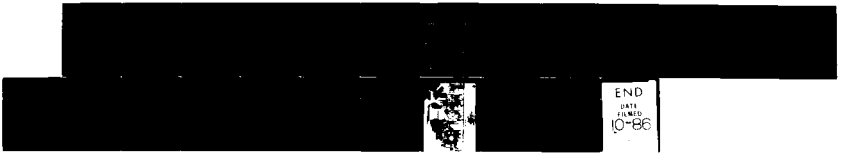
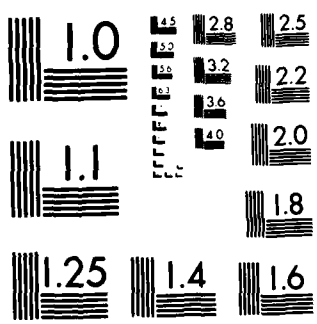
AD-A171 072 THE CYBERNETICS OF COGNITION(U) RHODE ISLAND UNIV 1/1
KINGSTON PASTORE CHEMICAL LAB H VON FOERSTER 30 JUL 86
N00014-86-G-0075

UNCLASSIFIED F/G 5/10 NL



END
DATE FILMED
10-86



SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

AD-A171 072

DTIC ELECTE AUG 21 1986 E

1a. RESTRICTIVE MARKINGS

3. DISTRIBUTION/AVAILABILITY OF REPORT
Approved for public release; distribution unlimited.

4. PERFORMING ORGANIZATION REPORT NUMBER(S)
—

5. MONITORING ORGANIZATION REPORT NUMBER(S)

6a. NAME OF PERFORMING ORGANIZATION
Gordon Research Conferences

6b. OFFICE SYMBOL (If applicable)

7a. NAME OF MONITORING ORGANIZATION
Office of Naval Research (Code 1142EP)

6c. ADDRESS (City, State, and ZIP Code)
Pastore Chemical Laboratory
University of Rhode Island
Kingston, RI 02881

7b. ADDRESS (City, State, and ZIP Code)
800 N. Quincy Street
Arlington, VA 22217-5000

8a. NAME OF FUNDING/SPONSORING ORGANIZATION
Naval Personnel R & D Center

8b. OFFICE SYMBOL (If applicable)
Code 1142EP

9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
Grant No. N00014-86-G-0075

8c. ADDRESS (City, State, and ZIP Code)
San Diego, CA 92152-6800

10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO	PROJECT NO.	TASK NO	WORK UNIT ACCESSION NO
			4424201-01

11. TITLE (Include Security Classification)
THE CYBERNETICS OF COGNITION (Unclassified)

12. PERSONAL AUTHOR(S)
von Foerster, Heinz - University of Illinois
von Glasersfeld, Ernst - University of Georgia

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final Report	FROM 1 Apr 86 TO 1 Aug 86	1986, July 30.	21

16. SUPPLEMENTARY NOTATION

17. COSATI CODES		
FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
acquisition of language; adaptation; alienation; child development; cognition; common sense; complexity; constructivism; expert systems; language; learning; observing; second order cybernetics; social dynamics; understanding.

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

In the framework of the Gordon Research Conferences of the Gordon Research Center, University of Rhode Island, Kigston, RI, an interdisciplinary and international conference on cognitive processes, with about 100 prticipants of 12 countries from 3 continents, was held from June 8 to June 13, 1986, at the Brewster Academie in Wolfboro, NH. Because of the lack of a comprehensive understanding of the multifaceted problem of the phenomenon of cognition which is, at present, approached from different perspectives by biologists, computer scientists, linguists, logicians, mathematicians, neurophysiologists, psychiatrists, psychologists, sociologists, etc., the conceptual bridges offered by cybernetics were taken as an integrating strategy. In 9 sessions 24 speakers presented their ideas that served as openers for intensive, lively, and clarifying discussions. After one or two days of overcoming crossdisciplinary difficulties in communicating, the conference sailed along under favorable winds. In the remaining days almost all participants felt that by their comments and contributions they were successful catalysts in facilitating constructive reactions and generals convergence. (Continued on reverse)

DTIC FILE COPY

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT
☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS

21. ABSTRACT SECURITY CLASSIFICATION
Unclassified/unlimited

22a. NAME OF RESPONSIBLE INDIVIDUAL
Dr. Heinz Von Foerster

22b. TELEPHONE (Include Area Code)
(415) 879-0616

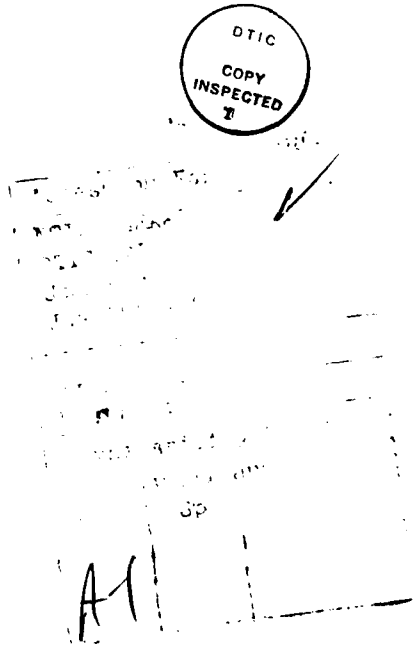
22c. OFFICE SYMBOL

DD FORM 1473, 84 MAR

83 APR edition may be used until exhausted.
All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE

19. ABSTRACT(continued) As one of the consequences of this sense of satisfaction it appears that the Gordon Research Center may host again a conference on cybernetics with an emphasis on an applied epistemology to be chaired by Messrs. Ernst von Glasersfeld and Paul Pangaro.



FINAL REPORT
on

THE CYBERNETICS OF COGNITION

Foreword

Reported are in the following pages the proceedings of the international and interdisciplinary conference on the cybernetics of cognition held at the Brewster Academy in Wolfeboro, NH, between June 8, and June 13, 1986, within the organizational framework of the Gordon Research Conferences of the Gordon Research Center, University of Rhode Island, Kingston, RH.

Since interest in the basic concepts of cybernetics, and their significance for dealing with deterministic systems that are, because of their internal organization, analytically indeterminable (hence, unpredictable), has, after a short flurry about a half century ago, only recently been rekindled, a brief account of the evolution of these notions in the period since their inception is, for the purpose of orientation, preceding reports on the detais of the conference.

This is followed by the Conference Program, whose specific aims are explained in a brief Prologue.

Since the central idea of the Gordon Research Conferences is to have participants with common scientific fascinations to learn from, and with one another through dialogue, discourse, and personal acquaintance, the Program proper lists not only the topics of the 9 sessions together with the titles of the 24 individual presentations and the names of their authors, but also gives a brief personality profile of the speaker as a scientist.

This is followed by a Summary of the sessions, a List of Participants and their Photograph in front of the College's AdministrationBuilding. The report concludes with its Distribution List.

