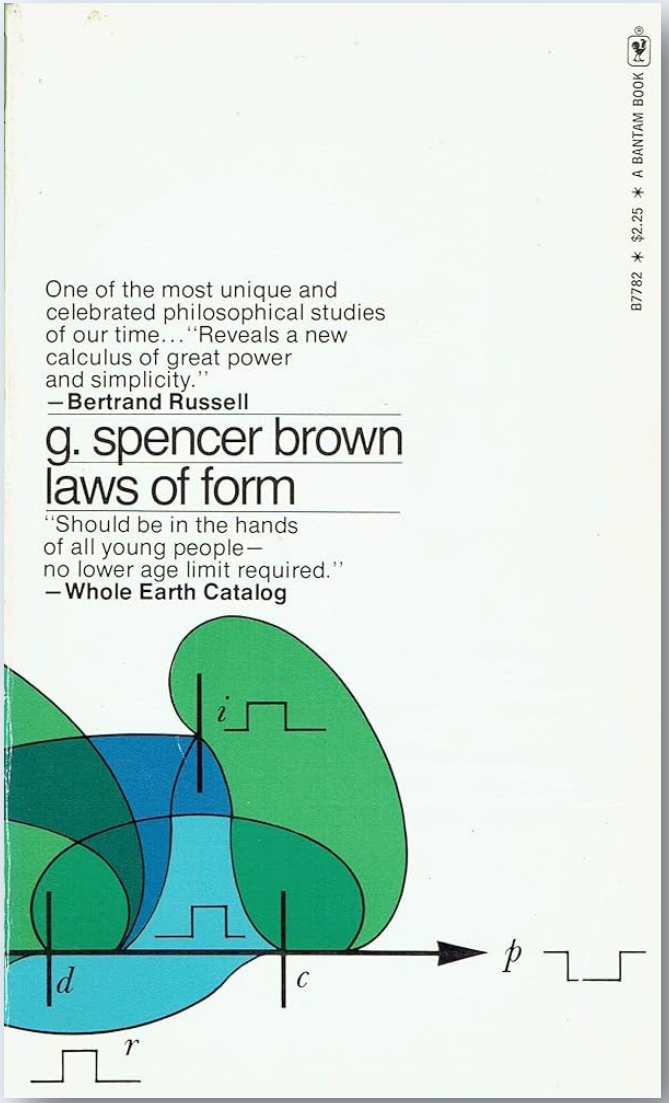
CYBERNETIC COUNTERCULTURES INTENSIVE

Week 5. Epistemological Constructivism: Heinz von Foerster

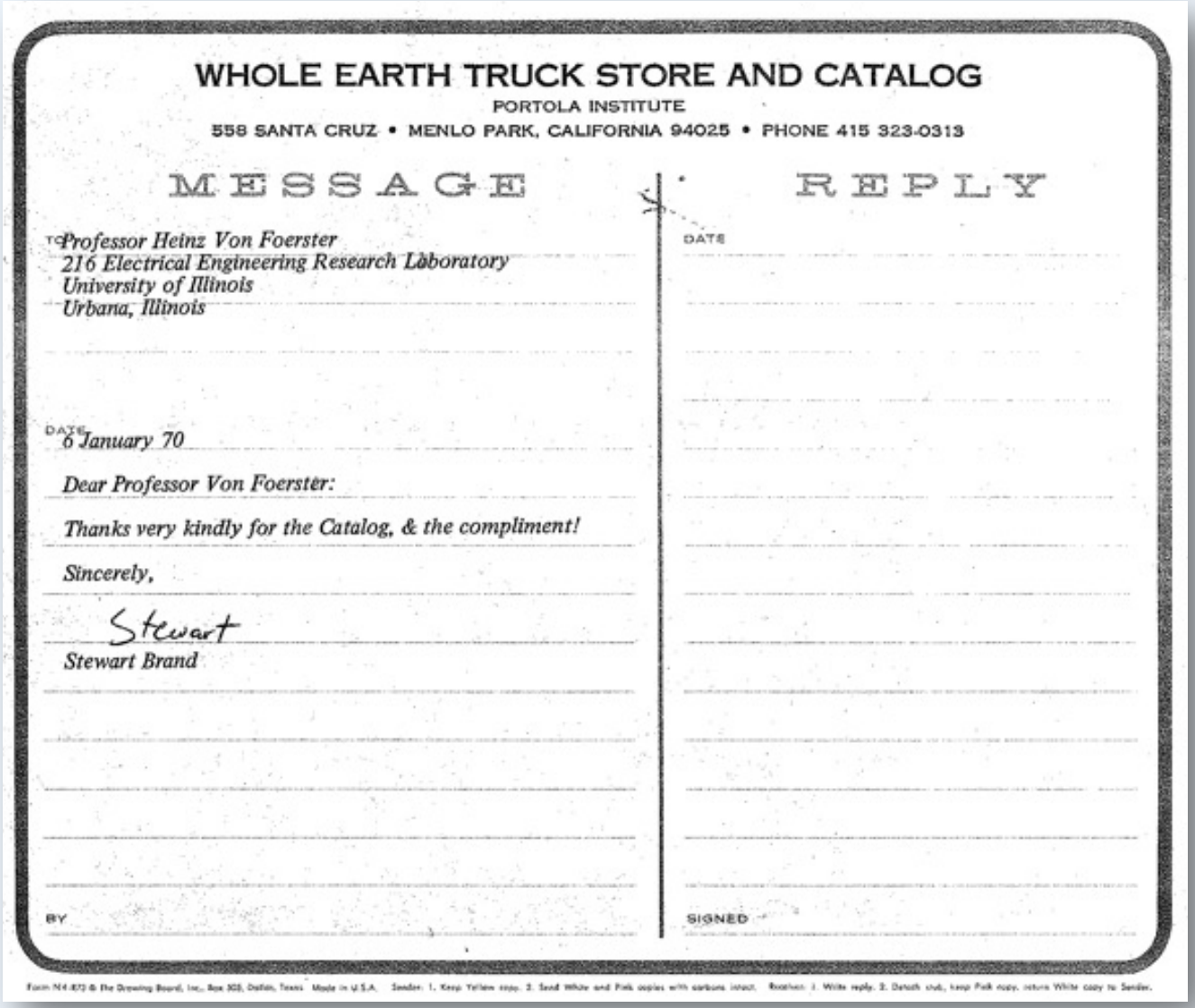
Bruno Clarke
brunoclarke@gmail.com

From *Laws of Form* to "On Constructing a Reality"



Chasing *Laws of Form*

Von Foerster initiates a connection with the *Whole Earth* network when he sends Stewart Brand a complimentary copy of the *Whole University Catalog* and receives this note of appreciation.



WHOLE EARTH TRUCK STORE AND CATALOG

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MESSAGE

REPLY

TO *Professor Heinz Von Foerster*
216 Electrical Engineering Research Laboratory
University of Illinois
Urbana, Illinois

DATE *6 January 70*

Dear Professor Von Foerster:

Thanks very kindly for the Catalog, & the compliment!

Sincerely,

Stewart

Stewart Brand

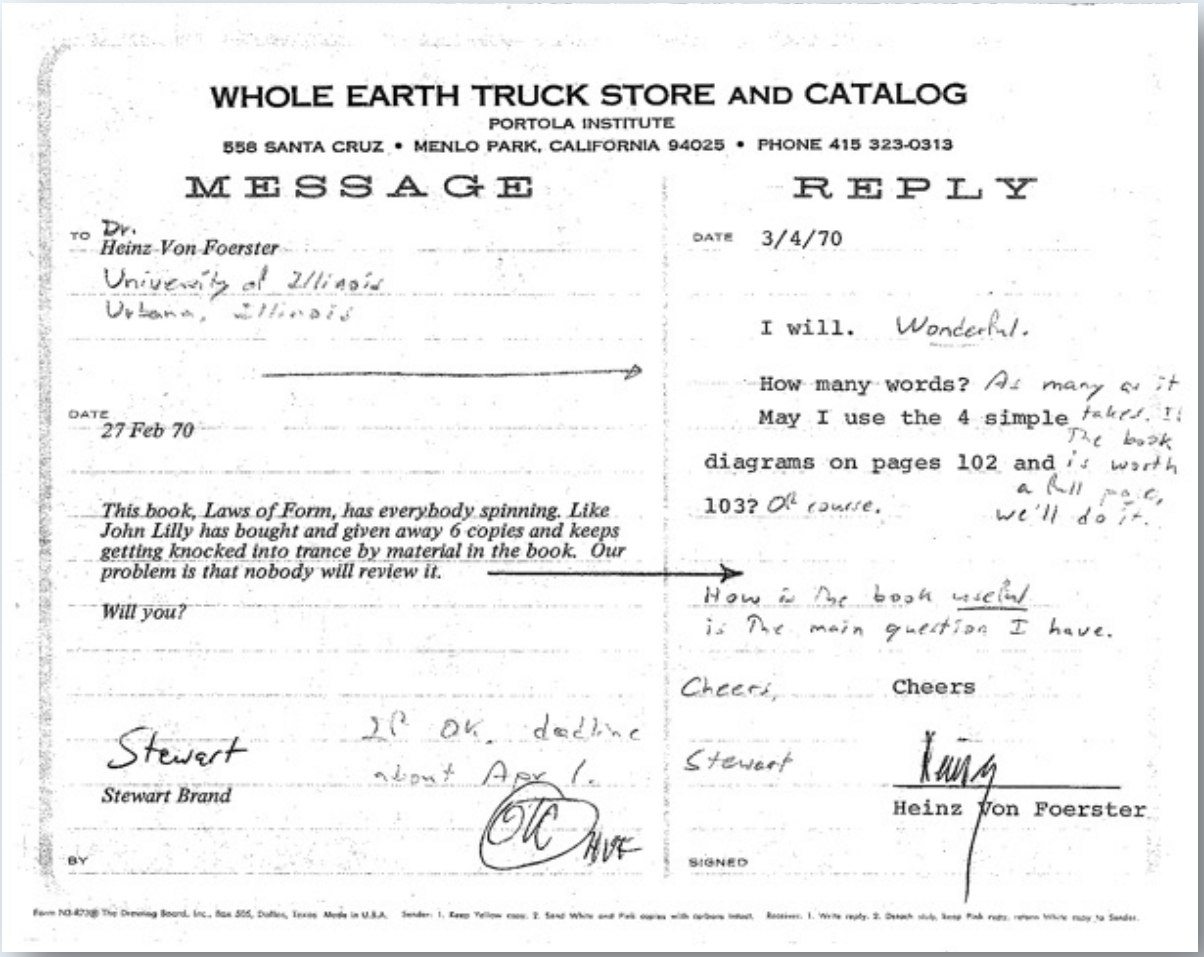
BY

DATE

SIGNED

Form N14-870 © The Drawing Board, Inc., Box 303, Dallas, Texas Made in U.S.A. Sender: 1. Keep Yellow copy. 2. Send White and Pink copies with carbons intact. Receiver: 1. Write reply. 2. Detach stub, keep Pink copy, return White copy to Sender.

Shortly thereafter, Brand has a hunch that this amiable BCL cyberneticist may have the intellectual moxie needed to penetrate a recently published work on the logic of distinctions that "has everybody spinning."



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MESSAGE

TO Dr. Heinz Von Foerster
University of Illinois
Urbana, Illinois

DATE 27 Feb 70

This book, Laws of Form, has everybody spinning. Like John Lilly has bought and given away 6 copies and keeps getting knocked into trance by material in the book. Our problem is that nobody will review it.

Will you?

Stewart

Stewart Brand

BY

REPLY

DATE 3/4/70

I will. Wonderful.

How many words? As many as it takes. If the book is worth a full page, we'll do it.
May I use the 4 simple diagrams on pages 102 and 103? Of course.

How is the book useful is the main question I have.

Cheers, Stewart

Cheers

Heinz Von Foerster

SIGNED

OK. deadline about Apr 1.

