

The Transitional Phase in Knowledge Evolution

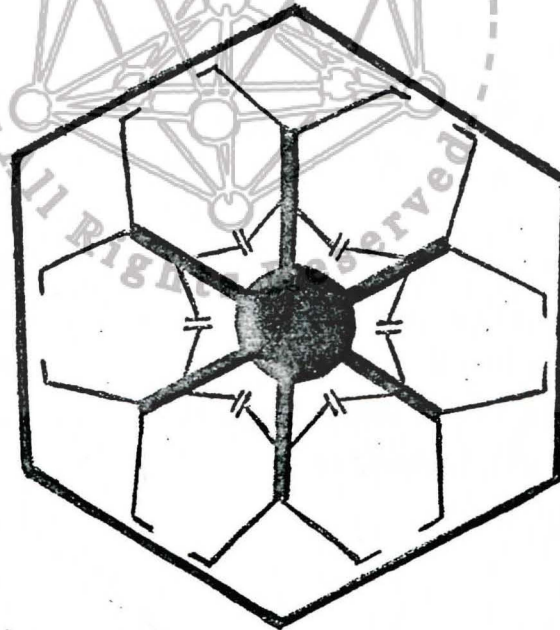
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I. Introduction

In 1968, through the good offices of Dr. Aristide Esser, I was given the opportunity to present one of the Moving Frontiers of Science Lectures at the Annual Meeting of the A.A.A.S. My subject was "Space and the Strategy of Life." There I showed that the course of change in numbers of humans was associated with, and dependent on, the acquisition and utilization of knowledge. It was even then apparent that we were on the threshold of a transition between a long term trend of population increase and a long term trend of population decrease. This transition in population size would be accompanied by a transition in the means through which we promote the increase of knowledge.

This earlier model only crudely envisaged the time course of this transition. My thoughts then also inadequately treated the kind of strategy likely to be most effective in getting us through this transition with respect to how we promote increase in knowledge. It will be my intent here to redress partially these two deficits.

II. Theoretical Constructs About the Knowledge Process

1. Review of the Basic Theory.

The physics of movement through physical space to secure resources by relatively solitarily living mammals will culminate through evolutionary time in the necessity of living as members of groups, whose optimum size consists of 12 adults. Humans derive from such a lineage. They peopled the earth with such groups (accompanied by their children) -- with each group inhabiting a range of about 7.5 miles in diameter. Carrying capacity of basically biological man remained at a world population of 4.5 million. All space was filled.

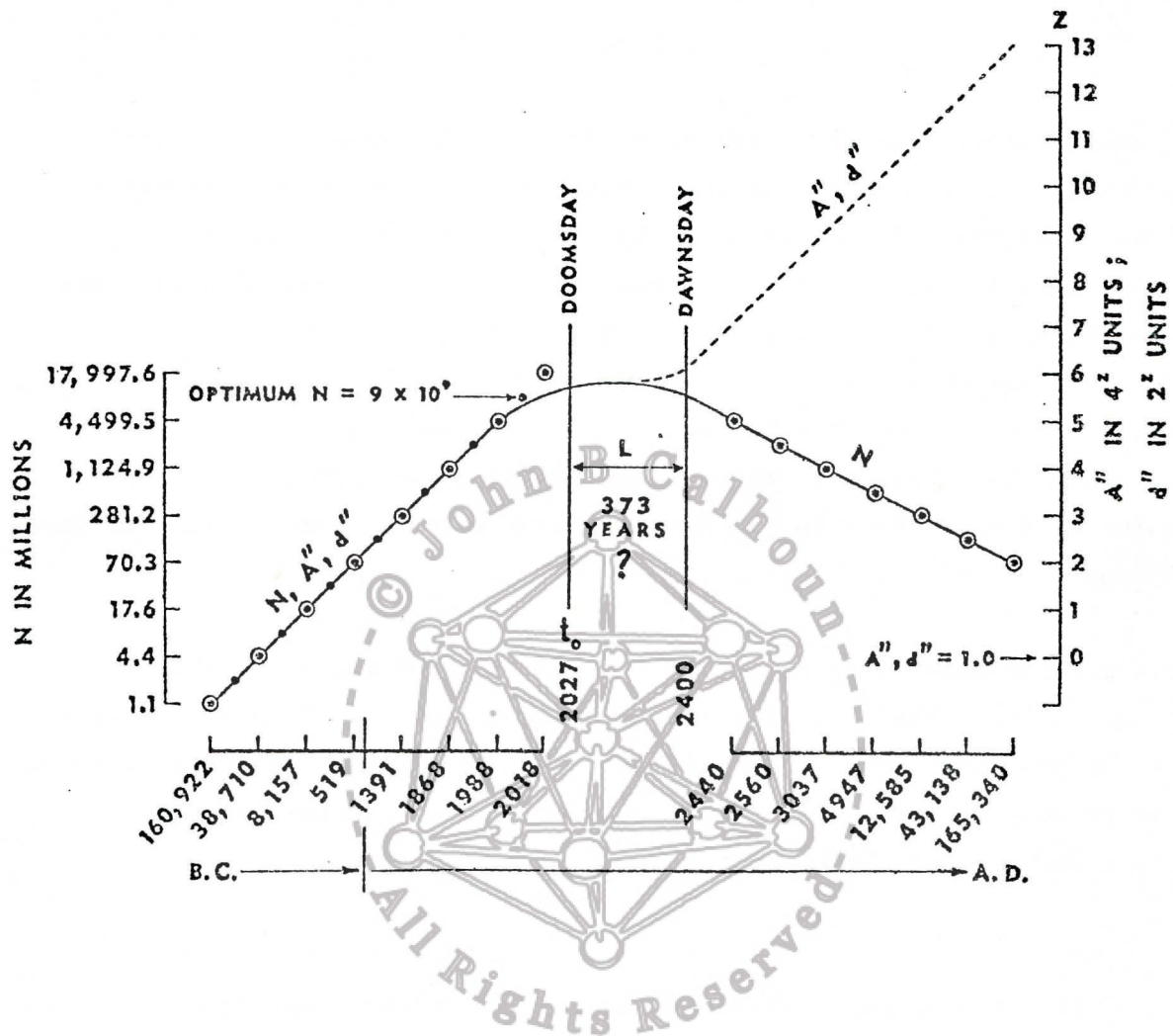


Fig. 1. 1968 formulation of human world population and knowledge evolution. At that time the length, L , of the transition between two eras of evolution was poorly estimated.

N = world population
 A'' = conceptual or informational space
 d'' = capacity of the average individual to acquire, and utilize concepts created from available information.

And yet, by at least 43,000 years ago population did begin to increase, and has increased ever since then. These early people discovered a new kind of space, conceptual space; they discovered how to create information and transform it into utilitarian concepts. A critical kind of concept involved production of new categories of social roles which reduced meaningful contacts with others to the level appropriate to that which earlier transpired in the small closed groups. Each increase in density and social roles increased the amount and diversity of information flowing over the contact network. This increased the probability of new ideas emerging, some of which increased the efficiency of resource acquisition, which in turn permitted more people to survive, and more social roles to develop. This self-process stimulating growth has continued to the present, with conceptual space keeping pace with population increase, and human conceptual capacity increased proportional to the square root of conceptual space. Von Foerster (1958) first elaborated equations describing the accompanying population change. In essence each sequential doubling of population required only half the time of the prior doubling (see Fig. 1). Continuation of past trends would see the population increase instantaneously to infinity about 2027 A.D. ("DOOMSDAY").

Considerations of utilization of biological-physical space and of conceptual space (Fig. 2) indicated that a transition to a declining population would shortly begin. This conclusion followed from the following line of reasoning: Just as biomass on earth has gradually stabilized to a near constant level, so would ideomass (the product of number of people and the average conceptual capacity). An, at least temporary, cessation in increase in ideomass was in part predicted as a result of the braking influence exerted by the completion of one of the means through which conceptual velocity had increased. This has been the enlargement of the network of people over which information flows by person to person communication. Theory was presented to show that final amalgamation of all people into a single network should accompany attainment of a worldwide population of 9 billion.

BASIC VARIABLES

FUNCTION	SPACE	
	BIOLOGICAL	CONCEPTUAL
COMMUNICATION	$\mu = dv/A$	$\mu'' = d''v''/A''$
MASS	$B = N\bar{w}$	$I = N\bar{d}''$
CAPACITY	$\bar{w} = B/N$	$\bar{d}'' = I/N$

Fig. 2. Basic variables affecting population size and conceptual capacity.

μ = a communication constant in physical space
 d = individual diameter, body size
 v = individual velocity
 A = physical area through which the individual moves
 μ'' = a communication constant in conceptual space
 d'' = conceptual diameter or capacity of the individual
 A'' = conceptual space
 B = biomass
 N = population size
 $\bar{w}$ = mean individual weight
 I = ideomass

2. The Transition Time Course

However, first it will be best to get an overview of the time course of the transition. Data on fertility changes available in 1979, accompanied by U.N. projections to the year 2000 indicated that the von Foerster Doomsday equation ceased to hold after 1975. With that essential datum it was apparent that the problem of the transition could be attacked. We incorporated data on (1) rates of change in fertility, (2) mortality and (3) age structure along with (4) the Doomsday and Dawnsday equations to run a complex computer simulation of population change.

The transition, shaded area in Figs. 3 and 4, is given a moderately long term perspective in Fig. 3 and a fairly short term perspective in Fig. 4. From the long term perspective it is apparent that experience of rapid rates of change represents a blip (1800 to 2300 A.D.) in history spliced between millennia long continuous rates of change hardly perceptible on the human life-time scale of experience. Fig. 3 also presents the opportunity of presenting the contrast between the United Nations projection of world population with our own. The process of evolution (decrease in the entropy: negentropy ratio) may well terminate if this U.N. projection of stability at 10.5 billion holds for very long.

The short term perspective (Fig. 4) is presented to depict better the course of change in human conceptual capacity, d'' , as it is influenced by the transition.

