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Measurement of Handwriting Area to Pressure Ratios During Psilocybin-Induced Hallucinations

by ROLAND FISCHER, THOMAS KAPPELER, PHILIP WISECUP and KAREN THATCHER

Division of Behavioral and Neurobiological Sciences, Departments of Psychiatry and Pharmacology, College of Medicine, The Ohio State University, Columbus, Ohio 43210

Abstract

We define hallucinations as experiences of intense sensations (S) during which the ability and intention for verification through voluntary motor (M) performance is damped or blocked. We have set out to quantify the high sensory to motor (S/M) ratio implicit in a hallucinatory experience by inducing the latter through the administration of 160 μg/kg psilocybin to 16 college-age volunteers. Handwriting area in cm^2 (S) and handwriting pressure in 10^4 dyn (M) – averaged over time and obtained through a pressure transducer and a voltage-to-frequency converter – were chosen as sensory and motor parameters for the computation of S/M ratios.

One of the more important results reveals that although for the group of volunteers the mean handwriting area increases from pre-drug to drug peak – while copying four times a 28-word text – the mean handwriting pressure decreases for only thirteen of them and increases for three. Through the administration of the Myers-Briggs indicator, a self-reporting personality inventory based on Jungian typology, we could differentiate between (1) the thirteen 'perceivers', as subjects characterized by a high S/M ratio during their psilocybin-induced intensely hallucinatory experiences, and (2) the three 'judgers' who attempt to maintain a low S/M ratio at drug peak and whose response to psilocybin results in a controlled, shorter, non-hallucinatory experience.

Another noteworthy result is the personality trait dependent nature of the 'dissociation' which prevails between the extent of drug-induced autonomic activity, expressed in terms of increase in pupillary diameter, and the extent and direction of drug-induced perceptual and behavioral change. This 'dissociation' is carried almost entirely by the 'perceivers' but not by the 'judgers'.

We have recently remodeled the old concept of hallucinations as 'perceptions without an object' to an operational definition: 'Sensations without action' [1]. Hallucinations, indeed, are intensely active sensations with blocked intention and ability to execute peripheral voluntary motor activity. It follows from this definition that methods or mechanisms which sufficiently increase the sensory to motor ratio can elicit hallucinations while factors lowering the sensory to motor ratio – for instance, increased voluntary motor performance – can contribute to the inhibition of hallucinatory phenomena. Our concept accomodates even DELAY and PICHOT's definition of phantom sensations as kinesthetic hallucinations [2]. Phantom phenomena, in fact, do impressively illustrate the meaning of our new definition since concomitant with the intensely active sensation of a (phantom) limb, its absence represents what we call a complete 'blocking' of voluntary motor manifestations. Our definition, in short, implies that the sensory to motor ratio (S/M) gradually increases on the perception-hallucination continuum and is highest during hallucinatory experiences.

But which parameters should be chosen to re-present and to quantify the sensory/motor ratio? The simplest S/M ratio appears to be one based on psycho/motor performance with handwriting space and handwriting pressure as its parameters. Indeed, handwriting space can be chosen as a sensory parameter since it is a projection onto a two-dimensional nearby plane of the multimodal sensory experience of body-image boundaries. In fact, handwriting ability and that part of spatial orientation which can be conceptualized as being related to body image depend on the intactness of two adjacent areas on the dominant side of the cerebral cortex: (1) the supramarginal and angular gyrus, which is part of the ingerior parietal lobe, and (2) the superior parietal lobe. Note also the frequently observed psychotomimetic drug-induced expansion of body image [1, 3] as well as of handwriting space

[4] first described in 1946 [5], and connect that excited-exalted state with the particular hallucinatory effect of the drug psilocybin on Barron's ballet dancer whose deeply introspective and primarily kinesthetic experience consisted of 'neither words nor visual phenomena', but of an experience only of 'the depths of her own body' [6]. Conversely, tranquilization results in a contraction of nearby space, that is, a significant diminution in size of handwriting [7, 8] and drawings.

On the other hand – literally so – handwriting pressure averaged over time, a spontaneous 'seismogram' expressing willed motor activity, may be a conveniently measurable parameter of voluntary *motor* performance. Moreover, an S/M ratio compounded from handwriting area and average handwriting pressure, can transcend the meaning customarily implied by the words 'sensory' and 'motor'. Handwriting area, namely can also be regarded as a 'sensory' indicator of 'data content' (a definition of space) and handwriting force, i.e. pressure averaged over time' a motor indicator of 'the rate of data processing, (a definition of time). An increase, therefore, in such a S/M ratio may be the reflection of hallucinatory experiences proceeding in sensory-mental space-time whereas a decreased S/M ratio would indicate a subject's increased participation in decision-making and voluntary motor performance, i.e. action-requiring physical space-time.

We have already had experience in measuring handwriting area [9] and needed a device with which to measure handwriting pressure. We set out, therefore, in cooperation with the electronic and machine shops of our department (Mssrs. John Neff, Jim Beuhler and Richard Wise) to design and build a handwriting pressure indicator which simultaneously enables us to measure the time involved in a handwriting task.

Handwriting pressure and time indicator

The indicator (see Fig. 1 and 2) operates on a pressure-to-voltage-to-frequency basis. The pressure produced by the tip of the fountain-pen during the handwriting task is transformed through a (Daytronic) pressure transducer to a proportionate output voltage to be amplified by a transducer amplifier. The output of the latter is fed (1) into a counter to trigger the *operating time* readout indicator and (2) into a (Hewlett-Packard) voltage-to-frequency converter which in turn produces a train of pulses, the frequency of which is proportionate to the input voltage, and, therefore, to the voltage produced by the transducer. This train of pulses is fed into a *force* counter representing the instantaneous pressure integrated over time. The 'operating time' counter counts time in seconds only while force is applied to the transducer. The *total time* counter, on the other hand, operates whenever the 'operate' switch is depressed and thus can be used to measure the duration of the complete handwriting task in seconds.

