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MATHEMATICAL PATHS IN THE STUDY OF HUMAN NEEDS

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CONTENTS

These papers by various members of the Romanian Team were presented at the GPID III Meeting, Geneva, 2-8 October 1978 and its continuation in Bucharest, 15-18 January 1979. They can be considered as a contribution to the Needs sub-project of the GPID Project.

Geneva, March 1980 Johan Galtung

They are being circulated in a pre-publication form to elicit comments from readers and generate dialogue on the subject at this stage of the research.

INTRODUCTION

> Development is fundamentally . . . about, by and for human beings. Development must therefore begin by identifying human needs. [Report on Human and Social Development, United Nations University, November 1975]

This work comprises four parts, besides this introduction, which describe several different directions of study in the mathematical approach to human needs, as developed by the Romanian Team within the Goals, Processes, and Indicators of Development project of the Human and Social Development Programme. Throughout these four parts mathematics is used both as an instrument and as a language. Sharing the same view of universal needs, the investigations found their common denominator in their methodological relationship with the Mallmann-Marcus approach to the needs problématique.

The sections are presented under the names of the authors in order to allow some flexibility of approach with respect to the increasing number of factors interacting with human needs through their dynamics, which are taken into account. Therefore, the first part deals with universal needs as pure theoretical constructs, defined with respect to illnesses. These are regarded in connection with desires and satisfiers only. The next part takes into account the interplay between universal needs and individuals, thus a new factor is added to the needs dynamics. In the last two parts, besides the factor "individual," which is defined in psycho-cybernetic terms, the needs existing as projections of universal needs and their dependence over time are investigated. In addition a new factor is taken into consideration: the social context. Accordingly, the interplay between universal needs, individuals, and social groups is investigated in order to make explicit the inner mechanisms of social evolution.

In the first part, "Algorithmic Procedures and Operational Characterizations for Needs Sets," Cristian Calude, Solomon Marcus, and Gheorghe Păun directly continue the work Empirical Information and Theoretical Constructs in the Study of Needs which inaugurated the Mallmann-Marcus approach. The authors propose an operational and algorithmic approach to the concepts of an independent set of needs, a complete set of needs, and a kernel of needs. Twelve ways of defining hierarchies of human needs with respect to these concepts are envisaged in order to explicate, besides the intrinsic properties, the contextual, relational, and operational properties of universal needs. All the concepts and results are then applied to the particular case of medical needs.

The second part by Marin Drăghici is "Subjective and Objective in Establishing Hierarchies of Needs." By pointing out the necessity of considering subjective aspects in the study of needs, the author claims that one should not trust, absolutely, general hierarchies of needs since, in many ways, they basically depend on the individual and on the stage of his life. Several criteria for establishing particular hierarchies of needs, depending upon the individual, are discussed. A mathematical model is used which results in a practical method which, for a given group of individuals, when rapid calculation devices are available, makes it possible to identify and order the needs on upper levels which are common to all the individuals of the group.

In the third part, "Needs Satisfaction and Behavioural Rules," Dan Romalo tries to analyse whether the desirable development of any human society could be aimed at a single general goal. The author aims at identifying an indicator able to represent, in a quantitative manner, the degree of satisfaction felt by a given individual in society. Then, some criteria against which a particular social state, or evolution, could be appraised if satisfactory as considered from a rational point of view are discussed in order to work out an axiomatic kernel from which all social behavioural rules could be derived in a purely analytical way. Finally, these ideas are generalized by the author in the last part of the work, "Desirable Dynamics for Human Development," by taking into account social evolution and its dependence over time.

As a report on the state of the art, this work is thus not a mere factual report. Each author, in turn, is trying to present a blueprint for the future of the mathematical study of human needs following the investigated and open directions. The tentative answers in the present work to some of the basic questions raised by needs research within the Goals, Processes, and Indicators of Development project should be seen as the authors' new contributions to the sub-project on needs, not as their final conclusions about the mathematical study of human needs.

I. ALGORITHMIC PROCEDURES AND OPERATIONAL CHARACTERIZATIONS FOR NEED SETS

Cristian Calude, Solomon Marcus, Gheorghe Păun

1. Introduction

The Mallmann-Marcus approach to the problem of human needs builds a conceptual framework having an explanatory power with respect to the relations between needs, desires, illnesses, and satisfiers. It also introduces the requirement of a more rigorous use of terminology. But, dealing with very abstract relations, we may ask to what extent their concepts and results are sufficiently operational to be used in concrete analyses of definite data. The aim of the present paper is to propose an operational and algorithmic approach to some of the most important concepts investigated in Mallmann and Marcus,[7] namely the concepts of an independent set of needs, of a complete set of needs, and of a kernel of needs. All these concepts belong to what is called in Mallmann and Marcus[7] the level of theoretical constructs in the study of human needs. This means that, to some extent, they have a conventional nature.

It is perhaps of some importance to point out twelve ways to define some hierarchies of human needs with respect to their belongingness to various kernels, to various independent sets of needs, and to various complete sets of needs. Three of these hierarchies are introduced in section 8, whereas the other nine hierarchies are defined in section 10. These hierarchies are strongly related to the dynamic, contextual, relational, and operational aspects of human needs rather than to their intrinsic properties. So, these hierarchies have very little in common with the already existing hierarchies proposed by various authors.

The reader can get a better idea of the significance of concepts and results discussed in this paper by looking at the examples concerning medical needs and illnesses, presented in the last paragraphs of the present paper.

2. Some Definitions and Conventions

We recall some definitions from Mallmann and Marcus.[7] Let S be the set of states of illness, partially ordered by a relation $<$ and let N be the set of (universal) needs. Let $g: N \rightarrow 2^S$ (2^S denotes the set of subsets of S) be a mapping which associates to each need n a set of states in S, namely, the states of illness whose avoidance requires the satisfaction of the need n. A need n such that g(n) is empty is called parasitic. If $N_1 \subseteq N$ (i.e., N_1 is included in N or equals N; for a proper containment we write $N_1 \subset N$), then

$$g(N_1) = \bigcup_{n \in N_1} g(n)$$

A state s in S is parasitic provided s does not belong to g(n).

In the following we suppose that the usefulness axiom (no need is parasitic) and the completeness axiom (saying that no state of illness is parasitic — see Mallmann and Marcus[7]) are fulfilled.

Let N_1 and N_2 be subsets of N. Following Mallmann and Marcus,[7] N_1 is dependent with respect to N_2 if $g(N_1) \subseteq G(N_2)$. The set N_1 is independent if no need n in N_1 is dependent with respect to $N_1 - \{n\}$, i.e., the set $\{n\}$ is not dependent with respect to the set of needs N_1 other than N; N_1 is complete if any need which is not in N_1 is dependent with respect to N_1. An independent and complete set of needs is called a kernel.

Our goal is to obtain some simple algorithmic procedures in order to determine the independent sets of needs, the complete sets of needs, and the kernels when S and N are known.

3. Characterization of Independent Sets of Needs

Let us observe that the function g is monotonous, i.e., for any A, $B \subseteq N$, if $A \subseteq B$ then $g(A) \subseteq g(B)$. It is possible to have two distinct sets of needs $A \subset B$ such that $g(A) = g(B)$, i.e., a set of needs can be dominated by a proper subset of needs. We characterize the independent sets of needs just using the negation of this property.

Proposition 1. A set $N^* \subseteq N$ is independent if and only if for any proper subset A of N^* the set g(A) is strictly contained in $g(N^*)$.

Proof. If N^* is singleton (contains only a single need) then the statement of the proposition is obviously true. Let us consider a set N^* with more than one element, and let $n \in N^*$. Suppose that $g(n) \subseteq g\ (N^* - \{n\})$; since $g(N^*) = g(N) \cup g(N^* - \{n\})$, it follows that $g(N^*) = g(N^* - \{n\})$. Since $N^* - \{n\} \subseteq N$, we get a contradiction. Hence, the set N^* is independent.

Conversely, let $N^* \subseteq N$ be an independent set of needs and let $A \subseteq N^*$. Let n in $N^* - A$. From the independence of the set N^* it follows that g(n) is not contained in $g(N^* - \{n\})$. Let us suppose that $g(A) = g(N^*)$. By the definition of g, we have: $g(N^*) = g(A) \cup g(N^* - A)$ and $g(N^* - A) \subseteq g(A)$. Since n belongs to $N^* - A$, we have $g(n) \subseteq g(N^* - A)$ and $A \subseteq N^* - \{n\}$, therefore $g(A) \subseteq g(N^* - \{n\})$. We have: $g(n) \subseteq g(N^* - A) \subseteq g(A) \subseteq g(N^* - \{n\})$, but this is not possible because it implies $g(n) \subseteq g(N^* - \{n\})$.

Remark. Proposition 1 shows that independent sets are exactly those sets N^* for which the satisfaction of no proper subset of needs is enough to face all illnesses we can face by satisfying all the needs in N^*.

Corollary 1. A set of needs $N^* \subseteq N$ is independent if and only if the restriction of g to the family of subsets of N^* is strictly monotonous.

Proof. The property of independence is hereditary (Mallmann and Marcus,[7] Proposition 1), i.e., any subset of an independent set is also independent. Let $A \subset B \subseteq N^*$. The sets A and B are independent; from Proposition 1 we get $g(A) \subset g(B)$. Conversely let A be a proper subset of N^*. Since g is strictly monotonous, by Proposition 1 we obtain $g(A) \subset g(N^*)$, i.e., N^* is independent.

4. Characterization of Complete Sets of Needs

Proposition 2. A set $N^* \subseteq N$ is complete if and only if $g(N^*) = g(N) = S$.

Proof. Obvious.

Corollary 2. If $N^* \subseteq N$ is complete and $N^* \subseteq N^{**} \subseteq N$, then $g(N^*) = g(N^{**}) = g(N)$.

Remarks. Proposition 1 and 2 above give a new way to find most of the results contained in the fourth paragraph of Mallmann and Marcus.[7] For instance, from Proposition 2 it follows that any superset of a complete set is complete. Proposition 2 also implies Propositions 6 and 7 of Mallmann and Marcus.[7] From Corollaries 1 and 2 it follows that no superset of a complete set is independent and no subset of an independent set is complete.

Corollary 3. Let N_1 and N_2 be subsets of N. If N_1 is complete, then $g(N_2) \subseteq g(N_1)$.

Proof. From the completeness of N_1 we get $g(N_1) = g(N)$; since g is monotonous, we have $g(N_2) \subseteq g(N) = g(N_1)$.

5. Characterization of Kernels

From Propositions 1 and 2 we obtain the following characterization of kernels.

Proposition 3. The set $N^* \subseteq N$ is a kernel if and only if $g(N^*) = g(N)$ and, for any $N^{**} \subset N^*$, $g(N^{**}) \subset g(N^*)$. In other words, a kernel is a minimal set (in the sense of the inclusion relation) which has the same power as N (modulo the function g).

We use the above characterizations in order to obtain algorithmic procedures for testing the properties of independence and completeness and for generating sets having these properties.

6. Algorithmic Test for the Property of Completeness

As inputs of our algorithmic procedures we take the sets N and S and the function g. In order to make them available for the computer, we must adopt a new codification of these data. For any $N_i \subseteq N$, we consider the matrix $A(N_i, S)$ having $p = \text{card}(N_i)$ rows and $t = \text{card}(S)$ columns. The generic element of the matrix $A(N_1, S)$, a_{ij}, is defined as

$$s_{ij} = \begin{cases} 0 \text{ if } s_j \text{ is not in } g(n_i) \\ 1 \text{ if } s_j \text{ belongs to } g(n_i) \end{cases}$$

Example 1. Let

$$N = \{n_1, n_2, n_3, n_4\}$$
$$S = \{s_1, s_2, s_3, s_4\}$$
$$g: \quad N \rightarrow 2^S$$

defined by

$$g(n_1) = \{s_1, s_3\},\ g(n_2) = \{s_2, s_3, s_4\},\ g(n_3) = \{s_2, s_4\},\ g(n_4) = \{s_4\}$$

The matrix A(N, S) is

1	0	1	0
0	1	1	1
0	1	0	1
0	0	0	1

Given a matrix $A(N_1, S)$ and an index j of one of its columns, we denote by $\alpha j[A(N_1, S)]$ the sum

$$\sum_{i=1}^{P} a_{ij}$$

The non-zero elements of the column j in the matrix $A(N_1, S)$ show the needs whose satisfaction is required by the state of illness s_j. Proposition 2 can be restated as:

Proposition 4. A set $N_1 \subseteq N$ is complete if and only if the product

$$\prod_{j=1}^{t} \alpha_j[A(N_1, S)]$$

is different from zero.

Using Proposition 4, we can describe an algorithmic procedure for testing the completeness of a set N_1 of needs.

Algorithm 1 (test of completeness).

Input: The matrix $A(N_1, S)$.

Output: "YES" or "NO" according to the fact that N_1 is complete or non-complete.

Steps:

1. For any $j = 1, \ldots, t$, compute $\alpha_j[A(N_1, S)]$.
2. Compute

$$\beta(N_1, S) = \prod_{j=1}^{t} \alpha_j[A(N_1, S)]$$

3. If $\beta(N_1, S)$ is not zero, then "YES" and go to 5.
4. "NO" and go to 5.
5. STOP.

7. An Algorithmic Test of Independence

Proposition 5. A set $N_1 \subseteq N$ is independent if and only if the matrix $A(N_1, S)$ has the following property: in any row i, there exists an element $a_{ij} = 1$ such that $\alpha_j[A(N_1, S)] = 1$. (In other words, in the column j of the matrix $A(N_1, S)$ there is a unique non-zero element.)