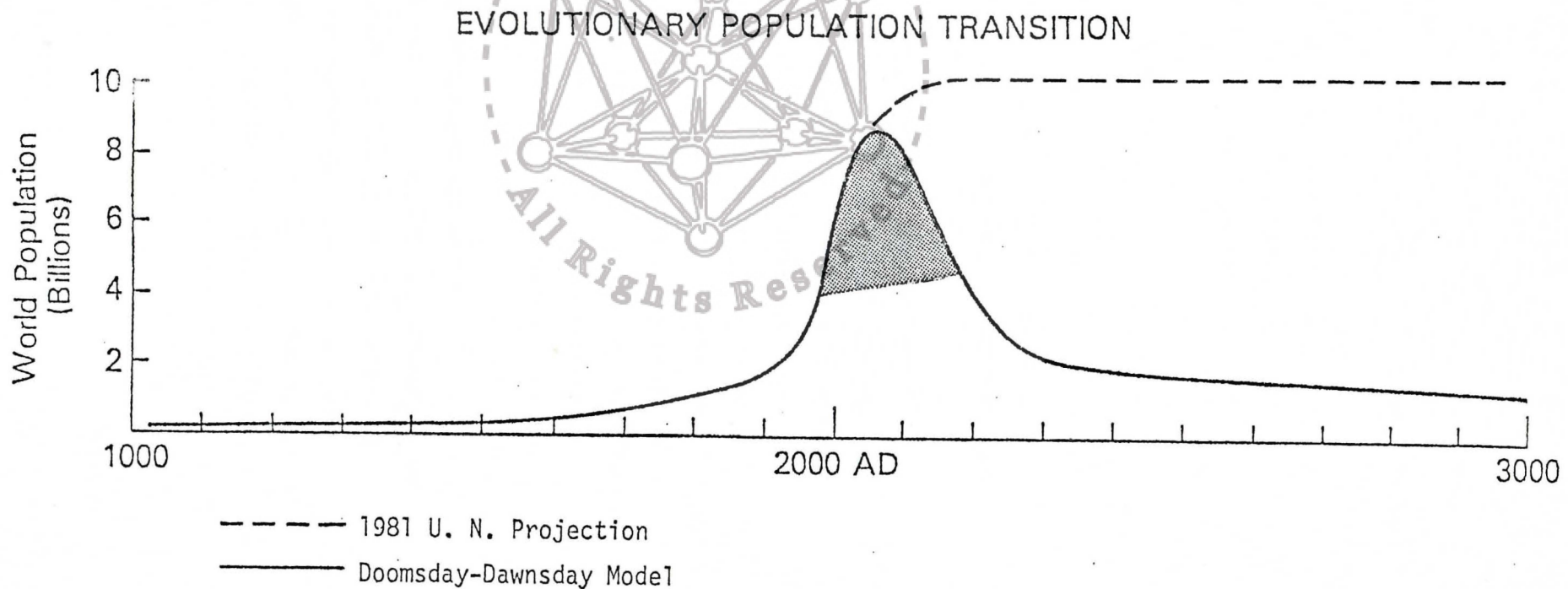
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Footnote: At $N_{\max}$ N will be 2000 times that at the inception of culture 43,000 years ago. Let M stand for this relative $N_{\max}$ of 2000. Then d'' (and also v'') may be calculated as follows:

Fig. 3. Evolutionary population transition

The shaded area defines the 1975 to 2175 period of transition between the sole function of two separate equations. From about 43,000 B.P. to 1975 A.D. population change conformed to the von Foerster "Doomsday" equation, whose operation leads to each doubling of population requiring only half the time of the prior doubling. After 2175 A.D. the Calhoun-Ahuja "Dawnsday"

equation will lead to each halving of population requiring four times as long as the prior halving. This model of the human future is quite at variance with the 1981 United Nations projection, which erroneously assumes that human world population change must obey the ecological-wildlife model of asymptotic approach to a maximum carrying capacity determined by availability of physical resources.



Even a temporary attainment of $I = Nd''$ is likely to insure its permanency simply because the relation can be rephrased as $d'' = I/N$. In this case d'' will double each time N halves, and each successive halving should require four times the time as the prior halving. Such changes presuppose the development of computer-like prostheses that evermore effectively develop capacities that simulate and extend biological brain function. The capacities of these prostheses to process information, enhanced by linkages among them represent the V'' variable of the μ'' communication constant. Focus on an initial objective they may accomplish forms the main purpose of the present paper.

$$\text{Before } N_{\max}: d'' \text{ or } v'' = (MN/N_{\max})^{1/2}$$

$$\text{After } N_{\max}: d'' \text{ or } v'' = (N_{\max}/N)(M)^{1/2}$$

Conceptual capacity, d'' , as a theoretical construct essentially is an equivalent to the meaning of knowledge. Knowledge and d'' will be utilized interchangeably hereafter. Let us consider increase in knowledge as the percentage change of d'' over 20 years. In 1980 it was 17%, the highest in all prior history. From now to $N_{\max}$ it will decline to 2%. The 50 year period around the time of $N_{\max}$, 2063, will likely be a time of accentuated crises due to the very depressed rate of knowledge increase. Given that we successfully navigate through this period of crisis, more pleasantly exciting times will ensue as the rate of knowledge increase increases again. A peak rate of change of about 19% will occur at the very end of the transition in 2175 or so. The eighty years surrounding the end of the transition may become the intellectually and affectively most stimulating period of all of history. From then on conditions will become ever more temperate as both population size and the rate of knowledge increase declines ever more slowly.

Fig. 4. The course of the knowledge transition.

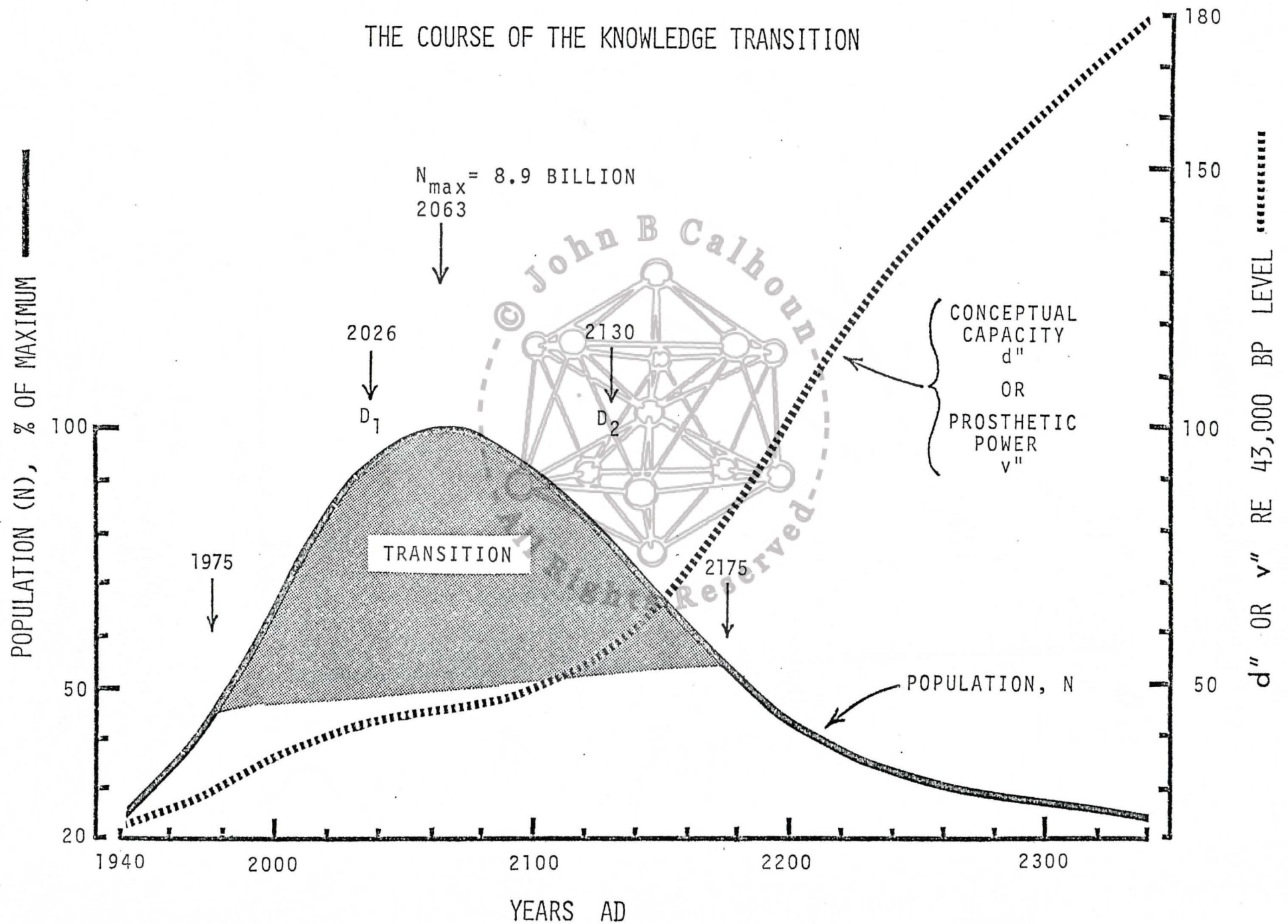
A 400-year center slice out of Fig. 3. At the beginning and the end of this span of time world population is only 25% of its maximum in 2063 A.D.

D_1 = Doomsday, one year before the world population goes instantaneously to infinity by the von Foerster equation, which ceased to apply in 1975 A.D.

D_2 = Doomsday, one year after world population very rapidly drops from an infinite size by the Calhoun-Ahuja equation, which will become fully operative in 2175 A.D.

The broken line represents the change in the conceptual capacity of the individual relative to that of biological man 43,000 years ago at the inception of the cultural era of evolution. At that transition $d'' = 1.0$. V' , conceptual velocity after maximum N becomes essentially a function of the number and effectiveness of computer-like information processing units and their interlinkage -- and thus may be designated "prosthetic power".

