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Hallucinogenic Drug-Induced Behavior Under Sensory Attenuation

Prediction of Response to Psilocybin

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Eight "stable" and four "variable" college-age subjects were given 160μg/kg psilocybin under conditions of sensory attenuation. Stability was defined by the magnitude of the standard deviation on handwriting area under predrug conditions.

Only the variable subjects, our large-standard deviants, responded to the drug with a significant decrease in mean pulse rate and increase in handwriting area. They also reported consistently more intense experiences under psilocybin than the small-standard deviants. The degree of variability on perceptual-behavioral measures, such as the SD on handwriting area, is significantly related to, and therefore a predictor of, the intensity of the ensuing drug-induced experience.

Recently we found that an individual's variability within a series of perceptual and behavioral tasks, as indicated by his standard deviation, is a reliable predictor of hallucinogenic drug-induced behavior.[1-4] Moreover, the SD under predrug conditions predicted performance during a hypnotically-induced drug experience.[5] We wondered, therefore, whether the SD on handwriting area, a simple perceptual measure, would also predict the outcome of a psilocybin-induced experience under conditions of sensory attenuation.

There is no agreement in the literature whether sensory attenuation diminishes or enhances the intensity of an hallucinogenic drug-induced experience.[6-9] This is not unexpected since no single factor seems to govern the intensity of a psilocybin, lysergic acid diethylamide (LSD) or mescaline-induced experience. The cross tolerance between the three compounds,[10,11] as well as the characteristic square-wave pattern of saccadic eye movement they elicit,[12] mark these drugs as *the* hallucinogenic, psychotomimetic, psychodelic, or psychodysleptic drugs. It is implied, therefore, that any state which can be induced by one of these drugs can be duplicated by the other as well.

We have singled out the SD on a perceptual and behavioral task as a possible predictor of drug-induced performance because two types of subjects could be differentiated on the basis of the magnitude of their SD: "stable" subjects, ie, those with consistently small and reproducible SD's on a series of tasks under no-drug conditions (T_1), who subsequently under drug-induced arousal (T_2) attempt to increase sensory input (maximizers); and "vari-

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Table 1.—Volunteers' SD Magnitude

Subject No./Sex	SD of Handwriting Area at T_1	
	Machine-Oriented	Free-Hand
Stable		
1/F	2.61	4.12
2/F	3.70	3.85
3/F	5.51	10.28
4/M	4.87	4.36
5/M	2.97	6.32
6/M	5.02	1.28
7/M	2.16	4.03
8/M	5.98	5.58
$\bar{X}$	4.10	4.97
Variable		
9/F	9.54	13.42
10/M	7.37	9.96
11/M	6.69	9.40
12/M	30.72	96.30
$\bar{X}$	13.58	32.27

able" subjects characterized by a variable but often large SD on tasks (at T_1), ie, subjects who at T_2 attempt to minimize sensory or subcortical input (minimizers).[13,14]

We assumed that under conditions of attenuated sensory input, stable maximizers and variable minimizers would undergo different drug-induced experiences. Specifically, it was hypothesized that sensory attenuation would diminish the intensity of psilocybin-induced experience in the stable maximizers, our small-standard deviants, whereas the variable minimizers will experience an increase in intensity.

Methods

Subjects were 12 college-age volunteers with a median age of 23 years, screened by the Minnesota Multiphasic Personality Inventory (MMPI) and the Myers-Briggs Type Indicator (MBTI), and already familiar with psilocybin under experimental conditions. They were categorized as stable (eight) or variable (four) subjects according to the magnitude of their SD on handwriting area. Stability or variability, ie, the SD itself, follows a log-normal distribution as we have found earlier in another comparable volunteer population (No. = 42). Thus, stable subjects are rather uncommon since variable volunteers constitute the middle range of the distribution representing about two thirds of the population. In this study, therefore, our concern was to select a larger sample of the less common stable subjects.

Initially the handwriting variability measure had been "machine obtained" with a handwriting pressure transducer beneath the paper while the heel of the subjects hand rested on a plate (not connected with the transducer) gliding up and down during the writing. The subject had to copy a 28-word text four times on separate sheets of paper under standardized conditions. Then the total surface area in square centimeters of each sample was determined and the SD on the handwriting area computed.[14]

Although the restraining conditions of the machine situation keep the SD within tighter limits, particularly in variable subjects, the SD on handwriting area under "free-hand" conditions was also shown to be comparable to the machine-measured value.[15] Both the machine-obtained and free-hand variability measures for these subjects are shown in Table 1, indicating that both machine and free-hand obtained variability measures are equally useful to define the stability or variability of a subject.