Proof. We use the characterization given by Proposition 1. Let $N_1 \subseteq N$ be independent and let $n \varepsilon n_1$. Let us consider the set $M = N_1 - \{n\}$. By Proposition 1, $g(M) \subset g(N_1)$; it follows the existence of a state s in $g(N_1) - g(M)$.

The column which corresponds to the state s in the matrix A(M, S) contains only zeros. Since $s \varepsilon g(N_1)$, there exists in the column of s in the matrix $A(N_1, S)$ at least one non-zero element. The matrix $A(N_1, S)$ differs from the matrix A(M, S) by only one row, namely, the row which corresponds to n; this line has the property stated in Proposition 5. Conversely, let $M \subset N_1$ and n in $N_1 - M$. In the row corresponding to n in the matrix $A(N_1, S)$, there exists an element $a_{ij} = 1$ such that $\alpha_j[A(N_1, S)] = 1$. From the constructions of $A(N_1, S)$ and A(M, S) it follows that $\alpha_j[A(M, S)] = 0$. Then the state s_j belongs to $g(N_1)$ and s_j does not belong to g(M); hence, $g(M) \subset g(N_1)$. By Proposition 1 it follows that N_1 is independent.

Algorithm 2 (test of independence).

Input: The matrix $A(N_1, S)$.

Output: "YES" or "NO," according to the fact that N_1 is independent or non-independent.

Steps:

1. Compute $\alpha_j[A(N_1, S)]$, for all j = 1, . . ., t.
2. For any j for which $\alpha_j = 1$, we look for the row i such that $a_{ij} = 1$. Retain the need n_i corresponding to the row 1.
3. If all needs in N_1 are retained, then "YES" and go to 5.
4. "NO" and go to 5.
5. STOP.

Remark. The independence of a set N_1 is not equivalent to the vectorial independence of the rows of the matrix $A(N_1, S)$. For, let us consider as N the set of needs used in Example 1. N is not independent, but the rows of the matrix A(N, S) are linearly independent (the null vector is not a linear combination of these rows).

For the test of "kernel" set we apply simultaneously the Algorithms 1 and 2.

8. Kernel-needs, Antikernel-needs, and Their Algorithmic Construction

A first idea is to generate all non-empty subsets of N and, using the Algorithms 1 and 2, to check for every subset whether it is independent and complete. This method is not economical, because we must check $2^{card(N)} - 1$ non-empty sets. A better solution is proposed in what follows, by using some criteria in Mallmann and Marcus.[7]

Let us also observe that the construction of a single independent (complete) set is trivial, because any singleton is independent (the total set N is complete). The problem of finding a maximal independent set (in the sense of the inclusion relation) can be easily solved, but this problem is not equivalent to the problem of finding a kernel. (Any kernel is both a maximal independent set and a minimal complete set. But there exist maximal independent sets which are not complete. For, let $N = \{n_1, n_2\}$, $S = \{s_1, s_2\}$, $g(n_1) = \{s_1\}$, $g(n_2) = \{s_1, s_2\}$. Obviously $\{s_1\}$ is maximal independent, but not complete.)

We have seen that <u>any kernel is a minimal complete set; the converse is also true</u>. When we are looking for the kernels, it is very useful to know the needs which belong to any kernel and the needs which belong to no kernel. These needs will be called <u>kernel-needs</u> and <u>antikernel-needs</u> respectively. Let us denote by KN and AN the set of kernel-needs, respectively, of antikernel-needs. Let $\mathcal{K}$ be the set of all kernels. Obviously, $KN = \cap K \ (K \in \mathcal{K})$ whereas $AN = N - \cup K \ (K \in \mathcal{K})$.

Kernel-needs and antikernel-needs are extreme situations of the notion of kernel-degree of a need n, defined as the quotient of the number of kernels to which n belongs and the total number of kernels. It is easy to see that the kernel-degree of a kernel-need is equal to one. The kernel-degree is always between zero and one. In this way, we get a hierarchy of needs with respect to their presence in the kernels. The importance of this hierarchy follows from its functional and global nature. A need n_1 comes before another need n_2 when n_1 belongs to a greater number of kernels than n_2 does. Obviously, this situation does not reflect an intrinsic property of n_1 and n_2; it is rather determined by the relation existing between n_1 and all other needs, as well as by that existing between n_2 and all other needs. We call this hierarchy <u>the kernel-hierarchy of needs</u>.

In a similar way we can define two more hierarchies of needs, as follows. Let us first define the independence-degree of a need n as the quotient of the number of independent sets to which n belongs and the total number of independent sets of needs. In a similar way we define the completeness-degree of a need by replacing, in the above definition, the word <u>independence</u> by the word <u>completeness</u>. These two parameters lead to two corresponding hierarchies, called respectively <u>the independence hierarchy</u> and the <u>completeness hierarchy</u> of needs. They share with the kernel hierarchy of needs the properties of functionality and of globality.

<u>Algorithm 3</u> (generation of all kernel-needs).

<u>Input</u>: A(N, S).

<u>Output</u>: KN.

<u>Steps</u>:

1. Compute $\alpha_j[A(N, S)]$ for all $j = 1, \ldots, t$.
2. Take $KN = \phi$.
3. If $\alpha_j[A(N, S)] \geq 2$ for any $j = 1, \ldots, t$, then go to 5.
4. For every need n_i for which there exists j such that $\alpha_j[A(N, S)] \cdot a_{ij} = 1$, we take $KN = KN \cup \{n_1\}$.
5. STOP.

Indeed, if $\alpha_j[A(N, S)] \geqslant 2$ for any $j = 1, \ldots, t$, then for every n_i we have: $\alpha_k[A(N - \{n_i\}, S)] \geqslant 1$ and $g(n_i) \subseteq g(N - \{n_i\})$. Hence, there is a subset of $N - \{n_i\}$ which is a kernel. If $\alpha_j[A(N, S)] = 1$, then the state of illness j belongs to a single set $g(n_i)$. For every $N \subset N - \{n_i\}$, the relation $g(n_i) \subseteq g(N_1)$ does not hold and thus n_i is a kernel-need.

Every need which is dominated by KN is an antikernel-need. However, there exist antikernel-needs which are not dominated by KN. For example, let us consider the system in Example 1. We have $KN = \{n_1\}$, $(\alpha_1[A(N, S) - 1, \alpha_2[A(N, S)] = \alpha_3[A(N, S)] = 2, \alpha_4[A(N, S)] = 3)$. A kernel contains either the need n_2 or the need n_3. Any such kernel dominates the need n_4, which becomes in this way an antikernel-need. However, KN does not dominate the need n_4.

Open problem. Find an algorithmic procedure to generate all the antikernel-needs, without the generation of the set $\cup K$, $K \in \mathcal{K}$.

9. Algorithmic Construction of Kernels

Let us take into consideration the general case, where N can be written as $N = KN \cup N_1 \cup N_2$, where N_2 is the (possible empty) set of antikernel-needs, whereas KN, N_1 and N_2 form a partition of N. We shall now give an algorithm for the generation of all kernels. There are two possibilities: (a) There exists only one kernel; in this case, we have $\{KN\} = \mathcal{K}$ and, thus, the previous algorithm gives the set $\mathcal{K}$; (b) There exist at least two different kernels (this information is obtained by checking the completeness of KN, using Algorithm 2). Then, the following algorithm can be applied:

Algorithm 4 (generation of all kernels).

Input: A(N, S).

Output: $\mathcal{K}$.

Steps:

1. Take $\mathcal{K} = \phi$.
2. Construct a tree as follows: Flag the root by KN and do a numbering of N, i.e., $N = \{n\ , \ldots, n_p\}$.
3. For every final vertex which is not flagged by a kernel, go to 4. If there is no such vertex, go to 10.
4. Let us consider a vertex flagged by a set M. If $n_p \in M$, then go to 7.
5. If $M = KN \cup \{n_{i_1}, \ldots, n_{i_k}\}$, $k \geq 1$, $i_1 < i_2 < \ldots i_k < p$ or $M = KN$, then construct the descendants of the vertex flagged by M as vertices flagged by the sets $M \cup \{n_j\}$, $j = i_k + 1, i_k + 2, \ldots, p$. (If $M = KN$ then $j = 1, 2, \ldots, p$.)
6. For every newly constructed vertex, check the independence of the associated set. If that set is not independent, go to 7; otherwise go to 8.
7. Erase the vertex together with all its ascendants which do not possess other descendants. Go to 4.
8. For any vertex flagged with an independent set test the completeness of the associated set. If the answer is "NO" go to 3.
9. $\mathcal{K} = \mathcal{K} \cup M$ and go to 3.
10. STOP.

This algorithm produces a tree whose terminal vertices show, without repetitions, all the kernels of the set N. Moreover, kernels whose number of elements is equal to card (KN) + i are written on the level i of the tree (the level of the tree is given by the distance to the root).

Example 2. Let us consider the following matrix:

	s_1	s_2	s_3	s_4
n_1	1	0	1	0
n_2	0	1	1	1
n_3	0	1	0	1
n_4	0	0	1	0
n_5	0	0	1	0
n_6	0	1	0	0

It is easy to see that $KN = \{n_1\}$, $AN = \{n_5\}$. Then $N_1 = \{n_2, n_3, n_4, n_6\}$ and put $N_1 = \{n'_1, n'_2, n'_3, n'_4\}$. We apply Algorithm 3 and we obtain the following trees:

Stage 1

$\{n_1\}$

Stage 2

$\{n_1\}$

$\{n_1, n'_1\}$ $\{n_1, n'_2\}$ $\{n_1, n'_3\}$ $\{n_1, n'_4\}$

The set $\{n_1, n'_1\} = \{n_1, n_2\}$ is a kernel; hence, we stop the generation of descendants. The set $\{n_1, n'_2\} = \{n_1, n_3\}$ is also a kernel and we stop the new generation. The set $\{n_1, n'_3\} = \{n_1, n_4\}$ is an independent set, but it is not complete; we continue the algorithm. The set $\{n_1, n'_4\} = \{n_1, n_6\}$ is independent, but not complete and it has no descendants. We erase it and we obtain:

Stage 3

$\{n_1\}$

$\{n_1, n'_1\}$ $\{n_1, n'_2\}$ $\{n_1, n'_3\}$

Stage 4

$\{n_1\}$

$\{n_1, n_2\}$ $\{n_1, n_3\}$ $\{n_1, n'_3\}$

$\{n_1, n'_3, n'_4\}$

The set $\{n_1, n'_3, n'_4\} = \{n_1, n_4, n_6\}$ is a kernel. This is the final tree. Hence, $= \{\{n_1, n_2\}, \{n_1, n_3\}, \{n_1, n_4, n_6\}\}$.

10. Economical Kernels

In some cases, it would be interesting to obtain only <u>some</u> kernels (with additional properties), and not <u>all</u> kernels. One possibility is to look for those kernels which are of minimal cardinality. We call them economical kernels. Algorithm 3 can solve this problem: we stop the generation of the tree at the first level where we find a kernel. With respect to this type of kernels, we can define the cardinal kernel degree (CKD) of a need n, in the following way. Let us denote by c(K) the cardinal number of a kernel K; by p the sum of numbers c(K) for any kernel K to which n belongs; by q the sum of all numbers c(K), for any kernel K. We take

$$CKD(n) = \frac{p}{q}$$

We can also define the cardinal kernel degree of economy (CKDE) of a need n by CKDE(n) = r/s, where r is the sum of all numbers c(K) for those economical kernels to which n belongs, whereas s is the sum of all numbers c(K), when $\mathcal{K}$ runs over all economical kernels. Finally, let us define the kernel degree of economy (KDE) of a need n as the quotient of the number of economical kernels to which n belongs and the total number of economical kernels. The last parameters are useful in comparing hierarchies.

In a similar way, we can define the cardinal independence degree, the cardinal completeness degree, the cardinal independence degree of economy, and the completeness degree of economy of a need.

Each of the above seven parameters leads to a corresponding hierarchy of needs, which goes far beyond common intuition and which is related to the operational behaviour of human needs, to their global and relational aspects rather than to their intrinsic properties.[9, 10]

Another case is the following. We associate to any need n_i a weight, $p(n_i)$, which shows the effort required by the satisfaction of n_i. In this way, we define a weight-function $p: N \to R_+$ ($R+$ is the set of positive reals). The problem is now to find a kernel for which the sum

$$p(\mathcal{K}) = \sum_{n \in \mathcal{K}} p(n)$$

is minimal. The problem can also be solved by a slight modification of Algorithm 3: the algorithm works in the same way until the first generation of a kernel. We compute the weight of this kernel. For every new generated vertex we proceed as follows:

1. If the vertex is flagged by a new kernel, then we compare its weight with the retained kernel weight. The kernel with maximal weight is erased.
2. If the vertex is flagged by an independent non-complete set and its weight is greater than the retained kernel weight, then this vertex is erased as well.

In other cases we continue Algorithm 3.

11. An Illustration: Medical Diseases and Medicaments

We are going to illustrate the methodology discussed above by a concrete example where the diseases are medical diseases and the needs result from the necessity to control them; in this case we may delimit the needs by means of the medicaments which medical science recommends for controlling the respective diseases. Indeed, according to their scientific, that is general and objective, uses, medicaments are not satisfiers; they are not (only and mainly) associated to desires but to needs.