THE COURSE OF THE KNOWLEDGE TRANSITION



SHORT SLEEP AND "THINKING" BEHAVIORAL STATES OF RATS

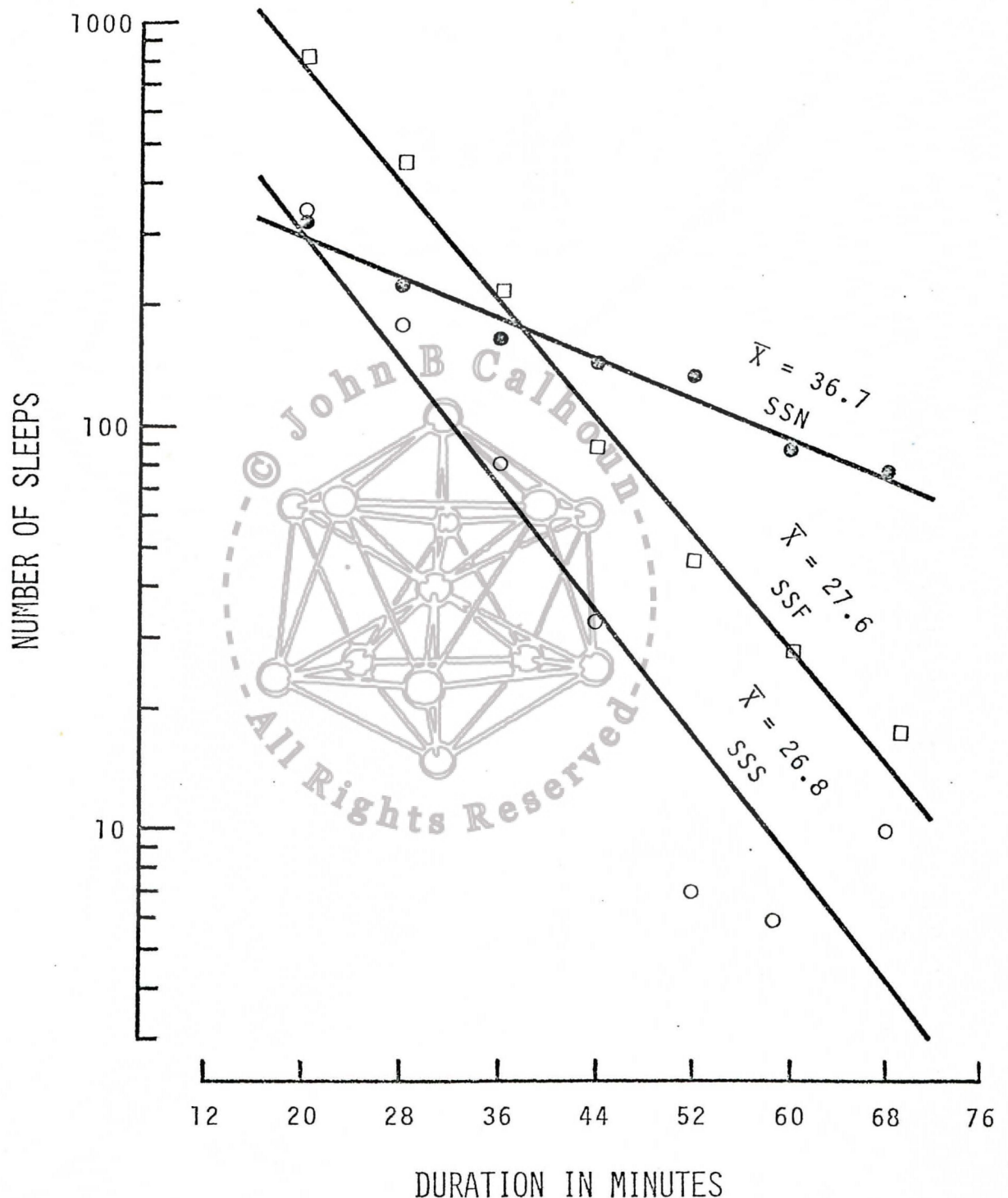


Fig. 5. Short sleep and "thinking" behavioral states in rats. Durations of 11 kinds of behavioral states (β) were recorded for 72 rats for 5 days each in a compartmentalized environment. SSN ($n = 1159$) = short sleep in the nest box. SSF ($n = 1658$) = short sleep in the field (i.e. outside the nest box). SSS ($n = 655$) = simulated short sleep (i.e. a sequence of 10 or more motor β intervening between the termination of an SSF and an SSN and the inception of the following SSF or SSN).

3. Focus on Knowledge-Increasing Brain Prostheses

The biological brain reached maximum functional potential 43,000 years ago. The socio-cultural brain, the network of interpersonal communications enhanced by mostly non-electronic means (prostheses) of preserving and transmitting information, has now essentially reached maximum functional capacity. These two types of "brains" have represented the last two leading edges of evolution that have promoted negentropy increase. Both are concerned with thought and knowledge. This in conjunction with the General principle that evolution builds upon and extends prior evolved structure and process suggests the following proposition:

The next phase shift in evolution should utilize computer-like devices and interlinked systems of them to simulate biological brain function to manipulate more effectively thought products of the human brain and process them for return use in human reflection.

The beginning of the population and knowledge transition in 1975 marks the initiation of this phase shift in evolution. During the coming era the already apparent mutualism between humans and information metabolizing machines will become more pronounced. Such machines will more and more represent enlargements of human being, identity, and capacity, rather than independent forms of life. Together they will form a higher order of life, increasing negentropy on earth through a natural process of affective and intellectual reactivity.

PROBABILITY CONTROL OF BEHAVIORAL STATES, β

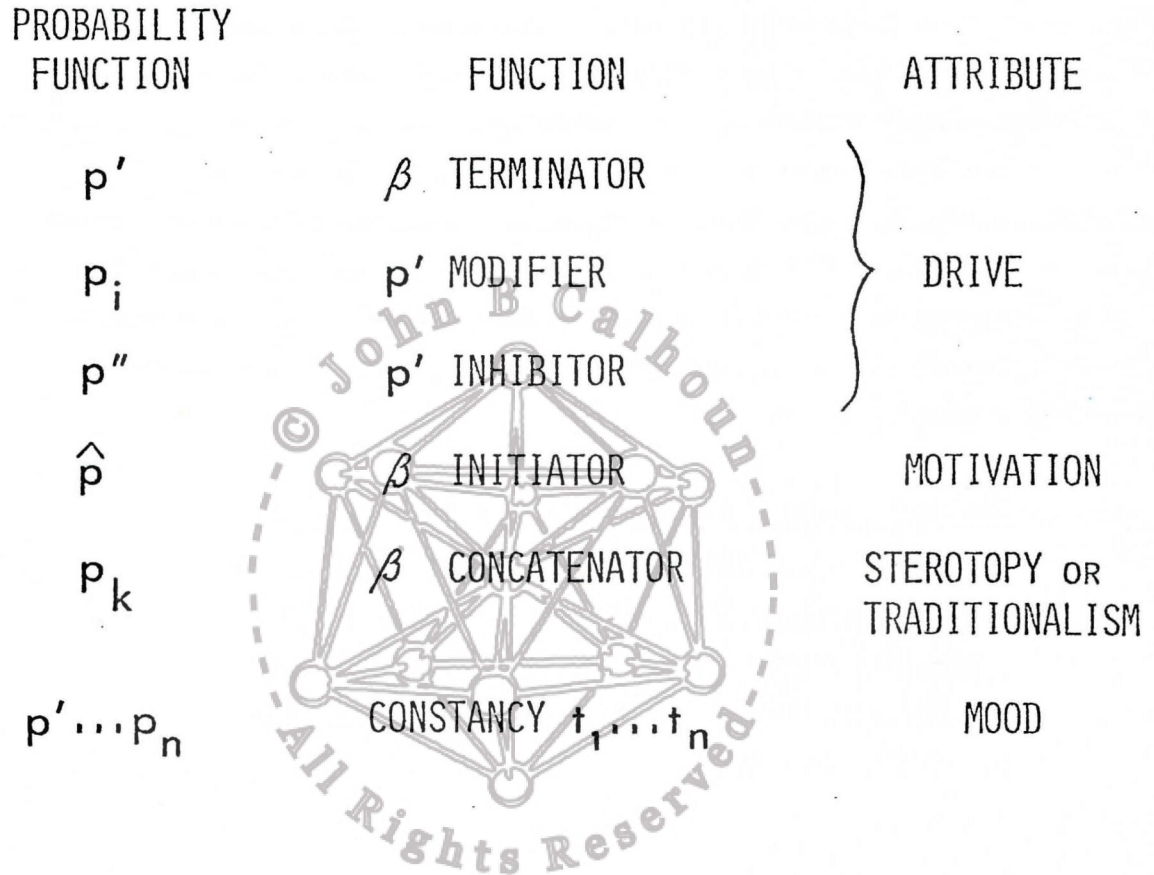


Fig. 6

4. Thought as a Behavioral State

Much of my research over the past 30 years has focused on analyses of the duration and sequence of behavioral states. Rats (Rattus norvegicus) in isolated and social settings have served as subjects. A behavioral state, β , is taken as any episode of activity or inactivity of the animal, which has internal consistence of component motor and physiological characteristics sufficient to enable recognition of the initiation, continuance and termination of the state. Mean durations of a particular kinds of β vary only within narrow limits, but among different kinds of β mean durations range from under one second to three hours. A small set of probability functions (Fig. 6) suffice to account for all the changes among behavioral states.

However, our major attention here is to only one of these probabilities, p' . Once initiated, each behavioral state is characterized by a particular p' , the constant probability that it will terminate during the next unit of time, t , -- no matter how long the particular state has already persisted. Large samples are gathered of durations of behavioral states. Each sample is partitioned into appropriate sized class intervals of duration. Nearly universally, over most of the duration range, a negative exponential equation describes these results, and p' may legitimately be calculated. We then know that we are dealing with a true behavioral state.

Three such beta are depicted in Fig. 5. Rats may sleep in their nest (SSN) in a small darkened box or they may lie prone and relaxed out in the "field" -- more stimulus exposed portions of the environment. In this latter short sleep (SSF) their eyes may be open, but they rarely -- even in a social setting -- respond to proximity of associates. It is obvious from the marked differences in mean duration between SSN and SSF, as well as the differences in slope of the curves, that SSN and SSF are different behavioral states.