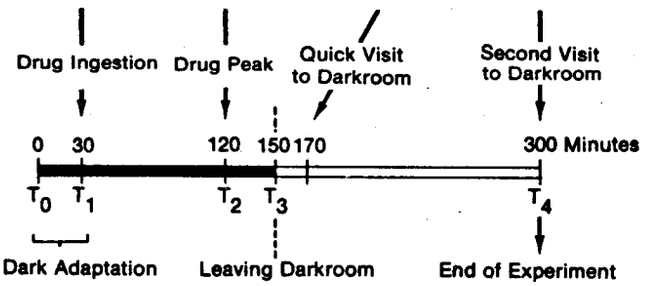

Fig 1.—Temporal sequence of experiment.

Table 2.—Pulse Rate of Stable and Variable Volunteers*

Subject No./Sex	Pulse Rate, beats/min	
	Predrug, T_1	Hallucinogenic Drug Peak, T_2
Stable		
1/F	88	68
2/F	75	65
3/F	83	92
4/M	85	73
5/M	83	70
6/M	70	73
7/M	70	70
8/M	66	60
$\bar{X}$	77.5	71.4
SD	±8.26	±3.3
Variable		
9/F	79	73
10/M	85	69
11/M	82	78
12/M	93	77
$\bar{X}$	84.7	74.25
SD	±6.02	±2.1

* The 160 μg/kg psilocybin-induced drop in the pulse rate is significant in the variable group only ($t = 3.28$, $P < .05$).

Sensory attenuation was achieved by placing the subjects in a sound-attenuated room 9⅝ × 8⅝ × 8½ ft, at 75 F with a mild, constant air-conditioning background noise and a light source of less than 1 foot-candle. This dimly lit room contained a wall-type table for the handwriting test, straight-backed chair, bed, and supply cabinet. There were no pictures or decorations on the wall.

Initially (T_0), the subject was tested in the dimly lit ("dark") room, but with 4 ft-c light (Fig 1). He completed four handwriting samples of a standard copy of 28 words on an aluminum tablet with a cartridge pen. Each sample was copied without access to the previous ones. Size of pupillary diameter (flash photographed with a camera fitted to a pupilometer[14]), one-minute pulse rate, and sublingual temperature were measured. Light was then reduced to less than 1 ft-c and the subject was given a typed set of instructions to be followed during the experiment.

After 30 minutes of dark adaptation the volunteer was retested on each measure (T_1). He was then given an oral dose of psilocybin, 160μg/kg body weight, and retested 90 minutes later, at drug peak (T_2) and 120 minutes later (T_3).

After completion of testing at T_3, the subject was released from the dark room but returned to it briefly 20 minutes later. Light in the room was adjusted to 4 ft-c and control pupil measurements under light adaptation were then obtained. At T_4 (in most cases

Table 3.—Drug-Induced Performance Measured as Mean Handwriting Area, sq cm*

Subject No./Sex	T_1	T_2†	T_3‡	T_4§
Stable				
1/F	50.72	59.72	74.43	55.78
2/F	73.95	73.42	71.42	79.32
3/F	140.15	151.50	121.78	109.05
4/M	70.60	90.92	90.75	58.30
5/M	66.35	85.68	85.55	70.50
6/M	64.38	72.28	68.28	70.70
7/M	59.12	216.15	150.25	85.52
8/M	109.18	166.48	159.73	119.00
$\bar{X}$	79.3	114.6	102.77	81.02
SD	±30.0	±56.3	±36.41	±22.75
Variable				
9/F	99.52	98.82	220.27	174.42
10/M	79.08	341.05	404.48	77.52
11/M	153.05	417.68	385.85	177.38
12/M	224.52	236.78	322.53	182.35
$\bar{X}$	139.0	272.1	333.28	152.91
SD	±64.9	±138.6	±83.11	±50.40

* Increases in means are significantly higher in the variable than stable subjects at T_2, T_3, and T_4.
† $t = 2.54$, $P < .05$
‡ $t = 6.12$, $P < .001$
§ $t = 3.12$, $P < .02$