Therefore, we may identify here the set N with the set made up of the following Romanian medicaments: acalor, acid acetylsalicylic, algocalmin, alindor, aminophenazona, aminophenazone L, antidoren, antimigrin, antineuralgic. The set S of diseases is formed of: feverishness, influenza, neuralgia, toothache, cephalalgia, rheumatic pains, post-operative pains.

The mapping g: $N \to 2^S$, which associates to each medicament the diseases which it is used to control, is the following:

g (acalor) = {feverishness, influenza, neuralgia, rheumatic pains}
g (acid acetylisalicylic) = {feverishness, neuralgia, toothache, rheumatic pains}

g (algocalmin) = {feverishness, influenza, cephalalgia}
g (alindor) = {rheumatic pains}
g (aminophenazona) = {feverishness, neuralgia, rheumatic pains}
g (aminophenazona L) = {feverishness, neuralgia, rheumatic pains}
g (antidoren) = {cephalalgia, rheumatic pains, post-operative pains}
g (antimigrin) - {feverishness, influenza, neuralgia, cephalalgia, rheumatic pains}
g (antineuralgic) = {feverishness, neuralgia, cephalalgia, post-operative pains}

The matrix associated (according to the device presented in section 4) to the diseases and medicaments described by g is the following (we write the diseases in columns and the medicaments in rows, in the order in which they have been enumerated):

1	1	1	0	0	1	0
1	0	1	1	0	1	0
1	1	0	0	1	0	0
0	0	0	0	0	1	0
1	0	1	0	0	1	0
1	0	1	0	0	1	0
0	0	0	0	1	1	1
1	1	1	0	1	1	0
1	0	1	0	1	0	1

12. Reducing the Number of Medicaments

Using this example we may illustrate the notions of independent set, complete set, and kernel. So, the set of medicaments {acalor, acid acetylsalicylic, algocalmin, antidoren} is a complete set of medicaments which is not independent. Indeed, if we form the matrix corresponding to these medicaments

1	1	1	0	0	1	0
1	0	1	1	0	1	0
1	1	0	0	1	0	0
0	0	0	0	1	1	1

and apply Algorithm 1, the answer we get is "yes" (since the product of sums in columns is different from zero). Therefore, this set is complete, that is, using these medicaments we may treat all the considered diseases. The significance of the result is obvious: the nine medicaments initially considered may be replaced by four of them only, without the curative effects being diminished. The important fact is that this result has been obtained using an algorithmic device which may be applied as well when considering not 9 but 99 or 999 medicaments, since the algorithmic nature of the device allows us to transfer its performance to a computer. The complete set we have identified is not independent, since applying the independence test (Algorithm 2) we do not keep the medicament algocalmin. This means that even if we give up algocalmin, we may get the same effect using the rest of the chosen medicaments; that is, from the initial set of nine medicaments we may keep only three, their curative effect being equal to that of the nine medicaments considered initially. This result is even more outstanding since by reducing the number of medicaments we also simplify considerably the problem of incompatibilities resulting from the contradictions associated to the various medicaments.

13. A Kernel-need: Acid Acetylisalicylic

Applying Algorithms 1 and 2 to the set of medicaments {algocalmin, alindor, aminofenazona, aminofenazona L, antidoren, antimigrin} we find that this set is neither complete nor independent. This means that this set of medicaments is not sufficient for curing all the seven diseases; at the same time we may give up at least one medicament without diminishing their global curative power.

The set consisting of algocalmin, alindor, aminofenazona L is independent (we cannot give up any of these medicaments without diminishing their global curative power) but it is not complete; that is, it cannot cure all the considered diseases.

Applying Algorithms 1 and 2, we find the following independent and complete matrices having only three rows

	1	1	1	0	0	1	0
k_1	1	0	1	1	0	1	0
	0	0	0	0	1	1	0

	1	1	1	0	0	1	0
k_2	1	0	1	1	0	1	0
	1	0	1	0	1	0	1

	1	0	1	1	0	1	0
k_3	1	1	0	0	1	0	0
	0	0	0	0	1	1	1

	1	0	1	1	0	1	0
k_4	1	1	0	0	1	0	0
	1	0	1	0	1	0	1

	1	0	1	1	0	1	0
k_5	0	0	0	0	1	1	1
	1	1	1	0	1	1	0

	1	0	1	1	0	1	0
k_6	1	1	1	0	1	1	0
	1	0	1	0	1	0	1

Accordingly, the following sets of medicaments are kernels:

k_1 = {acalor, acid acetylisalicylic, antidoren}

k_2 = {acalor, acid acetylisalicylic, antineuralgic}

k_3 = {acid acetylisalicylic, algocalmin, antidoren}

k_4 = {acid acetylisalicylic, algocalmin, antineuralgic}

k_5 = {acid acetylisalicylic, antidoren, antimigrin}

k_6 = {acid acetylisalicylic, antimigrin, antineuralgic}

These are also the economical kernels, in the sense of the smallest number of medicaments. Indeed, any set with less than three medicaments is not complete; therefore no kernel may have one or two medicaments only.

In the above analysis we notice that any kernel of three elements contains the medicament acid acetylsalicylic. Applying Algorithm 3 for generating the kernel-needs we get the result intuited above: the only kernel-need is the medicament acid acetylsalicylic.

14. A More Sophisticated Example: The Heart Diseases

We shall approach a more important problem, also belonging to the field of medicine: that of heart diseases. Here the set of medicaments is the following (we still consider Romanian medicaments): {adrenaline, aslavital, bronhodilatin, carbocromen, castrosid, clorzoxazon, digitalin, digoxin, dispezin, ederen, ephedrine, furosemid, guanetidin, hipozin, hipopresol, hiposerpil, miofilin, nidacil, persantin, propanold, sirogal E, spironolactona, tarosin}; the associated diseases are: bronchial asthma, cardiac arrest, cardiac syncope, myocardial infarct, cardiac insufficiency, arthritis, myositis, ischemic contractions, atrial fibrillation, cardiac oedema, ischemic heart disease, arterial hypertension, cardiac asthma.

Mapping g is defined as follows:

g (adrenaline) = {bronchial asthma, cardiac arrest}
g (aslavital) = {bronchial asthma}
g (bronhodilatin) = {bronchial asthma, cardiac syncope}
g (carbocromen) = {myocardial infarct}
g (castrosid) = {cardiac insufficiency}
g (clorzoxazon) = {arthritis, myositis, ischemic contractions}
g (digitalin) = {cardiac insufficiency, atrial fibrillation}
g (digoxin) = {cardiac insufficiency, atrial fibrillation}
g (dispezin) = {ischemic heart disease, arterial hypertension, cardiac asthma}
g (ederen) = {cardiac oedema}
g (ephedrine) = {bronchial asthma, cardiac syncope}

g (furosemid) = {cardiac oedema, arterial hypertension}
g (guanetidin) = {arterial hypertension}
g (hipazin) = {arterial hypertension}
g (hipopresol) = {arterial hypertension}
g (hiposerpil) = {arterial hypertension}
g (miofilin) = {bronchial asthma, cardiac insufficiency, cardiac asthma}
g (nidacil) = {cardiac insufficiency, atrial fibrillation}
g (persantin) = {ischemic heart disease}
g (propanolol) = {arterial hypertension}
g (sirogal E) = {bronchial asthma}
g (spironolactona) = {arterial hypertension}
g (tarosin) = {arterial hypertension}

In this case, the dimension of the associated matrix is 13 x 23, that is it has 299 elements. We do not give it here. It is important to notice that even at the level of this example the problems of determining the complete and independent sets and the kernels cannot be solved without the help of the computer.

However, we shall try to get some information by direct observation.

First, if we apply Algorithm 3 it follows that the medicaments adrenaline and clorzoxazon are kernel-needs. Any kernel must contain them.

Any kernel must also contain at least one medicament of the following pairs: (bronhodilatin, ephedrine), (digoxin, nidacil), (ederen, furosemid), (dispezin, persantin), (dispezin, miofilin).

It follows from the above analysis that any kernel should contain at least six medicaments determined as follows: adrenaline and clorzoxazon (since they are kernel-needs) and one from each of the four groups mentioned above (when we choose dispezin from the last pair).

The following matrix is complete and independent: the rows of the matrix are associated to the medicaments adrenaline, clorzoxazon, bronhodilatin, digoxin, ederen, dispezin, carbocromen, while the columns are associated to the diseases in the initially given order:

1	1	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	1	1	1	0	0	0	0	0
1	0	1	0	0	0	0	0	0	0	0	0	0
0	0	0	0	1	0	0	0	1	0	0	0	0
0	0	0	0	0	0	0	0	0	1	0	0	0
0	0	0	0	0	0	0	0	0	0	1	1	1
0	0	0	1	0	0	0	0	0	0	0	0	0

The set of these medicaments may cure all the 13 considered diseases, but it is minimal; that is it loses the mentioned property when any one of the medicaments is eliminated. Thus we notice that we could replace the initial set of 23 medicaments by a subset of seven medicaments only, without diminishing at all their curative capacity.

We may get more information by computer processing.

15. Saturated Pairs

Concluding our discussion, let us notice that in addition to the problem dealt with in the present and in the previous example (a problem which may be stated as follows: Given a collection S of diseases and a collection N of medicaments which control S, let us replace N by a sub-collection N_1, as reduced as possible, which can also control S) we may also consider a symmetrical problem, stated as follows: Given a collection N of medicaments and a collection S of diseases which may be controlled by N, let us extend S to a superset S_2, as rich as possible, such that all the diseases in S_2 might be controlled by the same set N. In other words, while in the former problem the set of diseases was fixed and we were interested in minimizing the number of medicaments controlling all the considered diseases, in the latter problem the set of medicaments is considered fixed and our aim is to maximize their efficiency, that is to extend the set of diseases which may be controlled by the same medicaments.

Further, it seems natural to combine, to overlap the two types of problems considered above. Thus, with respect to the set S_2 of diseases which may be controlled by the set N of medicaments, we may try to economize the medicaments used, that is replace N by a subset of it, N_1. We obtain, thus, a minimal set of medicaments which may control a maximal set of diseases. The pair (N, S) where N is minimal and S is maximal, is called a saturated pair. Such a pair answers the double requirement of economy and efficiency; no medicament may be eliminated from it, and no disease may be added to it. Here is an example of a saturated pair: the set of medicaments is made up of acalor, acid acetylsalicylic, antidoren (a kernel set, see section 7) and the maximal set of diseases is feverishness, influenza, neuralgia, rheumatic pains, toothache, cephalalgia, post-operative pains, polyarticular rheumatism, polyarthritis, myalgia, dysmenorrhoea; therefore, using only three medicaments we may cure 11 diseases (the seven diseases considered initially and four more).

16. Kernel Diseases and the Dialectic Diseases – Medicaments Diseases

Following the ideas in Mallmann and Marcus[7] we are going to study a few kernel diseases. Related to the example presented there we shall consider the application h: $S \to 2^N$, defined as follows:

h (feverishness) = {acid acetylisalicylic, algocalmin}

h (influenza) = {acalor, algocalmin, antimigrin}

h (neuralgia) = {acalor, acid acetilsalicilic, aminofenazona, antineuralgic}

h (toothache) = {acid acetylisalicylic}

h (rheumatic pains) = {acid acetylisalicylic, algocalmin, aminofenazona L, antidoren, antimigrin, antineuralgic}

h (post-operative pains) = {alindor, antidoren, antinevralgic}

The associated matrix becomes:

$$\begin{matrix} 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 1 & 0 & 0 & 0 & 0 & 1 & 0 \\ 1 & 1 & 0 & 0 & 1 & 0 & 0 & 0 & 1 \end{matrix}$$

0	1	0	0	0	0	0	0	0
0	0	1	0	0	0	1	1	0
0	1	1	0	0	1	1	1	1
0	0	0	1	0	0	1	0	1

(diseases in rows and medicaments in columns, the order being that of section 7).

Applying the above algorithm in Mallmann and Marcus[7] we shall determine the sets of diseases which are independent, or complete, and the kernels with respect to the medicaments used for cure. Thus, the algorithms previously described may be applied here, too. If we apply the kernel-illness test (Algorithm 3), it follows that neuralgia, rheumatic pains, and post-operative pains are kernel-illnesses; moreover, since the sub-matrix corresponding to this set of diseases is independent and complete, by applying Algorithms 1 and 3 to the matrix

1	1	0	0	1	0	0	0	1
0	1	1	0	0	1	1	1	1
0	0	0	1	0	0	1	0	1

it follows that this set constitutes a kernel.

17. Maximal Kernels and the Corresponding Hierarchies

There are obviously situations where we are interested in looking for the largest independent set, complete sets, and kernels of needs. Consequently, there is some interest in determining the degree to which a given need belongs to such large sets. To be more specific, we could observe that independent sets are more interesting when they are larger (because any subset of an independent set is independent), whereas complete sets are more interesting when they are smaller (because any superset of a complete set is also complete). So, both the smallest and the largest kernels are interesting. This situation suggests we could define four more parameters, which yield four more hierarchies of needs. Let us call a maximal kernel one which has the largest possible cardinal; in a smaller way we define a maximal independent set. In other words, a kernel (an independent set) is maximal where there is no other kernel (independent set respectively) having a larger cardinal. The kernel degree of maximality (KDM) of a need n is the ratio of the number of maximal kernels to which n belongs and the number of all maximal kernels of needs. Replacing here kernels by independent sets, we get the notion of independence degree of maximality (IDM) of a need. The cardinal kernel degree of maximality (CKDM) of a need n is defined as the ratio of u and v, where u is the sum of cardinals of all maximal kernels to which n belongs, whereas v is the sum of cardinals of all maximal kernels of needs. Replacing here kernels by independent sets we get the notion of cardinal independence degree of maximality (CIDM) of a need.