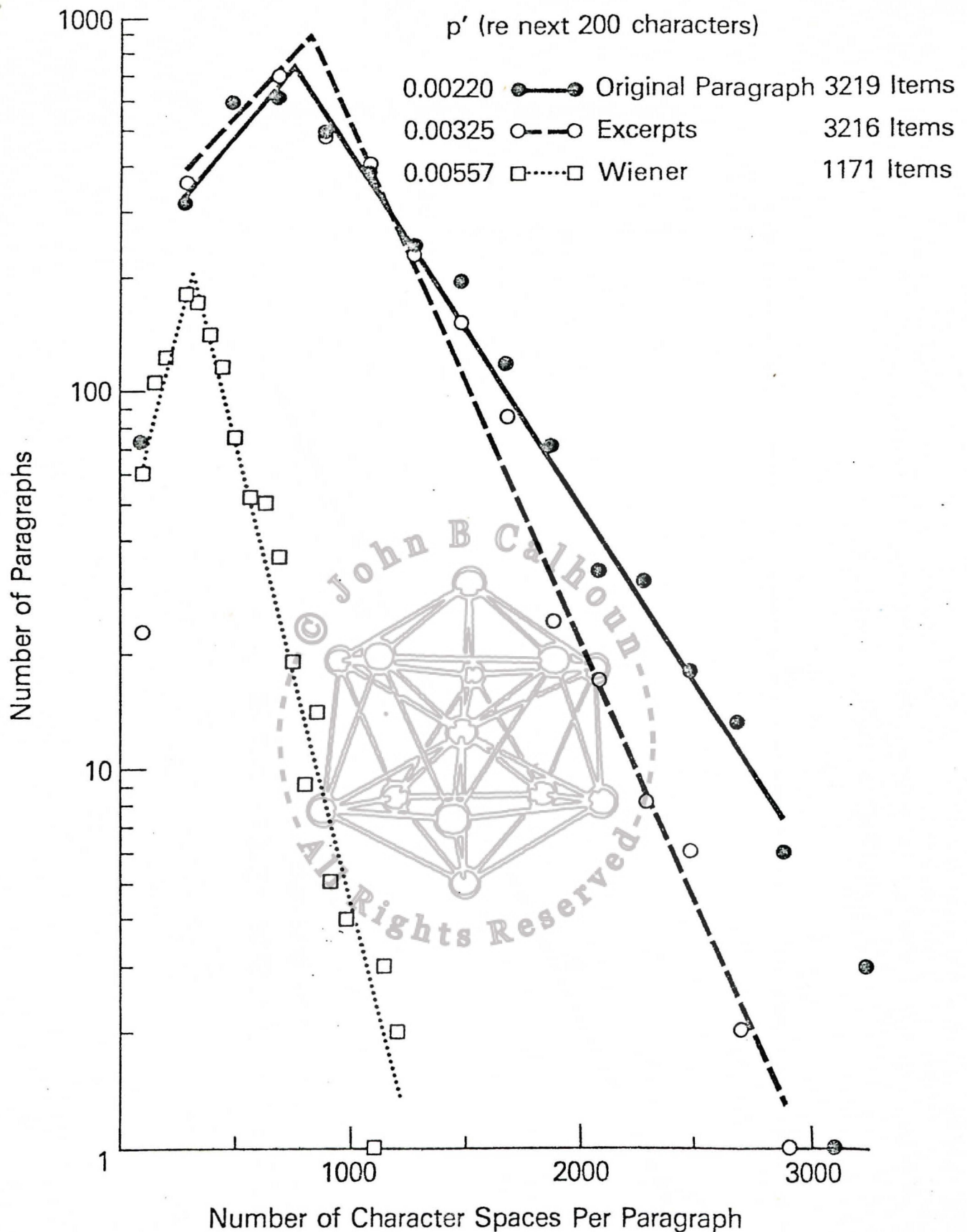


Fig. 7. Written paragraphs represent thinking behavioral states comparable to the "day-dream" like states of short sleep in the field (SSF) by rats. The paragraph durations shown in the two curves relate to an anthology on population and mental health. The dashed line represents a sample of artificial paragraphs (excerpts) derived by concatenating sequential excerpted passages across one or more original paragraphs. The solid line derives from the first paragraph from which each such excerpt was derived. Data encompassing Norbert Wiener's the "Tempter" is included to exemplify the universality of paragraphs as behavioral states of thinking.

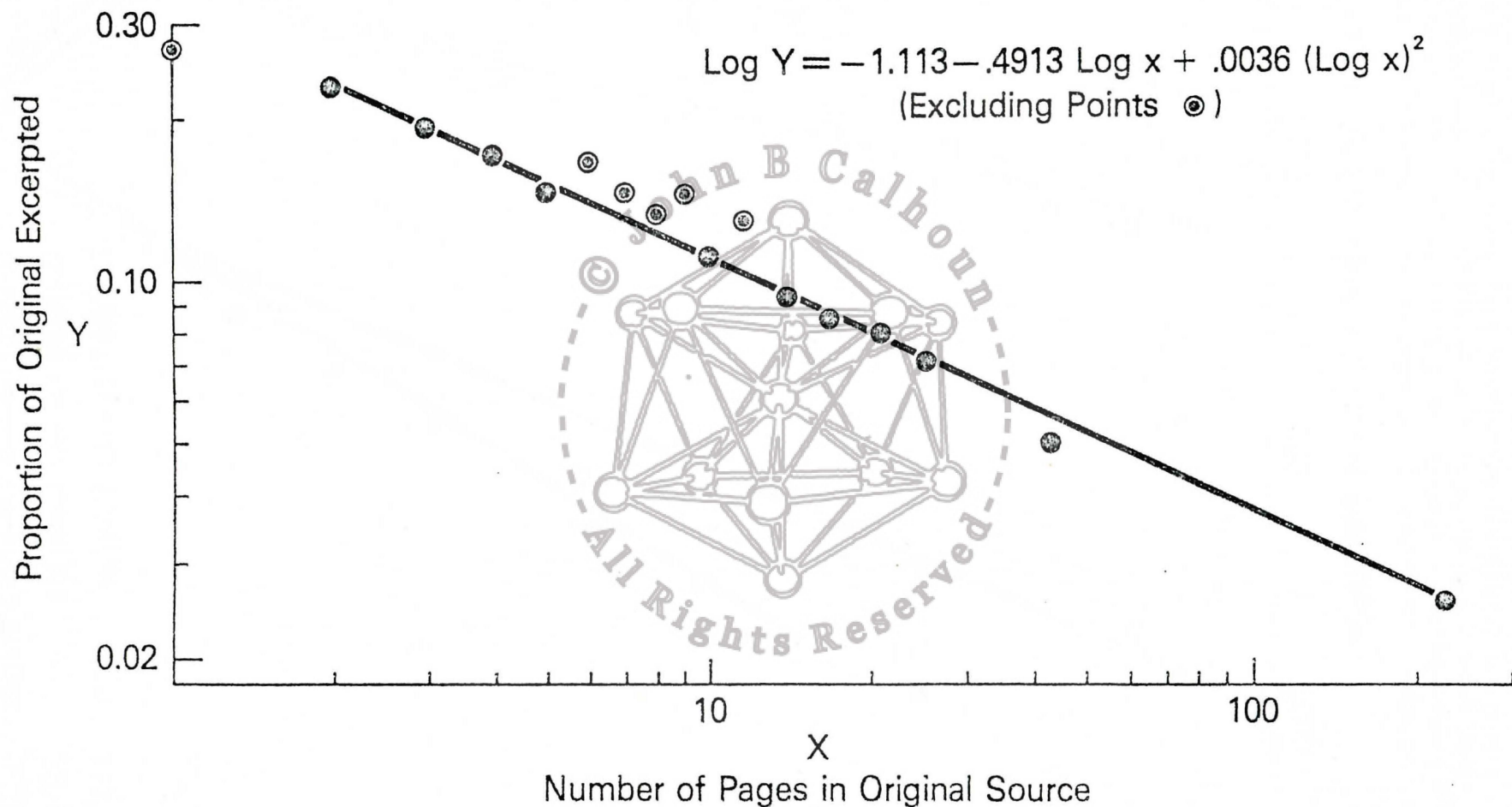


Fig. 8. Condensation of thought by selecting passages most pertinent to a particular domain of concern, in this case representing the 3216 excerpts forming the anthology on population and mental health shown in the dashed line of Fig. 7. By this selectivity the anthology was reduced to 10% of the original sources. Furthermore, the smaller the proportion of longer sources judged to be pertinent to the particular domain of concern suggests that the longer the source, the more domains of concern are encompassed.

I had often wondered about the implication of the SSF. Were the rat a person, particularly considering my own personal experience, I would infer a state of "day-dreaming", a mulling over of prior experience. Most experience involves motor components of behavior. Therefore, I wondered if the rat in its SSF "day-dreaming" state could be neurologically processing motor behavioral experiential states -- but without involvement of any motor components in their expression. If this was happening the rats could be said to be thinking. To test this notion we asked the computer to assemble the total durations of every sequence of motor behavioral states intervening between any pair of SSN or SSF. These durations were termed "Simulated Short Sleeps", SSS. As shown in Fig. 5, the slopes of SSF and SSS are nearly identical. This similarity is taken as presumptive evidence that rats engage in reflective thinking.

If this latter line of reasoning depicts reality one may suspect that thinking has a long pre-human lineage of development, and that its human expression obeys all the properties of behavioral states of other animals. Written paragraphs may be taken as concrete examples of human thought behavioral states. The solid line in Fig. 7 represents such a sample. It is based on 3219 paragraphs identified as introducing a particularly cogent idea as part of the development of an anthology on population and mental health. The fact that an exponential equation describes most of the distribution, and a p' can be calculated, leads to the conclusion that written paragraphs represent a thinking behavioral state.

It may be noted that there is also a reduction of the shorter length (duration) paragraphs. This results from the operation of the CNS p'' probability function. When there is a need to increase the average duration of a behavioral state, the CNS brings p'' into operation. p'' is the probability that p' will function. When the behavioral state, for which there is a need for its longer persistence on the average, is initiated, p'' has a low value, and thus more short durations are inhibited. The longer