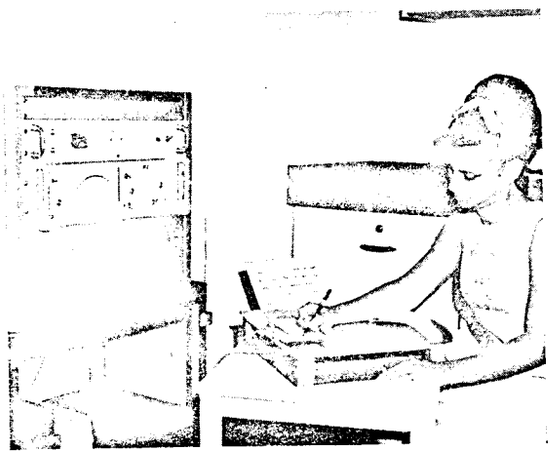


Figure 1
Handwriting pressure and time indicator operating on a pressure-to-voltage-to-frequency basis. The pressure transducer is beneath the paper, but it is not connected with the movable plate on which the heel of the subject's hand rests, gliding up and down during the writing. The counter is pictured on the left and one can see on its lower third the three readouts for Total Time, Operating Time and Total Force. It was not possible in the photograph to display the text to be copied, the counter and the transducer in their original test position.

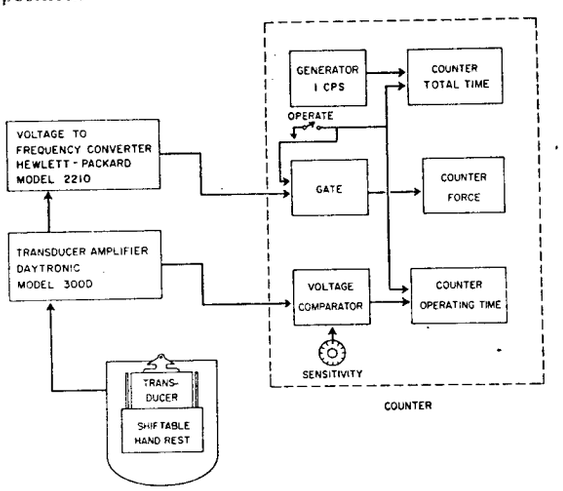


Figure 2
Blueprint of handwriting pressure and time indicator.

Name _____ Age _____ Sex _____

Mood Scale _____ Date _____ Time _____

Pen # _____ Recorder # _____ Tester _____

Conditions _____

_____

Total Time _____ Operating Time _____ Pause Time _____

Total Force _____ Average Force _____ Total Area _____

Figure 3
Display of the lower half of the reverse side of the handwriting test paper.

Calibration of the indicator

Plug the cord into a 110 V outlet, turn on the three units – namely, the *total time* counter, the *force* counter, and the *operating time* counter – and allow at least 10 minutes for the units to stabilize.

(1) Set the 'range selector' switch of the 'transducer amplifier' on the 0.5-inch position and, using the 'transducer zero' knob, adjust the meter for *exactly* a zero reading.

(2) Place a 500 g weight on the writing area of the transducer surface and set the sensitivity control on the 'transducer amplifier' for exactly full-scale deflection.

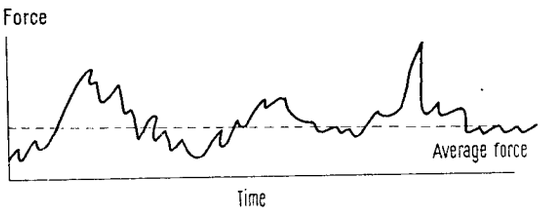
(3) Turn the 'range selector' switch to the 'cal' position and adjust the 'cal reference' screw for exactly full scale deflection. Repeat steps 1, 2 and 3 until further adjustments are no longer necessary. Return the 'range selector' switch to the 0.5-inch position and the instrument is ready for operation.

Operation of the indicator

Momentarily depress the 'reset' switch to set all the counters to zero. At the moment the subject starts the handwriting test, depress the 'operate' switch which shall remain in the 'on' position until released at the end of the test.

Interpretation of data output

Average force is derived from the variation of pressure or force over time:



The 'average force' can be calculated from the
Range Selector Reading (RS),
Total Force Reading (TF), and
Operating Time (OT) – [or, if desired, for the Total Time (TT)].

$$\text{Average force} = \frac{10 \times \text{RS} \times \text{TF}}{\text{OT [or TT]}} \times 10^4 \text{ dyn.}$$

The total Pause Time – if desired – is obtained by subtracting Operating Time from Total Time.

The handwriting test

During the handwriting test, the subject copies a 28-word neutral text placed in front of him, while he is seated on a straight-back desk chair with a seat 17.5 inches above the floor. During the test, the counter is turned away from the subject. The text printed in 0.5-inch letters reads:

the sun is shining, and the trees are green.
the birds are singing and fluttering about.
there is a soft wind, and it is a beautiful day.

The words are copied with a medium point fountain (not a ball-point!) pen[2]) on a sheet of 8.5 by 11 inches, unlined, 20 pound bond paper fastened to a 'clipboard', above the transducer which is covered by the paper in such a way that the writing is performed at a height of 28 inches above the floor (see Fig. 1). To selectively record the pressure of only the pen, the subject's hand rests on and glides with a movable plate not connected with the transducer. The first test sheet of subjects who have never taken the test before is discarded prior to collecting 4 samples on separate sheets of paper with the name, age, sex, date, etc. recorded on the reverse side of the paper (see Fig. 3).

Measurement of handwriting area

First, the total surface area in cm^2 of each handwriting sample is determined and then the standard deviation on the handwriting area (SDHA) is computed. Fig. 4 illustrates the measurement in cm^2 of the area covered by the handwriting: first, a rectangle is formed around the outer limits of that major part of the text which consists of complete lines; then, to the surface area of this rectangle is added that of the incomplete last line (see Fig. 4).