18. Hierarchies of Medicaments

Let us establish a hierarchy of the medicaments in section 11, according to the following two criteria: the degree to which they belong to economical, maximal kernels and to kernels.

In section 11 we built the set of economical kernels (each kernel contains three medicaments). A simple calculation leads to the following values for the parameter introduced in section 8, cardinal kernel degree:
CKD (acalor) = $2/5$; CKD (acid acetylisalicylic) = $5/5$; CKD (algocalmin) = $2/5$; CKD (alindor) = 0; CKD (amonofenazona) = 0; CKD (aminofenazona L) = 0; CKD (antidoren) = $3/5$; CKD (antimigrin) = $1/5$; CKD (antineuralgic) = $2/5$.
Thus we reach the following hierarchy (according to the kernel degree of needs and the cardinality of the economical kernels to which the given medicament belongs):

I acid acetylisalicylic
II antidoren
III acalor, algocalmin, antineuralgic
IV antimigrin

V alindor, aminofenazona, aminofenazona L

This hierarchy proves the importance of the medicament acid acetylisalicylic (aspirin) which is the basic Romanian medicament for treating local pains.

The hierarchy above coincides with the hierarchy obtained by measuring the degree to which a medicament belongs to all kernels, since the set of all kernels is the same with the set of economical kernels. Indeed, any kernel K, having at least four elements, must contain the medicament acid acetylisalicylic (which is a kernel medicament) and may not contain any of the medicaments acalor, algocalmin, antidoren, antimigrin, antineuralgic (when containing one of these medicaments an economical kernel is obtained; when containing two the independence property is lost).

We have still to analyse the set {acid acetylisalicylic, alindor, aminofenazona, aminofenazona L}; the associated matrix is:

1	1	1	0	0	1	0
1	0	1	1	0	1	0
0	0	0	0	1	1	1
1	1	0	0	1	0	0

It is complete but it is not independent.

For obtaining the other hierarchies, too, we have to determine all the independent (respectively complete) sets, which require the use of a computer (we have to check twice $2^9 = 512$ subsets of medicaments).

19. Conclusions

The significance of the concepts and results presented above can easily be understood when looking at the examples in the last paragraphs, despite their technical nature. But let us quote first a few lines from Patrick Healey's paper:[2]

> It is of course essential to distinguish between analysis aimed at increasing understanding and programmes of action designed to bring about some change in the world. These need-frameworks are clearly designed to increase understanding — not as programmes of action. In needs analysis, however, which has the concrete objectives of improving the lives of the poorest of the world, and which is above all <u>practical</u> and <u>participatory</u>, the social and political product of model building should be a major consideration in evaluating the models and the methodologies for deriving them.

But let us see whether there is really an opposition between "increasing understanding" and "programmes of action"; between the practical and participatory nature of the human needs problem, on the one hand, and the conceptual and theoretical aspects of the same problem, on the other. How can we set up effective programmes of action concerning human needs if we don't have a clear understanding of their functioning? Obviously, such an understanding is not sufficient (but it is necessary!) for an effective programme of action, because such a programme requires also an effective politics of needs. There is also an interplay between the theory of needs and the politics of needs, because the problems of the former are to a great extent determined by the orientation of the latter. But we have to stress how necessary is the understanding of conceptual, technical, and combinatorial aspects of the interplay between needs, illnesses, desires, and satisfiers in order to create an effective programme of action for the fulfilment of human needs. The participatory requirement for such a programme is correlated to an explanatory requirement concerning the dialectics between empirical and theoretical aspects of human needs. People will easier accept participation in a programme of action if one can explain to them the mechanism of the interaction between the individual, social, and universal aspects of needs, between their subjective and their objective tendencies. In this respect, one can use as an intermediary element the decision-makers, who can better understand the importance of conceptual clarifications in the field of needs and the difficulties related to their combinatorial and technical aspects.

Obviously, one can ask whether the necessary conceptual clarifications cannot be obtained in a simpler way, by avoiding such a long effort of mathematical definitions, propositions, and proofs. The answer seems to be rather negative. The reason is not only the lack of a successful non-mathematical approach to this problem; it also follows from the important requirement of creating a general framework within which the basic problems concerning human needs can be formulated in a strict order and in a rigorous way. This requirement is not only of a logical nature, but also of a practical one; an effective "programme of action" is not only a matter of participation and willingness, but also one of knowledge and competence. In this perspective, we have to interpret the topics of the present paper.

The algorithmic procedures determining the independent sets, the complete sets, and the kernels of needs give the possibility of solving some natural and practical problems such as finding the most economical sets of needs by means of which we can face a given set of needs. In this respect, the concept of a saturated pair, where a maximal set of illnesses is faced by means of a minimal set of needs seems to be of great theoretical and practical relevance.

Special attention should be given to the parameters we propose as means to get hierarchies of needs (see sections 8, 10, and 17). Let us take, for instance, the kernel degree of a need, but let us first recall, in this respect, that a kernel is the rigorous expression of what some authors such as Masini[8] and Mallmann[6] call a basic set of human needs, which should be, metaphorically speaking, like a base in a vector space (the elements of such a base are mutually independent, but each element which does not belong to the base is dependent with respect to at least one element of the base; the analogy with the concept of a kernel is obvious). The kernel degree of a need shows to what extent the need belongs to the kernels. Two limit cases occur here: a need may belong to each kernel of needs, but it may also belong to no kernel. In the first case, the kernel degree is one, in the second case it is zero. The intermediate situations, which occur for most needs, lead to various rational values between zero and one. From a practical point of view, it is important to point out the possibility of using such a parameter with respect to a class of illnesses. So, we do not have to wait until all human (medical, psychological, or social) illnesses are known in order to investigate them and the corresponding needs. The global nature of the considered parameter should be also pointed out; it is related to the total relational behaviour of a need, i.e., to a behaviour which is very relevant for its importance, although in most cases it cannot be intuitively perceived. Similar remarks are valid for the other 11 parameters proposed as criteria for ordering human needs. They all are related to their objective properties.

In further research we hope to be able to apply these tools to some classes of needs and illnesses other than medical ones, although the medical examples investigated in the present paper are symptomatic for the whole problématique of human needs.

It should be pointed out that our universal concept of need is different from those usually encountered in the literature. Let us take as an example in this respect one of the most interesting and most recent uses of the term "need," that of Katrin Lederer[4] (p. 33): "Needs are manifest or latent requirements of human beings in particular environments and with particular personality traits." It can be easily seen that Lederer's needs are somewhere between our (purely universal) needs and our (individual) desires.[7] So, generally speaking, no possibility exists of applying our procedures to Lederer's needs. But it is interesting to note that medicaments we have used in our examples correspond to both Lederer's needs and Mallmann-Marcus' needs.

We have also to thank A. Judge for his interesting remarks concerning the paper[7] and, particularly, for his recommendation to stress and comment on the concepts of independent set, complete set, and kernel of needs.[3] We hope we have satisfied this requirement in the present paper.

A fruitful connection between human needs and human values is established by Malitza.[5] We intend to follow and stress this idea in future researches.

References

1. J. Galtung, "Alternative Ways of Life Project. Preliminary List of Basic Human Needs," Preprint, Geneva, January, 1978.
2. P. Healey, "Basic Human Needs. The Politics of Mobilization," paper for UN University GPID project, 1978.
3. A. Judge, Remarks on Mallmann and Marcus, October, 1978.
4. Katrin Lederer, "Reflections About Needs," (3rd draft), Berlin, September, 1978.
5. Mircea Malitza, "No Limits to Learning," Chaps. I and II, Report to the Club of Rome, 1979.
6. C. Mallmann, "Needs and Processes, Goals and Indicators," draft paper for UN University GPID project, 1978.
7. C. Mallmann and S. Marcus, "Empirical Information and Theoretical Constructs in the Study of Needs," paper for UN University GPID Project, 1978.
8. E. Masini, "Social Minimum and Maximum and Their Relation to Human Needs," draft paper, 1976.
9. A.H. Maslow, Motivation and Personality, Harper and Row, New York, 1970.
10. A.H. Maslow, The Farther Reaches of Human Nature, The Viking Press, New York, 1971.

II. SUBJECTIVE AND OBJECTIVE IN ESTABLISHING HIERARCHIES OF NEEDS

M. Drăghici

One is tempted to build a hierarchy of needs, be it only for the impression that a priority "order" is thus established with respect to other, most often contradictory, possible orders. The way each individual deals with this problem is strongly subjective when he himself is concerned, and more objective when it refers to somebody else. Yet that objectivity is still fraught with many personal conceptions. Difficult problems in this respect are raised when an individual is going to study the needs of a group, his belonging or non-belonging to that group rendering relative the results of his study.

That is why we can hardly believe that a study of needs may be looked upon as acceptable from all points of view. Referring to the literature on the topic (the GPID literature included) we notice a great variety of opinions about the problem of hierarchies of needs (cf. C.A. Mallmann, Maslov, Curry, Malinovski).

The present paper points out the necessity of considering subjective aspects, processed according to a methodology independent of the subject, which may, however, be iterated and improved with a view to bringing the results nearer to a model of the subject which is subjectively acceptable.

The aim of the paper is to show we should not trust absolutely general hierarchies (the same methodology changes the hierarchy when the input, reflecting subjective aspects, changes); they depend on the individual and on the stage of his life. On the other hand, the paper shows that such hierarchies do exist, even if they have only a "short life." They may also point to some priority aspects which society has to consider (for example, a need on [upper] top levels for most of the individuals). Although the results of such approaches can not be considered final, it is obvious that they are improvements. Examples in this respect are numerous; we shall refer only to the forecasting studies.

The possibilities and criteria for establishing a hierarchy of human needs are the concern of the present paper. We benefit from already having a paper which lays the basis of a systematic approach of the need problématique,[1] and of an attempt, at the individual level, to deal with aspects meant to make obvious certain behaviours, mechanisms, and implications in the study of the quality of life.[4]

We are going to restrict the conceptual frame in Drăghici[4] to the situation — when the only operation is to add new connexions to the set of the existing ones, a particular case where each state of the system of connexions is a graph. It is not compulsory that all nodes should be connected by arcs; the dynamic approach considers it possible that new nodes and arcs may appear.

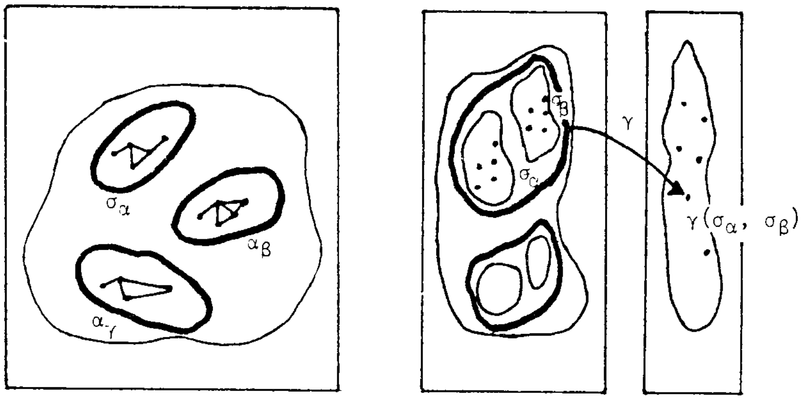
Let us denote by σ_α, σ_β, . . ., the states of the system of connexions. They make up the set σ. We shall say that $\sigma_\alpha < \sigma_\beta$ if the state σ_β contains all connexions in σ_α.

Let us denote by $C = \{(\sigma_\alpha, \sigma_\beta) / \sigma_\alpha, \sigma_\beta \in \sigma, \sigma_\alpha < \sigma_\beta\}$ and by N the set of needs defined in Mallmann and Marcus.[1] We consider that the turning of the possibility (adding new connexions) into reality (getting a new system of connexions) takes place when a certain (unique) need is satisfied.

To simplify our presentation we shall denote by n_0 the need "necessary" for not changing the state of connexions.

Let γ: $C \rightarrow N$ be defined as follows: $\gamma(\sigma_\alpha, \sigma_\beta)$ is the need whose satisfaction makes possible the connexions which are to be found in σ_β but are not in σ_α.

The following schemes represent an intuitive support for the notions presented above.



The set σ where $\sigma_\alpha < \sigma_\beta$ The set C   The set N

We suppose that for any $n \in N$ there is a couple $(\sigma_\alpha, \sigma_\beta)$ such that $n = \gamma(\sigma_\alpha, \sigma_\beta)$.

In N we may introduce a natural binary relation: $n_1 < n_2$ if for any σ_α, σ_β such that $\sigma_\alpha < \sigma_\beta$ and $n_1 = \gamma(\sigma_\alpha, \sigma_\beta)$ there is σ_δ such that $\sigma_\beta < \sigma_\delta$, and $n_2 = \gamma(\sigma_\alpha, \sigma_\delta)$.

<u>Observation 1</u>. The couple $(\sigma, <)$ is an ordered set. Indeed:

a. $\sigma_\alpha < \sigma_\beta$ since any σ_α contains at least the connexions in σ_β.

b. $\sigma_\alpha < \sigma_\beta$ and $\sigma_\beta < \sigma_\gamma$ implies $\sigma_\alpha < \sigma_\gamma$, since any connexion in σ_α is also to be found in σ_β, therefore in σ_γ too.

c. $\sigma_\alpha < \sigma_\beta$ and $\sigma_\beta < \sigma_\alpha$ means that any connextion in σ_α is to be found in σ_β and reversely, therefore $\sigma_\alpha = \sigma_\beta$.