Contents

CYBERNETICS by H. von Foerster (for the Encyclopedia of Artificial Intelligence, Wiley, 1987)

The phrase "control and communication in the animal and the machine" can serve as a definition of cybernetics. Although this term was used by André Marie Ampère about 150 years ago (1) and its concepts were used by Heron of Alexandria more than 1500 years ago (2), it was the mathematician Wiener who, in 1948, with the publication of *Cybernetics* (3), gave name and meaning to this notion in the modern context. The name cybernetics is derived from the Greek word for steersman, κυβερνήτης, which in Latin becomes *gubernator*, governor in English. The concept associated with this term was to characterize a mode of behavior that is fundamentally distinct from the customary perception of the operations of machines with their one-to-one correspondence of cause–effect, stimulus–response, input–output, and so on. The distinction arises from the presence of sensors whose report on the state of the effectors of the system acts on the operation of that system. Specifically, if this is an inhibitory action that reduces the discrepancy between the reported state of the effectors and an internal state of the system, the system displays goal-oriented behavior (4), that is, if perturbed by any outside means, it will return to some representation of this internal state, the goal. Although this scheme does not specify the physical nature of the states alluded to, nor of the signals reporting about these states—whether they are electric currents, mechanical or chemical agents, abstract symbols, or whatever—the biological flavor of the language used is apparent. This is no accident; in the formative years of this concept the close cooperation of Wiener with the neurophysiologist Rosenblueth created a physiological context. Moreover, this cooperation stimulated the philosophical inclination of these two men, and together with Bigelow they set the stage for still ongoing epistemological inquiries with the publication in 1943 of "Behavior, Purpose and Teleology" (5). Another fruitful *ménage à trois* of philosophy, physiology, and mathematics was the collaboration first of McCulloch, philosopher, logician, neurophysiologist, or "experimental epistemologist," as he liked to call himself, with a young, brilliant mathematician, Pitts, who published together two papers of profound influence on this emerging mode of thinking. The title of these papers almost give away their content: "A Logical Calculus of the Ideas Immanent in Nervous Activity" (6), written in 1943, and "How We Know Universals: The Perception of Auditory and Visual Forms" (7), published in 1947. Then von Neumann's fascination with seeing a parallelism of the logical organization of computations in nervous tissue and in constructed artifacts (8) brought him close to McCulloch (9) and the people around him. The underlying logic of these various ideas and concepts was the topic for 10 seminal conferences between 1946 and 1953, bringing together mathematicians, biologists, anthropologists, neurophysiologists, logicians, and so on, who saw the significance of the notions that were spelled out in the title of the conferences: "Circular Causal and Feedback Mechanisms in Biological and Social Systems" (10). The participants became the catalysts for the dissemination of cybernetic concepts into the everyday vernacular (e.g., "feedback"), for epistemological inquiries regarding mentality, and of course "mentality in machines" (11). Should one name one central concept, a first principle, of cybernetics, it would be circularity. Circularity as it appears in the circular flow of signals in organizationally closed systems, or in "circular causality," that is, in processes in which ultimately a state reproduces itself or in systems with reflexive logic as in self-reference or self-organization, and so on. Today, "recursiveness" may be substituted for "circularity," and the theory of recursive functions (see Recursion), calculi of self-reference (qv) (12), and the logic of autology (13), that is, concepts that can be applied to themselves, may be taken as the appropriate formalisms.

Mechanisms

Consider again systems with a functional organization whose operation diminish the discrepancy between a specific state and a perturbation. The system's tendency to approach this specific state, the "goal," the "end," in Greek τέλος (hence "teleology"), may be interpreted as the system "having a purpose" (14). The purpose of invoking the notion of "purpose" is to emphasize the irrelevance of the trajectories traced by such a system en route from an arbitrary initial state to its goal. In a synthesized system whose inner workings are known, this irrelevance has no significance. This irrelevance becomes highly significant, however, when the analytic problem—the machine identification problem—cannot be solved, because, for instance, it is transcomputational (15) in the sense that with known algorithms the number of elementary computations exceeds the age of the universe expressed in nanoseconds. Hence, the notion of purpose can become effective when dealing with living organisms whose goals may be known but whose behavioral trajectories are indeterminable. Aristotle juxtaposes the "efficient cause," that is, when "because" is used to explain the flow of things, with the "final cause," that is, when "in order to" is used for justifying actions. In the early enthusiastic stages of cybernetics language appropriate for living things like desires, wants, ethics, thought, information, mind, and so on were sometimes used in talking about synthesized behavior.

Traces of this are found today in terms like "computer memory," "processing of information," "artificial intelligence," and so on. The fascination with "bio-mimesis," that is, "imitating life" keeps the present-day followers of Aristotle searching for a synthesis of aspects of mentation by using the powers of the large mainframe computers. On the other hand, the analytic problem "what is mind?" and "whence ideas?" in the Platonic sense keeps cyberneticians searching for principles of computation and logic underlying sensorimotor competence, thought, and language.

Although in the early phases of this search the notion of purpose appeared in many studies of these processes, it is significant that a completely purpose-free language can be developed for the same type of systems by paying attention to the recursive nature of the processes involved. Of interest are circumstances in which the dynamics of a system transforms certain states into these very states, where the domain of states may be numerical values, arrangements (arrays, vectors, configurations, etc.), functions (polynomials, algebraic functions, etc.), functionals, behaviors, and so on (16). Depending on domain and context, these states are in theoretical studies referred to as "fixed points," "eigenbehaviors," eigenoperators," and lately also as "attractors," a terminology reintroducing teleology in modern dress. Pragmatically, they correspond to the computation of invariants, may they be object constancy, perceptual universals, cognitive invariants, identifications, namings, and so on. Of course, the classical cases of ultrastability and homeostasis should be mentioned here (17).

Epistemology

In thermodynamically open systems a significant extension of circularity is closure, either in the sense of organizational closure as, for example, in the self-organizing system, or in the sense of inclusion as, for example, in the participant observer. Self-organizing systems are characterized by their intrinsic, nonlinear operators, (i.e., the properties of their constituent elements· macromolecules, spores of the slime mold, bees, etc.), which generate macroscopically (meta-) stable patterns maintained by the perpetual flux of their constituents (18). A special case of self-organization is autopoiesis (19). It is that

organization which is its own Eigen-state: the outcome of the productive interactions of the components of the system are those very components. It is the organization of the living, and, at the same time, the organization of autonomy (20). The notion of "organization" carries with it that of order and then, of course, of disorder, complexity, and so on. It is clear that these notions are observer dependent, hence the extension of cybernetics from observed to observing systems and with this to the cybernetics of language (21). Here language is thought to be precisely that communication system that can talk about itself: a language must have "language" in its lexicon. Autology is the logic of concepts that can be applied to themselves (13). Among these are consciousness and conscience: Their corollaries, epistemology and ethics, are the crop of cybernetics.