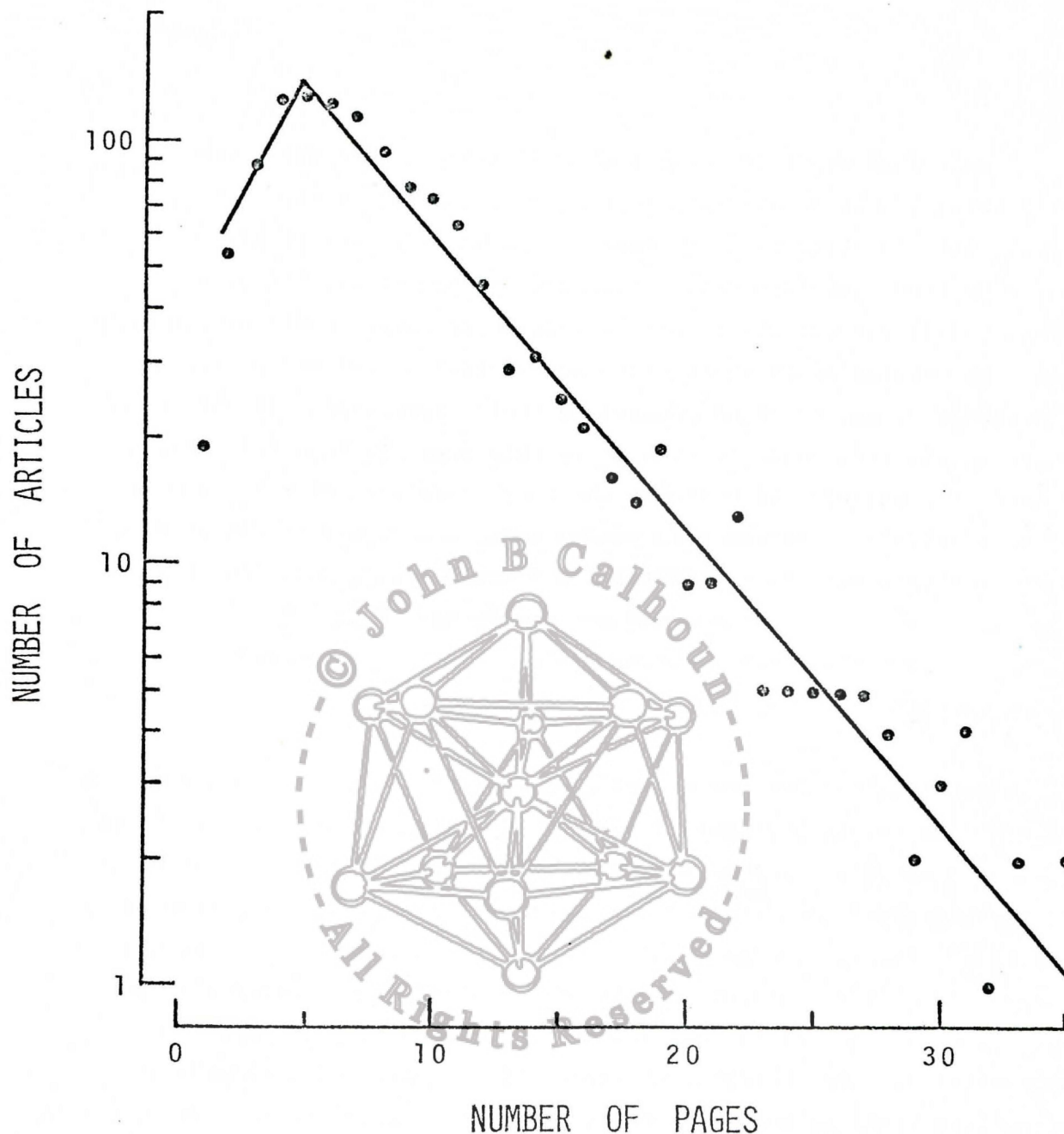


Fig. 9. Scientific articles as behavioral states formed by the concatenation of paragraph behavioral states. Data from 210 searches of the National Library of Medicine Medline data base to select sources appropriate to a 4-concept domain of concern, Psychological and Sociological Consequences of Population and Environment. All searches demanded that selected articles be indexed by descriptors in 3 or 4 of the four concept categories forming the domain. Selected articles represented 0.0077 of the data base.

the state happens to persist the larger p'' becomes and the fewer short durations are inhibited. At the inflection of the curve $p'' = 1.0$ and p' fully functions. We shall not in this paper be further concerned with the inhibition of short duration behavioral states.

In the development of the above mentioned anthology, artificial paragraphs, termed "excerpts" were constructed by connecting (concatenating) highly selected sequential passages across 1 to 10 of an author's original paragraphs. It may be noted that all of these excerpts read smoothly. The dashed line in Fig. 7 reveals that these excerpts are also behavioral states, they result from one brain's function (mine) entering that of another's to produce a more meaningfully compacted or condensed behavioral state. Such inter-brain interaction, focused on a particular domain of concern, operates in an orderly manner (Fig. 8). The longer the source being excerpted, the smaller the proportion of it found to be pertinent to a restricted domain of concern. We can gradually see that there are basic principles emerging which can guide the selection and metabolism of an extra-biological brain memory data base.

In the above process, new excerpt behavioral states are assembled from components of paragraph behavioral states. This exemplifies the general principle that any longer duration behavioral state is always composed of sequentially ordered examples of shorter duration behavioral states. If this principle holds, then it follows that collections of paragraphs assembled as scientific articles or chapters in books should form behavioral states having all the expected properties. To test this expectation a complex search matrix strategy was utilized to computer select articles most likely relevant to a four-concept domain of concern (Fig. 9). It resulted in selection of less than 0.8 of one percent of the total citation data base. The number of articles recovered as a function of their duration (length in pages) conforms to expectation that multi-paragraph articles represent behavioral states. This leads to an important inference:

ASSESSMENT OF CREATIVITY

SPECTRUM NO. ^{1/}	CHARACTERISTICS		
	A	B	C
	RESPONSE PROPERTY	AESTHETIC RESPONSE	PERSONAL QUALITY
1	NOVELTY	SURPRISE	ORIGINALITY
2	APPROPRIATENESS	SATISFACTION	SENSITIVITY
3	TRANSFORMATION	STIMULATING	FLEXIBILITY
4	CONDENSATION	SAVORING	POETIC
5	CONJUNCTION	EUREKA	SERENDIPITY
6	CONSENSUS	ASSURANCE	PERSISTENCE

^{1/} Spectra 1 to 4 from Jackson and Messick
Spectra 5 and 6 from Calhoun

Fig. 10. Characteristics appropriate to the assessment of creativity. These serve as criteria for making judgements relative to construction of data bases of thought behavioral states. It is essential that such a judgemental process apply to: (a) selection of original sources; (b) selection of concept descriptors for concept associational indexing.

If a sufficiently large extra-biological brain memory storage of selected excerpt type paragraphs is developed it should be possible to develop techniques and programs to simulate biological brain function to select and sequence such excerpts into manuscripts that function as higher order thought behavioral states.

III. Development of Operational Prostheses Brain Systems

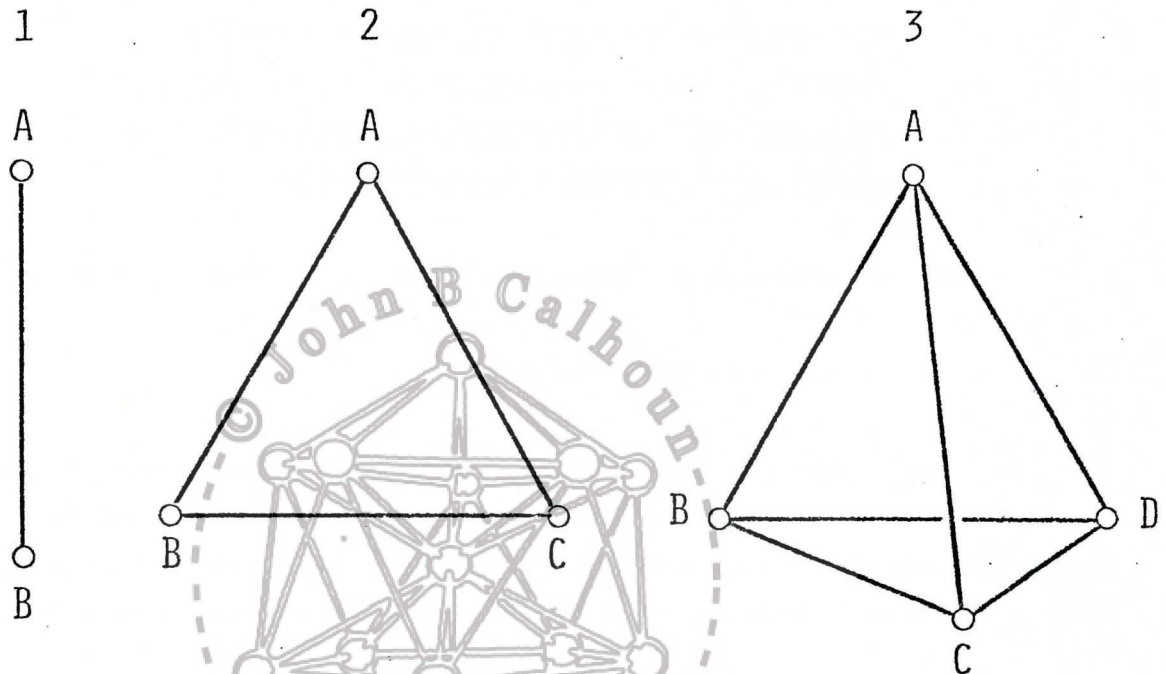
1. Assessment of Creativity

Up to this point in this paper we have been concerned with theoretical constructs necessary to appreciate the time course of the knowledge transition and thought as a behavioral state. We now shift to considerations of developing and utilizing thought behavioral state memory data bases.

We are in an evolutionary phase-shift crisis whose resolution requires that we humans assume responsibility for further increase in negentropy on earth. Directly or indirectly, such increase in negentropy can only follow further increase in knowledge. Prosthetic brain systems, linked mutualistically with humans, will likely be the major means for promoting such increase in knowledge. Effectiveness of prosthetic brain systems depends on whether their formation and use reflect creative processes. Fig. 10 and the Appendix summary of the 18 components may serve as a guide to the selection of excerpts for inclusion in the data base and the programming for selective retrieval and sequencing.

Creativity, as here viewed with respect to knowledge increase, has polar opposite representations, Spectra 1 as 6 in Fig. 10. We all recognize novel products as possibly creative. However, it is just as creative to explicate precisely what the consensus may be regarding

DOMAIN SELECTION



e.g. 1 = POPULATION - MENTAL HEALTH
 2 = ADAPTATION - POPULATION - ENVIRONMENT
 3 = PSYCHOLOGICAL & SOCIAL (CONSEQUENCES)
 OF POPULATION & ENVIRONMENT

Fig. 11. Selection of conceptual domains of concern. Two or more major conceptual points of focus (A to D nodes in figure) are essential to provide opportunity for interaction among concepts. More than four primary concepts for focus diffuses domain clarity too much. Domains 1 to 3 encompass the present author's research data bases developed during the past 15 years.

a particular topic of concern and the implications this consensus may have. I have conducted several crude simulations of brain function to assemble "multi-authored" original manuscripts from a 6,000 excerpt, 500 author, data base. Such a fabricated manuscript of 30 to 50 excerpts may represent the thoughts of 25 to 40 authors, and a consensus among them may be apparent, even when none of them could even delineate the problem for which they as a collective provided a consensus. It has been my impression from delving into this prosthetic brain data base that one gains a several year advantage in recognizing that there is a consensus about the character of an emerging problem, its parameter, as well as possible directions for for its solution.

2. Domain Selection and Data Base Construction

A domain is a restricted area of concern through which one may search for appropriate sources from which excerpts may be extracted. However, to be fruitful -- at least two broad conceptual areas must be brought into conjunction, brought into a confrontation with each other. My experience suggests that the limits of practicality are attained by a domain having primary focus on the interactions among four broad concepts (Fig. 11).

