"NEGENTROPY AND THE CONCEPTS OF FREEDOM, DEMOCRACY AND JUSTICE."

The news of the death on May 30th of physicist Dr. Leo Szilard, pioneer in the development of the atomic chain reaction, and ardent worker for the cause of world peace, led the author to review the potential impact of another development in physics in which Dr. Szilard was also a pioneer -- namely the relationship between entropy and information.

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"Negentropy and the Concepts of Freedom, Democracy and Justice."

Introduction

This study is an examination of the usefulness of a concept "negative entropy" or as it is sometimes abbreviated "negentropy" -- from the physical sciences in bridging the gap bwtween the two cultures of "humanities" and "sciences." This material is offered as a "thematic hypothesis" (1) on the the usefulness of the concept of entropy as a tool of potential value to applied social scientists. The results of this paper do not constitute a proof, but only show plausibility that this concept of negentropy can be used as a guide to help mankind direct our social organization of man toward "maximizing negentropy" to come closer to fulfilling Albert Schweitzer's concept of "reverence for life."

To test this "thematic hypothesis" is a formidable task, which will require the patient cooperation of many social scientists, physcial scientists, and concerned laymen. I do not expect that these hypotheses can be proved, but that our path of testing will be similar to the history of the testing of Einstein's Special Theory of Relativity. Namely that social scientists will apply these concepts to many observable phenomena and see which hypotheses are consistent with known phenomena, similar to the way physicists have compared a set of hypotheses regarding the relationship of electromagnetic fields and moving frames of reference and found that Einstein's Special Theory of Relativity was the only hypothesis consistent with all experiments.(2)

The possibility that entropy from thermodynamics might belong both to the family of measureable quantities of science and the family of values such as beauty and melody was suggested in 1928 by Eddington.(3) At the same time Leo Szilard was thinking about the quantitive relationship between the entropy lost by a gas and information gained by a hypothetical "Maxwell's demon," (4) opening and shutting the door between two compartments to separate the high- and low-energy particles of a gas.(5) Dr.Szilard's paper was relatively unnoticed until the development of the mathematical theory of communication by Shannon (7) in 1948, which became known as Information Theory, and the partially overlapping concepts of Cybernetics developed by Norbert Wiener.(8,9)

In this paper I shall confine my discussion to the relavency of the concept of negentropy to some important concepts in our civilization, namely "freedom," "democracy," and "justice." I shall try to avoid the difficulties that Raimon Lull ran into at the beggining of the 14th century when he developed a rudimentary logic machine. Lull was not content to start mankind on the path of developing a logic machine which would be a very useful tool, but he let his enthusiasm run too far ahead and tried to use his logic machine to prove theological arguments. His tackling of theological arguments led to his being stoned to death in Bugia, Morocco, in 1315. (10)

Plausibility Arguments

Biological systems preserve or increase order, decreasing entropy in a limited domain (11), even though over a larger domain entropy is increased in accordance with the Second Law of Thermodynamics. The units of information are related to both the life

process and to negative entropy in thermodynamics. (12) Physically entropy can be defined as: $S = k \ln P$, [1] where k is the Boltzman constant, "ln" means logarithm of, and P is the number of elementary states in which the system can be in.

Negentropy*in Information Theory, a branch of electrical engineering and mathematics, in respect to a set of n messages is: $H = -(P_1 \ln P_1 + P_2 \ln P_2 + \ldots\ldots\ldots + P_k \ln P_k + \ldots + P_n \ln P_n)$ [2] where P_k is the probability of occurance of message k. For a basic discussion of these concepts see Colin Cherry, On Human Communication (6) or J. R. Pierce, Symbols, Signals and Noise.(13)

If we take the formula for information or negentropy of a set of telegraph messages or computer instructions and substitute a set of n philosophical systems (or political systems) in place of the n messages or instructions, the probabilities of occurence of the respective philosophies among the population of a country assumes a role analogous to the probabilities of occurence of the n messages.