BIBLIOGRAPHY

1. M. Zeleny, "Cybernetics and general systems: A unitary science?" *Kybernetes*, 8(1), 17–23 (1979).
2. O. Mayr, *The Origins of Feedback Control*, MIT Press, Cambridge, MA, 1969.
3. N. Wiener, *Cybernetics: Or Control and Communication in the Animal and the Machine*, Wiley, New York, 1948.
4. R. Conant (ed.), *Mechanisms of Intelligence: Ross Ashby's Writings on Cybernetics*, Intersystems Publications, Seaside, 1981.
5. A. Rosenblueth, N. Wiener, and J. Bigelow, "Behavior, purpose and teleology," Philos. Sci., 10, 18–24 (1943).
6. W. S. McCulloch and W. H. Pitts, "A logical calculus of the ideas immanent in nervous activity," *Bull. Math. Biophys.*, 5, 115–133 (1943).
7. W. Pitts and W. S. McCulloch, "How we know universals: The perception of auditory and visual forms," *Bull. Math. Biophys.*, 9, 127–147 (1947).
8. J. von Neumann, *The Computer and the Brain*, Yale University Press, New Haven, CT, 1958.
9. J. von Neumann, The General and Logical Theory of Automata, in L. A. Jeffress (ed), *Cerebral Mechanisms in Behavior*, the Hixon Symposium, Wiley, New York, pp. 1–41, 1951.
10. H. Von Foerster et al., *Cybernetics: Circular Causal and Feedback Mechanisms in Biological and Social Systems*, Proceedings of the Sixth, Seventh, Eighth, Ninth, and Tenth Conferences on "Cybernetics: Circular Causal and Feedback Mechanisms in Biological and Social Systems," (5 vols., The Josiah Macy Jr. Foundation, New York, 1950–1955.
11. D. M. MacKay, Mentality in Machines, in *Proceedings of the Aristotelian Society*, Supplement 1952, pp. 61–86, 1952.
12. F. J. Varela, "A calculus for self-reference," *Int. J. Gen. Syst.*, 2, 5–24 (1975).
13. L. Löfgren, Autology for Second Order Cybernetics, in *Fundamentals of Cybernetics*, Proceedings of the Tenth International Congress on Cybernetics, Association Internationale de Cybernetique, Namur, pp. 17–23, 1983.
14. G. Pask, The Meaning of Cybernetics in the Behavioral Sciences (The Cybernetics of Behavior and Cognition: Extending the Meaning of "Goal"), in J. Rose (ed), *Progress of Cybernetics*, Vol. 1, Gordon and Breach, New York, pp. 15–44, 1969.
15. H. J. Bremmermann, Algorithms, Complexity, Transcomputability, and the Analysis of Systems, in W. D. Keidel, W. Haendler, M. Spreng, (eds.), *Cybernetics and Bionics*, R. Oldenbourg, Muenchen, pp. 250–263, 1974.
16. H. Ulrich and G. J. B. Probst (eds.), *Self-Organization and Management of Social Systems*, Springer, New York, 1984.
17. W. Ross Ashby, *An Introduction to Cybernetics*, Chapman & Hall, London, 1956.
18. P. Livingston (ed.), *Disorder and Order*, Stanford Literature Studies 1, Anma Libri, Stanford, 1984.
19. H. R. Maturana and F. J. Varela, *Autopoiesis and Cognition*, D. Reidel, Boston, 1980.
20. F. J. Varela, *Principles of Biological Autonomy*, Elsevier, North-Holland, New York, 1979.
21. H. R. Maturana: Biology of Language: The Epistemology of Reality, in *Psychology and Biology of Language and Thought*, Academic, New York, 1978.

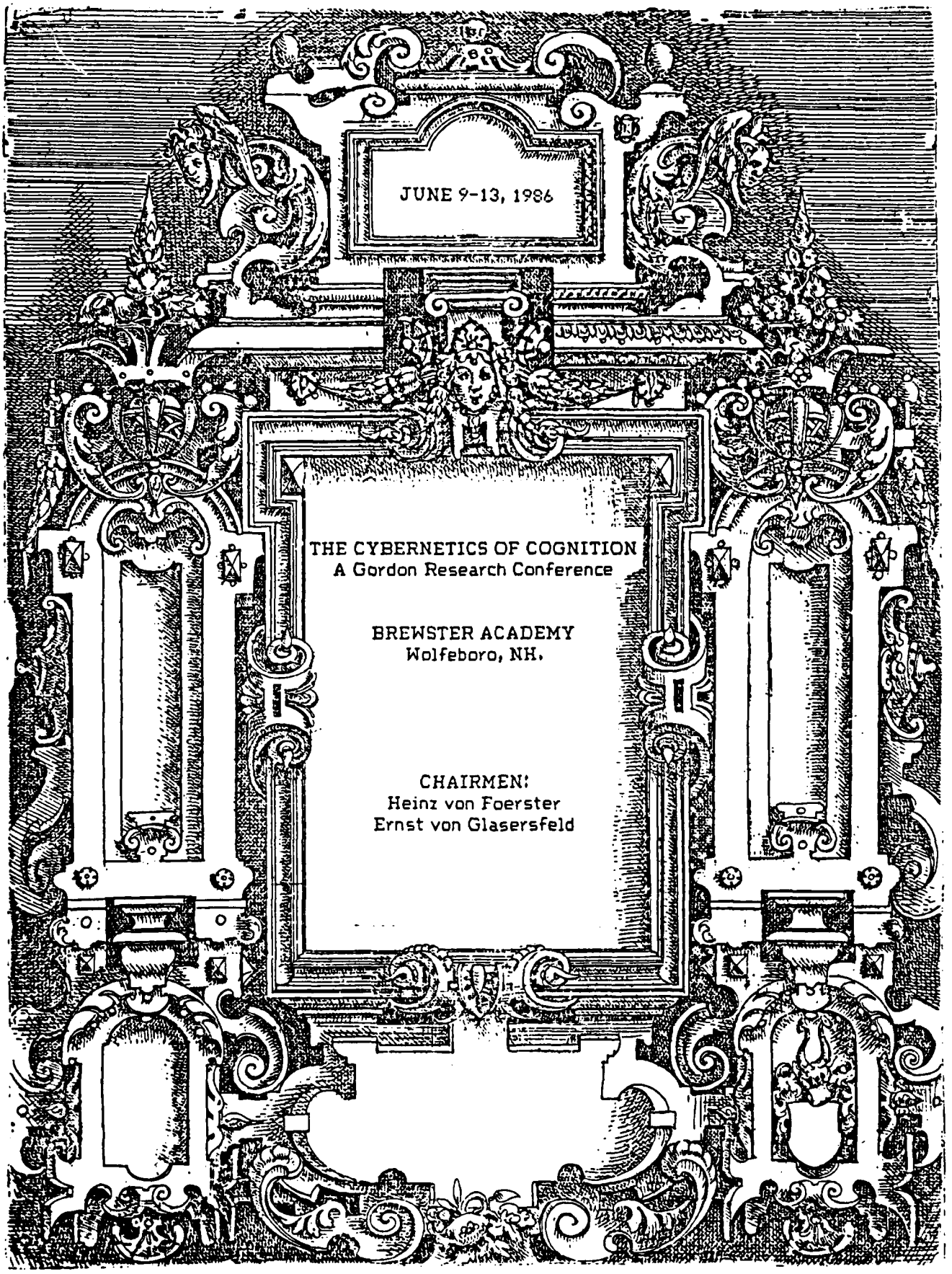
General References

K. Gunderson, Cybernetics, in *The Encyclopedia of Philosophy*, Macmillan, New York, Vol. 2, pp. 280–284, 1972.

B. P. Keeney, *Aesthetics of Change*, Guilford, New York, 1983.

W. S. McCulloch, *Embodiments of Mind*, MIT Press, Cambridge, MA, 1965.

W. T. Powers, *Behavior: The Control of Perception*, Aldine, Chicago, 1973.


JUNE 9-13, 1986
THE CYBERNETICS OF COGNITION
A Gordon Research Conference
BREWSTER ACADEMY
Wolfeboro, NH.
CHAIRMEN:
Heinz von Foerster
Ernst von Glasersfeld

6
PROLOGUE

This Gordon Research Conference on the Cybernetics of Cognition owes its existence to the success of the Gordon Conference on Cybernetics in 1984. Of the nine sessions which dealt with a wide spectrum from the most general aspects of cybernetics to specific areas as, e.g., adaptation, autonomy, education, management, organization,, etc., two created the most excitement and interest, namely, those that touched upon the communicative function of language as an essential component in our understanding of cognitive processes.