OK HVF

SB] This book, Laws of Form, has everybody spinning. Like John Lilly has bought and given away 6 copies and keeps getting knocked into trance by material in the book. Our problem is that no one will review it. Will you?

HvF] I will.
How many words?

May I use the 4 simple diagrams on pages 102 and 103?

SB] Wonderful.
As many as it takes. If the book is worth a full page, we'll do it.
Of course.
How is the book <u>useful</u> is the main question I have.

—A typical (also crucial) page of *Laws of Form*

Let us imagine, if we can, that the order to begin the step-sequence is never countermanded, so that the process continues timelessly. In space this will give us an echelon without limit, of the form

$$\overline{\overline{\overline{\overline{\ldots a\,|\,b\,|\,a\,|\,b\,|}}}}\ .$$

Now, since this form, being endless, cannot be reached in a finite number of steps from $\overline{a\,|\,b\,|}$, we do not expect it to express, necessarily, the same value as $\overline{a\,|\,b\,|}$. But we can, by means of an exhaustive examination of possibilities, ascertain what values it might take in the various cases of a, b, and compare them with those of the finite expression.

Re-entry

The key is to see that the crossed part of the expression at every even depth is identical with the whole expression, which can thus be regarded as re-entering its own inner space at any even depth. Thus

$$f = \overline{\overline{\overline{\overline{\ldots a\,|\,b\,|\,a\,|\,b\,|}}}}$$

E1 $$= \overline{fa\,|\,b\,|}\ .$$

We can now find, by the rule of dominance, the values which f may take in each possible case of a, b.

$$\overline{fa\,|\,b\,|} = f \qquad \text{E1}$$

$$\overline{fm\,|\,m\,|} = n$$

$$\overline{fm\,|\,n\,|} = m$$

$$\overline{fn\,|\,m\,|} = n$$

$$\overline{fn\,|\,n\,|} = m \text{ or } n.$$

For the last case suppose $f = m$. Then

$$\overline{\overline{mn\,|\,n\,|} = m}$$

and so E1 is satisfied. Now suppose $f = n$. Then

$$\overline{\overline{nn\,|\,n\,|} = n}$$

and so E1 is again satisfied. Thus the equation, in this case, has two solutions.

It is evident, then, that, by an unlimited number of steps from a given expression e, we can reach an expression e' which is not equivalent to e.

We see, in such a case, that the theorems of representation no longer hold, since the arithmetical value of e' is not, in every possible case of a, b, uniquely determined.

Indeterminacy

We have thus introduced into e' a degree of indeterminacy in respect of its value which is not (as it was in the case of indeterminacy introduced merely by cause of using independent variables) necessarily resolved by fixing the value of each independent variable. But this does not preclude our equating such an expression with another, provided that the degree of indeterminacy shown by each expression is the same.

Degree

We may take the evident degree of this indeterminacy to classify the equation in which such expressions are equated. Equations of expressions with no re-entry, and thus with no unresolvable indeterminacy, will be called equations of the first degree, those of expressions with one re-entry will be called of the second degree, and so on.

It is evident that J1 and J2 hold for all equations, whatever their degree. It is thus possible to use the ordinary procedure

DEPARTMENT OF ELECTRICAL ENGINEERING | UNIVERSITY OF ILLINOIS, URBANA, ILLINOIS 61801

216 Electrical Engineering
Research Laboratory

March 11, 1970

Mr. Stewart Brand
Whole Earth Truck Store and Catalog
Portola Institute
558 Santa Cruz
Menlo Park, California 94025

Dear Stewart,

Forgive me for sending you my review "Laws of Form" without waiting for your answers to my questions. Inspection of my calendar showed that this past weekend was the last before May in which I could afford enjoying such extra-curricular activities. I trust completely your editorial skills to chop my story to whatever size you see fit.

Thank you for giving me the opportunity to become acquainted with this superb piece. I relished every moment!

Can I order through you ten (10) more copies? (If not, where can I?).

Most cordially yours,

Heinz Von Foerster

HVF/br
Encl.

One week later, Heinz has dashed off a lengthy *Laws of Form* review, to the delight of Brand's assistant who "has had to answer number of enquiries about the book" and is "not really up to it."

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MESSAGE REPLY

TO Heinz Von Foerster
216 Electical Engineering
Research Laboratory
University of Illinois
Urbana, Illinois 61801

DATE March 17,1970

Dear Mr. Von Foerster,

Thankyou so much for the review we very much appreciate your taking the time to present us with such ~~a~~ thorough and readable description of LAWS OF FORM. I've had to answer a number of inquiries about the book and must admit that I'm not really up to it. Publication of your review will answer peoples' questions before they reach my desk. So I send you my personal THANKYOU. Also in the form of "thankyous"is the enclosed $10.00 check. Your 10 copies of LAWS OF FORM are on their way to you.
Sincerely,
Laura Besserman

BY Laura Besserman

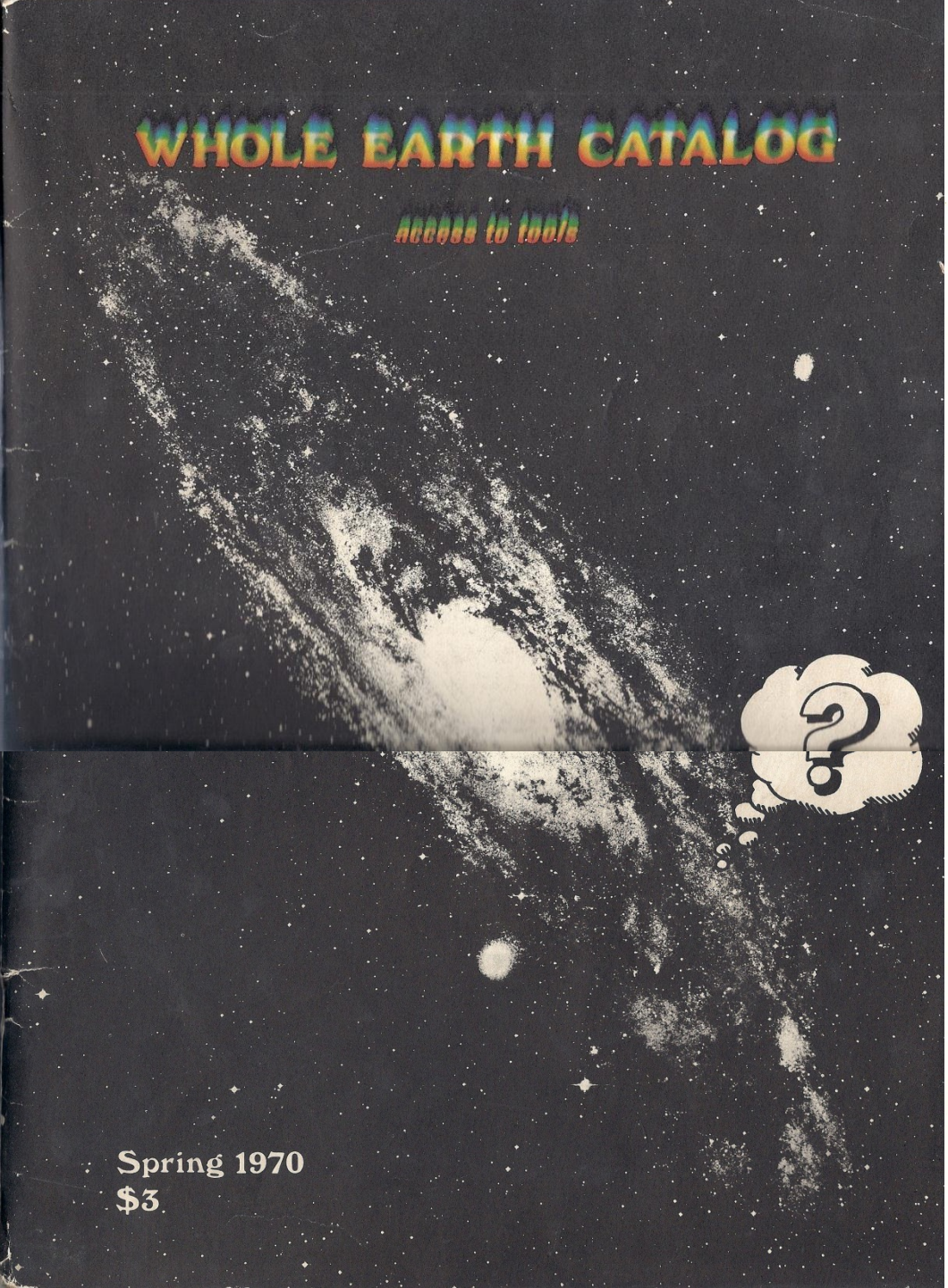
DATE

Super review.
Deepest Thanks.
—Stewart

SIGNED

WHOLE EARTH CATALOG

Access to tools



Spring 1970
$3

Laws of Form

The laws of form have finally been written! With a "Spencer Brown" transistorized power razor (a Twentieth Century model of Occam's razor). G. Spencer Brown cuts smoothly through two millennia of growth of the most prolific and persistent of semantic weeds, presenting us with his superbly written **Laws of Form.** *This Herculean task which now, in retrospect, is of profound simplicity rests on his discovery of the form of laws. Laws are not descriptions, they are commands, injunctions: "Do!" Thus, the first constructive proposition in this book (page 3) is the injunction: "Draw a distinction!" an exhortation to perform the primordial creative act.*

After this, practically everything else follows smoothly: a rigorous foundation of arithmetic, of algebra, of logic, of a calculus of indications, intentions and desires; a rigorous development of laws of form, may they be of logical relations, of descriptions of the universe by physicists and cosmologists, or of functions of the nervous system which generates descriptions of the universe of which it is itself a part.

*The ancient and primary mystery which still puzzled Ludwig Wittgenstein (***Tractatus Logico-Philosophicus***, A. J. Ayer (ed), Humanities Press, New York, 1961, 166 pp.), namely that the world we know is constructed in such a way as to be able to see itself, G. Spencer Brown resolves by a most surprising turn of perception. He shows, once and for all, that the appearance of this mystery is unavoidable. But what is unavoidable is, in one sense, no mystery. The fate of all descriptions is ". . . what is revealed will be concealed, but what is concealed will again be revealed."*

At this point, even the most faithful reader may turn suspicious: how can the conception of such a simple injunction as "Draw a distinction!" produce this wealth of insights? It is indeed amazing––but, in fact, it does.

The clue to all this is Spencer Brown's ingenious choice for the notation of an operator ⌐ *which does several things at one time. This mark is a token for drawing a distinction, say, by drawing a circle on a sheet of paper which creates a distinction between points inside and outside of this circle; by its asymmetry (the concave side being its inside) it provides the possibility of indication; finally, it stands for an instruction to cross the boundary of the first distinction by crossing from the state indicated on the inside of the token to the state indicated by the token (A space with no token indicates the unmarked state). Moreover, these operations may operate on each other, generating a primary arithmetic, an opportunity which is denied us by a faulty notation in conventional arithmetic as pointed out by Karl Menger in "Gulliver in the Land without One, Two, Three" (***The Mathematical Gazette, 53,** *24-250; 1959).*

These operations are defined in the two axioms (no other ones are needed) given on pages 1 and 2. They are:

Axiom 1. The law of calling

The value of a call made again is the value of the call.

That is to say, if a name is called and then is called again, the value indicated by the two calls taken together is the value indicated by one of them.

That is to say, for any name, to recall is to call.

(In notation: ⌐⌐ = ⌐ the "form of condensation".)

Axiom 2. The law of crossing

The value of a crossing made again is not the value of the crossing.

That is to say, if it is intended to cross a boundary and then it is intended to cross it again, the value indicated by the two intentions taken together is the value indicated by none of them.

That is to say, for any boundary, to recross is not to cross.

(In notation: ⌐| = the "form of cancellation".)