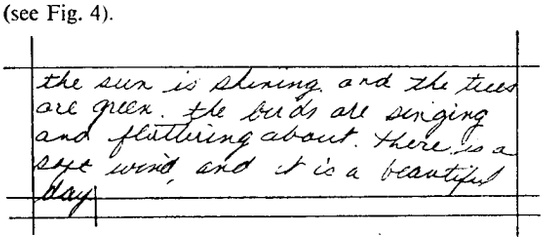


Figure 4
Illustration of the measurement of the handwriting area. In this particular example, the area of the large square containing the complete lines of the text is $13.2 \times 3.5 = 46.2\ cm^2$, to which the area of the incomplete line ($1.7 \times 0.5 = 0.9\ cm^2$) is added. The total handwriting area is $47.1\ cm^2$.

Our aim was to measure the sensory/motor ratio before drug administration (T_1), at drug peak (T_2), i.e. 110 minutes after the administration of a mildly hallucinatory dose of psilocybin, and 270 minutes after drug administration (T_3). Alterations in the S/M ratio – a ratio composed of handwriting area and average force – were hopefully expected to mark the position a subject would assume on the perception-hallucination continuum at the time of testing. Such a position was also meant to reflect the extent of ego control loss along the continuum, a loss accompanied by a gradual breakdown of the size constancies characteristic of physical space-time [10].

[2]) We used an inexpensive Sheaffer Cartridge pen with pen point M and either a Skrip or Sheaffer's washable blue ink cartridge.

The S/M ratio is expressed as follows:

$$S/M = \frac{\text{area } cm^2}{\text{force } 10^4 \text{ dyn}}$$

Subjects, personality profiles, time estimation and production – with and without psilocybin

Our subjects consisted of 16 predominantly taste-sensitive, and thus intuitive [11, 12] college-age volunteers with a median age of 23.1 years – 10 males and 6 females. Prior to any experimentation, the subjects were familiarized through a 10-mg dose of psilocybin with the psychodysleptic drug-induced experience [12]. Then 3 weeks later, in groups of three at a time, they were given 160 μg/kg psilocybin, a dose which in most cases induces mild hallucinations in only some subjects. On such a test day at T_1, T_2 and T_3, the pupillary diameter size was photographically determined with a Polaroid Land

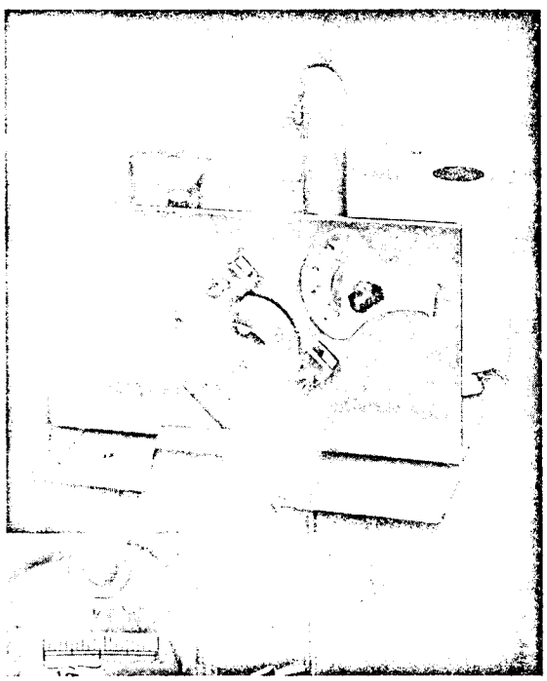


Figure 5
Polaroid Land Camera, Model 20 (the 'Swinger'), fitted to a pupilometer for the measurement of pupillary diameter. Modifications of the 'Swinger' designed by Dr. R. M. Hill, Professor of Physiological Optics, College of Optometry, The Ohio State University. The focal system of the camera was adjusted for an object distance of 58 mm by the addition of a high-quality aberration corrected doublet optic which provides a distortion-free field (within a 30° cone) of a 2:1 image to object magnification ratio. To minimize exposure time the camera system was fitted with a compatible flash unit. The pupil photograph at the bottom of the figure displays a millimeter scale in twofold magnification which appears on all photographs.

Camera Model 20 (the 'Swinger') which was modified by Dr. R. M. Hill (see Fig. 5), and the subject's sensory/motor ratio was determined as well. When not being tested, the volunteers spent their time in a non-laboratory, supportive atmosphere of a large room with a view overlooking a small courtyard garden. At 3-week intervals, they were repeatedly tested under the drug, with some subjects received doses up to 250 μg/kg. In terms of the Myers-Briggs Type Indicator (MBTI), a brief, self-reporting inventory based on Jungian typology, our subjects could be classified as: 15 intuitors (N) and 1 sensor (S); 12 introverts (I) and 4 extraverts (E); 13 perceivers (P) and 3 judgers (J) and 9 feelers (F) and 7 thinkers (T). Each subject's retest variability on the MBTI was determined within a 2-week interval followed by a 3-day experimentation period during which a card form of the MBTI was administered to each subject (T_1, Friday), then 70 minutes after the oral administration of 160 μg/kg of psilocybin (T_2, Saturday – the test day proper), and under post-drug conditions (T_3, Sunday).

Results

Table 1 lists the changes in handwriting area and average force induced by 160 μg/kg psilocybin in 16 volunteers prior to the drug administration (T_1); 110 minutes after, i.e. at drug peak (T_2); and 270 minutes later, i.e. – for all practical purposes – at the end of the experiment (T_3). Also listed are the changes in S/M ratios at T_1, T_2 and T_3 and the changes in S/M ratios in percent between T_2 to T_1 and T_3 to T_1 as well.

