approach. In: R.K. Siegel & L.J. West (Eds.) *Hallucinations: Behaviour, Experience, and Theory*. New York: Wiley.

Howard, J.H. 1957. The mescal bean cult of the Central and Southern Plains: An ancestor of the peyote cult. *American Anthropologist* 59 (1): 75–87.

Jones, K.A.; Blagrove, M. & Parrott, A.C. 2009. Cannabis and Ecstasy/MDMA: Empirical measures of creativity in recreational users. *Journal of Psychoactive Drugs* 41 (4): 323–29.

Kim, K.H. 2006. Can we trust creativity tests? A review of the Torrance Tests of Creative Thinking (TTCT). *Creativity Research Journal* 18 (1): 3–14.

Klüver, H. 1942. Mechanisms of hallucinations. In: Q. McNemar & M.A. Merrill (Eds.) *Studies in Personality*. New York: McGraw-Hill.

Knoll, M.; Kugler, F.; Höfer, O. & Lawder, S.D. 1963. Effects of chemical stimulation of electrically induced phosphenes on their bandwidth, shape, number, and intensity. *Confinia Neurologica* 23: 201–26.

Krippner, S. 1990. Psychedelics, hypnosis, and creativity. In: C.T. Tart (Ed.) *Altered States of Consciousness: A Book of Readings. Third Ed*. San Francisco: Harper Collins.

Lewin, R. 1991. Stone Age psychedelia: Was the cave art of Stone Age people the fruit of hallucinations induced by shamanistic rituals? *New Scientist Magazine* 1772: 30–34.

Lewis-Williams, J.D. 1997. Harnessing the brain: Vision and shamanism in Upper Palaeolithic Western Europe. In: M.W. Conkey, O. Sopher, D. Stratmann & N.G. Jablonski (Eds.) *Beyond Art: Pleistocene Image and Symbol*. Berkeley: University of California Press.

Lewis-Williams, J.D. & Dowson, T.A. 1988. The signs of all times: Entoptic phenomena in Upper Paleolithic art. *Current Anthropology* 29 (2): 201–45.

Life Magazine (unknown author). 1966. Psychedelic art. *Life Magazine* September 9: 61–69.

McGlothlin, W.H.; Cohen, S. & McGlothlin, M.S. 1967. Long lasting effects of LSD on normals. *Archives of General Psychiatry* 17 (5): 521–32.

McKenna, D.J.; Towers, G.H. & Abbott, F. 1984. Monoamine oxidase inhibitors in South American hallucinogenic plants: Tryptamine and beta-carboline constituents of ayahuasca. *Journal of Ethnopharmacology* 10 (2): 195–223.

Millar, G.W. 2002. *The Torrance Kids at Mid-life*. Westport: Ablex Publishing.

Narby, J. 2001. Shamans and scientists. In: J. Narby & F. Huxley (Eds.) *Shamans Through Time*. New York: Tarcher/Putnam.

National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research. 1979. *Ethical Principles and Guidelines for the Protection of Human Subjects of Research (The Belmont Report)*. Washington, DC: US Government Printing Office.

Oster, G. 1970. Phosphenes. *Scientific American* 222 (2): 83–87.

Rhodium Archive. 2009. *A Hypothesis of the Mechanisms Underlying Visual Distortions Caused by Psychedelic Drugs.* Available at http://www.erowid.org/archive/rhodium/pharmacology/visualdistortions.html

Riba, J.; Romero, S.; Grasa, E.; Mena, E.; Carrió, I. & Barbanoj, M.J. 2006. Increased frontal and paralimbic activation following ayahuasca, the pan-Amazonian inebriant. *Psychopharmacology (Berlin)* 186 (1): 93–98.

Richards, W. 1971. The fortification illusions of migraines. *Scientific American* 224 (5): 89–94.

Sangiah, S.; Gomez, M.V. & Domino, E.F. 1979. Accumulation of N,N-dimethyltryptamine in rat brain cortical slices. *Biological Psychiatry* 14 (6): 925–36.

Sessa, B. 2008. Is it time to revisit the role of psychedelic drugs in enhancing human creativity? *Journal of Psychopharmacology* 22 (8): 821–27.

Shanon, B. 2000. Ayahuasca and creativity. *MAPS Newsletter* 10 (3): 18–9.

Siegel, R.K. 1977. Hallucinations. *Scientific American* 237 (4): 132–40.

Szára, S. 1956. Dimethyltryptamine: Its metabolism in man; the relation to its psychotic effect to the serotonin metabolism. *Experientia* 12 (11): 441–2.

Torrance, E.P. 1977. *Discovery and Nurturance of Giftedness in the Culturally Different*. Reston: Council on Exceptional Children.

Torrance, E.P. 1974. *The Torrance Tests of Creative Thinking—Norms—Technical Manual Research Edition—Verbal Tests, Forms A and B—Figural Tests, Forms A and B*. Princeton, NJ: Personnel Press.

Torrance, E.P. 1966. *The Torrance Tests of Creative Thinking—Norms—Technical Manual Research Edition—Verbal Tests, Forms A and B—Figural Tests, Forms A and B*. Princeton, NJ: Personnel Press.

Treffinger, D.J. 1985. Review of the Torrance Tests of Creative Thinking. In: J.V. Mitchell Jr. (Ed.) *The Ninth Mental Measurements Yearbook*. Lincoln: Buros Institute of Mental Measurements.

Vitale, A.A.; Pomilio, A.B.; Cañellas, C.O.; Vitale, M.G.; Putz, E.M. & Ciprian-Ollivier, J. 2011. In vivo long-term kinetics of radiola-beled N,N-dimethyltryptamine and tryptamine. *Journal of Nuclear Medicine* 52 (6): 970–77.

Zegans, L.S.; Pollard, J.C. & Brown, D. 1967. The effects of LSD-25 on creativity and tolerance to regression. *Archives of General Psychiatry* 16 (6): 740–49.