Thanks to the magnanimity of the Board of Trustees of the Gordon Research Conferences, the Alfred P. Sloan Foundation of New York, and the Navy Personnel Research and Development Center of San Diego, we are now in a position to follow through with a conference devoted explicitely to the cybernetics of those aspects of cognition that stipulate "the other" from the outset, that is, looking at dialogue, sociality, omnipsism, nos, etc., rather than at monologue, solitude, solipsism, ego, etc. Again we wish to address a wide spectrum of problems from, say, the logic of communication systems that can speak about themselves, to language as a therapeutic agent, for instance in family therapy, to hermeneutics, to social and personal constructs of realities, and so on. But why cybernetics? What is to begained by that approach?

In her keynote address "Cybernetics of Cybernetics" to the American Society of Cybernetics at its First Annual Meeting about twenty years ago Margaret Mead began:

> As an anthropologist, I have been interested in the effects that the theories of cybernetics have within our society. I am not referring to computers or to the electronic revolution as a whole, or to the "implosion" and the end of dependence on script for knowledge, or to the way that dress has succeeded the mimeographing machine as a form of communication among the dissenting young. I specifically want to consider the significance of the set of cross-disciplinary ideas which we first called "feedback" and then called "teleological mechanisms,"[1] and then called "cybernetics"—a form of cross-disciplinary thought which made it possible for members of many disciplines to communicate with each other easily in a language which all could understand. This was an important motive for those of us who worked in those first conferences at the end of the 1940's. We were impressed by the potential usefulness of a language sufficiently sophisticated to be used to solve complex human problems, and sufficiently abstract to make it possible to cross disciplinary boundaries.

But it was not only then that fundamental notions of cybernetics facilitated integration of concepts that originated in various fields. The ramification of cybernetics during the last decade into biology, epistemology, language, learning, logic, mathematics, neurophysiology, psychiatry, psychology, sociology, etc., is well documented and suggests an even more promising cooperative development. The Gordon Research Conferences, with their insistence on fostering communication amongst scientists, provide an ideal climate to allow such synthesis to emerge. We are grateful to all who have accepted this invitation and have come from near and far to partake and contribute.

H.v.F. E.v.G.

GORDON CONFERENCE, Brewster Academy, Wolfeboro NH, June 9-13, 1986

THE CYBERNETICS OF COGNITION

Monday Morning

H.v.Foerster Introduction

1. *COGNITION - AN ADAPTIVE PROCESS, 1* Chair: E.v.Glasersfeld

B.Inhelder — Procedural and structural approaches to cognition: Contradiction or complementarity?
Archives J.Piaget

Bärbel Inhelder, Piaget's principal collaborator for more than thirty years, has published several books on cognitive development and co-authored some of Piaget's most important works (e.g. *The Early Growth of Logic in the Child*). She is the Director of the *Piaget Archives* in Geneva and the leading authority on Genetic Epistemology.

J. Mason — Reflection: The feedback mechanism for both teacher and learner.
Open University, U.K.

John Mason is Acting Director of the *Center for Mathematics Education* of the *Open University* in the United Kingdom. He is concerned particularly with cognitive development, human and artificial intelligence, the role of imagery and metaphor in learning mathematics, and ways of working in classrooms which promote mathematical thinking (including problem solving, investigation, etc.). He is co-author of the popular *Thinking Mathematically*, and author of *Learning and Doing Mathematics*.

H. Sinclair — Is cognition a process, and what adapts to what?
U. of Geneva

Hermine Sinclair, a prominent member of Piaget's team for more than twenty years, is a specialist in psycholinguistics and the early development of mathematical concepts. She has published extensively on problems of cognition and is a periodic guest researcher at *MIT* and the *Center for Didactic Studies at the University of Montreal* as well as a regular consultant for a French research group in the *Institut National de Recherches Pedagogiques* in Paris.

Monday Evening

2. *COGNITION - AN ADAPTIVE PROCESS, 2* Chair: W.Powers

E.Zurif — Language representation in the brain.
Brandeis U.

Edgar Zurif is a neurolinguist at *Brandeis University* whose well-known studies of aphasia and dislexia have led him to formulate a model of the functional architecture of the language faculty which lessens the distance between the description of language and the description of the neurological resources that seem to be instrumental in the construction of meaning.

Monday Evening *(continued)*

O.Selfridge — Learning in brains, genes, and artefacts.
GTE Laboratories

Oliver Selfridge has been personally and professionally associated from the beginning with the people and ideas corrected with cybernetics, particularly with those aspects of "communication and control" as they can be interpreted as computations in nervous tissues or in arefacts. He was one of the few who foresaw the tremendous advantages of parallel computation over the onion architecture of systems with central processors, and suggested already in the late 50-th an organization that became known as "Pandemonium". He was a contributor to the conferences on self-organization that were sponsored by the Office of Naval Research in the early 60-th, and participated in the establishment of Lincoln Lab with his novel design of computer architecture. He was author of some of the early chess playing programs, and has always been a link between the experimental epistemologists of cybernetics and the pragmatists of the artificial intelligentia.

Tuesday Morning

3. *LEARNING AS GUIDED CONSTRUCTION, 1* — Chair: E. Neimark

A.DiSessa — Systematicity and the lack of it in cognitive processing.
U.C., Berkeley

Andrea DiSessa has a Ph.D. in physics from MIT and is currently an associate professor in *Berkeley's Graduate School, Division of Mathematics, Science, and Technology*. He has worked at the intersection of cognition, technology, and education since his early involvement with Papert's *Logo Project* at MIT. His specialty is science and mathematics education; he has conducted psychological studies of learning with emphasis on genetic epistemology and the development of intuitive knowledge, designed computational environments for learning ("microworlds"), and written curriculum material, including the textbook, *Turtle Geometry: The Computer as a Medium for Exploring Mathematics*, co-authored with Hal Abelson.

E.Ackermann — The role of local knowledge in the construction of an invariant.
M.I.T.

Edith Ackermann-Valladao, a student and long-term collaborator of Piaget and Inhelder, has taught courses in cybernetics and genetic epistemology at the *University of Geneva*. She participated as research associate in the *Centre International d'Epistemologie Genetique* and is at present a guest researcher in Seymour Papert's group "Learning and Epistemology" at *MIT*. Her specialty is the role of modelling in the progressive understanding of complex phenomena. She is also interested in the relation between the concept of feedback and the Piagetian notions of assimilation, accommodation, and circular reaction in young children's sensorimotor schemes.

P.Clough — The construction/deconstruction of social reality.
Fordham U., N.Y.

Patricia Clough worked on self-regulating systems and communication at the *Biological Computer Laboratory of the University of Illinois* at Urbana. She is now a sociologist at *Fordham University*, studying the role of social interaction and constraints in the construction of social realities by self-organizing individuals.

Tuesday Evening

4. *LEARNING AS GUIDED CONSTRUCTION, 2* — Chair: G. Klir

J.Confrey — Anticipation and feedback in students' guided cognitive construction.
Cornell U.