If one philosophy is required as the official philosophy by order of a dictator and this philosophy is number "k," then:

$$H = -(0 \times 1 + 0 \times 1 + \ldots\ldots\ldots + 1 \times 0 + \ldots + 0 \times 1) = 0. \quad [3]$$

Thus the requirement that people adhere to an official philosophy is equivalent to a zero contribution to the negative entropy of the political system or the "life process" of the evolution toward a higher order of life. If we go back to equation [2] to

* The term "negentropy" was introduced by Leon Brillouin. (12)

see under what conditions there is a maximum contribution to the negentropy or "life process," we find when all P_i's are equal such that $P_i = 1/n$ is the condition for maximum H. Under these conditions $H = \ln n$. This corresponds to equal probability for each different philosophy, a condition approximating a democracy, provided that n is not so high that no decisions can be made by the country.

A List of Human Freedoms.

To assign a numerical value to "freedom" is a difficult task. There are many kinds of freedom, some of which are more valued than others. The ideal way to start this section would be to get some social psychologists to determine the relative weights to different types of freedom and the range of values to be expected in different political systems. Since such information is not presently accesible to me, I shall assume the following ten kinds of human freedom to have equal weight in order to obtain some trial calculations. See Table I for the list of freedoms.

I shall assign to each person a unit of "freedom," $F_i = 1.0$. If he is deprived of some of his freedom, his F_i becomes less than one, and the person or persons interfering with his freedom have F_i's greater than one. For example, if a dictator reduces the freedom of his subjects to 0.5 each and there are 100,000 people under his control then the dictator's freedom is $F_1 = 50,001$.

To obtain a measure of freedom that behaves like a probability function, we define a normalized "freedom" function,

$$G_i = F_i / n, \qquad [4]$$

where n is the population of the country sub-system. In the above case the normalized freedom for each subject is $G_i = 0.000005$ and that of the dictator $G_1 = 0.5$, i.e. the dictator has 100,000 times the freedom of a subject of his.

TABLE I. ASSUMED COMPONENTS OF HUMAN FREEDOM.

Number(j)	Description	Democratic Ideal' Value
(1)	Freedom of speech	0.1
(2)	Freedom of religion	0.1
(3)	Freedom to print, broadcast, televise and listen	0.1
(4)	Freedom to find sexual partner	0.1
(5)	Freedom to obtain education	0.1
(6)	Freedom from job discrimination on account of race, religion,or origin	0.1
(7)	Freedom to build or buy own home	0.1
(8)	Right to vote.	0.1
(9)	Right to trial by jury	0.1
(10)	Freedom to establish small business or farm	0.1
	Total F =	1.0

Negentropy As A Measure Of Democracy.

This analysis is a test of an hypothesis as to the analogy between "negentropy" and "democracy." At this stage it is incomplete, because of the lack of independent data. Our objective is to see,if replacing the probabilities of a set of messages by the normalized measure of freedom of the individuals in a social system will give a value of negentropy for the system which is a reasonable measure of the amount of democracy in the social system. If such a procedure gives a higher measure of democracy to a dictatorship than to an obviously democratic society, the hypothesis will have to be rejected. If however the resultant

measures of democracy fall into relative positions consistent with common sense concepts and with the more sophisticated analyses of political scientists and sociologists, we can accept the hypothesis until another hypothesis is found that gives better agreement with the available facts.

Using equation [2] and replacing H by D and P_i by G_i, we have:

$$- D = G_1 \ln_2 G_1 + G_2 \ln_2 G_2 + \ldots\ldots + G_k \ln_2 G_k + \ldots + G_n \ln_2 G_n. \qquad [5]$$

with the restraint that:

$$G_1 + G_2 + G_3 + \ldots\ldots + G_k + \ldots\ldots + G_n = 1.000 \qquad [6]$$

The subscript stands for a single individual unless otherwise noted. When a group of individuals are treated as a class without regard to individual performance, such as job discrimination on account of color, the subscript will refer to the group or class as a unit instead of to an individual. The negentropy measures of "democracy" for each of six hypothetical countries of 100,000 population each have been calculated and are listed in Table II.