<u>Observation 2</u>. The couple $(N, <)$ is a pre-ordered set.

a. $n < n$ $(\forall)$ $n \in N$. Indeed, when $n = \gamma(\sigma_\alpha, \sigma_\beta)$ and $\sigma_\gamma = \sigma_\beta$, we obviously have $\sigma_\alpha < \sigma_\beta < \sigma_\gamma$ and $n_1 = \gamma(\sigma_\alpha, \sigma_\beta)$, $n_2 = \gamma(\sigma_\beta, \sigma_\gamma)$, that is $n_1 < n_2$. However $n_1 = n_2 = n$.

b. <u>If $n_1 < n_2$ and $n_2 < n_3$, then $n_1 < n_3$ $(\forall)$ $n_1, n_2, n_3 \in N$.</u> Let us consider $\sigma_\alpha < \sigma_\beta < \sigma_\delta$ such that $n_1 = \gamma(\sigma_\alpha, \sigma_\beta)$ and $n_2 = \gamma(\sigma_\alpha, \sigma_\delta)$. Since $n_2 < n_3$, there is σ_λ such that $\sigma_\alpha < \sigma_\beta < \sigma_\delta < \sigma_\lambda$ and $n_3 = \gamma(\sigma_\alpha, \sigma_\lambda)$, which proves that $n_1 < n_3$.

c. We shall denote by N, the set when N/"<" and ">"; that is we shall not distinguish between two needs which satisfy the same connexions. (If $\gamma(\sigma_\alpha, \sigma_\lambda, \sigma_\beta, \sigma_\lambda) = \gamma(\sigma_\alpha, \sigma_\beta)$ no factorization is necessary anymore.)

Observation 3. We define in N notions similar to those in Mallmann and Marcus:[1]

a. The dependence of an element $n \in N$ on a subset $A \subset N$ if $\gamma^{-1}(n) \subset \gamma^{-1}(A)$.
b. The independence of an element $n \in N$ with respect to a subset $A \subset N$ (by negation).
c. $A \subset N$ is complete if $\gamma^{-1}(A) = C$.
d. $A \subset N$ is a kernel if A is complete and independent.

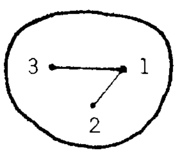
Observation 4. By analogy to Mallmann and Marcus[1] we can prove the following statements:

a. The property of independence of a set of needs is hereditary.
b. The property of completeness of a set of needs is ancestral.
c. No subset of an independent set of needs is complete.
d. No subset and no superset of a kernel of needs are kernels.

Example. Let us suppose that with a certain individual the system of connexions is established among the following elements (simplified action-goals couples):

1. the process of food earning;
2. the process of education, training, knowledge-acquisition;
3. the process of improving health.

The set σ is formed of the connexions σ_{12}, σ_{13}, σ_{23}, σ_{123}, σ_{132}, σ_{132}, σ_{312}, and σ_{1231}, where, for example σ_{312} is:



The relation "<" in σ is established as follows:

$\sigma_{12} < \sigma_{123}$ $\quad$ $\sigma_{12} < \sigma_{312}$ $\quad$ $\sigma_{12} < \sigma_{1231}$

$\sigma_{12} < \sigma_{132}$ $\quad$ $\sigma_{13} < \sigma_{312}$ $\quad$ $\sigma_{13} < \sigma_{1231}$

$\sigma_{123} < \sigma_{1231}$ $\quad$ $\sigma_{132} < \sigma_{1231}$ $\quad$ $\sigma_{312} < \sigma_{1231}$

The set C has nine elements:

$(\sigma_{12}, \sigma_{123})$ $\quad$ $(\sigma_{12}, \sigma_{312})$ $\quad$ $(\sigma_{12}, \sigma_{1231})$

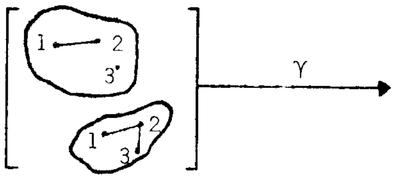
$(\sigma_{13}, \sigma_{132})$ $\quad$ $(\sigma_{13}, \sigma_{312})$ $\quad$ $(\sigma_{13}, \sigma_{1231})$

$(\sigma_{123}, \sigma_{1231})$ $\quad$ . . . etc.

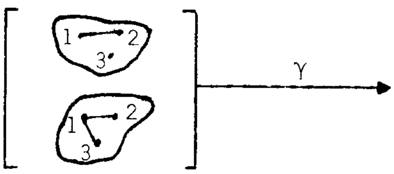
The delimitation of the set N and of the function:

$$N = \{n_1, n_2, n_3, n_4, n_5, n_6, n_7, n_8, n_9\}$$

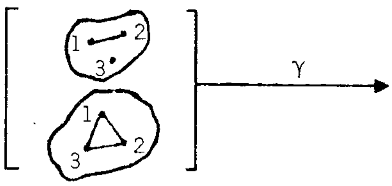
We are going to give an example to show how function γ may be established for an individual.



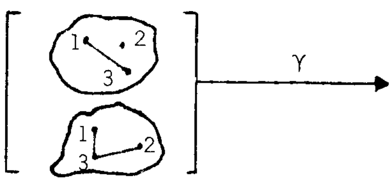
n_1 = the need for physical effort during the training process



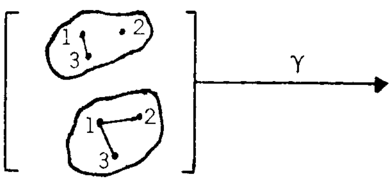
n_2 = the need for physical effort during the food-earning process



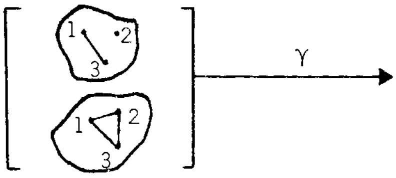
n_3 = the need for physical effort during both the training process and the food-earning process



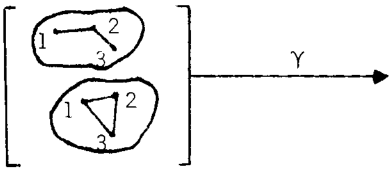
n_4 = practising sports according to scientific method



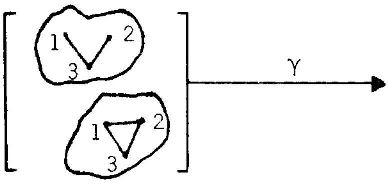
n_5 = technological progress of raising the level of cognition



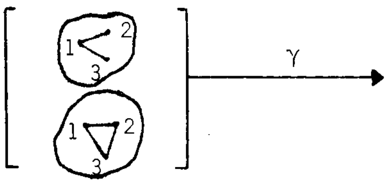
n_6 = the need to realize



n_7 = the need to realize oneself



n_8 = the need for asserting oneself



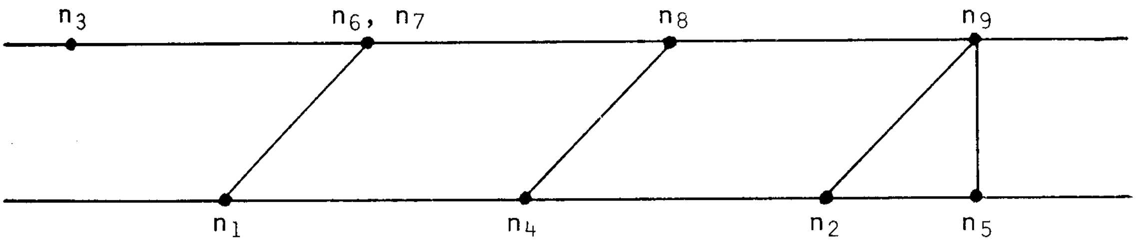
n_9 = the need for group living

The ordering of needs for the above individual:

$n_1 < n_7 = n_6$, $n_2 < n_9$; n_3 has no higher needs.

$n_4 < n_8$, $n_5 < n_9$; n_6, n_7, n_8, n_9 have no higher needs.

A possible hierarchy is the following:



A few remarks on the result obtained:

a. n_3 is superfluous, since n_1 and n_2 may replace n_3.

b. n_9 (group living) is most important, increasing the physiological and cognitive needs.

c. Such needs as realization and social recognition get priority as compared to the need for physical effort, for practising sports, etc.

d. Analogically, such needs as assertion get priority with respect to the needs stated at (c).

<u>A few remarks on the model used in building hierarchies of needs</u>:

a. The model may be applied at the individual level only; the needs associated to the new connexions differ from one individual to another. For example, for some individuals the passing from connexion σ_{132} (where the improving of health is connected to the earning of food and education) to connexion σ_{1231} (where the earning of food is connected to education) is not assertion but self-realization; thus the hierarchy will obviously change.

b. There are no intermediate levels since we have considered only three simplified action-goals couples, denoted by 1, 2, 3.

c. The needs are not correlated with states of illness[1] (which leads to a definition of the type: nonexistence → certain state of illness) but with the process of development, conceived as an addition of new connexions (that is sometimes convenient to the study).

d. When new simplified action-goals couples are added and the mapping is only an extension of the previous one, the hierarchy will have new nodes and arrows, but will not modify the ones existing in the previous hierarchy.

e. The practical importance of this method is the following: for the considered group of individuals, when rapid calculation devices are available, we may iterate the process, modifying the input data (connexions), thus making evident the needs on the upper levels, common to all the individuals in the group.

References

1. C.A. Mallmann and Solomon Marcus, "Empirical Information and Theoretical Constructs in the Study of Needs," Part I, paper for UN University GPID project, January 1979.

2. J. Galtung, "Goals, Processes and Indicators for Development — A Project Proposal," paper for UN University GPID project, 1977.

3. J. Galtung, "Alternative Ways of Life Project, Preliminary List of Basic Human Needs," Geneva, January 1979.

4. M. Drăghici, "A Processual-oriented Approach to the Qualify of Life Individual Systems," paper for UN University GPID project, 1978.

5. C.A. Mallmann, "Needs and Processes, Goals, and Indicatory," paper for UN University GPID project, 1978.

6. C. Calude, S. Marcus, and G. Păun, "Empirical Information and Theoretical Constructs of Needs," Part II (Operational Characterizations and Algorithmic Procedures), paper for UN University GPID project, January 1979.

III. NEEDS SATISFACTION AND BEHAVIOURAL RULES

Dan Romalo

1. Introductory Remarks

This paper is a formal study intending to analyse whether the desirable development of any human society, representable as a closed system, could be aimed at a single general goal.

Our paper is an attempt to put into a simple relationship two of the main concepts of the GPID Project: Goals and Indicators (see Galtung[4]). Our strategy could give the impression of an oversimplification of the problem, because we try to show that one basic goal can explain human behaviour. From this point of view, our approach is close to what Lederer calls a "holistic view of needs" (Lederer[5], section 3.5).

We believe that a basic goal exists, which could ensure, under given universal conditions, the satisfaction, with equity, of as many as possible of the needs of the individuals belonging to the considered society.

The investigation is presented as a theoretical reflection, associated with a tentatively axiomatized mathematical formulation of the subject. From this point of view our approach could be related to that considered by Mallmann and Marcus[6] and by Calude, Marcus and Păun,[3] but our interest for behavioural rules goes beyond their aims.

The particular aim of the axiomatic part of the study is to investigate whether one can, by theoretical means, recognize that set of norms of behaviour in society which will ensure both social equity and optimal social development.

The study is based on the following premises.

1. The system is considered to be constituted by the individuals together with the material support on which they make their livings. The individual is considered as an element of the system and, as such, subjected to restrictive rules and norms of behaviour in society.

2. Satisfactory solutions of the problems of a human society cannot be achieved on the basis of economic criteria alone (as in Mesarovic and Pestel,[7] for example). This is so because the economic indicators do not represent directly men's fundamental needs. They are only intermediate parameters between the material structure on which society is based and the real determinant parameters of the problem.

3. The only indicators capable of representing correctly man's needs in society are the psychological and biophysical characteristics of the individuals composing the society.

4. By solving, in theory, the fundamental social problems of a given human society we shall understand the abstract operation of identifying a set of behavioural rules capable of ensuring: (a) the easier survival of each individual if these rules are respected than if they were not, and (b) an equitable redistribution of the satisfactions life can give, among all the individuals belonging to the considered society.

5. The set of behavioural rules accepted as a theoretical solution of the social problems of a given society must be compatible with the behavioural motivations of all the individuals composing the considered society. Without this condition being satisfied, the theoretical solution is not implementable as a practical solution. It will remain a simple idealized theoretical product.

6. For any human society there exists at least one particular set of rules and norms of behaviour which, if respected by all the individuals in the society, will ensure an easier survival of each individual than if they are not, or if the individual has to live outside the society.

This is, in fact, the definition of society, as we understand it.

7. We say that the totality of such rules and norms, if actually applied, constitutes the morals of the studied society. The morale, so understood, will make sense only if related to a particular society. The same set of rules and norms could be good or bad, depending on the society to which they are applied.

We also say that ethics is defined as the study of these rules and of the conditions under which they can realize an optimal well-being of all individuals.

8. If the morals and ethics of a given society are understood as in (7) then the general cybernetic goal for any human society will obviously be to organize its social evolution in such a manner as to actually realize that particular evolution which is correct when considered from an ethical point of view as well as from a moral one.