For instance, take a complex expression

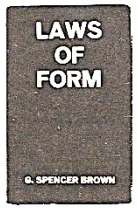
E = ⌐⌐|⌐|

Then, by the two axioms

Sometimes the reading gets rough because of Spencer Brown's remarkable gift for parsimony of expression. But the 30 pages of "Notes" following the 12 Chapters of presentation come to the reader's rescue precisely at that moment when he lost his orientation in the lattice of a complex crystal. Consequently, it is advisable to read them almost in parallel with the text, if one can suppress the urge to keep on reading Notes.

In an introductory note Spencer Brown justifies the mathematical approach he has taken in this book: "Unlike more superficial forms of expertise, mathematics is a way of saying less and less about more and more." If this strategy is pushed to its limit, we shall be able to say nothing about all. This is, of course, the state of ultimate wisdom and provides a nucleus for a calculus of love, where distinctions are suspended and all is one. Spencer Brown has made a major step in this direction, and his book should be in the hands of all young people––no lower age limit required.

[Reviewed by Heinz Von Foerster.
Suggested by Steve Baer]



Laws of Form
G. Spencer Brown
1969; 141 pp.
$5.40 postpaid
from:
Blackwell's
Broad Street
Oxford, ENGLAND

or WHOLE EARTH CATALOG

無名天地之始

CONSTRUCTION
Draw a distinction.

CONTENT
Call it the first distinction.
Call the space in which it is drawn the space severed or cloven by the distinction.
Call the parts of the space shaped by the severance or cleft the sides of the distinction or, alternatively, the spaces, states, or contents distinguished by the distinction.

INTENT
Let any mark, token, or sign be taken in any way with or with regard to the distinction as a signal.
Call the use of any signal its intent.

•

In all mathematics it becomes apparent, at some stage, that we have for some time been following a rule without being consciously aware of the fact. This might be described as the use of a *covert* convention. A recognizable aspect of the advancement of mathematics consists in the advancement of the consciousness of what we are doing, whereby the covert becomes overt. Mathematics is in this respect psychedelic.

•

One of the most beautiful facts emerging from mathematical studies is this very potent relationship between the mathematical process and ordinary language. There seems to be no mathematical idea of any importance or profundity that is not mirrored, with an almost uncanny accuracy, in the common use of words, and this appears especially true when we consider words in their original, and sometimes long forgotten, senses.

•

The main difficulty in translating from the written to the verbal form comes from the fact that in mathematical writing we are free to mark the two dimensions of the plane, whereas in speech we can mark only the one dimension of time.

Much that is unnecessary and obstructive in mathematics today appears to be vestigial of this limitation of the spoken word.

•

Any evenly subverted equation of the second degree might be called, alternatively, evenly informed. We can see it over a subversion (turning under) of the surface upon which it is written, or alternatively, as an in-formation (formation within) of what it expresses.

Such an expression is thus informed in the sense of having its own form within it, and at the same time informed in the sense of remembering what has happened to it in the past.

We need not suppose that this is exactly how memory happens in an animal, but there are certainly memories, so-called, constructed this way in electronic computers, and engineers have constructed such in-formed memories with magnetic relays for the greater part of the present century.

We may perhaps look upon such memory, in this simplified information, as a precursor of the more complicated and varied forms of memory and information in man and the higher animals. We can also regard other manifestations of the classical forms of physical or biological science in the same spirit.

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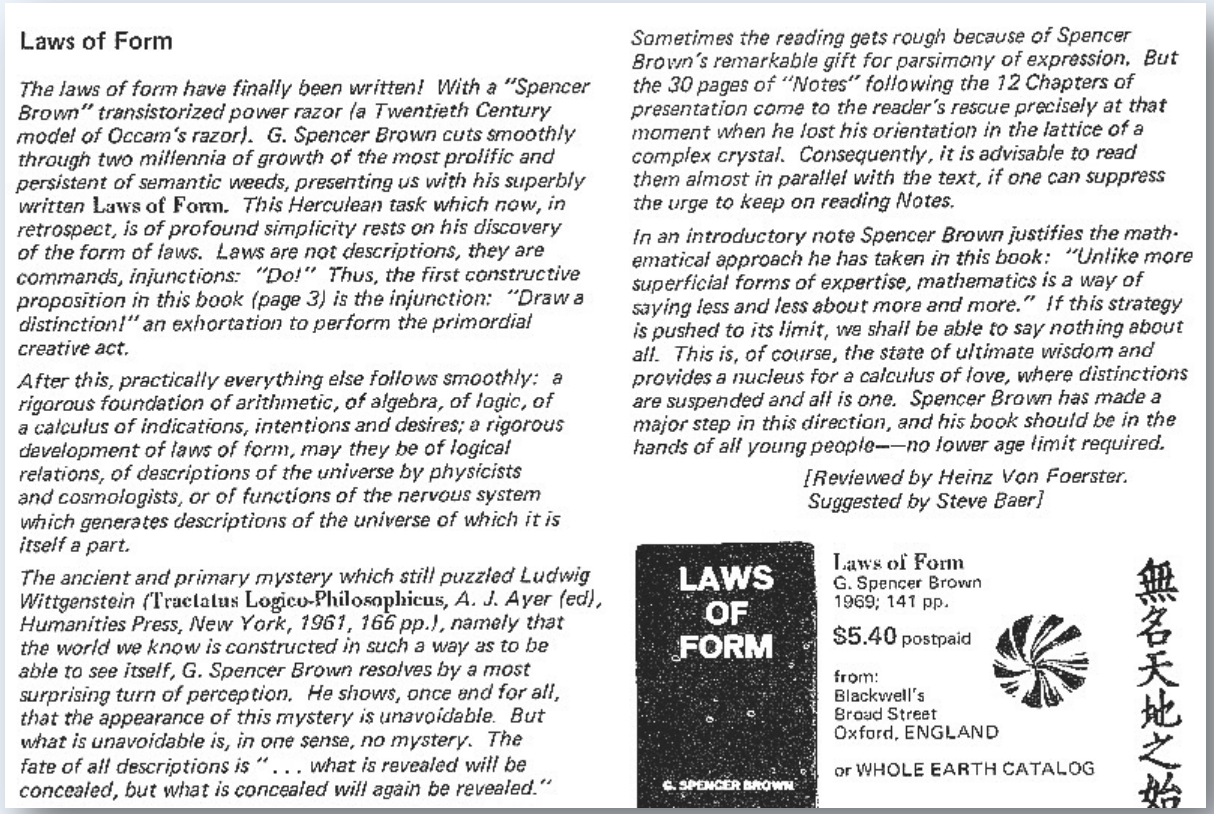

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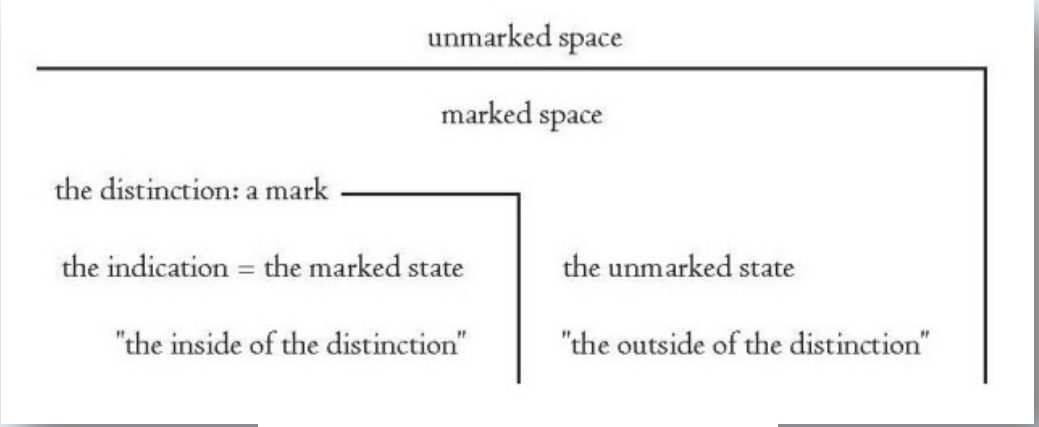
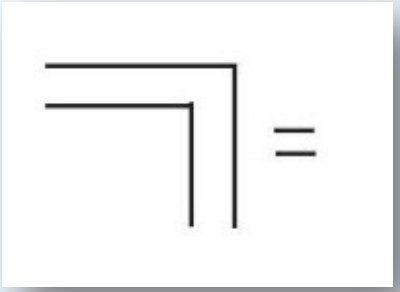
—*Laws of Form* dovetails with neocybernetics as both a theory and a technique of *observation.*

"Spencer Brown's ingenious choice for the notation of an operator ⌐ does several things at one time. This mark is a token for drawing a distinction, say, by drawing a circle on a sheet of paper which creates a distinction between points inside and outside of this circle; by its asymmetry (the concave side being its inside) it provides the possibility of indication; finally, it stands for an instruction to cross the boundary of the first distinction by crossing from the state indicated on the inside of the token to the state indicated by the token (a space with no token indicates the unmarked state). Moreover, these operations may operate on each other . . . ."

The Form



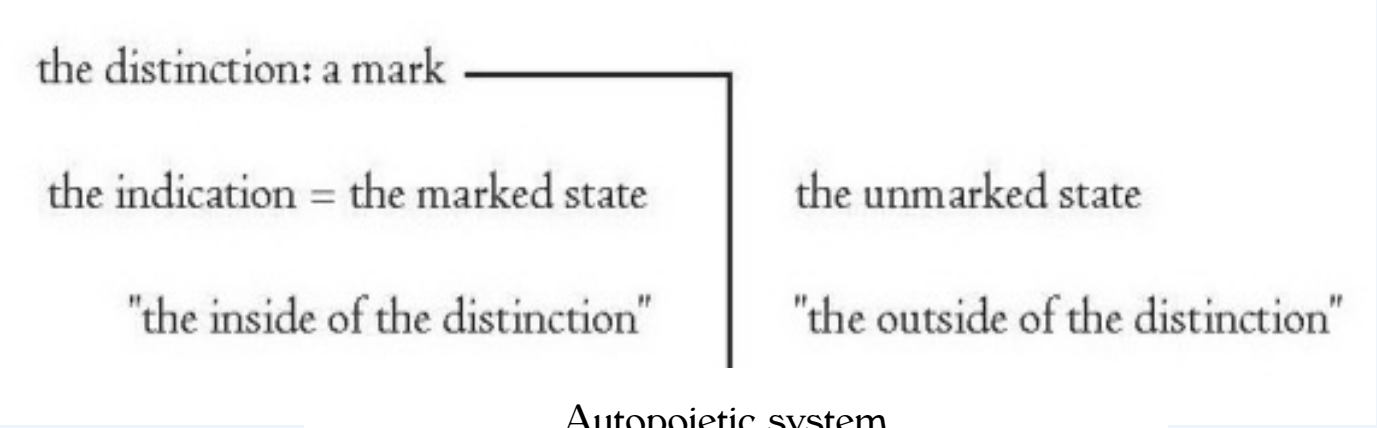
"the unity of the distinction"



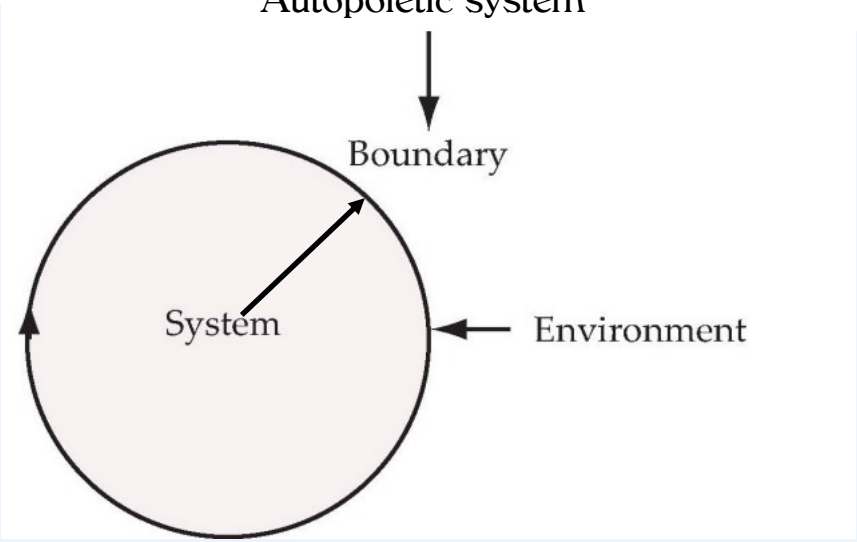
Spencer-Brown's *form of cancellation*, the "law of crossing": "For any boundary, to recross is not to cross."