Except for two subjects, there is an increase in the drug-induced handwriting area, our sensory parameter. For the total sample, the handwriting area in cm^2 increases 25% from T_1 to T_2 whereas the total cumulative handwriting pressure, or average force, in 10^4 dyn – our motor indicator – increases only 4%. The mean increase of the S/M ratio for the group, therefore, is 15.9% regardless whether the ratio expresses change between T_2 and T_1 or between T_3 and T_1. The standard deviation of the mean between T_3 and T_1, however, is smaller. The data for individual subjects in Table 1 represent the mean of 3 to 4 determinations, except for J.H. ♀ and S.P. ♀ for whom we have only single values. Table 2 shows the standard deviations (SD) and their means ($\bar{x}$) for the handwriting area and the average force parameters at T_1, T_2 and T_3 indicating that for the group both parameters increase somewhat at T_2 with the mean SD of the area increasing more than that of the average force.

Of the 4 out of 16 subjects who decrease their S/M ratios in percent from T_1 to T_2, 3 are 'thinkers' and 2 are 'judgers' (in terms of the MBTI) although the total sample consists of only 7 'thinkers' and 3 'judgers'. Moreover, all 3 subjects who decrease their S/M ratio in percent between T_1 and T_3 are 'thinkers' and the only 'judgers' of the whole sample. 'Judgers' are indeed in a category by themselves. They control any developing anxiety during the drug experience by exerting more pressure during writing – apparently, a protective feedback mechanism – which of course contributes to a decrease in the S/M ratio, testifying to the voluntary, pressure-controlled, non-hallucinatory nature of the experience. From pre-drug to drug peak, the mean average force while copying four times the 28-word text decreases for the 13 'perceivers' by -2.78×10^4 dyn (S.D. = ± 18.1), whereas it increases for the 3 'judgers' by $+28.6 \times 10^4$ dyn (S.D. = ± 12.7).

That this is indeed the case is illustrated in Figure 6 in which the ordinate shows the perceiving-judging scale of the MBTI of the 16 subjects at T_1 while the abscissa displays the average handwriting force exerted T_2 to T_1 in 10^4 dyn. In spite of the very small sample of 'judgers', they are clearly a very forceful group.

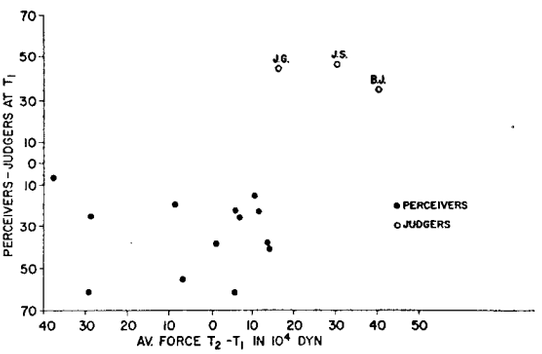


Figure 6
Illustration of the drug-induced increase in handwriting pressure (average force T_2 to T_1 expressed in 10^4 dyn) which is more pronounced in 3 'judgers' (in terms of the MBTI) than in 13 'perceivers'.

At this point, it should be mentioned that the drug-induced changes in both handwriting area and average force for the 16 subjects are not interrelated, a finding which is in accordance with GRÜNEWALD's results [13] which show that under the influence of the sympathomimetic 'peripherine' handwriting pressure and time are independent variables, a justification for using them in forming the S/M ratio ($r = -0.128$ for area; $r = -0.391$ for average force). Further-

Table 1
Mean handwriting area in cm² (S) and mean average force in 10^4 dyn (M) measured in 16 college-age volunteer subjects – performing four times the 28-word handwriting task – without drugs (T_1), 90 minutes later, i.e. at the peak of a 160 µg/kg psilocybin experience (T_2) and 4½ hours later (T_3). The respective sensory to motor (S/M) ratios are also listed for T_1, T_2 and T_3 together with the T_2 to T_1, as well as T_3 to T_1 Δ S/M ratios in percent.

	T_1		T_2		T_3		T_1	T_2	T_3	Δ S/M ratio in %	
Volunteers	Area in cm²	Average force in 10^4 dyn	Area in cm²	Average force in 10^4 dyn	Area in cm²	Average force in 10^4 dyn	S/M	S/M	S/M	T_2–T_1	T_3–T_1
L.C. ♂	27.5	86.2	20.2	48.0	23.2	70.7	0.31	0.42	0.32	35.4	3.2
D.D. ♂	69.4	92.3	84.0	106.6	75.3	79.7	0.75	0.79	0.94	5.3	25.2
J.G. ♂	40.0	52.0	64.8	67.2	46.6	66.6	0.77	0.96	0.69	24.6	−10.3
S.H. ♂	77.4	103.8	71.4	75.8	80.2	62.6	0.74	0.94	1.28	26.6	72.9
B.J. ♂	71.0	65.5	84.0	106.0	70.0	83.0	1.08	0.79	0.84	−26.8	−22.2
G.M. ♂	61.4	74.2	66.4	76.6	64.0	70.6	0.80	0.87	0.91	8.7	13.7
A.P. ♂	52.0	53.9	53.7	60.3	67.4	59.2	0.96	0.89	1.14	−7.2	18.7
E.P. ♂	69.4	80.8	116.9	93.6	96.7	78.7	0.86	1.24	1.23	45.3	43.0
J.S. ♂	105.4	77.9	139.8	108.0	112.0	83.4	1.35	1.29	1.34	−4.4	−0.7
S.S. ♂	69.0	152.3	72.5	145.4	71.1	139.2	0.45	0.50	0.51	8.8	13.3
E.A. ♀	104.2	60.2	113.7	70.9	111.6	58.9	1.73	1.60	1.89	−7.5	9.2
Y.F. ♀	93.6	40.0	184.8	46.4	152.8	42.1	2.34	3.98	3.63	70.0	12.3
J.H. ♀	53.3	49.6	63.4	57.1	61.4	55.6	1.07	1.11	1.10	3.7	3.0
J.H. ♀	79.6	56.4	82.0	58.0	75.4	51.8	1.41	1.41	1.45	.0	2.7
S.P. ♀	42.3	51.3	53.8	43.0	56.2	46.5	0.82	1.25	1.21	57.3	47.5
M.W. ♀	85.0	120.8	109.5	135.1	97.4	113.9	0.70	0.81	0.86	15.7	22.8
										$\bar{x}$ = 15.9	$\bar{x}$ = 15.9
										S.D. = ± 28.3	S.D. = ± 22.5

Table 2
Magnitude of the standard deviation on handwriting area in cm² as well as the average force in 10^4 dyn for 16 college-age volunteers based on their 28-word handwriting task performed 4 times each at T_1, T_2 and T_3.