Jere Confrey has argued for a dramatic reconceptualization of the teaching of mathematics. Focusing on the construction of concepts through reflection and negotiation of meaning, she developed and refined interactive systems which promote student autonomy. Starting with the *SummerMath* program for young women at *Mount Holyoke College* and currently with a large pre-calculus program at *Cornell University*, she has demonstrated how through the use of multiple representations. tools and forms of presentation, students can learn to think quantitatively and to assess the quality of their own learning. Her current work focuses on how to conceptualize teaching within such a system.

J.Richards — Expert systems: Keeping students in control.
Newton, MA

John Richards, a philosopher and computer scientist by training, is exploring the integration of computers into the curriculum in ways that give students control over their own learning. He has been Executive Vice President of two educational software companies and as co-founder of "Window, Inc." he published the first magazine-on-a-disk. Prior to his engagement with software, Richards was on the faculty at the *Division for Study and Research in Education* at *MIT*. His books include *Computers in teaching mathematics* (with P.Kelman, et al. Addison-Wesley, 1983) and he is at present writing *Expert systems in education* (Erlbaum Associates, 1987).

Wednesday Morning

5. *LANGUAGE AND COMMUNICATION* — Chair: M.Bickhard

W.Mason — Biological dispositions, constraints, and consensual domains.
U.C., Davis

William Mason is Professor of Psychology and Senior Research Scientist at the *California Primate Research Center at Davis*. He was the first primatologist to demonstrate purposive communication among rhesus monkeys in a controlled experiment. His work on cognitive processes in primates provides an invaluable complement to the contemporary studies of cognitive scientists working with humans.

M.Tomasello — Joint attention and interaction in language development.
Emory U., Atlanta

Michael Tomasello is a neo-Piagetian who does empirical research on the beginnings of communication in mother-infant dyads. His recent work at *Emory University* on the role of attention in communicatory interactions adds a new facet to the study of language acquisition and relates it to feedback control theory.

Wednesday Morning (continued)

C.Linde — Expert systems, explanatory systems, and common sense.
Structural Semantics

Charlotte Linde is a linguist trained in sociolinguistics and discourse analysis. She is the co-director of *Structural Semantics*, a research firm specilizing in the study of communication problems in organizational settings. One of her specialties is the study of communication problems in commercial aviation and their role in accidents. She has also conducted extensive research on the construction of life stories.

Wednesday Evening

6. *THE GENERATION OF CONSENSUAL DOMAINS* — Chair: A.Becker

H.Maturana — The ontology of observing.
U. of Chile

Humberto Maturana received his Ph.D. in Biology from *Harvard* in 1958, and is now Professor of Biology on the faculty of Sciences at the *University of Chile* in Santiago. In the tradition of S. Ramon y Cajal, Maturana paid extraordinary attention to questions of anatomy and structure in general as the key to an understanding of the operation of the nervous system. He is well known for his contribution to the understanding of the neurophysiology of vision through two basic works: "What the frog's eye tells the frogs' brain" (with Lettvin, McCulloch, and Pitts; *Proceedings of IRE*, 1959, 47, 1940-51) and "Anatomy and physiology of vision in the frog (*Rana pipiens*) (with Lettvin, McCulloch, and Pitts; *J. of General Physiology*, 1960, 43, 129-75). His more recent work has to do with "The biology of cognition" (1970). The theory of autopoiesis that was developed from this biological approach has profound epistemological consequences in several domains, particularly in the biology of language.

S.Schmidt — Understanding in a constructivist model.
U. Siegen, Germany

Siegfried Schmidt, Director of the *LUNIS Center* at the *University of Siegen*, Germany, an internationally known expert in linguistics and literary scholarship, has developed a model of human text processing that incorporates a constructivist epistemology and the principle of cognitive self-oragnization. In addition he has established a new direction in literary research, viz., empirical studies on the basis of a constructivist theory of knowledge.

Thursday Morning

7. *INDIVIDUAL AND SOCIAL DYNAMICS* — Chair: P.Pangaro

U.Telfener — Second order cybernetics and systems therapy.
Rome, Italy

Umberta Telfener belongs to the dynamic group of young Italian therapists, whose work, ideas and method is in the United States usually associated with the names Luigi Bosco and Gianfranco Cecchin of Milan. The significance of their ideas for our conference is twofold: first, they are explicitly concerned with epistemological questions regarding the change of cognitions that results from the therapist's (purely linguistic) intervention; second, as strategy in conducting the dialogue with their clients, the Milan school applies straightforward cybernetic principles. Because of her extensive clinical work in the United States, and her recent publication, with Marisa Malagoli Togliatti, of a collection of theoretical papers, *La Terapia Sistematica: Nuove tendenze in terapia della famiglia* (Rome: Edizioni Astrolabio, 1983), Telfener moves easily between theory and practice.

Thursday Morning (continued)

B.Keeney — The construction of systemic therapeutic realities.
U. of Texas, Austin

At first glance it would appear that the two books written by this young man within the last two years, *Aesthetics of Change* (New York: The Guilford Press, 1983) and, with J.M.Ross, *Mind in Therapy* (New York: Basic Books, 1985), are "how-to" books for therapists. On second thought, however, they prove to be profound contributions to an understanding of the dialogic aspects of language in a therapeutic context. Keeney's fascination--and competence--is to follow, study, and interpret the effects of the only medicine at the therapist's disposal, namely language, on the cognitions of the members of the family seeking help. Keeney is essentially an epistemologist, and one, moreover, who understands and uses the cybernetics of epistemology.

M.Elkaim — From maps to maps.
Brussels, Belgium

Moni Elkaim is the author/editor of the volume *Psychotherapie et reconstruction du reel* (Paris: Editions Universitaires, 1983) and one of the leading young men in the Belgian scientific circles around Ilya Prigogine, who advance our knowledge about phenomena of dynamic stability in thermodynamically open systems. Elkaim was among the first to apply ideas from the work in non-equilibrium thermodynamics to the field of human interaction in families, groups, and social systems. One aspect of this understanding is to see the role of language as a catalyst for stability or change in psychotherapy, family therapy or, most general, in social theory. Moni Elkaim has outlined these ideas in recent papers such as "Non-equilibrium, chance, and change in family therapy" (*J. of Marital and Family Therapy*, July 1981) and "Openness: A round-table discussion" (with Prigogine, Guattari, Stengers, and Deneubourg, in *Family Process*, March 1982).

Thursday Evening

8. *INTERACTION WITHIN SOCIAL SYSTEMS* — Chair: Karl Tomm

S.Braten — Consent and dissent: Crossing boundaries during social interaction.
U. of Oslo

Stein Braten, Professor of Sociology and chairman of the Social Informatic Program at the *University of Oslo*, Norway, has for years investigated the cognitive and emotive undercurrents in human dialogue and communication networks. Concerned with conditions that prevent conversation between perspectives and promote a model monopoly, his dialogic systems theory is a powerful counterpoint to cybernetic theories that assume closure from a single perspective.

J-P.Dupuy — Complexity and alienation.
Polytechnique, Paris

Jean-Pierre Dupuy belongs to that group of young French avantgardistes who search for an epistemological underpinning in the evolution of socio-cultural processes, be they economic, political, philosophical, paradigmatic, etc. He is the co-founder of an interdisciplinary research group at the *Centre de Recherche Epistemologie et Autonomie*, a department of the *Ecole Polytechnique* in Paris. Of the perpetual stream of his publications only one monograph shall be mentioned here, *Ordres et Desordres: Enquete sur un nouveau paradigme* (Paris: Seuil, 1982), in which he draws our attention to the dependence of order (disorder) upon semantic constraints (or latitudes) of language.