TABLE II. MEASURE OF DEMOCRACY FOR SIX POLITICAL SYSTEMS.

(Calculated from average negentropy of a set of assumed distributions of freedom.)

Country	Type of Political System	Negentropy Measure of Democracy
A	Ideal democracy	16.61
B	Approximate democracy with 10% under-privileged group based upon individual performance	16.52
C	Partial democracy with upper & lower classes; classes based upon race, place of birth, etc.	13.90
D	Oligarchy of 12 man committee	6.31
E	Cast system	3.25
F	Dictatorship	2.98

Note: The assumed freedom distributions and sample calculations are included in Socio-Engineering Problems Reoprt No. 88-B, 12/27/63, available from P.O. Box 85, Campbell, Calif.

Examination of Table II indicates a general agreement between our theoretical calcualtions of negentropy with the relative degree of democracy one would ascribe by common sense to the different types of social organization. This means that we can seriously consider using the calculation of negentropy to evaluate social systems where we do not have good common sense references. However we would have to check more rigorously the method of computing the normalized "freedoms" G_i.

Another feature is that a democratic sountry like case B can have an appreciable portion of its population with seriously curtailed freedom, provided the restrictions are based on an individual basis related to individual performance and are determined by due process of law. For example having 10% of the population restricted in this way reduces the negentropy by 0.5%, while an equivalent amount of restrictions based on classification of people by race or national origin instead of individual performance reduces the negentropy by 16.4%.

Comparision of Countries E and F indicates that a rigid caste system or a one man dictatorship knock the negentropy down to one-fifth the ideal value. Another feature of interest is that a society run by a rigid set of rules can be almost as bad as a one-man dictatorship. This may also have relevance to centralized business and governmental agency accounting systems.

Another feature is that a substantial increase in negentropy results when a one-man dictatorship changes to a twelve-man oligarchy. This indicates the possibility of developing a more detailed measure of "freedom" to put into the negentropy formula to monitor changes in non-democratic systems to determine whether they are becoming more or less democratic.

Future Developments and the Concept of Justice.

A more fundamental limitation on the above procedure is that the measure of democracy is a static measure. It does not give a direct measure of the ability of the democratic state to maintain itself with time, i.e., to be able to protect itself agianst attack by a dictatorship. It is proposed that the present dictionary definition of "justice" be narrowed to form a concept of "dynamic-justice" which would include a measure of the ability of the system to preserve and increase its democratic properties over a period of time, say one generation.

The above definition of "dynamic-justice" requires a more complicated model than the single discrete communication channel used for the static definitions of "freedom" and "democracy." (For an elementary description of these communication channels see references 6 or 13.) For example Countries A through F could be considered as six communication channels in which each channel would have a noise signal derived from the other five channels. This would require the analysis of a complex network of feedback loops (Cybernetics) which are beyond the scope of this study. If the number of countries in the system were large and represented a random distribution of social organization, it might be possible to formulate the approximate effect with a gaussian noise model in a continuous channel.

A possible path to try to get a measure of "dynamic-justice" would be to investigate the correlation function of the normalized freedom function and the optimum freedom function predicted for maximizing negentropy of the channel under the given noise distribution.

Conclusions.

When these concepts are tested against more complete data by sociologists and political scientists, the use of negentropy as a measure of democracy could lead to a useful measure in dealing with domestic problems like civil rights, job discrimination, freedom of religion, and freedom of speech.

When developed further to the proposed concept of "dynamic-justice," the conditions of maximizing negentropy could lead to a useful measure in analysing international problems and in particular disarmament problems.

Although Drs. Leo Szilard, A.S. Eddington, and Norbert Wiener are no longer living, their scientific, mathematical and humanistic ideas continue to inspire the next generation of scientists to organize the struggle for a better, more human society.

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