	Total area in cm²			Average force in 10^4 dyn		
Volunteers	T_1	T_2	T_3	T_1	T_2	T_3
L.C. ♂	5.23	2.24	3.39	6.34	2.78	10.52
D.D. ♂	9.57	9.63	2.83	5.39	13.24	14.65
J.G. ♂	3.06	4.21	2.62	2.29	4.03	5.08
S.H. ♂	3.67	6.24	11.69	10.06	19.96	3.19
B.J. ♂	4.33	7.41	4.03	8.04	7.07	4.44
G.M. ♂	4.58	6.97	1.98	3.07	4.21	4.56
A.P. ♂	6.99	2.33	8.99	4.95	3.61	2.40
E.P. ♂	6.51	13.06	6.42	5.23	8.38	2.02
J.S. ♂	7.66	12.01	6.66	10.32	7.12	11.12
S.S. ♂	3.72	4.52	7.83	7.23	4.08	8.06
E.A. ♀	14.54	8.94	5.92	4.69	6.10	4.21
Y.F. ♀	7.98	43.68	17.82	2.92	8.54	1.46
J.H. ♀	4.65	4.12	3.14	6.52	4.57	4.38
J.H. ♀	10.07	6.00	4.90	4.98	8.73	3.30
S.P. ♀	2.01	2.12	5.64	0.95	8.66	1.30
M.W. ♀	6.50	12.01	6.91	11.87	10.70	8.78
	$\bar{x}$ = 6.31	$\bar{x}$ = 9.09	$\bar{x}$ = 6.29	$\bar{x}$ = 5.92	$\bar{x}$ = 7.61	$\bar{x}$ = 5.59

more, the drug-induced increase in pupillary diameter (IPD), which follows a dose-response relationship and is a reliable indicator of the level of autonomic arousal, is unrelated to the drug-induced change in our 'sensory' (S) parameter, handwriting area ($r = -0.135$). Evidently that which is to be interpreted – the autonomic arousal – is independent or 'dissociated' from that which is part of its 'sensory', i.e. perceptual-behavioral interpretation. On the other hand, the drug-induced change in average handwriting force, our motor (M) parameter, shows a weak but significant and not unexpected relationship to the drug-induced IPD ($r = 0.490$, $p < 0.05$).

Figure 7 illustrates the psilocybin-induced changes in the handwriting of Y.F., who is a typical American college girl: 'extravert', 'intuitor', 'feeler' and 'perceiver' on the MBTI. She displays the highest increase in S/M ratio from T_1 to T_2 of all the subjects, or in other words at drug peak her loss of ego control or departure from physical space-time to the sensory-mental dimension can justly be called a very intense hallucinatory experience. The formal structure of her control handwriting (top of Fig. 7) undergoes accordingly a childlike, 'regressed' ornamental-geometric patterning, apparently a reflection of the content of her hallucinations (see lower half of Fig. 7) while presumably the increase in size of her handwriting at T_2 mirrors the drug-induced changes in body image.

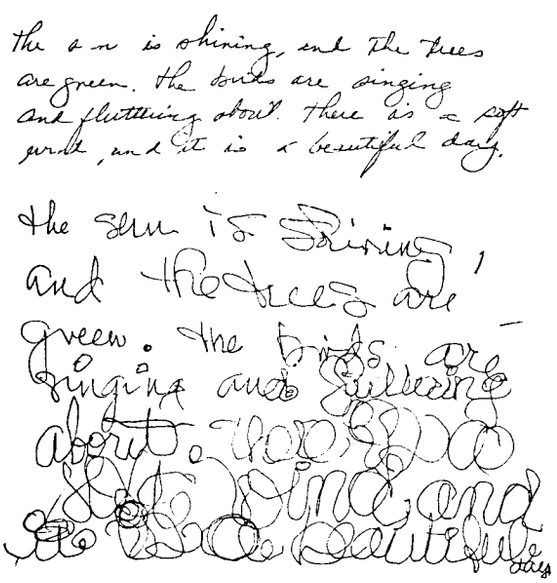


Figure 7
One of the four 28-word handwriting test sheets at T_1 of Y.F., the extravert, creative female feeler (MBTI:ENFP) (top) and at T_2 (bottom). Note the childish features of the handwriting at T_2, i.e. during a state of lost ego control. If, as we assume, the size of the handwriting mirrors the drug-induced changes in body image and the content of hallucinations is reflected in the formal structure of the handwriting, then one can look at the drug-induced handwriting as a pantomime dramatizing the content of hallucinations, a content which for our subject must have been a happy one since she was smiling a delicate, Mona Lisa smile. (Reduced to approximately half of the original size.)