This generalized formulation is extremely important. It embodies the essence of a creative process subsumed by creativity spectrum No. 5 in Fig. 10. When Remer (1965) reviewed the history of the word "serendipity", it appeared to me that there was an incompleteness in everyone's attempt to conceptualize what appears to be a real creative process. Ten years later, while reflecting on the course of my own life in research (1977), the roots of my own creativity become apparent. For reasons still unknown to me, my habit has been to follow two to four only partially related paths of inquiry at any one time. When I looked back at the

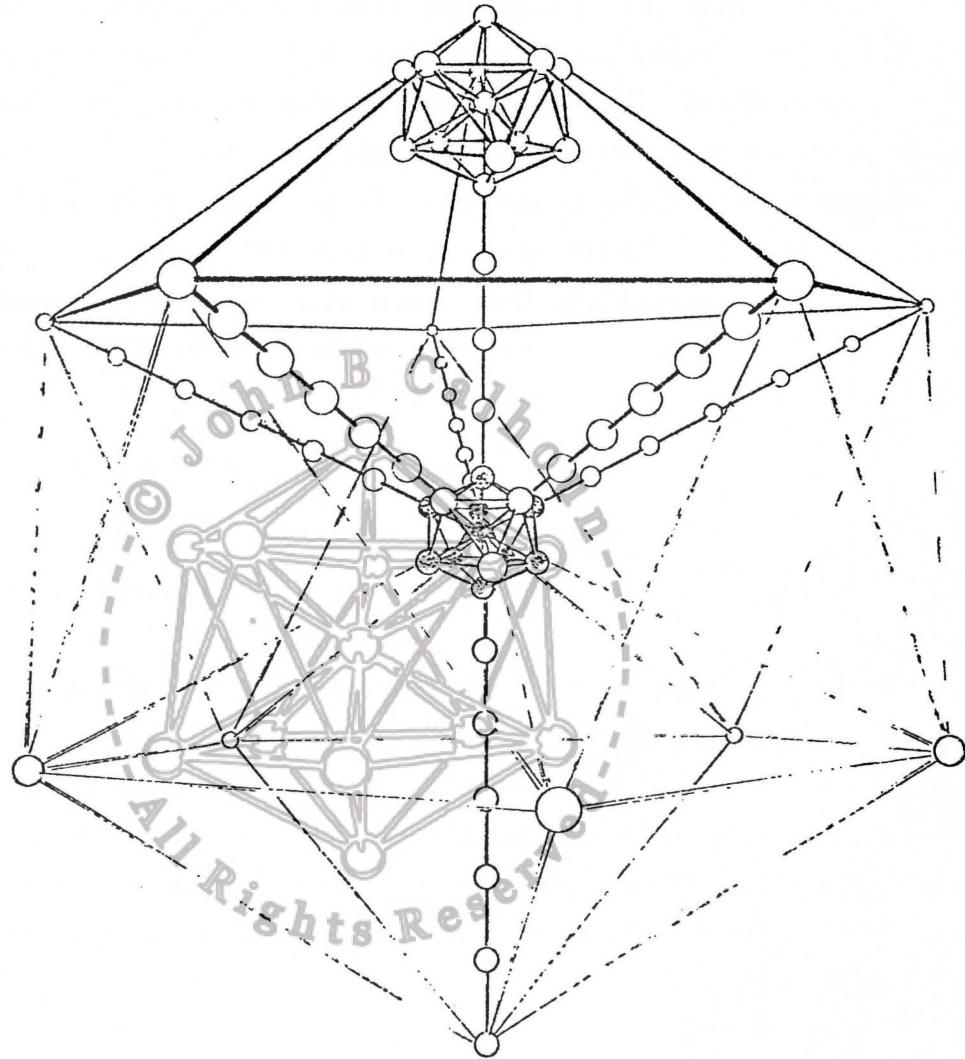


Fig. 12. Schematic representation of the interconnectivity within the brain of experientially known concepts. There are approximately 1625 nodes in this 8-level (7-steps of differentiation from the center) network. The 7 steps from the center represent evolutionary refinements in conceptual differentiation. From an operational, simulation of biological brain function, perspective each of the 1625 nodes may be considered as a repository for all thought paragraph behavioral states which include the concept which that nodes represents.

origin of particularly cogent insights, it nearly always happened that there had been a temporary convergence between at least two research paths. The insight would not have developed had each path been assiduously followed for a while irrespective of the other. This is what a good excerpt data base should provide -- an opportunity to follow two or more routes through it until important conjunctions between them occur. Starting off with two to four broad concepts, which might be anticipated to interrelate, increases the likelihood that excerpts relating to them will truly stimulate creative conjunction.

Sources screened: The person who assumes responsibility for selecting sources for excerpting must be fairly knowledgeable in the domain of concern, but not necessarily an expert in all its facets. No precise figures can be presented at this time. All I can say from my own experience is that enough sources should be screened so that those finally selected should represent only between 5% and 1/2 of 1% of those initially examined. Furthermore, the excerpts should represent less than 10% of the sources selected.

This process culminates in a very rich data base. As it accumulates one gets the impression that it takes an ever larger number of additional excerpts to introduce a significant enlargement of scope. Presently I estimate that 5,000 excerpts will very well represent a domain of concern that reflects thought over a 3-year period. Such a rich source cannot be effectiely mined without a condiderable additional effort.

3. The Experiential Concept Network

Very early (1966) in this effort it became apparent that every excerpt must be indexed by pairs of concepts whose treatment in the context indicated close association. Author's own words were utilized to avoid my introducing biases. However, in many excerpts an author utilized

A 9-CONCEPT PRODUCING NETWORK

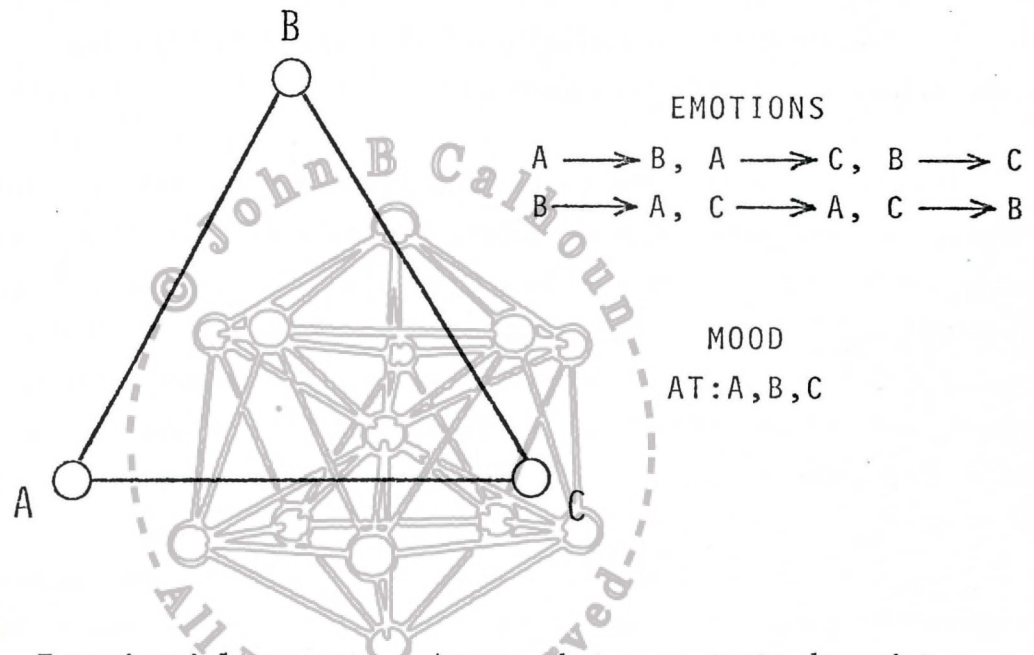


Fig. 13. Experiential concepts. Assume that a separate descriptor word can be selected to denote the conceptual implication of being near each of the 1625 nodes represented by Fig. 13. Let A, B, and C in the present figure represent any three neighboring nodes. Shifting attention from one node to an adjoining one clothes the concept with a change-of-state emotional quality. Likewise any delving into the thought behavioral states at a node represents a steady-state mood. Such modification of concepts by mood and emotion enlarge the experientially knowable conceptual vocabulary to an excess of 20,000 (not including the knowing of things). This size vocabulary characterized the pre-verbal level of human evolution and its utilization, whether verbalized or not, is essential to the acquisition of more rational knowledge.

two or more words of very similar meaning in an attempt to convey intent. My original purpose in doing this was just to develop a collection of clusters of words with shared meaning. This would enable retrieval of all excerpts that included some emphasis on the conceptual area encompassed by each cluster. About 10,000 such pairs of terms having shared meaning were identified. These included duplications of many pairs.

Attempts to identify clusters of words with closely shared meaning revealed that all such concept designating words formed an extended 3-dimensional network. One could follow a route through the network from any particular concept to any other one through a period of gradual changes in meaning. No attempt was made to develop a rigorous definition of "concept" for use in selecting descriptor words. Rather, it was decided that they should reflect processes, consequences and qualities. Words denoting the things, and their attributes which establish a specific context of a process, were avoided.

Our efforts to determine the relational structure of the concept network led to working with a center point icosahedral extended network (Fig. 12) as the best initial approximation for modeling purposes. The centermost concept proved to be "TRADITION" in the sense of process which assures survival under normal conditions. Outward from the center seven steps of gradual transition in meaning occur. Then the network bends back on itself to form a closed system. The seven outward steps are presumed to define seven stages of biological brain evolution, successively increasing conceptual capacity and ability to store memory traces of experience with greater discrimination and detail.

1625 conceptual nodes suffice to form the network. We have not yet completed the assignment of words to denote the conceptual emphasis at each of the nodes. However, we have been able to determine the general character of the six axes as well as the approximate nature of the concept network. A network such as this has both theoretical and practical implications.