This study attempts to reach the following objectives.

1. To identify an indicator of a biophysical and psychical nature, able to represent, in a quantitative manner, the degree of satisfaction felt by an individual who lives in society.

2. To discover the criteria against which a particular social state, or evolution, can be appraised as satisfactory if considered from a rational point of view.

We assume that the criterion of rationality is decisive in this problem because it is reason, man's specific feature, which has placed him above all species and given him ever-increasing control over nature. Consequently, by no means can we assign in our analysis a secondary place to reason, without making a fundamental error with respect to nature.

3. To work out an axiomatic kernel from which all social behavioural

rules can be derived in a purely analytical way. The axiomatic kernel has to be so structured as to ensure that the rules of behaviour it generates are acceptable, on a rational basis, to all individuals living in a society.

2. Tentative Definition of a Single-valued Indicator for Quality of Life, as Perceived by an Individual

In order to evaluate the satisfaction an individual feels living in society, one has proposed and widely discussed in the past years indicators linked to the notion of "quality of life." We shall admit that such indicators can actually represent and evaluate, in a generally adequate manner, the very complex overall sensation of well-being (or ill-being) an individual feels when living in society. We shall raise on this subject two questions: (1) Is the perception of the quality of life (in abbreviated form PQL) of an individual, at a given moment of his existence, representable as a single-valued indicator and, if so, (2) can the PQL be quantified so as to permit social measurements to be performed and processed in the frame of an abstract model representing the studied society and the actual processes by which it evolves?

In answer to the first question we shall admit as a working hypothesis — a hypothesis of such importance for what follows that, in fact, it is equivalent to the admission of a principle — that the PQL is measurable and representable as a single-valued function dependent on time and on all the stimuli to which the particular individual considered is sensible.

We base this assumption on the following observations. In life an individual has always to decide by choosing between two opposed or contradictory alternatives: to take the car or go on foot, to stay at home or go to a concert, to divorce or not to, etc. If there are more than two alternatives the individual will proceed by evaluation, comparison, and elimination of the weaker alternatives, which finally leads him to the same two alternatives for decision-making.

To choose between two possible alternatives the individual has to compare the expected satisfactions he will obtain from each of them.

To do this he has to evaluate and compare in his mind two levels of global satisfaction, each of them linked to one of the considered alternatives. Because he cannot chop the two given alternatives into a number of small components, to select those components which best suit his personal needs and motivations and to rebuild these selected components into an optimal real alternative, he has to evaluate and compare the advantages of each alternative, considered as a whole. To do that he has to evaluate, in his mind, the number of satisfactions he can obtain from each alternative, to compare their effects on his personal needs, desires, and motivations, to build two overall mental estimates of well-being, corresponding to each alternative, and, finally, to compare in his mind these two overall estimates. Only after having performed such a mental process will he be able to decide which of the two possible alternatives he wants to try in real life.

This is why we consider that the individual's PQL can be represented by a single-valued indicator, that is by a single-valued function of time and of all the individual's needs and desires or, equivalently, of all the stimuli to which the individual is sensitive, through his motivations, at a given moment. Our result is alternative (but not contradictory) to that obtained by Paun,[8] who shows the impossibility, in some sense, of aggregating, under reasonable assumptions, several indicators, in order to obtain one indicator only.

In what follows we shall assume that the value of an indicator of this kind will increase when the individual perceives changes in the quality of life he feels favourable to him.

As for the second question we shall observe that if the PQL is considered as an overall perception, generated by the interference of all the particular sensations resulting from the influence of the external stimuli and correlated with the motivations of the individual, the PQL will be measurable to the extent by which: (a) the simple sensations are measurable as functions of the stimuli producing them; (b) there exists a possibility of correlating the above-mentioned sensations within a coherent overall sensation of well-being.

With respect to the measurability of simple sensations, psychophysical studies have evidenced in many ways the quantitative correlation between stimuli and sensations. The Weber Fechner law is a classical example in this sense and the presence on any electronic sound-device of potentiometers with logarithmic resistance distribution is a massive and everyday confirmation of this law.

With respect to the possibility of correlating all momentary life-sensations of an individual into a coherent overall sensation of well-being, we shall only mention that this has not been factually proved till now. However, we shall assume it to be true, on the basis of the arguments presented earlier in relation to the PQL being a single-valued indicator.

In conclusion to everything previously said we shall assume that it is possible to determine a set of single-valued functions of time and of all the variables to which the individuals in a given society are sensitive, associated with all the variables representing the individual motivations at a given moment, functions capable of representing in a satisfactory manner the PQL of each individual belonging to the considered society.

3. Proposed Principles for a Normative Social Optimization

Going on with our analysis we shall ask the following question: Assuming that the whole set of the above-defined functions, corresponding to a given human society, has been identified, how should it be used to discover the set of norms of co-existence the individuals should respect so as to ensure a rational optimization of the satisfactions life can give to each individual.

We shall try to answer this question from a general systems theory (GST) standpoint, considering the human society together with its material basis a closed system and the individual an element of the system. In such a frame the social optimization we have referred to constitutes a "one-piece" goal, but what a goal so defined really means remains rather fuzzy.

To make precise a goal in a GST way we have to describe first of all the essential (fundamental) demand we ask the goal to satisfy.

In the present study individual equity has been chosen as the essential, by definition, goal of any rational human social evolution, because one can observe, in extension to what was shown in section 2, that this value is relevant at the fundamental level, i.e., at the individual level, as well as at any level of arbitrary partition of the whole human society into a number of particular subsystems (nations, classes, collectivities, etc.).

But what equity means at the inter-individual level is not quite clear yet. Is equality between individuals actually a criterion for equity? And equality with respect to what value (or values) must be granted to the individuals of the same society so that the society should be optimally oriented and organized from a rational standpoint? Are individuals to be equal before the law, that is before civil laws, and/ or before the ethical norms of life in society? But the utility of establishing a goal for social development is, essentially, to permit the identification of behavioural rules for co-operative co-existence of the individuals in a society evolving towards better individual ways of life. To impose equality with respect to some existing laws or norms is to freeze any significant social progress in a possibly unsatisfactory state or evolution. It follows that such a criterion is unsatisfactory from the point of view of the present analysis.

Is equality in relation to human rights a better criterion? We think it is not, because it states essentially the same thing as above, the rights of man being granted and obtained by applying civil laws and social co-existence norms.

Are individuals to be equal with respect to work and payment? That is too narrow a standard since it does not include those who are naturally handicapped (the infirm, the sick, the under-gifted, etc.).

We shall assume that equity for the individuals in the same society and doing their best in social life is granted by imposing the following fundamental principle: co-existence of individuals within a given society according to moral criteria supposes them all to be in an equivalent relation to the PQL (Principle I).

We consider the principle to be of a moral nature and we shall say that a society satisfying this principle is a moral one.

Principle I seems to represent, at first glance, a socially equalizing operator. A deeper study shows that this is not quite true. Principle I recommends not equality in the possession of goods or social power but equality in the perception of life's quality in society.

This means that individuals with different aptitudes and talents who nonetheless supply the same effort towards a coherent social activity should be made to perceive the quality of life on the same level, no matter what results they obtain as a consequence of their being differently gifted. This point of view is based on the observation that a man's personal merit is not his talent but only his effort to cultivate it. It follows that principle I suggests that the moral norm is that each individual produce in proportion to the possibilities nature has endowed him with.

The point of view adopted is based on the hypothesis that man can be educated, within a restricted number of generations, so as to do his best for the general social welfare, not only for his personal well-being. So it follows that the principle adopted recommends equality when comparing the built-in effort, not necessarily the results.

In a certain sense this viewpoint is correlated to the one adopted by Galbraith who states that, in modern society, the inequalities arising from comparisons between individuals no longer play an essential role after the attainment of a certain quality of life, since these individuals no longer try to "keep up with the Joneses." Therefore it seems that not even the differing results obtained for an equal level of vital effort made play an essential role in a society that has gone beyond a certain level of the quality of life.

Proceeding with the analysis, one observes that to ensure overall individual equity in a given society represents a goal which includes many individual aspirations but, definitely, not all of them. For example one can imagine a moral society so badly administrated that the needs and desires of the individuals would be equally satisfied, but much less so than by an efficient administration. This observation shows that besides the first goal of a moral nature, stated by principle I, one has to adopt another goal, this one of a rational nature, a goal establishing that any human society has to administer itself so as to ensure the maximum possible general well-being for all the individuals belonging to it. More explicitly: when looking at any kind of human society one observes that the influences exerted on it by the environment are always weak enough to permit the administrators to select one particular evolution out of a very large number of potentially possible alternative evolutions. It follows that the essential task of the social philosopher is to discover those principles by which one can recognize which of all possible evolutions is best suited to the beings composing the society. To do so, he has to observe that the first principle (principle I) reduces the degrees of freedom a society has in choosing the cybernetically best evolution out of all the alternative evolutions permitted by the environmental physical world. This means that if principle I may be satisfied at any given moment by two or more alternative social evolutionary states, all possible from a practical point of view, then the social philosopher is confronted with the problem of finding a criterion by which one can identify the most favourable evolutionary state corresponding to a given society.

Since there is no physical principle allowing the identification of such a state we shall, as a first step, introduce a new value, defined as the average perception of the quality of life, the average being worked out among all the individuals constituting the society at a given moment. This being done, one can admit as a goal for any rationally oriented society a second principle, this one of a social-cybernetic nature, stating that: The socially optimal momentary state of a society should ensure that the average perception of the quality of life should be maximal or, more explicitly, as great as permitted by principle I and by the environmental (physical, economic, etc.) momentary conditions (Principle II).

4. Axiomatic Mathematical Formulation of Principles for a Normative Optimization of Social Systems

4.1. About the use of mathematics in social optimization

In what follows we shall try to work out an axiomatic version, expressed in a mathematical language, of what has been said above.

One may ask: Why mix mathematics with this subject? We think that our doing so is justified by the following principal considerations.

1. Mathematics is a most clear and precise language which readily reveals any inconsequences in assumptions or in procedures.

2. Any social-cybernetic attempt at organizing social evolution, as well as any social forecasting, are based on an assumed (explicitly or not) model. Mathematics very much clarifies the assumptions and limitations of such a model.

3. Mathematics permits quantitative evaluations and we strongly believe that scientific thinking cannot avoid using measurements and

quantitative processing of data, whatever the area under study.

4. Quantitative modelling of human social evolution is the best (if not the only) instrument capable of reducing the number of adventurous and often painful social experiments, as well as of clarifying the processes by which an adequate cybernetics of worldwide human society may be implemented so as to ensure significant chances to evolve without catastrophic convulsions.

In support of the above and as a conclusion to it we shall quote Mario Bunge, who writes:

> One should be able to build a model, or at least a theoretical framework, within which discussions of well-being (or quality of life) could be conducted in as exact a manner as the engineer studies the performance-optimal — satisfactory, or defective — of a machine or factory . . . we need more theoretical (if possible mathematical) models and more methodological studies to deal with the subject.*

4.2. An illustrative example of the method of using principles I and II

To demonstrate in a more simple and practical way why and how mathematics are to be used in solving social problems in a scientific manner, that is by making precise predictions which should prove afterwards to be true, we shall imagine a very simplified practical example. Let us suppose we want to solve the following problem: In an economically stable working factory with N employees the executive staff has to decide at a given moment (as a consequence of accumulated benefits, for example) how to readjust the working time and/or the salary of the personnel so as to satisfy, in the best possible social way, the general interests of the collectivity. We shall admit as a simplifying hypothesis that the factory represents a closed system, the single essential relation with the broader external system being the financial and material-products input-output.

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* M. Bunge, "What is a Quality of Life Indicator?" 1975, pp. 479-485.

If one has to solve this problem without using mathematics, very many words would be necessary just to outline the problem. Using mathematics simplifies the descriptive part of the problem as well as the procedure for solving it, as we shall try to show in the following.

If the factory staff is profit-oriented, the solution to the problem will follow from purely economic considerations (and equations). But this is not our problem. Our problem is to find that solution which corresponds to the principles established in the previous section.

To do so we shall first observe that both principles are operating on the mappings representing each individual's way of perceiving the quality of life. In consequence, as a first step, one has to characterize each employee by an appropriate individual mapping representing the values which express his personal way of perceiving the quality of life; let these mappings be noted by s^i.*

In a roughly simplifying manner we shall assume that s^i could be represented as functions of only two essential stimuli: the working time, denoted by T, assumed, for administrative reasons, to be the same for all employees, and the net personal income, denoted by V_i and linked to the worked time by the relation (of an economic nature):

$$V_i = p_i T \qquad (1)$$

in which p_i represents a wage-establishing co-efficient.

As a further simplification we shall admit that s^i is a sum of two components, each of them dependent on only one of the stimuli, so that

$$s^i = s_1^i\ (T) + s_2^i\ (V_i) \qquad (2)$$

We shall suppose that the forms of the functional dependences of the components s_1 and s_2 as well as the dependence on the worked time of an individual's productivity-factor Π_i, defined as:

$$\Pi_i T = P_i \qquad (3)$$

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* For a more rigorous formulation of this and of some of the following statements, see the mathematically axiomatized part of the study.