Table 3 displays the phenomenon of 'dissociation' which by now has been repeatedly observed [12, 14] to exist between the extent of drug-induced autonomic activity, as expressed in terms of drug-induced IPD, and the extent and direction of perceptual and behavioral change at T_2. The subdivision of all volunteers (bottom in Table 3) into 'perceivers' ($N = 13$; middle) and 'judgers' ($N = 3$; top) – in terms of the MBTI – allows us to specify that the above mentioned 'dissociation' is carried almost entirely by the 'perceivers'. All correlations throughout the paper, if not explicitly stated otherwise, are Pearsonian product moment correlations (r). Note that the positive correlation in the 'perceivers' column is that which prevails between $\Delta(T_2-T_1)$ IPD, on the one hand, and the change in the MBTI total score (T_2-T_1) on the other – showing simply that 'perceivers' in general are significantly more sensitive to the drug-induced change than are 'judgers'. The lack of 'dissociation' between the level of autonomic activity as measured by the $\Delta(T_2-T_1)$ IPD and some other perceptual-behavioral variables is restricted to the small sample of 'judgers' (see upper third of Table 3). There is a significant negative correlation between the $\Delta(T_2-T_1)$ IPD and the change in S/M ratio both at (T_2-T_1) ($r = -0.993$, $p < 0.01$) as well as (T_3-T_1) ($r = -0.993$, $p < 0.01$), indicating that 'judgers' respond to psilocybin with a non-hallucinatory experience, i.e. with a low S/M ratio, an experience which is apparently cut short by the 'judgers' anxiety and its control. This control reveals itself through increased handwriting pressure which in turn is implicit in a low S/M ratio. 'Perceivers', however, can be called less anxious since they do not increase significantly their handwriting pressure as evidenced by a lack of correlation between both drug-induced autonomic activity, i.e. $\Delta(T_2-T_1)$ IPD, and S/M ratio at T_2 to T_1 ($r = -0.338$, N.S.) and T_3 to T_1 ($r = -0.284$, N.S.).

Table 3
'Dissociation', at the peak of a psilocybin-induced experience (T_2) between perceptual-behavioral parameters, on the one hand, and the extent of autonomic arousal as measured by pupillary diameter change in millimeter (T_2–T_1) in 16 college-age volunteers – 3 'judgers' and 13 'perceivers' – on the other hand. The 'dissociation', that is the lack of relation between the intensity of drug-induced arousal and the direction and extent of perceptual-behavioral change at T_2, is nearly complete only in the 'perceivers'. For the Pearsonian Product Moment correlations (r) the respective levels of significance are: *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

		Operating time of handwriting (T_1)	Operating time of handwriting (T_2–T_1)	S.D. of handwriting force at T_1	S/M (T_1)	S/M (T_2–T_1)	S/M (T_3–T_1)	MBTI total score (T_2–T_1)
Δ (T_2–T_1) pupillary diameter	'Judgers' n = 3	−0.931	0.720	0.818	0.688	−0.993**	−0.993**	0.248
	'Perceivers n = 13	0.157	0.003	−0.138	−0.078	−0.338	−0.284	0.641*
	All volunteers n = 16	0.150	−0.056	0.111	0.019	−0.605**	−0.437*	0.488*

The meaning of the most significant negative correlation ($r = -0.605$, $p < 0.01$) for all 16 volunteers ('judgers' and 'perceivers') between $\Delta(T_2–T_1)$ IPD and S/M ratio (T_2–T_1) is that this correlation is carried entirely by the 3 'judgers' of the total sample (compare the even higher negative correlation between the same two variables for the 3 'judgers' [$r = -0.993$, $p < 0.01$] and the lack of any relation between the same two variables for the 13 'perceivers' [$r = -0.338$, N.S.]). The converse is true for the relation between $\Delta(T_2–T_1)$ IPD and MBTI total score (T_2–T_1): the positive correlation which prevails for all volunteers ($r = 0.488$, $p < 0.05$) is carried almost entirely by the 'perceivers' ($r = 0.641$, $p < 0.05$).

Does an increase in the dose of psilocybin result in a relative increase in the S/M ratio? In two stable male volunteers, A.P., with an INFP profile, and S.S., with an ENFP profile on the MBTI, we have administered 160 µg/kg as well as 250 µg/kg psilocybin on two different occasions. The change in S/M ratio from T_1 to T_2 in A.P. was from 0.96 to 0.89 in response to the lower drug dose, whereas the S/M ratio rose from 0.57 at T_1 to 0.85 at T_2 in response to the higher drug dosage. In S.S., the respective changes were from 0.45 to 0.50 and from 0.61 to 0.81. In both subjects, the higher drug dose raised the S/M ratio at T_2 relative to its T_1 value for that particular day.

Can the intensity and the euphoric quality of a psychotomimetic drug-induced hallucinatory experience be significantly reduced by the simultaneous administration of amphetamine? Our experience is based on experimentation with only 1 subject, a stable male volunteer, an ISTJ on the MBTI at T_1, T_2 and T_3, who has been repeatedly exposed to psilocybin and D-amphetamine sulphate separately, and to whom 10 mg of each of the two compounds were then administered simultaneously. In the latter case we observed a reduction of hallucinatory intensity, a reduction which can evidently be ascribed to the amphetamine in the drug-mixture. There was no flushing of the face, although under the influence of psilocybin only this subject always responds with a distinctive flush. In this connection we should like to recall another set of data which show that in a sample of college-age volunteers (N = 13) the 10 mg amphetamine-produced increase in pupillary diameter (IPD) is only 8.4% whereas the IPD produced by 160 µg/kg psilocybin amounts to 20%. Cognitive ability appeared to be enhanced by the added amphetamine, resulting in 'an unjamming' of the psilocybin-induced 'jammed computer' state apparently by increasing the rate of data processing; this is the meaning we are inclined to assign to our observation that the time necessary to perform 'the serial seven test' was cut in half under the influence of the drug

mixture as compared to the time which is required under psilocybin. Lastly, the psilocybin-induced increase in total handwriting time, we find, can significantly be reduced by the simultaneous administration of amphetamine; so can the S.D.'s on the handwriting area, average force, total time, OT and pause time.