Friday Morning

9. *REVIEW AND PROJECTIONS* Chair: H.v.Foerster

K.Krippendorff Hindsight and foresight.
U. of Pennsylvania

Klaus Krippendorff, Professor of Communication at the *Annenberg School of Communication* of the *University of Pennsylvania*, was one of the outstanding students of W. Ross Ashby at the University of Illinois, and has made major contributions to our understanding of the connections between cognitions, communication, and society. He was organizer of a major international conference on the cybernetics of social organizations, and edited its transactions, *Communication and Control in Society* (New York: Gorden & Breach,1979). He has published books and articles on content analysis, information theory, and agreement statistics. As president of the *International Communication Association* he delivered his Inaugural Address at their annual 1985 conference under the title: "On the Ethics of Constructing Communication".

J.Voneche Cybernetics and the theory of cognitive development.
U. of Geneva

Jacques Voneche, co-author with Howard Gruber, of *The Essential Piaget*, is as much philosopher as psychologist and has investigated the conceptual similarities and differences of genetic epistemology and cybernetics. He is one of the very few scholars who can make this comparison from the vantage point of a thorough acquaintance with the European philosophical tradition.

Heinrich Bauersfeld Reflections and conclusion
Universitaet Bielefeld

* * *

SUMMARY

Most interdisciplinary conferences begin as multidisciplinary meetings, because, understandably, contributors like to start out holding on to their solid ground of expertise and discipline. It takes a while for the participants to sense that in the early satges of such a multilog to listen is even more important than to talk.

This was evident on the first day of this meeting when, because of a last minute cancellation of one speaker, a cautious transition, as planned, from epistemological issues to computer implementations had to be digested within this very day. This made the conceptual gap between the analytic problem of cognition (e.g., how does one learn a language?), and the synthetic problem (e.g., how does one build a speach recognizer?) more than apparent: the same words in these two different contexts mean fundamentally two different things. Morover, such difficulties do arise not only from differences in philosophy, but also from temperamental differences of the corresponding philosophers.

Under the usual conditions of overscheduled conferences, such discrepancies and tensions would be hard to overcome. However, the style adopted by the Gordon Research Conferences, with three short presentations in the morning, followed by extensive discussions until lunch; two presentations in the evenings with open ended discussions; but no scheduled activity after lunch until supper, turned out to have a most catalytic effect. During the afternoons small groups of participants could be seen either sitting on the lovely lawns of the campus and heatedly discussing some diverging points, or developing some ideas on the blackboards in the many small classrooms put to our disposal.

If the analytic/synthetic dichotomy generated tensions on the first day,the kaleidoscopic variety in which one and the same topic, namely "learning", was approached by the speakers of the entire second day, this dichotomy gave additional richness to the discussions which became more lively and more honest as the day progressed. In order to account for the origin of language the notion of "consensual domain" was developed about 15 years ago by the biologist Humberto Maturana. It was this notion that was at the core of discussions on the third day, and again the extraordinary richness of the various approaches, particularly in their overlap, complementarity, and extension enlarged the consensual domain of all participants.

While these sessions touched upon the most general notions of language, its acqusition, its self-referentialty, its biological foundations, etc., in the following days specific contexts of the communicative aspects of language were in the center of interest. It is indeed most fascinating to see the therapeutic use and effect of language in the context of family therapy. In contrast to the psychoanalytic approach which requires (mono-) logical separation of therapist and patient, discussed were here approaches in which the therapist enters the relational network formed by the member of the family requesting help. Since language is the only medicine at the therapist's disposal, this situation allows probing into epistemology and theory underlying the strategies of such interventions.

Of course, the notion of "communicative competence" (as opposed to "linguistic competence", i.e., the production of "well-formed sentences", whether understood or not) can be carried over from the small group to larger aggregates, even to society itself. Since this step carries with it an impressive surge of complexity, rather sophisticated mathematical and logical techniques are called for. We were treated to some of the latest European developments along this line, and the concluding presentations demonstrated the compatibility if many of the points made along this conference, may they have originated in epistemology, in painstaking work with children, in theoretical studies, in computer simulations or extensions.

The conference was adjourned with the prospects of continuing these creative discussions, again under the auspices of the Gordon Research Conferences, with the suggestion to turn now to the cybernetics of an applied epistemology.

PARTICIPANTS

GORDON RESEARCH CONFERENCES

CYBERNETICS

JUNE 8-13, 1986
Brewster Academy, Wolfeboro, New Hampshire

Heinz von Foerster, Chairman
Ernst von Glasersfeld, Vice-Chairman

REGISTRATION LIST

Abell, Troy D. Lake Motel
Oklahoma Univ. Health Sciences Ctr.
800 N.E. 15th St.
Oklahoma City, OK 73190

Ackermann, Edith Est. Rd. 4
MIT (Learning and Epistemology)
Boston, MA 02114

Baker, Lisa C. Lake Motel
Oklahoma Univ. Health Sciences Ctr.
800 N.E. 15th St.
Oklahoma City, OK 73190

Bauersfeld, Heinrich Brook 17
IDM Der Universitat
Postfach 8640
Bielefeld, West Germany D-4800

Becker, A.L. Brook 12
University of Michigan
1091 Frieze/Linguistics
Ann Arbor, MI 48109

Berendes, Christoph Sargent 202
San Jose State University
One Washington Square
San Jose, CA 95195

Bickhard, Mark H. Brook 3
University of Texas, Austin
EDB 504 ED Psych
Austin, TX 78712

Blount, Alexander Sargent 104
Crossroads Community Growth Ctr., Inc.
207 Elm St.
Holyoke, MA 01040

Bourbon, Tom Chamberlain 1
Stephen F. Austin St. University
Department of Psychology
Nacogdoches, TX 75962

Braten, Stein Brown 8
University of Oslo, Inst. of Sociology
Blindern, P.O. Box 1096
Oslo 3, Norway 0317

Campanella, Miriam L. Kimball 7
Dept. of Political Science
20 S. Ottavio
Torino, Italy 10124

Cariani, Peter Sargent 108
SUNY Binghamton, Watson School
C/O 37 Paul Gore St. #2
Jamaica Plain, MA 02130

Cashman, Tyrone Chamberlain 3
American Society of Cybernetics
3428 Fremont Ave. South
Minneapolis, MN 55408

Clough, Patricia T. Kimball 6
Fordham University, Div. of Social Sciences
Lincoln Center Campus
New York, NY 10023

Cobb, Paul Brook 17
Purdue University
Education Building
W. Lafayette, IN 47907

Confrey, Jere Kimball 2
Cornell University, Dept. of Education
Room 490 Roberts
Ithaca, NY 14853

De Zeeuw, Gerard Brook 2
University of Amsterdam
Grote Bickersstraat 72
Amsterdam, Netherlands 1013KA

Disessa, Andrea Brook 2
University of California
School of Ed., Tolman Hall
Berkeley, CA 94720

Donaldson, Rodney E. Brook 1
Amherst College
P.O. Box 1798
Amherst, MA 01002

Donn, J.S. Brook 1
Cornell University, Dept. Of Education
Roberts Hall
Ithaca, NY 14853