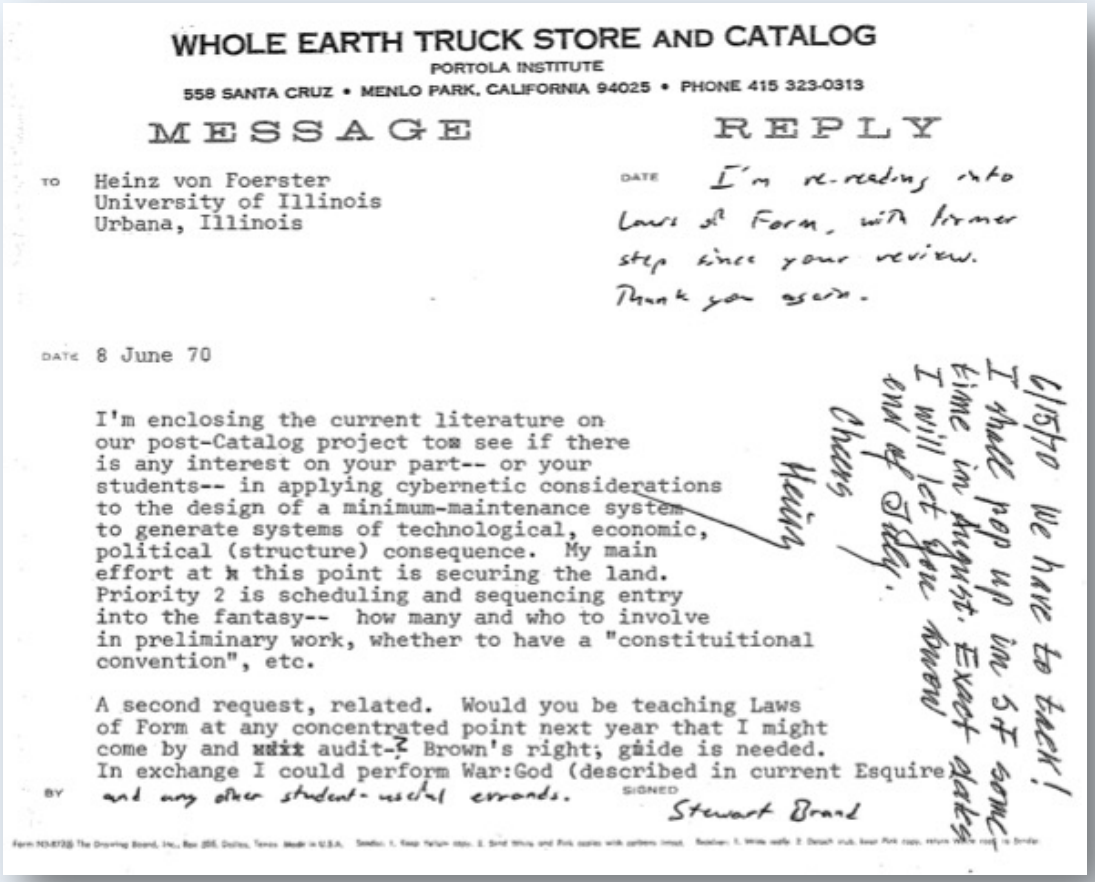
Laws of Form as applied to autopoietic systems theory:

The Form



Autopoietic system





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MESSAGE

TO Heinz von Foerster
University of Illinois
Urbana, Illinois

DATE 8 June 70

I'm enclosing the current literature on our post-Catalog project to see if there is any interest on your part-- or your students-- in applying cybernetic considerations to the design of a minimum-maintenance system to generate systems of technological, economic, political (structure) consequence. My main effort at this point is securing the land. Priority 2 is scheduling and sequencing entry into the fantasy-- how many and who to involve in preliminary work, whether to have a "constituitional convention", etc.

A second request, related. Would you be teaching Laws of Form at any concentrated point next year that I might come by and audit? Brown's right; guide is needed. In exchange I could perform War:God (described in current Esquire) and any other student-useful errands.

BY SIGNED Stewart Brand

REPLY

DATE I'm re-reading into Laws of Form, with firmer step since your review. Thank you again.

6/15/70 We have to talk! I shall pop up in S.F. some time in August. Exact dates I will let you know end of July. Cheers, Heinz

"I'm re-reading into Laws of Form, with firmer step since your review. Thank you again." [SB]

"6/15/70 We have to talk! I shall pop up in S.F. some time in August. Exact dates I will let you know end of July. Cheers, Heinz"

"Would you be teaching Laws of Form at any concentrated point next year that I might come by and audit? Brown's right, guide is needed. . . ." [SB]

It seems that Brand was seriously contemplating a "post-Catalog project," moving upcountry himself to run existential experiments of some sort for "systems of technological, economic, political (structure) consequence. My main effort at this point is securing the land." What happens in any event is a period during which Brand and von Foerster team up to dig further into *Laws of Form*. A year later they team up for an Esalen seminar on that topic.

PROGRAMS WITH THE ESALEN STAFF

Some of the four-week, two-week, one-week and five-day programs listed below will be led by members of the Esalen Staff. Esalen/San Francisco staff will also be drawn upon.

Big Sur Staff includes: Diana Bechetti, Michael Butler, Deborah Carson, Roberta DeLong, Al Drucker, Betty Fuller, Ann Heider, Peggy Kriegel, Janet Lederman, Milton Lees, Dub Leigh, Theodora Lyon, Hector Prestera, Richard Price, Carole Rosenblatt, Gabrielle Roth, William Schutz, Julian Silverman, Simone Surpin, Gerald Thatcher and Sharon Wheeler.

Jean Butler, Seymour Carter, Jack Downing, John Heider, John Lilly and Steven Stroud will be on study leave until January, 1972.

John Argue will be in residence during Fall, 1971.

PROGRAMS

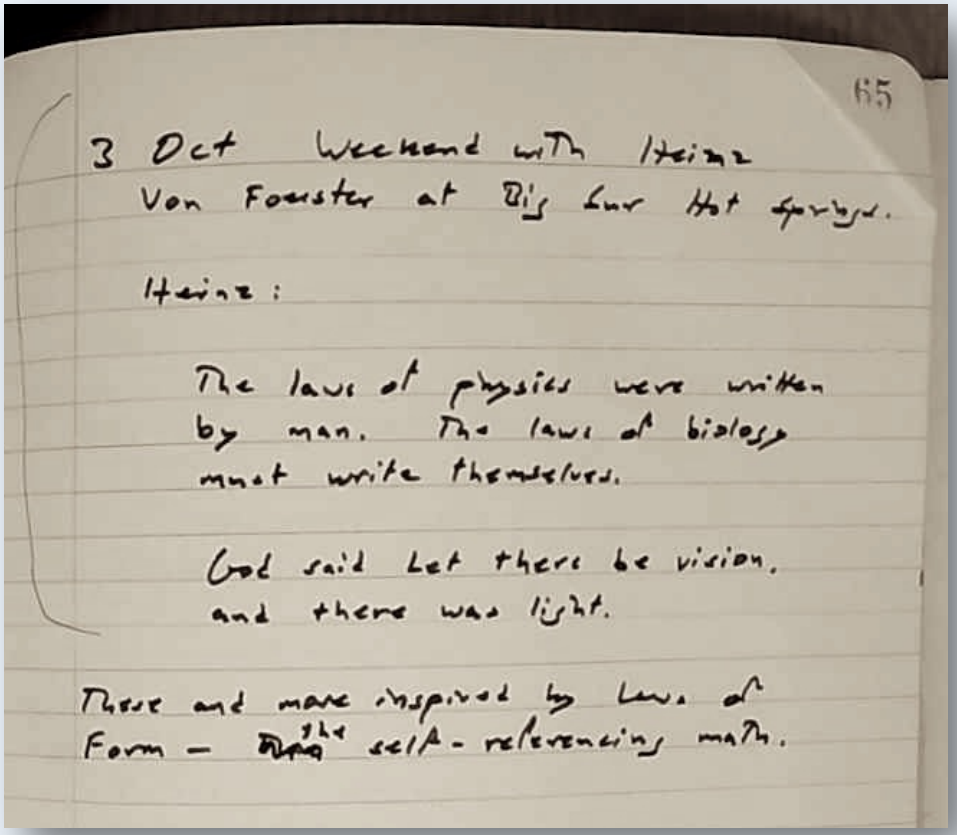
October 1-3 Weekend Seminar
THE LAWS OF FORM Stewart Brand and Heinz Von Foerster

"Draw a distinction. Call it the first distinction." Thus opens the first canon of a revolutionary book which charts routes to resolving understandings of the Tao, mathematics, consciousness and time. The book is *Laws of Form* by G. Spencer Brown. The purpose of the weekend is to penetrate the book and to mine it for practical use. $85.00 per person.

For Leaders' Biographies, See Pages 20 & 21

1971

Stewart Brand's journal, recording two more of Heinz's "substantious nutshells":



—Stewart Brand papers, Stanford University library

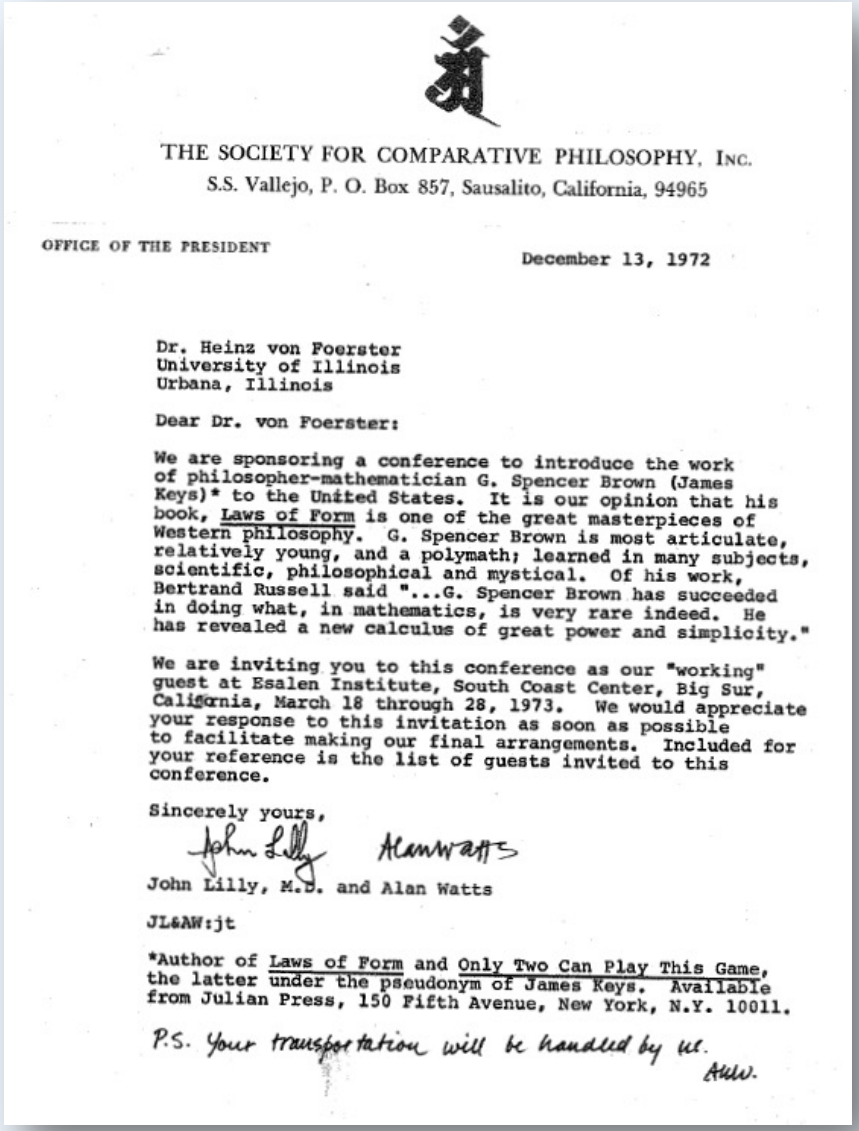
3 Oct [1971] Weekend with Heinz Von Foerster at Big Sur Hot Springs.