Is the S/M ratio in healthy, college-age volunteers affected by a single dose of chlorpromazine? Our experience is limited to two 'stable' male subjects, J.G. an ISTJ on the MBTI, and G.M., an ENFP, whose S/M ratios did not change appreciably after the administration of a 50 mg chlorpromazine dose. The chronic administration of chlorpromazine to five acutely ill mental patients (diagnosed schizophrenic) results in a range of S/M ratios which resembles that shown by our healthy volunteers under psilocybin. Specifically, the three improving patients, each having received a cumulative dose of approximately 10,000 mg of chlorpromazine, display the highest S/M ratios. These same improving patients, in spite of massive tranquilization, display small gustatory Weber ratios as well as high S/M ratios. This is in agreement with the results of our previous study [16], in which it was observed that irrespective, or more accurately, despite the damping effect of trifluoperazine, *improving* patients display small Weber ratios – indicative of increased taste acuity – which were within the range displayed by healthy volunteers under psilocybin.

Discussion

An important aspect of this study is that our subjects can be differentiated into MBTI '*judgers*' and MBTI '*perceivers*' based on their difference in handwriting pressure output at T_1 and T_2. 'Judgers' have lower S/M ratios to begin with (i.e., at T_1) and maintain that low S/M ratio at drug-peak (T_2) apparently by controlling any developing anxiety through increased handwriting pressure. 'Perceivers', on the other hand, display at T_1 higher S/M ratios than 'judgers', and, through a relatively large increase in handwriting area as compared to the increase in average force, further raise their already high S/M ratios at T_2. In other words, 'judgers' – by definition as well as in terms of their low S/M ratios at T_1 – are forceful, rational, non-hallucinating subjects who are able to maintain even under psilocybin the constancy of the S/M ratio, whereas 'perceivers', i.e. the majority of our subjects whose higher S/M ratios at T_1 label them already as 'daydreamers-hallucinators, further raise their S/M ratios during their hallucinatory experience at T_2.

A few words should be said about the phenomenon of 'dissociation' which is displayed in Table 3 and which exists between the extent of drug-induced autonomic activity – as expressed in terms of drug-induced IPD – and the extent and direction of perceptual and behavioral change at T_2. As stated earlier, this 'dissociation' is carried almost entirely by the 'perceivers' but not by the 'judgers'. These results can be regarded as a replication of our previous studies in which an analogous dichotomy could be observed between 'reactors' and 'non-reactors'. 'Non-reactors' were subjects with Minnesota Multiphasic Personality Inventory (MMPI) difference scores less than 625 and T_2 MMPI profiles similar to their pre- and post-drug profiles, whereas 'reactors' displayed difference scores greater than 625 and T_2 profiles clearly characteristic of an acute psychotic state [15]. Evidently our 'perceivers' behave like the 'reactors' in the previous study [15] and our 'judgers' behave as do the self-controlled, stable 'non-reactors'.

Based not only on the data published in this paper but also on newly accumulating experimental material, it appears that there are two different mechanisms by which at T_2 the relative constancy of the S/M ratio is maintained or even an 'over-compensated' decrease may take place: either by a proportionate increase on both handwriting area and force (T_2–T_1) or by compensation for the area increase with an even larger increase in average force.

The conclusions we have put forward are based on pilot data obtained in self-selected, college-age volunteers. Moreover, 15 of our 16 volunteers – 5 second-year medical students and 11 college graduates – are intuitors and 13 of them introverts in terms of the MBTI. All of them, except for one (J.G. ♂), are taste-sensitive subjects – taste-sensitivity having been shown to be associated with behavioral sensitivity in terms of 'intuition' as measured by the MBTI [11, 12] – who gladly volunteer for an introversive and intuitive-type drug experience. Taste-sensitive subjects are distinctively different in various respects from taste-insensitive subjects we have found earlier. They display shorter reaction times [17] and are also drug-sensitive, i.e. they need a smaller cumulative dose of tranquilizers, for instance, than do insensitive tasters in order to sooner develop extrapyramidal symptoms [18].

These observations have been recently confirmed by JOYCE et al. [19] who have found in 38 healthy medical students that the injection of the same dose of hyoscine butylbromide resulted in a significantly greater increase in heart rate in the taste-sensitive group as compared to that group with higher taste thresholds. If perceptual, behavioral and pharmacologic (autonomic) sensitivity, are intercorrelated, our subject sample is a slanted one because it consists mainly of taste-sensitive intuitive, and thus drug-sensitive, subjects. It is possible that only in such a group is one able to differentiate, as we have done, between two types of subjects at T_2: the 'judgers' with their lower S/M ratio and the 'perceivers' with a higher one. It is likely, of course, that by applying higher dosages of the drug, ultimately 'judgers' would respond with a further increase of their S/M ratios and thus with a more intense hallucinatory experience. However, neither we nor our 'judger' volunteers were willing to experiment with psilocybin doses higher than 250 μg/kg.

What is the drug-induced context within which the changes in the S/M ratio occur? We conceive of *perceptions* as being on one end of a continuum while *hallucinations* are on the other [1]. At moderate or normal levels of arousal connected with daily routine, motor activity is inextricably enmeshed with the perceptual state: properties of visual situations may be such as to induce or change motor activity while motor activity itself also determines what is visually present or what may become visually effective [20]. In fact, 'perceptual constancy' [21] evolves through visually produced motor change with information derived from visual parallax cues upon head and neck movements [22–24]. A gradual *separation* of voluntary motor activity from perception occurs, however, with increasing central sympathetic arousal, irrespective whether that arousal results in a drug-induced hallucinatory waking state or in dreaming every 90 minutes while asleep, i.e. during the REM state. Thus, we can define dreams and hallucinations as intense sensations with simultaneously blocked ability and intention to verify those sensations in physical space-time through voluntary motor performance. It is the gradual separation and then blocking of voluntary motor performance from perception which is accompanied by an increase in the S/M ratio reaching its maximum at the peak of a most intense hallucinatory or dream experience.