P_i being the financial value of the work done by the individual i, has been determined by psychophysical tests and measurements and has been represented as shown (in a non-precised metric) in Figures 1 to 3. The

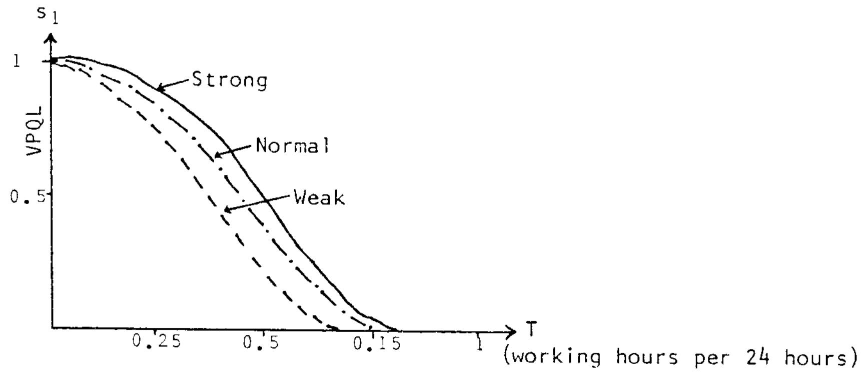

FIG. 1. Dependence of the s_1 Component of VPQL on the Average Working Time for Different Types of Individuals

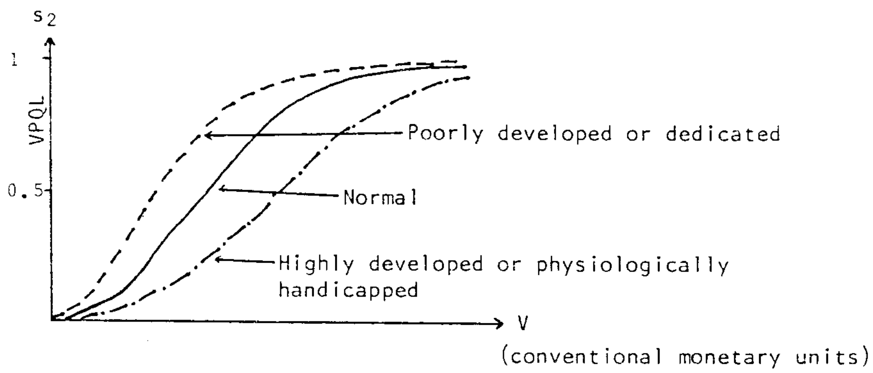

FIG. 2. Dependence of the s_2 Component of VPQL on the Net Income of Different Types of Individuals

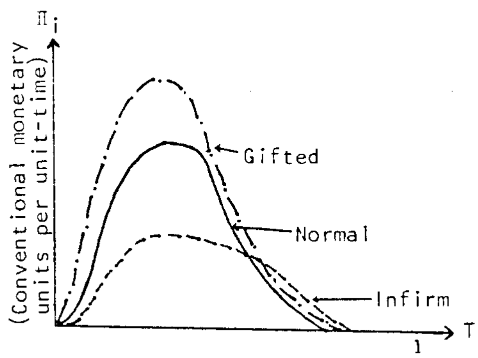

FIG. 3. Dependence of the Productivity Co-efficient Π_i on the Average Working Time for Different Types of Individuals

sketched characteristics represent the curves of response of the individuals differing by their somatic typology. One has to understand that each individual shall be characterized by a set of specific response curves (only three in our simplified example).

For solving the problem chosen as an illustrative example we shall assume that each employee can be represented by a set of three curves, obtained by combining in an adequate manner the individual characteristics shown in Figures 1 to 3: e.g., weak, Figure 1; highly-developed, Figure 2; and gifted, Figure 3; or strong (physically), physiologically handicapped (infirm or weak, lowly-developed, infirm, etc.).

If, finally, one supposes that an overall economic condition of the (overwhelmingly simplified) form:

$$\sum p_i T = \sum \Pi_i T \qquad (4)$$

should be respected, then the answer to the problem set forth could be obtained by using, as an example, the following algorithm.

1. Assume the working time T to have the value T_1.

2. Read, from Figure 3, the values $\Pi_i(T_1)$, corresponding to T_1, for all employees and calculate the value of:

$$\sum \Pi_i(T_1)$$

3. Determine the values of P_i so that the following conditions should be met:

A. The values $s_i(T_1)$ corresponding to a working time T_1 should be equal for all employees (as a consequence of principle I: $s^i = s^j$ for any i and j belonging to the system).

B. The economic condition:

$$\sum p_i(T_1) = \sum \Pi_i(T_1) \qquad \text{(rel. 4)}$$

should be satisfied for values of p_i and Π_i correspondingly to T_1. We shall observe here that:

i. To establish the values of p_i as a result of condition A means that the employees are rewarded not in consideration of their achievements, but rather of their efforts in doing their best.

ii. To calculate the values of all p_i (N in number) some computation has to be done. One has, in view of the need to determine the values of all p_i, to follow an algorithmic subroutine as, for example:

a. Read, from Figure 1, the values of the components $s_1^i(T_1)$, corresponding to T_1, for all employees.

b. Consider, as a first step in a trial-and-error procedure, that all s^i get the same arbitrarily chosen value. Let this assumed value be noted by s, so that $s^i = s$ for all i, i.e., for all employees.

c. Compute the values of the components $s_2^i = s - s_1^i$ for all i.

d. Read, from Figure 2, the values of all individuals' net income V_i, corresponding to the assumed value of s.

e. Compute the corresponding values of the different p_i from the relation

$$P_i = \frac{V_i}{T_1} \qquad \text{(rel. 1)}$$

f. Read from Figure 3 the values of Π_i corresponding to the assumed value T_1 of the working time.

g. Check if

$$\sum p_i = \sum \Pi_i \qquad \text{(rel. 4)}$$

is satisfied or not. If not, the value of s has to be adjusted in an adequate manner so as to reduce the error in satisfying relation 4, and the computation reset, beginning with step a of the subroutine. If yes, the values obtained for the p_i are the desired ones and the computation can go further.

4. Consider the resulted

$$s^i(T_1) = s_1^i(T_1) + s_2^i(p_i T_1)$$

values which by our hypotheses will be all equal and, by this, also equal to the average VPQL ("value of the perception of the quality of life" — see section 4.3 below) defined as:

$$\frac{\Sigma s_1(T_1)}{N} = \bar{s}(T_1)$$

and plot this value in a $\bar{s}$ versus T diagram.

5. Assume for the working time a new value, T_2, differing from T_1 by a small amount, and reiterate the whole computing beginning with step 2 to 5.

6. After a number of such interactions, implying an adequate set of values, T_1, T_2, . . ., T_n for the working time, find the value T_M for which s(T) is the greatest. The value T_M so defined is, as consequence of principle II, the actual answer to the proposed problem.

As a consequence of principle II it also results that the optimal values for the wage co-efficients p_i are those which correspond to T_M, i.e., $p_i(T_M)$, the optimal values for the salaries being:

$$V_i = p_i(T_M) \cdot T_M$$

The figures so obtained constitute a full answer to the problem set forth.

One has, however, to observe that for actually solving such problems the metric in Figures 1 to 3 has to be previously established in a precise, quantitative manner. This is a task for scientists specialized in the field of psychophysics, biophysics, human physiology, etc. We shall propose here only a very simplified method of utilizing such diagrams, as a tentative first approach. In this sense, we shall assume that the functions s^i, representing the individual VPQL can be divided in a sum of n terms of the form $k_j\sigma_j$ in which j = 1, 2, . . ., n, each variable σ_j representing the response in the VPQL to a single stimulus x_j and, as such, representable by a diagram of the same kind as 1 and 2, used in the previous example. If this is possible, the s^i functions could be written as weighted sums in which each term depends on a single independent variable, so that:

$$s^i = \frac{\sum_{j=1}^{n} k_j^i \sigma_j^i}{\sum_{j=1}^{n} k_j^i} \qquad (5)$$

The measuring scale for the VPQL of the different components σ_j should be chosen in such a manner as to represent the influence of each component in a normalized manner, let us say by values between 0 and 1, irrespective of the importance of the component σ_j in building the general individual VPQL, that is s^i. The importance of the component σ_j for the total value of s^i is established by the values attributed to the co-efficients k_j. The values of these co-efficients should also be normalized in accordance with the importance of each stimulus upon the VPQL of the particular individual considered. For example k_j could take values near 1 if the stimulus x_j corresponds to one of the fundamental needs of the Marlow classification, for example; or a value near zero if the considered stimulus corresponds to a need of a higher order (or, let us say, a desire) in the same classification.

Obviously, the values of the k_j^i so defined could be made to depend on any of the σ_k, so as to relate the importance of one stimulus on the degree to which the other needs, of a more fundamental nature, are satisfied, i.e., on the momentary motivational state of the individual.

If one should like to refine the above discussed example, one could consider a supplementary component in the individual VPQL, let us say σ_3, related, for example, to the improvement by learning of the individual's professional-knowledge level. If so, one has to add to Figures 1 to 3 another diagram establishing the functional dependence of σ_3 to the time allotted for professional-knowledge improvement.

Considering that a net non-zero income is a fundamental need for any individual, a need which cannot be satisfied without the carrying out of useful work, one shall assume for k_1^i and k_2^i the value 1, while assuming for k_3^i a value smaller than 1, as a consequence of the fact that improving one's level of professional knowledge is seldom vital.

Using relation 5 within the computing algorithm at points 1 to 6 (obviously, one has to refine points 3a to 3g so as to match the new requirements), one can establish not only the optimal working-time and wages, but also the optimal time to be allotted to learning (we have not discussed the individual's ability to learn). Most evidently the example discussed above represents a very drastic simplification of reality. It has been presented only as a method-illustration, without aiming at all at establishing precise figures.

As a conclusion to this section we have asked ourselves the question: is it really worth using mathematical models and methods in searching for adequate goals for human development?

In our opinion it is, because an answer without mathematics, even to the very simple problem analysed above, would have asked for a great amount of words and, perhaps, would have led to rather risky human-group experiments to get an answer. We believe that mathematical modelling of such a subject should, at least, clarify the necessary premises in a problem-solving process and facilitate the getting of first-approach decision-making data.

4.3. Mathematical model

In what follows we shall present an attempt at establishing a mathematically axiomatized form of the proposed theory. This form will deal only with instantaneous social states. An extension of the here-obtained results to evolutionary social processes will be presented in a later study.

As a consequence of what was said in section 2, one states that the perception of the quality of life (PQL) of an individual is representable in mathematical form by a real function "s" of a certain number of variable arguments, $x_1, x_2, \ldots, x_n$. Each of these arguments represents the action of a particular type of stimulus. The value of the functions "s" represents, on a given scale, the "comfort level"[3] or well-being corresponding to the psychophysiological standard we called PQL.

Thus we could write:

$$s = f(x_1, x_2, \ldots, x_n, t) \qquad (6)$$

in which t represents the explicit dependence of the function s on time, a dependence that translates the historical determinant influences accumulated up to the given moment t in the structure of the individual considered, while $x_1, \ldots, x_n$ describes the dependence of this function on stimuli which act on an individual at a given moment. The stimuli x_j will also be considered as functions of time:

$$x_j = g_j(t) \qquad j = 1, 2, \ldots, n$$

In order to differentiate the notion "perception of the quality of life" as such from the PQL notion considered as a measurable quantity, defined by the relation 1, we shall call it the value of the perception of the quality of life and shall refer to it as the VPQL. This notion is partly new and more schematic than the first one.

We shall assume, as a working hypothesis, that the function s defined by relation 6 is practically determinable if all the stimuli acting on an individual are known. The individual should be characterized through a set of parameters representing his personal features and moment-by-moment motivations.

The hypothesis, still very incompletely verified in practice, is so important for this study that it is reasonable to consider it as the main axiom. Its rejection would refute the validity of the whole study.

In conformity with the axiom, the perception of existence which an individual gets is characterizable through a function of VPQL which depends on: (1) the individual's biophysical structure; (2) the experiences he has undergone; (3) the circumstances he lives in; and (4) those he believes he will live in the future. Consequently the individual's VPQL function will be structured so as to translate the influences of all the parameters belonging to the four categories of factors as stated beforehand.

In the case of the individual living in a society of N similar individuals one has to operate with N functions of VPQL simultaneously. The VPQL of a particular individual in a society composed of N individuals is written as:

$$s^i = f_i(x_1^i, x_2^i, \ldots, x_j^i, \ldots, x_{n_i}^i, t) \qquad (7)$$

where $s^i \in R$, $i = 1, 2, \ldots, N$ is the index of the individual in the society under consideration and $j = 1, 2, \ldots, n_i$ is an index of identification of the type of stimulus acting upon him.

In this context, the VPQL functions can in no way be independent; they have to be very complexly interdependent. When structuring the VPQL functions, the following considerations should be kept in mind.

1. The mathematical form of the individual's VPQL functions must represent the individual's biophysical structure and his motivational state at any given moment.

2. The x_j^i arguments must represent the influences on each individual, namely the whole set of stimuli he is sensitive to. Among these one has to consider at least the following broad categories:

a. Stimuli stemming from the material environment outside the individual.
b. Personal organic stimuli determined by internal physiological or psychological causes.
c. Stimuli stemming from the feelings of an individual "i" for another individual "k" to whom the former is linked through an affective relationship so that the "i" individual's VPQL function becomes dependent upon the value of the "k" individual's VPQL function. This can be expressed as:

$$A^{x_j^i} = \phi_j^i\ (s^k)$$

ϕ being an adequate mathematical function, and $i = 1, 2, \ldots, N$; $j = 1, 2, \ldots, n_A^i$ and $k = 1, 2, \ldots, N$ with $k \neq i$. Index A indicates that the stimuli so defined belong to a class of affective stimuli.
d. Stimuli which translate the hopes and anxieties generated by the capacity of a rational being to project itself into the future.