Heinz:

> The laws of physics were written by man. The laws of biology must write themselves.
>
> God said let there be vision, and there was light.

These and more inspired by Laws of Form—the self-referencing math.

A year later, planning is under way for a meeting on *Laws of Form* with Spencer-Brown, organized by John Lilly and Alan Watts. An A-list of the Cybernetic Countercultures is invited for a week-long program:



THE SOCIETY FOR COMPARATIVE PHILOSOPHY, INC.
S.S. Vallejo, P. O. Box 857, Sausalito, California, 94965

OFFICE OF THE PRESIDENT

December 13, 1972

Dr. Heinz von Foerster
University of Illinois
Urbana, Illinois

Dear Dr. von Foerster:

We are sponsoring a conference to introduce the work of philosopher-mathematician G. Spencer Brown (James Keys)* to the United States. It is our opinion that his book, Laws of Form is one of the great masterpieces of Western philosophy. G. Spencer Brown is most articulate, relatively young, and a polymath; learned in many subjects, scientific, philosophical and mystical. Of his work, Bertrand Russell said "...G. Spencer Brown has succeeded in doing what, in mathematics, is very rare indeed. He has revealed a new calculus of great power and simplicity."

We are inviting you to this conference as our "working" guest at Esalen Institute, South Coast Center, Big Sur, California, March 18 through 28, 1973. We would appreciate your response to this invitation as soon as possible to facilitate making our final arrangements. Included for your reference is the list of guests invited to this conference.

Sincerely yours,

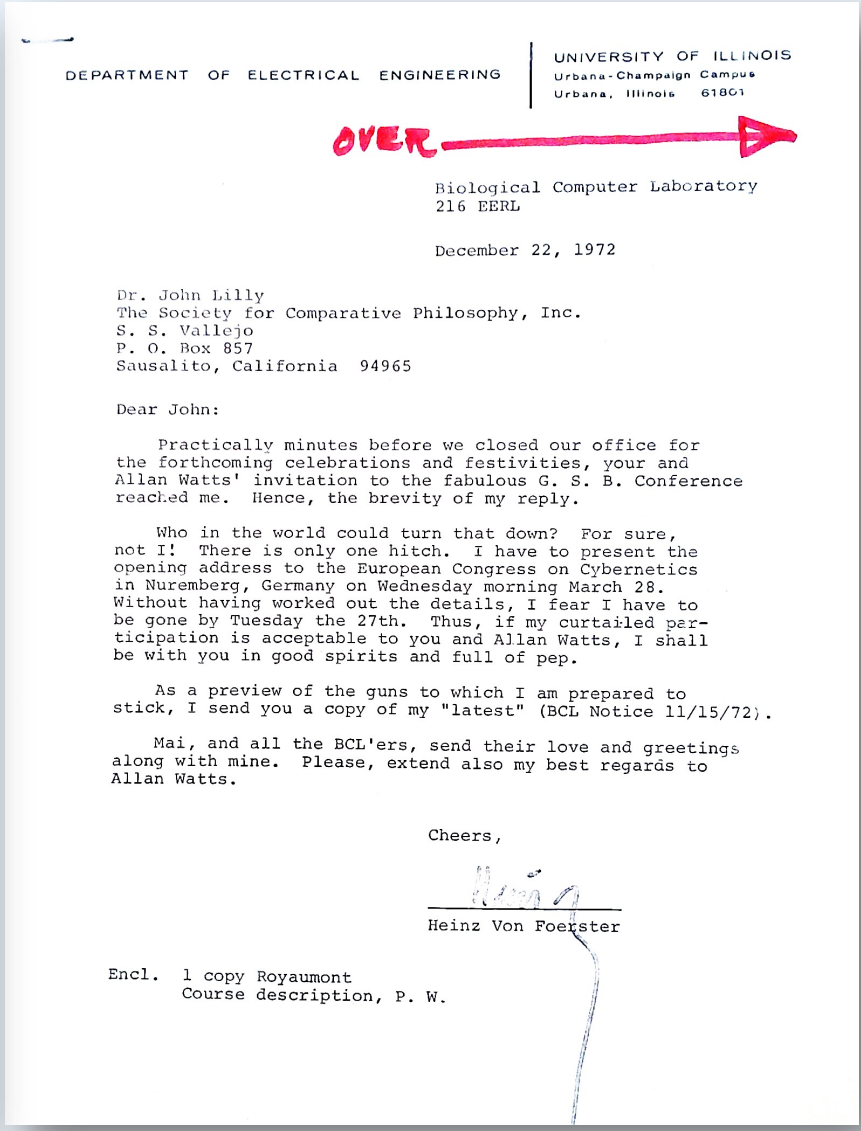
John Lilly Alan Watts

John Lilly, M.D. and Alan Watts

JL&AW:jt

*Author of Laws of Form and Only Two Can Play This Game, the latter under the pseudonym of James Keys. Available from Julian Press, 150 Fifth Avenue, New York, N.Y. 10011.

P.S. Your transportation will be handled by us.
AWW.



DEPARTMENT OF ELECTRICAL ENGINEERING

UNIVERSITY OF ILLINOIS
Urbana-Champaign Campus
Urbana, Illinois 61801

OVER

Biological Computer Laboratory
216 EERL

December 22, 1972

Dr. John Lilly
The Society for Comparative Philosophy, Inc.
S. S. Vallejo
P. O. Box 857
Sausalito, California 94965

Dear John:

Practically minutes before we closed our office for the forthcoming celebrations and festivities, your and Allan Watts' invitation to the fabulous G. S. B. Conference reached me. Hence, the brevity of my reply.

Who in the world could turn that down? For sure, not I! There is only one hitch. I have to present the opening address to the European Congress on Cybernetics in Nuremberg, Germany on Wednesday morning March 28. Without having worked out the details, I fear I have to be gone by Tuesday the 27th. Thus, if my curtailed participation is acceptable to you and Allan Watts, I shall be with you in good spirits and full of pep.

As a preview of the guns to which I am prepared to stick, I send you a copy of my "latest" (BCL Notice 11/15/72).

Mai, and all the BCL'ers, send their love and greetings along with mine. Please, extend also my best regards to Allan Watts.

Cheers,

Heinz Von Foerster

Encl. 1 copy Royaumont
Course description, P. W.

THE G. SPENCER BROWN-AUM CONFERENCE

ESALEN INSTITUTE, SOUTH COAST CENTER, BIG SUR

MARCH 18 - 25, 1973

List of Conferees

1 G. Spencer Brown
17 Halifax Road
Cambridge, England

2 Bruce Badenoch
Star Mountain School
Mountain Center, California 92361

3 Gregory Bateson
University of California
Santa Cruz, California 95060

4 Stewart Brand
283 Rose Street
San Francisco, California 94102

5 John Brockman
241 Central Park West
New York, New York 10024

6 Baba Ram Dass
1939 Virginia
Berkeley, California 94703

7 George Gallagher
505 N. Jackson Street
Glendale, California 91206

8 Theodore Guinn, Dept. of Mathematics
University of New Mexico
Albuquerque, New Mexico 87106

9 Joseph Hart
1472 Filbert, #603
San Francisco, California 94109

10 Douglas Kelley
National Safety Council
425 N. Michigan Avenue
Chicago, Illinois 60611

11 Luanne P. King, Director
Educational Development Center
Claremont Colleges, 9th & Amherst
Claremont, California 91711

12 John Lilly
8910 Beverlywood Street
Los Angeles, California 90034

13 Antoinette Oshman
8910 Beverlywood Street
Los Angeles, California 90034

14 Brendan O'Regan
Stanford Research Institute
Menlo Park, California 94025

15 Karl Pribram, Dept. of Psychology
Stanford University
Stanford, California 94305

16 Richard Price
Esalen Institute
Big Sur, California 93920

17 Robert Shapiro
612 N. Michigan Avenue, Suite 507
Chicago, Illinois 60611

18 Charles Tart, Dept. of Psychology
University of California
Davis, California 95616

19 Jean Taupin
382 E. Las Milpas
Green Valley, Arizona 85614

20 Celia Thompson
382 E. Las Milpas
Green Valley, Arizona 85614

21 Heinz Von Foerster, Dept. of Electri-
University of Illinois cal
Urbana, Illinois 61801 / Engineering

22 Kurt Von Mier
Box 124
Oakville, California

Walter (cross singles) cont.

Guest list with von Foerster's notes

. . . Then, a premonition that there may be trouble with the guest of honor:

THE SOCIETY FOR COMPARATIVE PHILOSOPHY, INC.

S.S. Vallejo, P. O. Box 857, Sausalito, California, 94965

OF THE PRESIDENT

March 9, 1973

Re: G. SPENCER BROWN-AUM CONFERENCE, March 18 - 25, 1973

Dear Conferee:

We regret that G. Spencer Brown, may not, because of business and personal commitments, be able to attend this conference. If Mr. Brown does attend it will be for only a few days. Despite this change, the conference will proceed as planned, with the exception that it will only last through Sunday the 25th of March rather than the 28th of March. Drs. Lilly and Von Foerster will teach the "Laws of Form" in Mr. Brown's absence.

I have enclosed the list of conferees as well as general information and the itinerary applying to this conference. As you are our guest, we will be covering your expense of room and board (on double occupancy basis) for the duration of the conference. If there are any changes in your plans, please notify me by Friday, March 16th. We look forward to seeing you at ESALEN.

Most sincerely,

Joan Tabernik

Joan Tabernik, Conference Coordinator
(for Alan Watts & John Lilly)

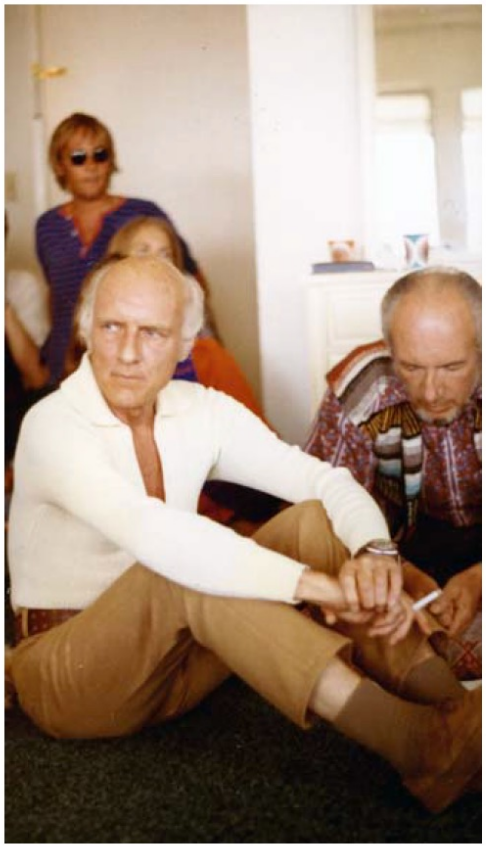
P.S. We will reimburse you for your plane fare on coach class basis. J.T.

As it turned out, Spencer-Brown appeared, led the workshop for a day and a half, and then disappeared. Taped and transcribed, those sessions provide one of the most accessible and authoritative deep dives into *Laws of Form*. I have put a print-out in the Knowledge Base under its given title "Gurus in the Mud," in honor of the Big Sur hot springs.

So, as anticipated, once Spencer-Brown absconded, Heinz had to fill the breach. This proved to be an occasion for him to consolidate a presentation of the second-order cybernetics that would inform his most famous paper, "On Constructing a Reality."