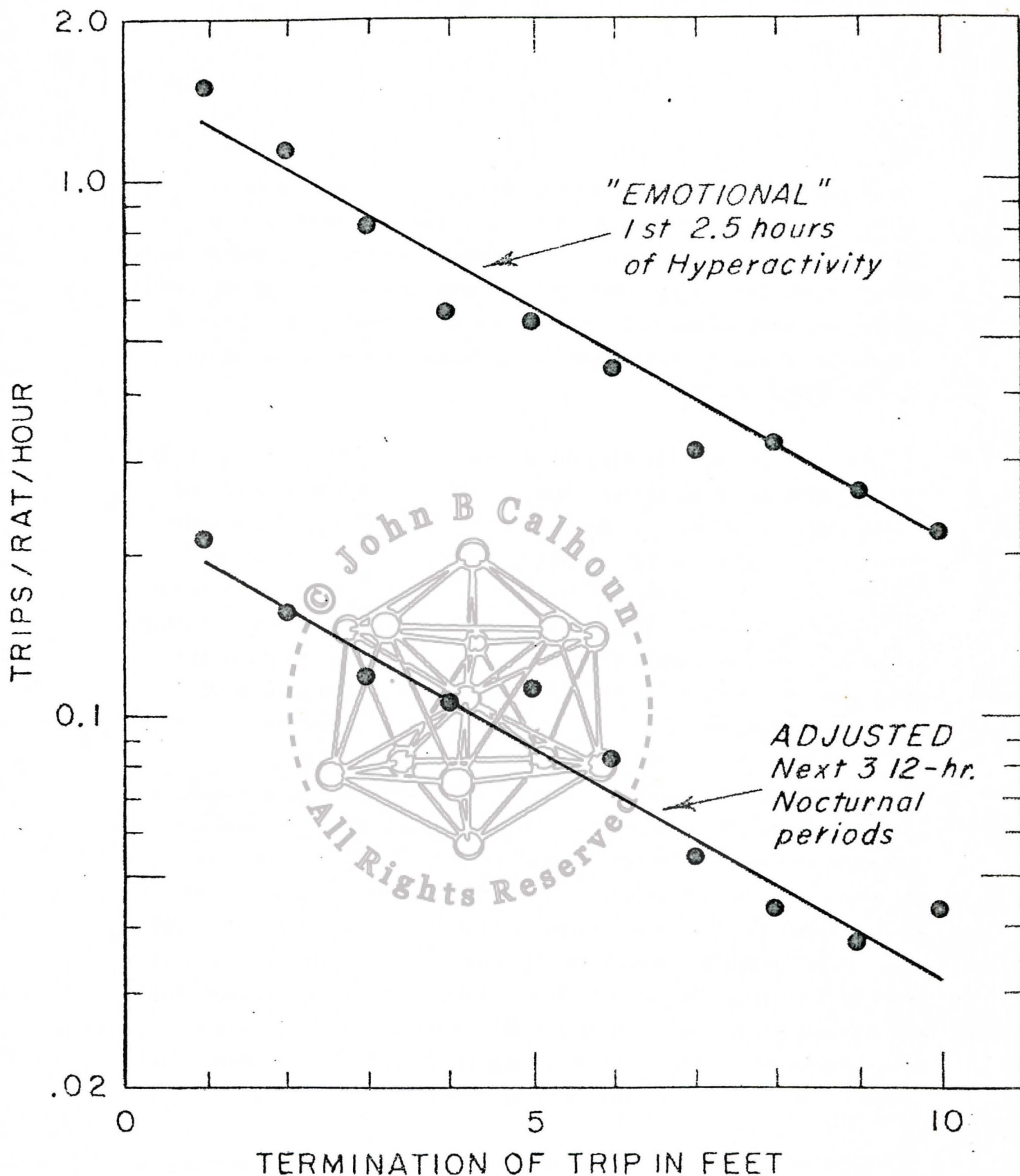


Fig. 14. Emotional hyperactivity to exposure to a novel environment. The fact that these two curves are parallel denotes an invariance in the p' probability that governs the duration of such activity. However, the increase in the number of diffuse motor behavioral states denotes that exposure to novelty increases the $\hat{p}$ probability of such states at the expense of reduction of inception of other behavioral states. Normally $\hat{p}$ declines to a usual level over the next 2.5 to 3.5 hours following initial exposure to the novel situation. Such an increase and decline in $\hat{p}$ is requisite to full incorporation of the experience.

Theoretical implications: If the seven steps (8 levels) do reflect evolutionary development within mammals at least, then it follows that what we are terming concepts reflect categories of experience that do not require verbal accompaniment for either their retention or utilization in thought. Furthermore, the 8th level, should represent the final increment in experiential conceptualization attained by the genus Homo prior to the superimposition upon it of the capacity for verbalization. Total experiential conceptual vocabulary, however, is about 20,000. Consider any three neighboring nodes A, B, and C (Fig. 13). Perusing the contents of a node represents a steady state mood. Shift from A to B or C represents a change in mood, that is to say an emotion. Since there is the possibility of moving from each node to any of its 12 adjoining nodes (except for the peripheral nodes which have fewer neighboring nodes) the total experiential concepts must be somewhat under $13 \times 1625 = 21,125$. The actual vocabulary of most advanced pre-verbal animals must be considerably above this when there is added all the ideosyncratic things and their attributes of which each animal has recurrent experience.

There is a large component of affect (mood and emotion) (See Figs. 10 and 13) in the incorporation of experience and its utilization thought. This particularly applies to novel experience (Spectrum 2, Fig. 10). Jackson and Messick say (1965, p. 317): "Confrontation with an unusual object or event characteristically evokes surprise in the viewer. ... and requires a period of adaptation during which the unusual object or event is assimilated into the viewer's experience." This same process applies to rats. Exposure to a novel situation evokes hyperactivity (Fig. 14) expressed as increase in $\hat{p}$, here the probability of initiating episodes of locomotion, rather than altering p' -- the probability of terminating activity. Such episodes of increased activity decline to normal levels of activity in 2.5 to 3 hours. Interruption of this decline, particularly by exposure to another novel situation, blocks the incorporation into memory of both experiences.

SUPRA-GENERIC CONCEPT USAGE

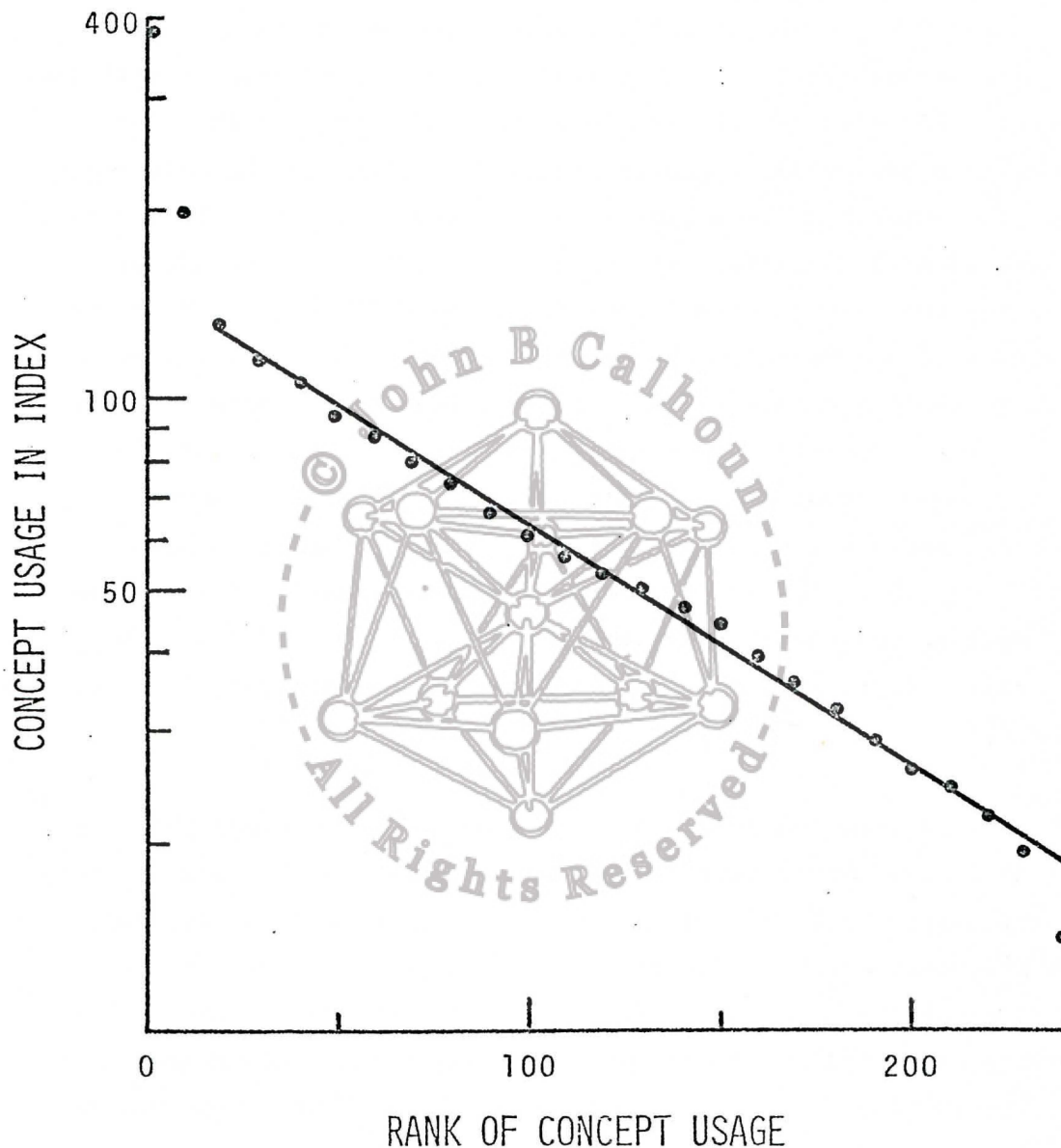


Fig. 15. Differential numerical importance of supra-generic concept descriptors in the Adaptation-Population-Environment domain data base. The over 2,000 descriptors selected from usage by the several authors were reduced to 242 by computer programs that considered their frequency of usage and their sharing of meaning. These 242 supra-generic concept descriptors were used to construct a concept associational index to source paragraphs as shown in Fig. 16.

4. Practical Development of a Brain Prosthesis

The network model of Fig. 12 can also be considered as a set of numbered repositories (nodes) for filing excerpts and similar products of human thought. The number of the node would define its topographical position with reference to other nodes. Search programs could then be written to take specific travel paths, along which excerpts would be sampled from the nodes passed. Such sampling requires that each excerpt be indexed in depth.

Concept associational indexing: The average excerpt can be fairly well represented by four pairs of concepts, for which their usage in context makes a firm intent by the author quite clear. These, permuted and alphabetized, form a utilitarian index to guide selection of excerpts. And the separate concept terms define the nodes in which each concept is to be "deposited". One copy of each excerpt is deposited in the node location of each concept occurring in the associational index applicable to that excerpt.

Unless the data base is very large it may be necessary to clump concepts to obtain a fewer number. The necessity for this lies in the fact that, were a data base to include all 1625 basic concepts, there would be over a million different concept associational pairs. Our concern for the present is to increase the utility of data bases of about 5,000 excerpts.

We developed a practical solution to a data base of 2,500 excerpts. We set up a computer file of "equivalences" (i.e. two words that share meaning) for words occurring in the original associational index that used author's own words only. A rank-ordered frequency count was made of the over 2000 different words in this index. The 242 words of highest frequency of usage were selected for use in the index. Another computer program then pooled a few of the many remaining concepts with each of the 242 selected concepts. Results are presented in Fig. 15.