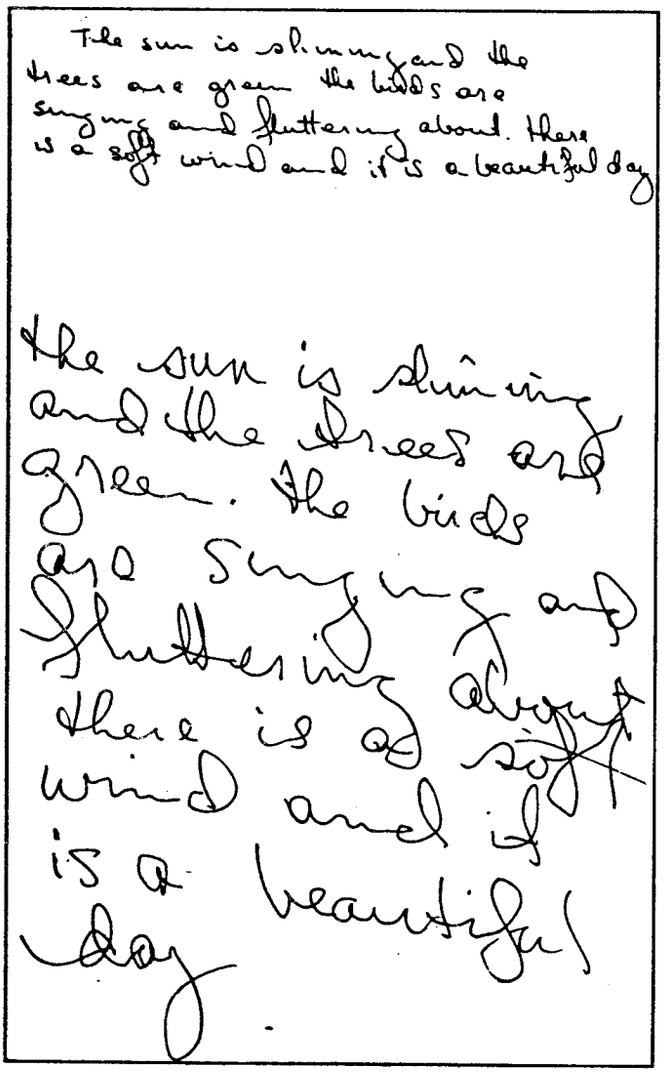

Fig 2.—Psilocybin-induced handwriting area increase in a variable volunteer (No. 10/M); the smaller sample (top) was obtained predrug (T_1) and the larger (bottom) at drug peak (T_2). Each sample is one of four collected to determine SD on area at T_1, T_2, T_3, and T_4. Samples are 80% of original size. Drug-induced increase in handwriting area confirms our prevoius observations[3] and is interpreted as an arousal-induced closing-in of nearby visual space.[4]

postdrug) the subject was again returned to the dark room and tested on all measures (Fig 1).

Results

The psilocybin-induced ergotropic arousal,[16] or central sympathetic excitation syndrome[17] (raise in body temperature, metabolic rate, blood sugar, rate of heart beat, pupillary dilation, facilitation of monosynaptic reflexes such as the knee jerk reflex, etc), affects stable as well as variable volunteers under conditions of sensory attenuation, specifically with respect to T_2 to T_1 pupillary diameter increase, rise in sublingual temperature, and increase in handwriting area.

There is, however, a significant ($P < .05$) drug-induced drop in pulse rate from T_1 to T_2 ($x = 84.7 \pm 6.02$ to $x = 74.25 \pm 2.1$) for variable minimizers only. This drop may be accounted for by the initially higher mean predrug or T_1 value of the variable subjects ($x = 84.7 \pm 6.02$) compared to that of the stable group ($x = 77.5 \pm 8.26$, see Table 2).

Our contention that drug-induced performance is predicted by the magnitude of the SD on handwriting area under predrug conditions (measured at T_1) is borne out by the results as presented in Table 3. Drug-induced performance measured as mean handwriting area at T_2, T_3, and T_4 indeed shows significant increases (between the stable and variable groups) at each point ($P < .05$, $P < .001$, and $P < .02$ at T_2, T_3, and T_4, respectively). An illustration

of the psilocybin-induced increase in handwriting area is given in Fig 2.

Whether the intensity of an hallucinogenic drug-induced experience has been increased or decreased through sensory attenuation can also be assessed on the basis of subjective reports submitted by volunteers after the drug experiment. The following sample (from the report of a female volunteer) was considered to be representative for a stable maximizer:

> Because I'm not used to sensory deprivation, I could not be sure that the drug was having any effect. My thoughts were very introspective. I thought about me and the rest of the world, contemplating my own existence more than my relationships with people or things. I was intrigued by my own perception, by the songs running through my head, by my perception of my own experiences. . . . I felt very private and very alone, but not lonely. I did not think much about colors or emotions or other people. At no time did it seem that I would not be able to stand the time in the room. I always had a strong sense of time; I knew when the experimenter would be coming back (approximately). I felt no impulse to do something physical; no sexual stimulation; no boredom.

The fairly rational tone in the above example sharply contrasts the intensely emotional experience of the variable minimizer. A sample from such a representative report (by another female volunteer) reads:

> I sat down again with my head bowed. I tried my "cosmic consciousness" experience again. This time, however, I no longer perceived a void, but a gray, soupy mass that enveloped everything; I felt as though I was descending into it. It was like a cold, churning ocean and I felt its pressure and its coldness, but no moisture, as if I were wearing a wet suit. I began to feel vast, huge, all-encompassing. I was no longer a person but like the infinite gelatinous mass. I lost all body image and orientation. I could not tell whether I was asleep or awake. It was the most profound feeling of dehumanization I have ever experienced.