Computing a Reality

Heinz von Foerster's Lecture at the A.U.M Conference in 1973
Edited by Albert Müller



Heinz von Foerster at the A.U.M. conference.

Computing a reality

Heinz von Foerster: I will do a brief spiel at the moment, because the mailman is here at 12:30 and I would not like you to miss the opportunity to buy some cigarettes, matches, newspapers, etc. etc.

Voice from the audience:[1] Speak as long as you like.

HVF: I speak as long as *you* like. [Audience laughing]

I would like to give a brief spiel on this proposition "computing a reality." Each word is carefully chosen.

The whole works and caboodle "computing a reality" I would put into a bag which I call cognition. You may say my view of cognition is a different one. Absolutely perfectly alright. In my humble ignorance I will use at the moment the term cognition for representing something which is computing a reality. Now I am not speaking here to physicists and to chemists and to people from the natural sciences, therefore I have not yet gotten a revolution whereby everybody would jump up from his chair and would say: What do you mean by *a* reality, you mean *the* reality.

The whole problem of cognition is now re represented here as recursive computations. Recursive computations.

Voice from the audience: Of what?

HVF: Of the previous computation, of course. You've come out with what. You've come out with a computation, compute on that computation, of that you had computed, and then you come back to the computation.

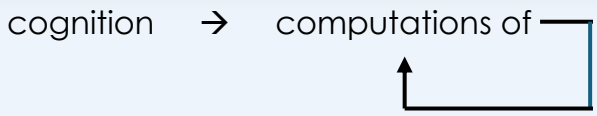
Voice from the audience: So that is …

Heinz von Foerster.

HVF: Of what, of course, of what, of what. Would be a problem of everything, anything. What is the main goal of these computations? The essential features of this computation?

This gives us a clue of what these computations are all about. And this is what I would call the Principle of epistemic homeostasis. *Ladies and gentlemen, the principle epistemic homeostasis.* (Audience laughs) So it's good to have all these names, it's good to remember them

… What does it say? The principle of epistemic homeostasis says that the computations are devised in such a fashion, or organized in such a fashion, or now to be very tricky, organizing themselves into such a fashion that the reality that is computed is stable. The system operates in such a way or operates in such a way, or generates its own organization in such a way that it computes a stable reality.



". . . the **Principle of epistemic homeostasis** says that the computations are devised in such a fashion, or organized in such a fashion, or now to be very tricky, organizing themselves into such a fashion that the reality that is computed is stable. The system operates in such a way or operates in such a way, or generates its own organization in such a way that it computes a stable reality."

—Here is von Foerster's version of Maturana and Varela's initial insight about the nervous system being "capable of generating its own conditions of reference," what Varela would go on to call the "operational closure of the nervous system."

“On Constructing a Reality”

On Constructing a Reality

Heinz von Foerster

(1973)

This is an abbreviated version of a lecture given at the opening of the fourth International Conference on Environmental Design Research on April 15, 1973, at the Virginia Polytechnic Institute in Blacksburg, Virginia.

Abstract: "Draw a distinction!"[1]

The Postulate

I am sure you remember the plain citizen Jourdain in Moliere's *Bourgeois Gentilhomme* who, *nouveau riche*, travels in the sophisticated circles of the French aristocracy, and who is eager to learn. On one occasion with his new friends they speak about poetry and prose, and Jourdain discovers to his amazement and great delight that whenever he speaks, he speaks prose. He is overwhelmed by this discovery: "I am speaking Prose! I have always spoken Prose! I have spoken Prose throughout my whole life!"

A similar discovery has been made not so long ago, but it was neither of poetry nor prose — it was the environment that was discovered. I remember when, perhaps ten or fifteen years ago, some of my American friends came running to me with the delight and amazement of having just made a great discovery: "I am living in an Environment! I have always lived in an Environment! I have lived in an Environment throughout my whole life!"

However, neither M. Jourdain nor my friends have as yet made another discovery, and that is when M. Jourdain speaks, may it be prose or poetry, it is he who invents it, and likewise when we perceive our environment, it is we who invent it.

Every discovery has a painful and a joyful side: painful, while struggling with a new insight; joyful, when this insight is gained. I see the sole purpose of my presentation to minimize the pain and maximize the joy for those who have not yet made this discovery; and for those who have made it, to let them know they are not alone.

Again, the discovery we all have to make for ourselves is the following postulate: *the environment as we perceive it is our invention*.

The burden is now upon me to support this outrageous claim. I shall proceed by first inviting you to participate in an experiment; then I shall report a clinical case and the results of two other experiments. After this I will give an interpretation, and thereafter a highly compressed version of the neurophysiological basis of these experiments and my postulate of before. Finally, I shall attempt to suggest the significance of all that to aesthetical and ethical considerations.

I. *Blindspot.* Hold [Figure 1] with your right hand, close your left eye and fixate asterisk of Fig. 1 with your right eye. Move the book slowly back and forth along line of vision until at an appropriate distance, from about 12 to 14 inches, the round black spot disappears. Keeping the asterisk well focused, the spot should remain invisible even if the figure is slowly moved parallel to itself in any direction.

This localized blindness is a direct consequence of the absence of photo receptors (rods or cones) at that point of the retina, the "disc", where all fibers, leading from the eye's light sensitive surface, converge to form the optic nerve. Clearly, when the black spot is projected onto the disc, it cannot be seen. Note that this localized blindness is not perceived as a dark blotch in our visual field (seeing a dark blotch would imply "seeing"), but this blindness is not perceived at all, that, is, neither as something present, nor as something absent: whatever is perceived is perceived "blotch-less".

Figure 1

BC] The argument rests entirely on the qualification *as we perceive it*, which places cognitive function before cognitive experience.

(Print out this page to follow the instructions.)

"Note that this localized blindness is not perceived as a dark blotch ... but ... is not perceived at all."

Two more "substantious nutshells" from von Foerster's neocybernetic platter:

1. "Perceiving is Doing." In other words, perception is not a passive registration but an active and embodied realization.

2. "If I don't see I am blind, I am blind; but if I see I am blind, I see." In other words, perception depends on proprioception as well as sensation. Or, there's more to seeing than meets the eye.

As with the Blind Spot, "Note again the absence of perception of 'absence of perception.'"

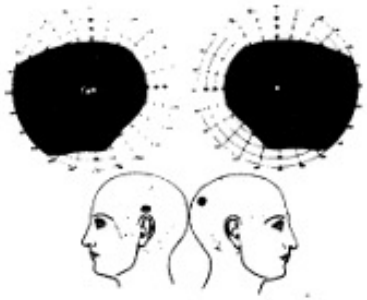


Figure 2

II. *Scotoma.* Well localized occipital lesions in the brain, e.g., injuries from high velocity projectiles, heal relatively fast without the patient's awareness of any perceptible loss in his vision. However, after several weeks motor dysfunction in the patient becomes apparent, e.g., loss of control of arm or leg movements of one side or the other, etc. Clinical tests, however, show that there is nothing wrong with the motor system, but that in some cases there is substantial loss of a large portion of the visual field (*scotoma*) (Fig. 2)[2]. A successful therapy consists of blindfolding the patient over a period of one to two months until he regains control over his motor system by shifting his "attention" from "non-existent" visual clues regarding his posture to "fully operative" channels that give direct postural clues from "Proprioceptive" sensors embedded in muscles and joints. Note again the absence of perception of "absence of perception", and also the emergence of perception through sensor-motor interaction. This prompts two metaphors: "Perceiving is Doing"; and, "If I don't see I am blind, I am blind; but if I see I am blind, I see".

III. *Alternates.* A single word is spoken once into a tape recorder and the tape smoothly spliced, without a click, into a loop. The word is repetitively played back with a high rather than low volume. After one or two minutes of listening, from 50 to 150 repetitions, the word clearly perceived so far abruptly changes into another meaningful and clearly perceived word: an "alternate". After 10 to 30 repetitions of this first alternate, a sudden switch to a second alternate is perceived, and so on[3].

The following is a small selection of the 758 alternates reported from a population of about 200 subjects who were exposed to a repetitive playback of the single word Cogitate: *agitate; annotate; arbitrate; artistry; back and forth; brevity; ca d'etait; candidate; can't you see; can't you stay; cape cod you say; card estate; cardio tape; car district; catch a tape; cavitate; cha cha che; cogitate; computate; conjugate; conscious state; counter tape; count to ten; count to three; count yer tape; cut the steak; entity; fantasy; God to take; God you say; got a date; got your pay; got your tape; gratitude; gravity; guard the tit; gurgitate; had to take; kinds of tape; majesty; marmalade.*

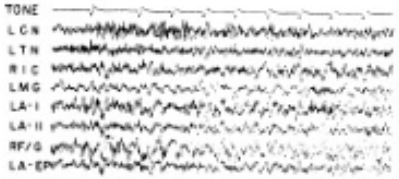


Figure 3: Trial 1 (no behavioral evidence of learning)

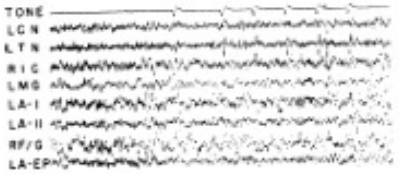


Figure 4: Trial 13 (begins to wait for tones)

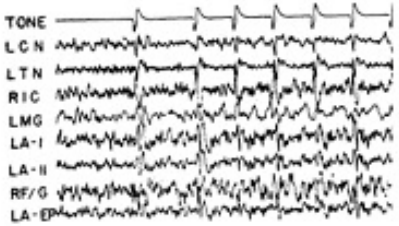


Figure 5: Trial 4/20 (hypothesizes)

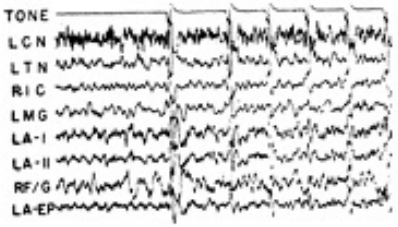


Figure 6: Trial 6/9 (understands)

IV. *Comprehension.* Literally defined: *con* ⇒ together; *prehendere* ⇒ to seize, grasp. Into the various stations of the auditory pathways in a cat's brain, microelectrodes are implanted which allow a recording, "Electroencephalogram", from the nerve cells first to receive

auditory stimuli, Cochlea Nucleus: CN, up to the Auditory Cortex[4]. The so prepared cat is admitted into a cage that contains a food box whose lid can be opened by pressing a lever. However, the lever-lid connection is operative only when a short single tone (here C6, that is about 1000 Hz) is repetitively presented[5]. The cat has to learn that C6 "means" food. Figures 3 to 6 show the pattern of nervous activity at eight ascending auditory stations, and at four consecutive stages of this learning process[6] The cat's behavior associated with the recorded neural activity is for Fig. 3: "Random search"; Fig. 4: "Inspection of lever"; Fig. 5: "Lever pressed at once"; and for Fig. 6: "Walking straight toward lever (full comprehension)". Note that no tone is perceived as long as this tone is uninterpretable (Figs. 3, 4; pure noise), but the whole system swings into action with the appearance of the first "beep" (Figs. 5, 6; noise becomes signal) when sensation becomes comprehensible, when our perception of ''beep", "beep", "beep", is in the cat's perception "food", "food", "food".

Learning. The arrival of *comprehension* transforms perceptions from meaningless noises to meaningful signals.

Interpretation

In these experiments I have cited instances in which we see or hear what is not "there", or in which we do not see or hear what is "there", unless coordination of sensation and movement allows us to "grasp" what appears to be there. Let me strengthen this observation by citing now the, "Principle of Undifferentiated Encoding":

> The response of a nerve cell does not encode the physical nature of the agents that caused its response. Encoded is only "how much" at this point on my body, but not "what".

The Principle of Undifferentiated Encoding. "The response of a nerve cell does not encode the physical nature of the agents that caused its response. Encoded is only 'how much' at this point on my body, but not 'what.'"