Dreier, Olivia S. Kimball 2
University of Massachusetts
127 Hills North
Amherst, MA 01003

Donnelly, Denis Chamberlain 4
Siena College
Department of Physics
Loudonville, NY 12211

Dupuy, Jean-Pierre Brown 3
Ecole Polytechnique
Crea 1 Rue Descartes
Paris, France 75005

Elkaim, Mony Brown 7
Square Des Nations 5
Brussels, Belgium 1050

Fleischaker, Gail R. Kimball 1
Margulis Lab--Biological Sci Center
2 Cummington Street
Boston, MA 02215

Goldfarb, Larry
Mind in Motion
P.O. Box 2265
Santa Cruz, CA 95063

Grey, Burl Brook 6
P.O. Box 3705
West Palm Beach, FL 33402

Grossing, Gerhard Sargent B6
Atominstitut
Schuttelstrasse 115
Vienna, Austria a-1020

Harries-Jones, Peter Sargent B6
York University
4700 Keels St.
Downsview
Ontario, Canada m3j1p3

Haupt, Edward J. Brook 6
Dept. of Psychology
Montclair State College
Upper Montclair, NJ 07043

Helmersen, Per Sargent B8
University of Oslo, Dept. of Psychology
Box 1094
Oslo 3, Norway

Henderson, Hazel Kimball 1
P.o. Box 14997
Gainesville, FL 32605

Herron, J. Dudley Sargent 208
Purdue University, Dept. of Chemistry
West Lafayette, IN 479073

Hoffman, Lynn
Brattleboro Family Institute
50 Eliot St.
Brattleboro, MA 01059 KIMBELL 3

Horn, Robert Sargent 3
The Lexington Institute
80 Merrett Road
Lexington, MA 02173

Hunt, Susan Kimball 3
Route 3, Box 650
Dexter, ME 04930

Inhelder, Barbel Estabrook Rd. 3
University of Geneva
Geneva, Switzerland 12U-4

Jaffe, Joseph Chamberlain 4
Columbia University
722 W. 168th Street
New York, NY 10032

Janvier, Claude Sargent B5
University of Quebec in Montreal
P.O. Box 8888, St. "A"
Cirade, Montreal, Canada H3C 3P8

Jorgenson, Jane Sargent 105
University of Oslo, Insitute of Psychology
Box 1094, Blindern
Oslo, Norway

Jung, Richard Brown 5
University of Alberta
Director, Ctr, for Systems Research
Edmonton, Alberta, Canada T6G 2H4

Kallikourdis, Dionysius Sargent B5
Kallikourdis and Associates
P.O. Box 17014, Kolonaki
Athens, Greece 10024

Keeney, Bradford Brown 2
Texas Tech University
Lubbock, TX 79410

Klir, George Brook 14
Watson School
Dept. of Systems Science
SUNY Binghamton
Binghamton, NY 13901

Kochen, Manfred Sargent 207
The University of Michigan
205 Washteraw Pl.
Ann Arbor, MI 48109

Kreitman, Kevin B. Estabrook Rd. 2
San Jose SLate University
Cybernetic Systems Program, SJSU
One Washington Square
San Jose, CA 95152-0113

Kuppers, Gunter Brown 4
University of Bielefeld
Universitatsstrabe
P.O. Box 8640
Bielefeld, West Germany 4800

Krippendorff, Klaus Sargent 102
University of Pennsylvania
The Annenberg School of Communications
Philadelphia, PA 19104

Lannamann, John W. Sargent B4
University of New Hampshire
PCAC, Department of Communication
Durham, NH 03824

Lawler, Robert W. Brook 9
GTE Laboratories, FRL
40 Sylvan Road
Waltham, MA 02254

Leonard, Frank N. Brook 18
Appolonius Solutions
10270 Wilde Lake Terrace
Columbus, MD 21044

Lewin, Philip Brook 7
Clarkson University
Liberal Studies Center
Potsdam, NY 13676

Lewis, Brian Sargent 101
Washington County Mental Health Services
P.O. Box 647
Montpelier, VT 05602

Linde, Charlotte Kimball 4
Structural Semantics
P.O. Box 707
Palo Alto, CA 94320

Lochhead, Jack Sargent B2
University of Massachusetts
Physics Department
Amherst, MA 01003

Mason, John Sargent 110
Open University
Maths Faculty
Milton Keynes, United Kingdom MK76AA

Mason, William A. Sargent 107
University of California
Psychology Department, Young Hall
Davis, CA 95616

Masselle, Eric Brook 8
SUNY Binghamton Watson School
Systems Science Dept.
Vestal Parkway
Binghamton, NY 13901

Maturana, Humberto Sargent B9
University of Chile
Santiago, Chile

Neimark, Edith Kimball 4
Rutgers University
319 Tillett, Kilmer Campus
Dept. of Psychology
New Brunswick, NJ 08903

Pangaro, Paul Brook 5
Pangaro Incorporated
800 3rd St. NE
Washington, D.C. 20002

Pedretti, Annetta Sargent 209
Princelet Editions
Box 872
Champaign, IL 61820

Pixley, Rolf Brook 18
University of Amsterdam
Grote Bickerstraat 72
1013 KS Amsterdam, Netherlands

Powers, William Sargent 205
Independent Investigator
1138 Whitfield Rd.
North Brook, IL 60062

Mary Powers (guest of William Powers)

Probst, Gilbert Chamberlain 2
University of ST. Gallen
Inst. Fur Betreibswissenshaft
Dufourstrasse 48
St. Gallen, Switzerland 9000

Richards, Laurence Sargent 108
Old Dominion University
Engineering Management Program
Norfolk, VA 23508

Richards, John Sargent B1
43 Pennsylvania Avenue
Newton, MA 02164

Robinson, Alexander Sargent 103
The Breakthrough Foundation
25 Van Ness Avenue
San Francisco, CA 94120

Selfridge, Oliver Sargent B3
GTE Laboratories
40 Sylvan Road
Waltham, MA 02254

Silverman, Paul S. Brown 1
University of Montana
Psychology Department
Missoula, MT 59812

Sinclair, Hermina Kimball 2
University of Geneva
FPSE, Uni II
3 Place de L'Universite
Geneve 4, Switzerland 1211

Smith, Elin W. Sargent 202
Cybernetics Sustems Program
San Jose State University
San Jose, CA 95195

Steedman, Phillip H. Chamberlain 3
University of Nevada
College of Education
Las Vegas, NV 89154

Steg, Doreen Sargent 109
Drexel University
Dept. of Human Behaviour and Development
32nd and Market Street
Philadelphia, PA 19104

Steg, Leo Sargent 109
Steg Enterprises
1616 Hepburn Drive
Villanova, PA 19085

Steier, Fredrick Sargent 105
University of Oslo
Inst. of Psychology
Box 1094, Blindern
Oslo 3, Norway

Stodola, Steve Sargent B1
Revet Environmental Laboratory
7 Neponset Street
Worcester, MA 01606

Telfener, Umberta Kimball 5
Piazza Del Ricci 129
Rome, Italy 00186

Tomasello, Mike Brown 1
Psychology Department
Emory University
Atlanta, GA 30322

Tomm, Karl Sargent B4
University of Calgary Medical Clinic
Family Therapy Program
3350 Hospital Drive N.W.
Calgary, Alberta, Canada T2N 4N1