Each subject's report was graded "blind" by one of us (Y.P.) for intensity of experience, using three stars as the highest score. Table 4 lists these ratings individually, with a typical sentence from each report.

It is common knowledge that, in mice[18] and man,[19] hallucinogenic drugs like psilocybin can only "provoke symptoms which are already potentially present within the cerebral organization," a statement which implies that the set, setting, expectations (the "total personality") governs the quality of the drug experience. Or in biocybernetic terminology: man, the self-referential system, cortically, ie, cognitively or perceptual-behaviorally, interprets the drug-induced change in subcortical activity. Apparently the magnitude of the SD on a series of perceptual-behavioral measures, including handwriting area, under predrug conditions (T_1) is related during the following few hours to the "cortical repertoire," the set, setting, past experience, and expectations.

Interestingly, variable minimizers, those with large SD at T_1 (as we have found earlier[13]) prefer to minimize brightness (sensory input) at the peak of an hallucinogenic drug experience (T_2). These variable minimizers, who are MMPI drug reactors and MBTI perceivers, can be contrasted with the stable maximizers, those with small SD at T_1, who prefer to increase brightness (sensory input at T_2). We have found that these stable maximizers are also

Table 4.—Subjects' Retrospective Reports Rated for Drug Experience Intensity

Subject No./Sex	Typical Sentences from Report of Drug Experience	Graded Intensity of Experience as Revealed by Report†
Stable		
1/F	Most of the time I was either sitting in the chair or sitting on the bed. The green bedspread reminded me of a spread I had when I was a kid.	**
3/F	If I had to stay in the dark room for a longer period of time, I would have become frightened. As it was, I felt serene. There were no great revelations for me.	*
4/M	I found it hard to break my pattern of living even under the drug—I still organized the time to experience as many subjects as possible—sex, love, religion, philosophy, even horror (only curiously).	**
5/M	At no time did I hallucinate—I never had since childhood—although I did notice visual distortions in the sleep lab but for some reason was unusually uninterested.	**
6/M	I found it difficult, and at times impossible to detach myself from the "real" world around me and to concentrate only on my own thoughts.	*
7/M	My mind carried me to all places of my imagination. It was a unique experience and gave me a good look at myself.	**
8/M	The most significant factor about my experience was that I could not, in fact, introspect. That is, I simply did not think about myself, my past or my future. I spent the greatest part of my time with my eyes closed just "watching the show."	**
Variable		
10/M	When the experimenter came in I remember thinking it took years for her to come and yet on the other hand it seemed to take only a few seconds when I looked back on it after the fact.	***
11/M	Suddenly the sensory input became markedly increased . . . I was bombarded by several thoughts, none of which was I able to capture for more than a fleeting moment.	***
12/M	The pleasures I have had tumbling and doing various two-man and three-man dives were then relived (and compared to diving) as I became totally immersed in thinking of the pleasures of body movements, I noticed my own body was in a state of a cross between making love and swimming, which I was enjoying tremendously. (I was not sexually aroused.)	***

† Three stars indicate the most intense experience.

MMPI nonreactors and MBTI judgers.[2] According to the present findings the variable minimizers display a higher mean pulse rate at T_1 which may be interpreted as indicative of a higher level of ergotropic arousal when compared to the lower pulse rate and arousal level of the stable maximizers. Apparently the greater drug-induced drop in the variable minimizers mean pulse rate is related to the larger perceptual-behavioral variability or cortical repertoire.

Our variable minimizers and stable maximizers seem to be stimulus-seeking and stimulus-bound subjects,[20] respectively, but they can not be classified as reducers and augmenters according to Silverman's perceptual styles[21] based on Petrie's concepts.[22] Silverman's subjects reduce and augment under no-drug conditions, whereas our variable minimizers and stable maximizers do so at the peak of psilocybin-induced arousal. There is, however, a report by Silverman which describes eight male LSD users who were tested *during* the LSD experience. It was found that:

> Group I subjects are more open, receptive, and seeking of environmental and internal stimulation than Group II subjects. On the basis of the LSD-day sensory-perceptual testing, Group I subjects are found to be quite sensitive to low-intensity auditory stimulation and tend to reduce the experienced intensity of strong stimulation to a greater extent than Group II subjects.[23]

Evidently group I subjects seem to correspond to our variable minimizers while group II subjects resemble our stable maximizers.

To sum up, we find that the degree of variability of the SD on perceptual-behavioral measures is significantly related to, and therefore a predictor of, the intensity of the ensuing hallucinogenic experience whether drug-induced,[1-3] hypnotically-induced,[5] or modified by sensory attenuation.

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