Take, for instance, a light sensitive receptor cell in the retina, a "rod", which absorbs the electro-magnetic radiation originating from a distant source. This absorption causes a change in the electrochemical potential in the rod which will ultimately give rise to a periodic electric discharge of some cells higher up in the post-retinal networks with a period that is commensurate with the intensity of the radiation absorbed, but without a clue that it was electro-magnetic radiation that caused the rod to discharge. The same is true for any other sensory receptor, may it be the taste buds, the touch receptors, and all the other receptors that are associated with the sensations of smell, heat and cold, sound, etc.: they are all "blind" as to the quality of their stimulation, responsive only as to their quantity.

Although surprising, this should not come as a surprise, for indeed "out there" there is no light and no color, there are only electro-magnetic waves; "out there" there is no sound and no music, there are only periodic variations of the air pressure; "out there" there is no heat and no cold, there are only moving molecules with more or less mean kinetic energy, and so on. Finally, for sure, "out there" there is no pain.

Since the physical nature of the stimulus — its *quality* — is not encoded into nervous activity, the fundamental question arises as to how does our brain conjure up the tremendous variety of this colorful world as we experience it any moment while awake, and sometimes in dreams while asleep. This is the "Problem of Cognition", the search for an understanding of the cognitive processes.

The way in which a question is asked determines the way in which an answer may be found. Thus, it is upon me to paraphrase the "Problem of Cognition" in such a way that the conceptual tools that are today at our disposal may become fully effective. To this end let me paraphrase (→) "cognition" in the following way:

COGNITION → computing a reality

With this I anticipate a storm of objections. First, I appear to replace one unknown term, "cognition" with three other terms, two of which, "computing" and "reality", are even more opaque than the definiendum, and with the only definite word used here being the indefinite article "a". Moreover, the use of the indefinite article implies the ridiculous notion of other realities besides "the" only and one reality, our cherished Environment; and finally I seem to suggest by "computing" that everything, from my wristwatch to the Galaxies, is merely computed, and is not "there". Outrageous!

Let me take up these objections one by one. First, let me remove the semantic sting that the term "computing" may cause in a group of women and men who are more inclined toward the humanities than to the sciences. Harmlessly enough, computing (from *com-putare*) literally means to reflect, to contemplate (*putare*) things in concert (*com-*), without any explicit reference to numerical quantities. Indeed, I shall use this term in this most general sense to indicate any operation, not necessarily numerical, that transforms, modifies, re-arranges, or orders observed physical entities, "objects", or their representations, "symbols". For instance, the simple permutation of the three letters A, B, C, in which the last letter now goes first: C, A, B, I shall call a computation. Similarly, the operation that obliterates the commas between the letters: CAB; and likewise the semantic transformation that changes CAB into TAXI, and so on.

I shall now turn to the defense of my use of the indefinite article in the noun-phrase "a reality". I could, of course, shield myself behind the logical argument that solving for the general case, implied by the "a", I would also have solved any specific case denoted by the use of

Or again, "The environment contains no information. The environment is as it is."

Von Foerster expands the semantics of *computation* beyond technical application to "any operation . . . that transforms, modifies, re-arranges, or orders . . . 'objects,' or . . . 'symbols.'"

"the". However, my motivation lies much deeper. In fact, there is a deep hiatus that separates the "The"-school-of-thought from the "A"-school-of-thought in which respectively the distinct concepts of "confirmation" and "correlation" are taken as explanatory paradigms for perceptions. The "The-School": My sensation of touch is *confirmation* for my visual sensation that here is a table. The "A-School": My sensation of touch in *correlation* with my visual sensation generate an experience which I may describe by "here is a table".

I am rejecting the THE-position on epistemological grounds, for in this way the whole Problem of Cognition is safely put away in one's own cognitive blind spot: even its absence can no longer be seen.

Finally one may rightly argue that cognitive processes do not compute wristwatches or galaxies, but compute at best *descriptions* of such entities. Thus I am yielding to this objection and replace my former paraphrase by:

COGNITION → computing descriptions of a reality

Neurophysiologists, however, will tell us that a description computed on one level of neural activi ty, say a projected image on the retina, will be operated on again on higher levels, and so on, whereby some motor activity may be taken by an observer as a "terminal description", for instance the utterance: "here is a table"[7]. Consequently, I have to modify this paraphrase again to read:

COGNITION → computing descriptions of ↺

where the arrow turning back suggests this infinite recursion of descriptions of descriptions … etc. This formulation has the advantage that one unknown, namely, "reality" is successfully eliminated. Reality appears only implicit as the operation of recursive descriptions. Moreover, we may take advantage of the notion that computing descriptions is nothing else but computations. Hence:

COGNITION → computations of ↺

In summary, I propose to interpret cognitive processes as never ending recursive processes of computation, and I hope that in the following *tour de force* of neurophysiology I can make this interpretation transparent.

Neurophysiology

I. *Evolution*. In order that the principle of recursive computation is fully appreciated as being the underlying principle of all cognitive processes — even of life itself, as one of the most advanced thinkers in biology assures me — it may be instructive to go back for a moment to the most elementary — or as evolutionists would say, to very "early" — manifestations of this principle.[6] These are the "independent effectors", or independent sensory-motor units, found in protozoa and metazoa distributed over the surface of these animals (Fig. 7). The triangular portion of this unit, protruding with its tip from the surface, is the sensory part, the onion-shaped portion the contractile motor part. A change in the chemical concentration of an agent in the immediate vicinity of the sensing tip, and "perceptible" by it, causes an instantaneous contraction of this unit. The resulting displacement of this or any other unit by change of shape of the animal or its location may, in turn, produce perceptible changes in the agent's concentration in the vicinity of these units which, in turn, will cause their instantaneous contraction, etc. Thus, we have the recursion:

↺ change of sensation → change of shape ↺

Separation of the sites of sensation and action appears to have been the next evolutionary step (Figure 8). The sensory and motor organs are now connected by thin filaments, the "axons" (in essence degenerated muscle fibers having lost their contractility), which transmit the sensor's perturbations to its effector, thus giving rise to the concept of a "signal": see something *here*, act accordingly *there*.

The crucial step, however, in the evolution of the complex organization of the mammalian central nervous system (CNS) appears to be the appearance of an "internuncial neuron", a cell sandwiched between the sensory and the motor unit (Fig. 9). It is, in essence, a sensory cell, but specialized so as to respond only to a universal "agent", namely, the electrical activity of the afferent axons terminating in its vicinity. Since its present activity may affect its subsequent responsivity, it introduces the element of computation in the animal kingdom, and gives these organisms the astounding latitude of non trivial behaviors. Having once developed the genetic code for assembling an internuncial neuron, to add the genetic command "repeat" is a small burden indeed. Hence, I believe, it is now easy to comprehend the rapid proliferation of these neurons along additional vertical layers with growing horizontal connections to form those complex interconnected structures we call "brains".

The "The"-school is old school: empiricism, or positivism, or objectivism. Explanatory paradigm: *confirmation*.

The "A"-school is the new epistemological constructivism (*not* "subjectivism" or, worse, "solipsism.") Explanatory paradigm: *correlation*.

"Reality appears only implicit as the operation of recursive descriptions." Or, whatever reality may be, what cognition is capable of computing is descriptions of descriptions for which one may then seek perceptual correlations. Here again is the operational closure of the nervous system in autopoietic theory.

This should be note 7.

See p.5, top left.

For an update, see interneurons.

The evolution of the interneuron "introduces the element of computation in the animal kingdom, and gives these organisms the astounding latitude of non-trivial behaviors."

That would be Humberto Maturana.

Figure 7

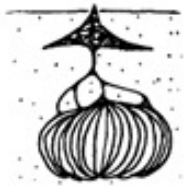


Figure 8

Figure 9

II. *Neuron*. The neuron, of which we have more than ten billion in our brain, is a highly specialized single cell with three anatomically distinct features (Fig. 10): (a) the branch-like ramifications stretching up and to the side, the "dendrites"; (b) the bulb in the center housing the cell's nucleus, the "cell body"; and (c), the "axon", the smooth fiber stretching downward. Its various bifurcations terminate on dendrites of another (but sometimes [recursively] on the same) neuron. The same membrane which envelopes the cell body forms also the tubular sheath for dendrites and axon, and causes the inside of the cell to be electrically charged against the outside with about one tenth of a volt. If in the dendritic region this charge is sufficiently perturbed, the neuron "fires" and sends this perturbation along its axons to their terminations, the synapses.

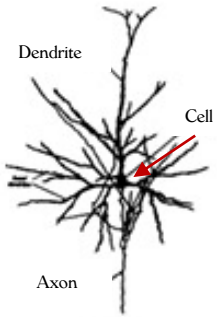


Figure 10

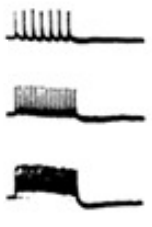


Figure 11

III. *Transmission*. Since these perturbations are electrical, they can be picked up by "microprobes", amplified and recorded. Fig. 11 shows three examples of periodic discharges from a touch receptor under continuous stimulation, the low frequency corresponding to a weak, the high frequency to a strong stimulus. The magnitude of the discharge is clearly everywhere the same, the pulse frequency representing the stimulus intensity, but the intensity only.

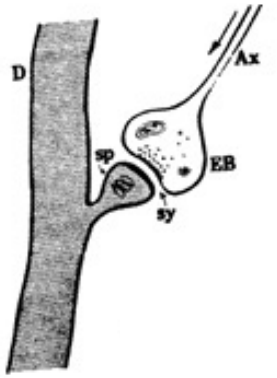


Figure 12

IV. *Synapse*. Fig. 12 sketches a synaptic junction. The afferent axon (Ax), along which the pulses travel, terminates in an end bulb (EB) which is separated from the spine (sp) of a dendrite (D) of the target neuron by a minute gap (sy), the "synaptic gap" (Note the many spines that cause the rugged appearance of the dendrites in Fig. 10). The chemical composition of the "transmitter substances" filling the synaptic gap is crucial in determining the effect an arriving pulse may have on the ultimate response of the neuron: under certain circumstances it may produce an "inhibitory effect" (cancellation of another simultaneously arriving pulse); in others a "facilitory effect'" (augmenting another pulse to fire the neuron). Consequently, the synaptic gap can be seen as the "micro-environment" of a sensitive tip, the spine, and with this interpretation in mind we may compare the sensitivity of the CNS to changes of the *internal* environment (the sum-total of all micro-environments) to those of the *external* environment (all sensory receptors). Since there are only a hundred million sensory receptors, and about ten-thousand billion synapses in our nervous system, we are 100,000 times more receptive to changes in our internal than in our external environment.

Note the ramification of the *environment* for living systems: *external* for the organism as a whole, *internal* for the vast majority of the cells—in particular, the nerve cells—comprising that body.

Figure 13

V. *Cortex*. In order that one may get at least some perspective on the organization of the entire machinery that computes all perceptual, intellectual and emotional experiences, I have attached Fig. 13 which shows magnified a section of about 2 square millimeters of a cat's cortex by a staining method which stains only cell body and dendrites, and of those only 1% of all neurons present[8].

Although you have to imagine the many connections among these neurons provided by the (invisible) axons, and a density of packing that is a hundred times that shown, the computational power of even this very small part of a brain may be sensed.

VI. *Descartes*. This perspective is a far cry from that being held, say three hundred years ago: "If the fire *A* is near the foot *B* (Fig. 14), the particles of this fire, which as you know move with great rapidity, have the power to move the area of the skin of this foot that they touch; and in this way drawing the little thread, *c*, that you see to be attached at the base of toes and on the nerve, at the same instant they open the entrance of the pore, *d*, *e*, at which this little thread terminates, just as by pulling one end of a cord, at the same time one causes the bell to sound that hangs at the other end[9].

Figure 14

Now the entrance of the pore or little conduit, *d*, *e*, being thus opened, the animal spirits of the cavity *F*, enter within and are carried by it, partly into the muscles that serve to withdraw this foot from the fire, partly into those that serve to turn the eyes and the head to look at it, and partly into those that serve to advance the hands and to bend the whole body to protect it."