*KNOWLEDGE

[EPISTEMOLOGY, MAN-KNOWLEDGE, SOPHISTICATION, WISE]
 ACT 5-5-2, 5-5-14, 7-5-1, ANALYZE 5-10-6,
 APPROACH 5-7-8, FOUND 4-2-4, 13-3-1, CHOICE 2-13-1,
CHOICE 2-13-4, 2-13-8, 2-13-13, 6-10-11,
 CLASSIFY 5-5-1, COGNITION 12-6-10,
COMMUNICATE 5-10-1, 8-8-12, 13-3-1, COMPLEX 5-6-2,
 CONSCIOUS 2-10-2, CONTROL 2-12-11, COOPERATE 5-5-8,
 CREATE 5-5-11, CRISIS 10-3-10, DECIDE 2-4-7, 9-8-11,
 DESIGN 2-13-11, 5-5-2, DESTROY 5-13-9,
 DIGNITY 8-12-5, EARLY 7-6-8, ECOLCGY 2-13-8, 5-5-1,
 ENHANCE 5-5-6, ENVIRONMENT 2-1-18, 9-6-2,
ETHIC 2-13-11, 2-13-14, 5-10-13, EVOLVE 5-5-15,
 EXIST 5-10-8, EXPECT 5-5-6, FAIL 5-10-7,
 FEEDBACK 10-5-1, FIT 5-5-6, FUTURE 12-10-7,
 GOAL 6-10-3, 8-7-5, 12-14-18, GROW 2-13-13, 13-12-2,
GUIDE 2-1-4, 10-2-10, HIERARCHY 2-1-4, 2-1-8,
 HUMAN 5-5-4, IMAGE 5-2-5, INADEQUACY 2-3-3, 2-10-2,
INCREASE 5-6-1, 5-6-3, 9-6-9, INFORMATION 2-9-2,
 INFORMATION 5-7-8, INTEGRATE 7-13-4, 12-11-9,
 ISOLATE 5-5-14, LACK 2-10-4, 8-10-5, 10-13-18,
 LEARN 7-5-4, LEVEL 5-5-16, LIMIT 2-10-3, 7-11-3,
 LONG-TERM 5-5-9, LOSS 10-12-13, MAN 5-5-4,
MEANING 2-7-5, 8-1-9, MIGRATE 6-10-2, MODEL 9-6-1,
 PATHOLOGY 2-13-3, PERSONAL 5-2-5, PHEROMONE 13-7-8,
 POLICY 5-6-1, POLITICAL 6-9-4, POPULATION 5-5-14,
 POTENTIAL 9-2-9, POWER 5-5-3, 5-5-14, 8-8-12,
PROBLEM 2-1-18, 5-5-9, PROMOTE 5-10-11,
 REALITY 2-10-2, RECOGNIZE 5-5-10, REDUCE 5-10-7,
RELATION 2-1-11, 5-5-10, RESEARCH 5-4-5,
RESOURCE 2-13-10, 4-8-14, 13-12-2, RULE 5-7-9,
 SATISFY 6-11-3, SELF 9-6-6, SETTING 2-1-5,
 SHARE 8-8-12, STRUCTURE 2-1-18, SUCCESS 5-5-7,
 SYSTEM 5-5-11, TECHNOLOGY 7-5-9, TERRITORY 5-5-14,
TERRITORY 8-1-11, 11-10-19, 12-11-5, THEORY 5-2-5,
 THEORY 5-5-7, THREAT 5-5-4, VARY 11-12-16,
 WORLD 4-1-9,

Fig. 16. Example of a supra-generic concept associational index. Hyphenated numbers identify paragraphs. These paragraph numbers may be utilized to retrieve full text by computer programs. Underlined words associated with "knowledge" represent concept associations for which the data base contains at least one paragraph from each of two authors. Such comparisons provide a basis for both stimulating creative thought and developing an understanding of consensus of thought.

Concept words of ranks 1 to 19 exhibited an exceptionally high frequency, probably by the bias introduced in the short paragraph I wrote, including most of these words, prior to assembling this domain of excerpts to provide a guide to its assembly. The exponential decline in the frequency of the remaining supra-generic terms suggests that the lower the frequency count of a word the farther it lies from the center of the domain.

A printed associational index (Fig. 16) was prepared so that anyone could explore the utility of the present philosophy for developing conceptual prostheses to the biological brain. Underlined words denote associations including excerpts from at least two authors. Such entries present enhanced opportunity to perceive either novelty or consensus of a conceptual relationship.

A really good experimental data base, would consist of 13 domains, each of 5,000 excerpts (Fig. 17). Only after their completion could one determine their exact relational positions to each other according to this model. However, judicious selection of 13 domains could insure that the final product encompassed many of the salient issues of our time.

A 13-DOMAIN STRATEGY

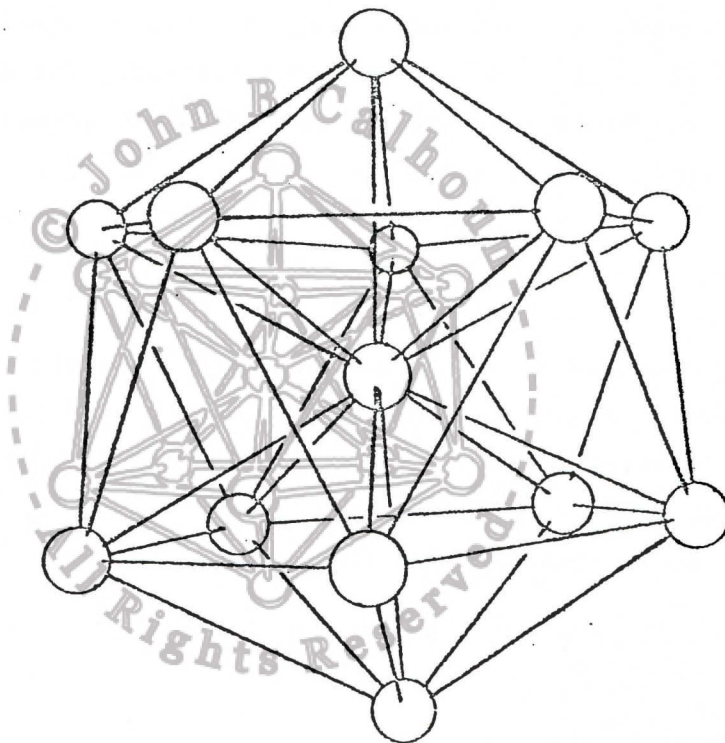


Fig. 17. A 13-domain strategy for developing an initial operational prosthetic brain knowledge retrieval system that encompasses all major human concerns. Each domain (see Fig. 11) should contain at least 5,000 highly selected excerpt paragraphs. Thus the basic data base, exclusive of associational indexing, would contain between 8 and 13 million words.

APPENDIX: Expansion of Fig. 10: Characteristics re Assessment of Creativity

A: Response Property

1. NOVELTY (unusual)
 - infrequent re norms or expectations
2. APPROPRIATENESS
 - fits its context
 - meets intention
3. TRANSFORMATION
 - of reality to overcome restraints
 - high in heuristic value
 - create new forms
4. CONDENSATION
 - intensity & concentraton of meaning
 - requires contemplation
 - full implication delayed
 - multiple interpretation
 - unites simplicity & complexity
5. CONJUNCTION
 - An $A \times B = C$
 - meeting of related paths of inquiry
6. CONSENSUS
 - agreement among minds
 - emergence of tradition

B: Aesthetic Response

- SURPRISE (evoked)
- requires adaptation period for assimilation into the viewer's experience
- SATISFACTION (comfort)
- product is just right, complete and sufficient
- STIMULATING
- alters conventional perception of world
 - the product changes the environment
- SAVORING
- worth pondering
- EUREKA
- piloerection
 - intellectual orgasm
- ASSURANCE
- protection from a threatening world

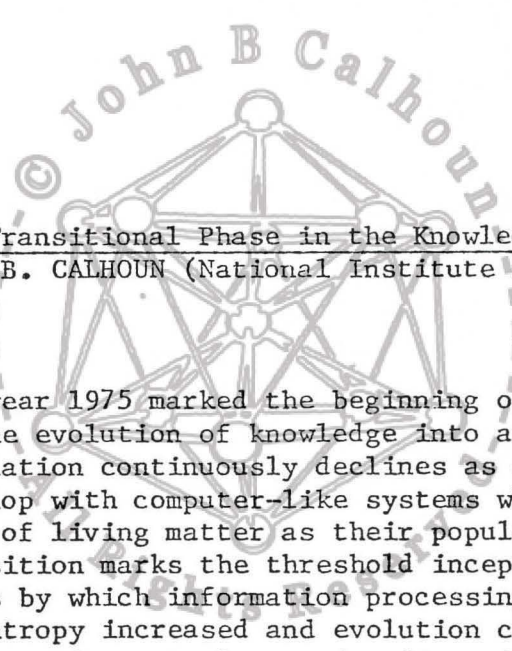
C: Personal Qualities

- ORIGINALITY
- tolerance of ambiguity
- SENSITIVITY (to environment)
- analytical-intuitive mix of attitude
- FLEXIBILITY
- fluidity of conceptual systems
 - transcends traditional boundaries
 - openmindedness
 - playful attitude toward reality
- POETIC
- fusion of contradictory qualities
 - fusion of thought & feeling
 - unification of things thought of as separate
- SERENDIPITY
- travel several routes
 - multiple personality
 - live in several worlds at the same time
- PERSISTENCE
- searches for a "home"

THE HUMAN KNOWLEDGE PROCESS: An Evolutionary Dilemma

William Gray, M.D.

Aristide H. Esser, M.D.



The Transitional Phase in the Knowledge Evolution.

JOHN B. CALHOUN (National Institute of Mental Health)

The year 1975 marked the beginning of a 200 year transition in the evolution of knowledge into an era when the human population continuously declines as commensal relations develop with computer-like systems which assume more properties of living matter as their population increases. This transition marks the threshold inception of the 8th major means by which information processing is enhanced, and thus negentropy increased and evolution continued. These means are genetic control, species diversification, systems complexification, brain and learning, "velocity" (i.e. access to information), linkage into communication networks, information prostheses, and prosthetic systems. The generic concept "brain" encompasses all 8 processes. A computer simulation, based on observed data and theoretical constructs, reveals the transition between the increase of human population and that of the increase in the population of prosthetic systems. One overriding process demands our attention in order to ease our way through this transition. It is to develop operative information prosthetic systems which simulate biological brain function in selecting and sequencing human thought. Written paragraphs represent behavioral states. Theoretical models, and aspects of a partially operative system will be presented to demonstrate one strategy for producing the needed commensalism between human brain function and prosthetic brain function.