As we depart from physical space-time, for instance while falling asleep or while moving into the psychotomimetic drug-induced experience, we gradually ascend on the perception-hallucination continuum. Simultaneously, we experience a breakdown of the learned perceptual size constancies; a loss of ego boundaries; a decrease in sensory input or information; and an increase in output or matching response manifested in an increased S/M ratio and experienced as intensified meaning. At the same time, a transition occurs from Aristotelian binary, survival logic to a symbolic, multi-valued logic with a concurrent inability to distinguish between symbols and 'real' things, while the breakdown of perceptual size constancies results in a geometric-ornamental manneristic style, an elaboration of Klüver's hallucinatory form constants [14].

There is another common feature between the REM state and the drug-induced hallucinatory state: both remind us of an alternating figure-ground relationship in which one plays an actor's role and at the same time is a captive audience of his own drama.

Finally, we propose that both ends of the perception-hallucination continuum can be labelled 'normal' and 'pathological'. Paranoid patients may give a pathological interpretation to their percepts whereas creative people may have unusual, innovative and still 'normal' hallucinations. The ultimate criterion whether a perception or hallucination should be labelled as normal or pathological is public verifiability and/or usefulness to society or the species at large. It is our contention that original and truly creative scientific, artistic and religious concepts originate in hallucinatory experiences. The common misconception which labels all hallucinatory experiences as pathological is rooted in the fact that psychiatrists are almost exclusively confronted by hallucinated mental patients and not by the Einsteins or Picassos.

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References

[1] R. Fischer, *The Perception-Hallucination Continuum, A Re-examination*, Dis. Nerv. System, *30*, 161–171 (1969).

[2] J. Delay and P. Pichot, *Abrégé de Psychologie*, 2nd ed. (Masson & Cie, Paris 1964).

[3] R. Fischer, *Out on a (Phantom) Limb, Variations on the Theme: Stability of Body Image and the Golden Section*, Perspect. Biol. Med. *12*, 259–273 (1969).

[4] R. Fischer, S. M. England, R. C. Archer and R. K. Dean, *Psilocybin Reactivity and Time Contraction as Measured by Psychomotor Performance*, Arzneimitt.-Forsch. *16*, 180–185 (1966).

[5] R. Fischer, *Selbstbeobachtungen im Meskalinrausch*, Schweiz. Z. Psychol. *5*, 308–313 (1946).

[6] F. Barron, *The Relationship of Ego Diffusion to Creative Perception*, in *Widening Horizons in Creativity* (Ed. C. W. Taylor and F. Barron; John Wiley & Sons, New York 1968).

[7] G. Grünewald, *Zur Physiologie der Schreibhandlung. Iserlohner Schreibkreis*, Rundbrief No. *21*, 1–8 (1959).

[8] H. J. Haase, *Das therapeutische Achsensyndrom neuroleptischer Medikamente und seine Beziehungen zu extrapyramidaler Symptomatik*, Fortschr. Neurol. Psychiat. *29*, 245–268 (1961).

[9] R. Fischer, *Time Contraction and Psychomotor Performance Produced by 'Psilocybin'*, Nature *209*, 433–434 (1966).

[10] R. Fischer, *Psychotomimetic Drug-Induced Changes in Space and Time*, Paper presented at 4th International Congress of Pharmacology, 14–18 July 1969, Basle, Switzerland.

[11] R. Corlis, G. Splaver, P. Wisecup and R. Fischer, *Myers-Briggs Type Personality Scales and Their Relation to Taste Acuity*, Nature *216*, 91–92 (1967).

[12] R. Fischer, P. H. Marks, R. M. Hill and M. A. Rockey, *Personality Structure as the Main Determinant of Drug Induced (Model) Psychoses*, Nature *218*, 296–298 (1968).

[13] G. Grünewald and H. Mücher, *Über den Einfluss zentraler Funktionsaktivierung auf die Schreibmotorik*, Psychopharmacologia *5*, 372–389 (1964).

[14] R. Fischer, *On Creative, Psychotic and Ecstatic States*, in: Proceedings of the 5th International Colloquium of the Society f. Psychopathology of Expression; April 1968, Los Angeles (Ed. I. Jakab; Karger, Basel 1969).

[15] R. Fischer and D. Warshay, *Psilocybin-Induced Autonomic, Perceptual and Behavioral Change*, Pharmakopsychiatrie-Neuro-Psychopharmakologie (Thieme, Stuttgart) *1* (4), 291–302 (1968).

[16] R. Fischer, L. P. Ristine and P. Wisecup, *Increase in Gustatory Acuity and Hyperarousal in Schizophrenia*, Biol. Psychiat., in press (1969).

[17] R. Fischer, F. Griffin and M. A. Rockey, *Gustatory Chemoreception in Man: Multi-Disciplinary Aspects and Perspectives*, Persp. Biol. Med. *9*, 549–577 (1966).

[18] R. Fischer, W. Knopp and F. Griffin, *Taste Sensitivity and the Appearance of Phenothiazine Tranquilizer Induced Extrapyramidal Symptoms*, Arzneimitt.-Forsch. *15*, 1379–1382 (1965).

[19] C. R. B. Joyce, L. Pan and D. D. Varanos, *Taste Sensitivity May be Used to Predict Pharmacological Effects*, Life Sci. *7*, 533–537 (1968).

[20] H. Klüver, *Certain Effects of Lesions of the Occipital Lobes in Macaques*, J. Psychol. *4*, 383–401 (1937).

[21] Y. Akishige, *Experimental Researches on the Structure of the Perceptual Space*, Bull. Fac. Lit. Kyushu University *9* (1965).

[22] J. Bossom and R. Held, *Transfer of Error-Correction in Adaptation to Prisms*, Am. Psychol. *14*, 436 (Abstract) (1959).

[23] R. Held, A. Efstathiou and M. Greene, *Adaptation to Displaced and Delayed Visual Feedback from the Hand*, J. Exp. Psychol. *72*, 887–891 (1966).

[24] J. Bossom and A. K. Ommaya, *Visuo-Motor Adaptation (to Prismatic Transformation of the Retinal Image) in Monkeys with Bilateral Dorsal Rhizotomy*, Brain *91*, 161–172 (1968).