Note, however, that some behaviorists of today still cling to the same view with one difference only, namely, that in the meantime Descartes' "animal spirit" has gone into oblivion[10].

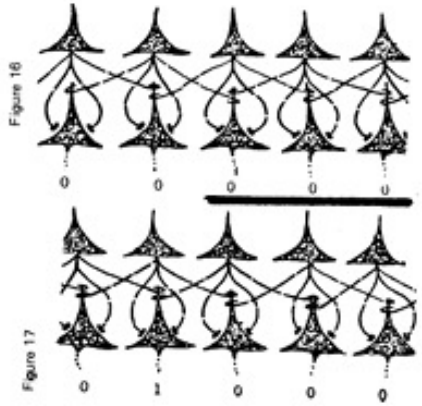
VII. *Computation*. The retina of vertebrates with its associated nervous tissue is a typical case of neural computation. Fig. 15 is a schematic representation of a mammalian retina and its post-retinal network. The layer labeled #1 represents the array of rods and cones, and layer #2 the bodies and nuclei of these cells. Layer #3 identifies the general region where the axons of the receptors synapse with the dendritic ramifications of the "bipolar cells" (#4) which, in turn, synapse in layer #5 with the dendrites of the ganglion cells (#6) whose activity is transmitted to deeper regions of the brain via their axons which are bundled together to form the optic nerve (#7). Computation takes place within the two layers labeled #3 and #5, that is, where the synapses are located.

The reference is to B. F. Skinner, renowned American behavioral psychologist. HvF's polemical point is that mainstream behaviorism is still wedded to an antiquated stimulus – response model of neural function.

Figure 15

As Maturana has shown, it is there where the sensation of color and some clues as to form are computed[11]

Form computation: take the two-layered periodic network of Fig. 16, the upper layer representing receptor cells sensitive to, say, "light". Each of these receptors is connected to three neurons in the lower (computing) layer, with two excitatory synapses on the neuron directly below (symbolized by buttons attached to the body), and with one inhibitory synapse (symbolized by a loop around the tip) attached to each of the two neurons, one to the left and one to the right. It is clear that the computing layer will not respond to uniform light projected on the receptive layer, for the two excitatory stimuli on a computer neuron will be exactly compensated by the inhibitory signals coming from the two lateral receptors. This zero-response will prevail under strongest and weakest stimulation as well as to slow or rapid changes of the illumination. The legitimate question may now arise — "Why this complex apparatus that doesn't do a thing?"



Consider now Fig. 17 in which an obstruction is placed in the light path illuminating the layer of receptors. Again all neurons of the lower layer will remain silent, except the one at the edge of the obstruction, for it receives two excitatory signals from the receptor above, but only one inhibitory signal from the sensor to the left. We now understand the important function of this net, for it computes any spatial variation in the visual field of this "eye", independent of intensity of the ambient light and its temporal variations, and independent of place and extension of the obstruction.

Although all operations involved in this computation are elementary, the organization of these operations allows us to appreciate a principle of considerable depth, namely, that of the computation of abstracts, here the notion of "edge".

I hope that this simple example is sufficient to suggest to you the possibility of generalizing this principle in the sense that "computation" can be seen on at least two levels, namely, (a) the operations actually performed, and (b) the organization of these operations represented here by the structure of the nerve net. In computer language (a) would again be associated with "operations", but (b) with the "program". As we shall see later, in "biological computers" the programs themselves may be computed on. This leads to the concepts of "meta-programs", "meta-meta-programs", ... etc. This, of course, is the consequence of the inherent recursive organization of those systems.

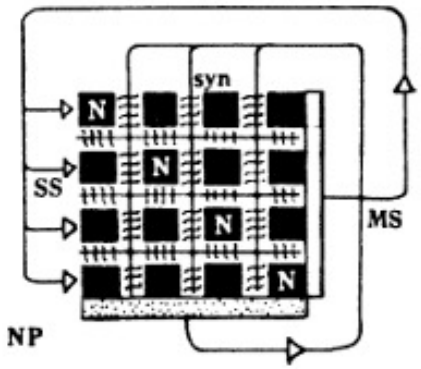


Figure 18

VIII. *Closure*. By attending to all the neurophysiological pieces, we may have lost the perspective that sees an organism as a functioning whole. In Fig. 18 I have put these pieces together in their functional context. The black squares labeled N represent bundles of neurons that synapse with neurons of other bundles over the (synaptic) gaps indicated by the spaces between squares. The sensory surface (SS) of the organism is to the left, its motor surface (MS) to the right, and the neuropituitary (NP) the strongly innervated mastergland that regulated the entire endocrinal system, is the stippled lower bound-

Organic cybernetics, anyone? Here you go, and good luck!

ary of the array of squares. Nerve impulses traveling horizontally (from left to right) ultimately act on the motor surface (MS) whose changes (movements) are immediately sensed by the sensory surface (SS), as suggested by the "external" pathway following the arrows. Impulses traveling vertically (from top to bottom) stimulate the neuropituitary (NP) whose activity releases steroids into the synaptic gaps, as suggested by the wiggly terminations of the lines following the arrow, and thus modify the *modus operandi* of all synaptic junctures, hence the *modus operandi* of the system as a whole. Note the double closure of the system which now recursively operates not only on what it "sees" but on its operators as well. In order to make this twofold closure even more apparent I propose to wrap the diagram of Fig. 18 around its two axes of circular symmetry until the artificial boundaries disappear and the torus (doughnut) as in Fig. 19 is obtained. Here the "synaptic gap" between the motor and sensory surfaces is the striated meridian in the front center, the neuropituitary the stippled equator. This, I submit, is the functional organization of a living organism in a (dough)nut shell. (Fig. 19)

Figure 19

The computations within this torus are subject to a non-trivial constraint, and this is expressed in the Postulate of Cognitive Homeostasis:

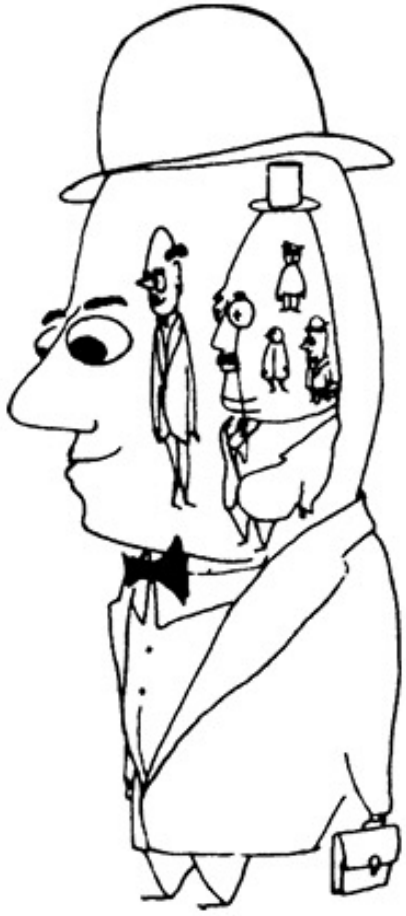
> The nervous system is organized (or organizes itself) so that it computes a stable reality.

This postulate stipulates "autonomy", i.e., "self regulation", for every living organism. Since the semantic structure of nouns with prefix "self-" becomes more transparent when this prefix is replaced by the noun, "autonomy" becomes synonymous with "regulation of regulation". This is precisely what the doubly closed, recursively computing torus does: it regulates its own regulation.

Postulate of Cognitive Homeostasis. Here is the definitive version of the "principle of epistemic homeostasis" from the von Foerster's impromptu talk at the AUM meeting. Here, too, is our segue into *biological autonomy* as Francisco Varela will pick up that theme in his early work.

Significance

It may be strange in times like these to stipulate autonomy, for autonomy implies responsibility: If I am the only one who decides how I act then I am responsible for my action. Since the rule of the most popular game played today is to make someone else responsible for *my* acts — the name of the game is "heteronomy" — my arguments make, I understand, a most unpopular claim. One way of sweeping it under the rug is to dismiss it as just another attempt to rescue "solipsism", the view that this world is only in my imagination and the only reality is the imagining "I". Indeed, that was precisely what I was saying before, but I was talking only about a single organism. The situation is quite different when there are two, as I shall demonstrate with the aid of the gentleman with the bowler hat (Fig. 20).



BC] There may be a single and true reality, and while that can never be definitively *confirmed*, it can be *correlated* to form a reasonable thesis. Meanwhile, there are as many different observing systems as there are living systems, from single cells on up, each one of which is organically distinct, operationally closed, and autonomous regarding its own cognitive contingencies. "Reality" is not a given datum but an ethical choice. Different realities will accrue to distinct communities and their choices how to pool and correlate their shared perceptions.

He insists that he is the sole reality, while everything else appears only in his imagination. How ever, he cannot deny that his imaginary universe is populated with apparitions that are not unlike himself. Hence, he has to concede that they themselves may insist that they are the sole reality and everything else is only a concoction of their imagination. In that case their imaginary universe will be populated with apparitions, one of which may be he, the gentleman with the bowler hat.

According to the Principle of Relativity which rejects a hypothesis when it does not hold for two instances together, although it holds for each instance separately (Earthlings and Venusians may be consistent in claiming to be in the center of the universe, but their claims fall to pieces if they should, ever get together), the solipsistic claim falls to pieces when besides me I invent another autonomous organism. However, it should be noted that since the Principle of Relativity is not a logical necessity, nor is it a proposition that can be proven to be either true or false, the crucial point to be recognized here is that I am free to choose either to adopt this principle or to reject it. If I reject it, I am the center of the universe, my reality are my dreams and my nightmares, my language is monologue, and my logic mono-logic. If I adopt it, neither me nor the other can be the center of the universe. As in the heliocentric system, there must be a third that is the central reference. It is the relation between Thou and I, and this relation is IDENTITY:

Reality = Community

What are the consequences of all this in ethics and aesthetics?

The Ethical Imperative: Act always so as to increase the number of choices.

The Aesthetical Imperative: If you desire to see, learn how to act.

Acknowledgement

I am indebted to Lebbeus Woods, Rodney Clough and Gordon Pask for offering their artistic talents to embellish this paper with Figs. (7, 8, 9, 16, 17), (18, 19), and (20) respectively.

Notes

[1]Brown, G. S., *Laws of Form*. New York, Julian Press, page 3, 1972.

[2]Teuber, H. L., "Neuere Betrachtungen uber Sehstrahlung und Sehrinde" in Jung, R., Kornhuber H. (Eds.) *Das Visuelle System*, Berlin, Springer, pages 256–274, 1961.

[3]Naeser, M. A., and Lilly, J. C., "The Repeating Word Effect: Phonetic Analysis of Reported Alternates", *Journal of Speech and Hearing Research*, 1971.

[4]Worden, F. G., "EEG Studies and Conditional Reflexes in Man", in Brazier, Mary A. B., *The Central Nervous System and Behavior*, New York, Josiah Macy Jr. Foundation, pages 270–291, 1959.

[5]"Hz" means 1 cycle per second, is the unit for oscillations named after Heinrich Hertz who generated the first radio signals.

[6]*op cit.*

[7]Maturana, H. R., "Neurophysiology of Cognition," in Garvin, P., *Cognition: A Multiple View*,. New York, Spartan Press, pages 3–23, 1970.

[8]Sholl, D. A., *The Organization of the Cerebral Cortex*, London, Methuen, 1956.

[9]Descartes, R., *L'Homme*, Paris, Angot, 1664. Reprinted in *Ouevres de Descartes*, XI, Paris, Adam and Tannery, pages 119-209, 1957.

[10]Skinner, B. F., *Beyond Freedom and Dignity*, New York, Knopf, 1971.

[11]Maturana, H. R., "A Biological Theory of Relativistic Colour Coding in the Primate Retina", Arch. Biologia y Medicina Exper., Suppl. No. 1, Soc. Biologia de Chile, Santiago, Universidad de Chile, 1968.