Trachtman, Paul Brook 15
Smithsonian Institution
A and I Room 2363
900 Jefferson Drive, SN
Washington, DC 20560

Tweedale, James Sargent 110
Navy Personnel R and D Center
San Diego, CA 92152-6800

Umpleby, S.A. Sargent 102
George Washington University
Dept. of Management Science
Monroe Hall 203A
Washington, D.C. 20052

von Foerster, Heinz Brook 16
1 Eden West Road
Pescadero, CA 94060

von Glasersfeld, Ernst Sargent 201
University of Georgia
Department of Psychology
Athens, GA 30602

von Glasersfeld, Charlotte
(guest of Ernst von Glasersfeld)

Voneche, Jacques Brown 9
University of Geneva
Department of Psychology
Geneva, Switzerland 1204

Wootton, Robert Brook 7
Jubilee Partners
1201 Rockinwood Dr.
Athens, GA 30606

Zeleny, Milan Brook 4
Fordham University
GBA 626E
New York, NY 10023

Zurif, Edgar Brown 6
Brandeis University
Program in Linguistics and Cognitive Sciences
Department of Psychology
Waltham, MA 02254

Addendum

Hejl, Peter M. Sargent 203
Lumis University of Seigen
5900 Seigen, P.O. Box 101240
Seigen, West Germany 5900

Hoffman, Lynn Kimball 3
Brattleboro Family Institute
50 Elliot Street
Brattleboro, VT.05301

Janvier, Claude Sargent B5
University of Quebec in Montreal
P.O. Box 8888, St. A
Cirade, Montreal, Canada H3C 3P8

Lax, William D. Sargent 101
Brattleboro Family Institute
50 Elliot Street
Brattleboro, VT 05301

Pattee, Howard H. Sargent 206
SUNY Binghamton, Watson School
Systems Science Dept.
Binghamton, NY 13901

Schmidt, Siegfried J.
University of Siegen
Department of Literature
Holderlinstr
Siegen, West Germany NRH D-5900


GORDON RESEARCH CONFERENCE
Brewster Academy
CYBERNETICS
1966

GORDON RESEARCH CONFERENCES
BREWSTER ACADEMY, WOLFEBORO, NEW HAMPSHIRE
JUNE 8-13, 1986

CYBERNETICS

CHAIRMAN: Heinz von Foerster

VICE-CHAIRMAN: Ernst von Glasersfeld

ROW 1: (from left to right) Braten, S., Maturana, H.R., Powers, W., Tomasello, M., Keeney, B., Krippendorf, K. de Zeeuw, G., Linde, C., von Foerster, H., von Glasersfeld, E., Klir, G., Inhelder, B., Zurif, E., Hoffman, L., Elkaim, M.

ROW 2: Kallikourdis, D., Neimark, E., Kochen, M., Quinn, W., Dreier, O., Zeleny, M., Fleischaker, G., Steg, D., diSessa, A., Telfener, U., Sinclair, H., Confrey, J., Richards, J., Kreitman, K., Cariani, P., Lannamann, J., Clough, P.

ROW 3: Grey, B., Berendes, C., Voneche, J., Cashman, T., Steier, F., Umpleby, S., Lochhead, J., Ackermann, E., Henderson, H., Probst, G., Mason, W., Jung, R., Jaffe, J., Pixley, R., Cobb, P.

ROW 4: Campanella, M., Jorgenson, J., Helmersen, P., Bourbon, T., Smith, E.W., Wootton, R., Grossing, G., Kuppers, G., Herron, D., Hunt, S., Haupt, E., Baker, L., Mason, J., Abell, T., Goldfarb, L., Pangaro, P., Trachtman, P., Tweedale, J., Heji, P., Robinson, H.A.

ROW 5: Blount, A., Lewin, P., Stodola, S., Leonard, F., Schmidt, S., Lewis, B., Lax, W., Donaldson, R., Becker, A., Tomm, K.

ROW 6: Pattee, H., Masselle, E., Richards, L, Donnelly, D., Silverman, P., Bickhard, M., Steg, L., Lawler, R., Steedman, P., Donn, S., Harries-Jones, P., Dupuy, J-P., Bauersfeld, H.

OFFICE OF NAVAL RESEARCH

Engineering Psychology Program

TECHNICAL REPORTS DISTRIBUTION LIST

Engineering Psychology Program
Office of Naval Research
Code 1142EP
800 N. Quincy Street
Arlington, VA 22217-5000

Physiology & Neurobiology Program
Office of Naval Research
Code 1141NP
800 N. Quincy Street
Arlington, VA 22217-5000

Cdr. Thomas Jones
Code 125
Office of Naval Research
800 N. Quincy Street
Arlington, VA 22217-5000

Director
Technical Information Division
Code 2627
Naval Research Laboratory
Washington, DC 20375-5000

Dr. R. Penn
Code 04
Navy Personnel R & D Center
San Diego, CA 92152-6800

ACO
ONR Resident Representative
Harvard University
Holyoke Center, 2nd Floor
1350 Massachusetts Avenue
Cambridge, MA 02138-4993

Dr. Eugene E. Gloye
ONR Detachment
1030 East Green Street
Pasadena, CA 91106-2485

Dr. Edgar M. Johnson
Technical Director
US Army Research Institute
Alexandria, VA 22333-5600

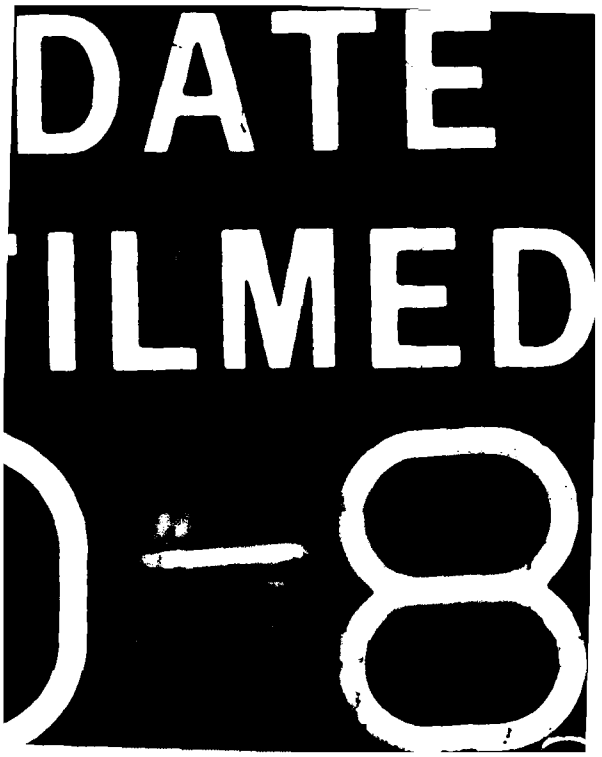
Dr. J. Weisz
Technical Director
US Army Human Engineering Laboratory
Aberdeen Proving Ground, MD 21005

Dr. Kenneth R. Boff
AF AMRL/HE
Wright-Patterson AFB, OH 45433

Dr. J. Tangney
Directorate of Life Sciences
AFSOR
Bolling AFB, DC 20032-6448

Defense Technical Information Center
Cameron Station, Bldg 5
Alexandria, VA 22314

Dr. Tomaso Poggio
Massachusetts Institute of Technology
Center for Biological Information
Processing
Cambridge, MA 02139


DATE
ILMED
-8