Any other stimuli capable of influencing the individual's behaviour in society may be taken in consideration.

Thus the VPQL function written down as in (3) must translate the complex interdependence of all these factors.

As already said, the time dependence explicitly written in Mesarovic and Pestel[7] expresses the fact that the individual's structure changes with time as a consequence of direct material influences as well as of the whole set of psychological events he has lived through.

Principle I was expressed in section 3 in the form: Co-existence of individuals within a given society according to moral criteria supposes them all to be in an equivalent relation to VPQL (Principle I).

In a mathematical form this statement is equivalent to a law of equipartition of VPQL, which may be expressed as:

$$s^i = s^j \tag{8}$$

a relation which must be true for any i and j belonging to the considered society and is obviously satisfied in an identical manner for $i = j$.

We shall say that if, within a given society, the rules of behaviour ensure equipartition of the VPQL, that society may be called a moral one.

One has to observe that the first principle, mathematically expressed by relation (8), reduces the degrees of freedom a society has in choosing the correct evolution, out of all the evolutions permitted by the environment. This can be easily shown. Let us consider for this purpose all the values the descriptive co-ordinates x_e^i with $i = 1, 2, \ldots, N$; $e = 1, 2, \ldots, n_i$ and $s_e^i \in R$ may take, if not restricted by any social laws. From this set, principle I, imposing a number of N-1 conditions (i.e., $s^i = s^j$) to the co-ordinates x_e^i, selects a set with a reduced number of permitted values. Let this set be written $\{x_e^i(t)\} = M$. It follows that any state of the society under study, characterized at a given moment t by one of the $\sum_{i=1}^{N} n_i$ dimensional vectors $[x_e^i(t)]_M$, belonging to the allowed set M, will be a correct social state if considered only from a moral viewpoint.

This does not mean implicitly that it is also satisfactory from a rational ethical viewpoint.

Indeed, if it is possible that the system of relation (8) be satisfied, at any given moment, by more than a single set of values $[x_e^i(t)]_M$ then the social philosopher is confronted with the problem of finding a criterion on the basis of which one can identify the most favourable state for the considered society.

Supposing that such a state, at a given moment t, has been found, then it will be representable by a $\sum_{i=1}^{N} n_i$ dimensional vector, as above. Let this vector be written as $[x_e^i(t)]_E$. Obviously this vector will belong to the $\{[x_e^i(t)]_M\}$ set. Since there is no physical principle allowing the identification of this state, we shall at first consider the average VPQL defined in paragraph 4.2 as:

$$\bar{s}(t) = \frac{1}{N} \sum_{i=1}^{N} s^i(t) \qquad (9)$$

which we shall name the specific VPQL corresponding to the society under study. Then we shall admit as a second social principle based on purely rational considerations that the optimum state from an ethical viewpoint is that which satisfies the condition:

$$s([x_e^i(t)]_M) = \max_{x_e^i \, \varepsilon \, R} \qquad (10)$$

Principle II is thus conventionally and more concisely represented as:

$$[x_e^i(t)]_E = \arg \left(\max_{\substack{x_e^i \, \varepsilon \, M \\ i,e \, \varepsilon \, R}} [s([x_e^i(t)]_M)]\right) \qquad (11)$$

Theoretically, a state characterized by a vector $[x_e^i(t)]_M$ that satisfies condition (10) will be correct from the moral viewpoint as well as from that of rational ethics.

5. Conclusions

The above study tries to cast light on some cybernetic aspects of the relation between general goals for social development and the needs and aspirations (desires) of the individual. The most important results obtained are, in our opinion, the following.

1. If the assumed hypothesis of single-valuedness of the VPQL indicator of an individual shall prove correct, then comparing the well-being levels of differently structured and/or differently living individuals becomes possible, because the measure of an individual's VPQL is determined in his own needs-satisfiers system (in the same way the energy-rates of very differently built power-plants, e.g., atomic, hydraulic, thermal, solar, etc., are determined by the fissible-material consumption, the water flow, the coal consumption, the reflector's surface etc.). By this method, well-being levels of individuals as different as a metropolitan businessman in search of funds, a man fighting for the restoration of a religious government, a scientist asking for experimental facilities, an uneducated, poor peasant harvesting only half the crop he needs for sustaining his family, can be compared.

Supposing the set of needs-satisfiers, i.e., of stimuli representing the variables of the individual's VPQL functions have been established and the form of these functions is known, then it should be possible to determine the way in which changes in the set of needs-satisfiers, i.e., of social stimuli, will affect the individual's well-being in social life. This should ensure previsibility of the responses obtained as results of imposed changes on the set of social-life parameters in which one can actually act through social norms.

2. The study has attempted to demonstrate that a general goal for an optimized social development can be satisfied by imposing social norms of behaviour, determinable on the basis of theoretical considerations.

The fact that a general goal for social development can be expressed in the form of only two principles seems to be a non-trivial theoretical result.

3. The observation that these two principles are acting on two clearly separate levels helps us outline a cybernetic approach for the adequate social administration of any kind of society assumed to be independent (closed-system hypothesis). The first principle, being a moral one, has to be satisfied compulsorily, in our opinion. The second one, being of a rational nature, has to be satisfied in the measure the first one has been satisfied, because if the first principle is not satisfied, any criterion of optimization loses all social meaning.

Both these principles are operating only in a normative way, i.e., establishing generally advantageous behavioural norms. One has to observe that, if they were made to operate outside the field of restrictions imposed by the biological and, equally important, psychological structures of the individuals belonging to the society, that is beyond the frontiers of the possible behavioural natural laws of the individual, the two stated principles will generate inoperant structures of norms.

4. If the form of the functions of VPQL for a sufficient number of types of individuals living in different parts of the world could be actually established, one could outline, on the basis of the two stated principles, a set of tentative optimal norms for international economic relations.

The first step in such an attempt should obligatorily be the equalizing of VPQL inside the different national groups. This is so because principle I cannot keep its sense in a worldwide extension if one has to equalize national values of perception of the quality of life, obtained by an arbitrary processing of unequal individual values. Only after principle I is respected on a national level can it be extended to an international level, if one wants to consider equity as understood in this study. This is, in our opinion, a not quite trivial theoretical result.

5. The first step in implementing and testing the above theoretical considerations should be the search for the actual form of the functions defined by relation (6), in as large a human spectrum as possible, and to do correlational tests to check the ability of such functions to express the way individuals, living in very different conditions, perceive the quality of life. This seems to be a task for a whole team of social scientists.

6. Finally, we shall observe that the model operating on principles I and II is an open algorithm model. It is so because the s^i / x^i_j $(i = 1, 2, \ldots, N, j = 1, 2, \ldots, n_i)$ interplay is considered as permanently readjustable under the influence of new discoveries, the new structures created by social evolution, and the progress of human knowledge in which the model is called to participate. If considered thus, the model is a self-adjusting model in which learning is used on a most general scale as a feedback loop for readjusting the structures of the mathematical processes (or algorithm) by which the two principles are made to operate.

References

1. Balaceanu, C., and Nicolau, E., Personalitatea umană — o interpretare cibernetică [The human personality — a cybernetic interpretation], Iasi, Editura Junimea, 1972.

2. Botez, M., and Celac, S., "Noua ordine economică si politică internatională în perspectiva dinamicii sistemelor" [The new economic order and international politics considered from the dynamics of systems point of view], in Sisteme în ştiinţele sociale [Systems in the Social Sciences], edited by Mircea Maliţa, Editura Academiei R.S.R., 1977,

3. Calude, C., Marcus, S., Păun, C., "Empirical Information and Theoretical Constructs in the Study of Needs," part 2, GPID Bucharest meeting, January 1979.

4. Galtung, J., "Goals, Processes, and Indicators for Development — A Project Proposal," paper for UN University GPID project, 1977.

5. Lederer, Katrin, "Reflections About Needs," 3rd draft, September 1978.

6. Mallmann, C.A., and Marcus, S., "Empirical Information and Theoretical Constructs in the Study of Needs," part 1, Berlin

Conference on Basis Needs, May 1978.

7. Mesarovic, M., and Pestel, E., Mankind at the Turning Point, New York, E.P. Dutton and C.P. Inc., Reader's Digest Press, 1974.

8. Păun, G., "Possibilities and Limits in Reducing the Social Indicators Complexity," paper for UN University GPID project, 1979.

IV. DESIRABLE DYNAMICS FOR HUMAN DEVELOPMENT

Dan Romalo

The present study is conceived as a conceptual reflection intending to establish the theoretical bases on which normative control of human development, along a desirable path of social evolution, can be founded.

A closely related study on this subject has already been presented,[10] but in a more restricted form, adequate for analyses of transitory social states only. The present study tries to extend the significance of the principles stated in Romalo[10] by expressing these principles in a more general form, thus making them adequate for the investigation of dynamic social phenomena.

Human development being the main subject of this study, considering goals, processes, and — of course — indicators for development will be unavoidable. This is why we shall begin by looking a little more closely at these concepts and at their interrelation.

It was stated in Romalo[10] that any intent to control a human social process should be aimed towards a single goal, this goal being the satisfaction of two principles. The principles are of a moral and of an ethical nature. We shall say that, in our opinion, any social cybernetic approach, whatever its aim and fundamental premises are, must satisfy above all these moral and ethical principles. Any other criteria, let them be economic, political, or of any other nature, have to be considered, in our opinion, only through the general frame of the principles of morals and ethics.

In extension of what was assumed in Romalo[10] we shall consider human society as a dynamic (i.e., evolving in time) closed system acted upon by all the environmental influences and by all the interactions between individuals. Particular to such a system is its high degree of self-determination, i.e., its large number of individually controlled degrees of freedom, resulting from the great multitude of feedback loops generated by the interactions between individuals, their behaviour, and their sensations and being determined by the set of stimuli acting upon each of them as well as their momentary state of motivation.

It follows that, if so considered, a social system will evolve by transformation processes which shall, all, have two components of an essentially different nature.

1. A component of a hard, compulsory, and, at any given moment, unavoidable mode of variation of the variables describing human development. We shall call this component the "hard-path development" and think, e.g., of the total energy radiated by the sun on the earth, the duration of the sideral year, the chemical structure of the genes, the productivity-wage-benefit relation under given conditions, the historically established religious beliefs in a given coherent community, and the behavioural social responses they can produce, the human and animal behavioural rules under strong stimuli and motivations, etc.

2. A soft, previsionally multiform (alternative futures) component, upon which the social administrators can act by normative means. We shall name it the "soft path development," and think, e.g., of alternative programmes of education, learning themes, correlations between wages or different activities, the number of working hours per week, the chromosomal transformations one can bring about in human genetics, etc.

In the present study we shall not analyse the implications for social cybernetics of the hard-path development, considering this part of the problem solvable by known procedures of physics and the exact sciences. We shall concentrate our attention on soft-path development only.

Our point of view, presented in Romalo,[10] is that there exists for each individual a singie-valued indicator which is capable of representing quantitatively the level of the quality of life an individual perceives at a given moment.

From Katrin Lederer's point of view,[6] the above assumption is severely holistic. We believe it is justified, however, by the arguments given in Romalo[10] and also by the theoretical considerations developed in Paun,[9] leading to the conclusion that the use of aggregated compensatory indicators is unavoidable.

The proposed indicator was called in Romalo[10] the "value of perception of the quality of life" (VPQL in abbreviated form) and was represented as a function of all the variables to which an individual may be sensitive at a given moment. We have assumed in Romalo[10] that these variables were the whole set of stimuli to whose influence an individual is subjected at a given moment.

In the present study we shall try a slightly different approach, based on needs as defined in Bossel,[1] Galtung,[3,4] Mallmann and Marcus,[7] and Massini,[8] because by doing so a much clearer synthesis of social phenomena can be obtained. This is so because:

1. Adequate satisfaction of man's needs is the fundamental obligation of any controlled social-organization process.
2. The needs of the individual as well as the social needs have been subjected finally to an extremely wide and intense investigation process.
3. Advanced knowledge of hierarchization, interplay, and theoretical systematization of human needs has been reached (e.g., Mallmann and Marcus,[7] Calude, Marcus and Paun,[2] Wirak,[12] and Sicinski[11]).

Consequently we shall assume that the VPQL of an individual i living in a society of N individuals is representable by a function:

$$s^{(i)} = f(n_1^i, n_2^i, \ldots, n_j^i, \ldots, n_{J_i}^i, t) \qquad (1)$$

with $i = 1, 2, \ldots, N$ and $n_j^i(t)$ representing the degree to which a certain need j ($j = 1, 2, \ldots, J_i$), is satisfied at a given moment. We shall consider that the variables $n_j^i(t)$ depend on time as well as on a number of other variables, also dependent on time, $x_l(t)$, $l = 1, 2, \ldots, L$, so that the state of the system may be represented by a vector $[n_j^i(t); x_l(t)]$. The components of this vector are to be imagined as a system of generalized co-ordinates (in a mechanistic acception) built around the needs of the individuals as a kernel. Their total number will obviously be equal to the number of generalized co-ordinates; the greater the number of these co-ordinates, the more elaborate the representative model of the society. (This kind of approach is, indeed, that following from a deterministic philosophy.)

So, one can write:

$$n_j^i = f_{i,j}(x_1, x_2, \ldots, x_l, \ldots, x_L, t) \tag{2a}$$

or, more generally, if one also takes into account the psychological interactions between individuals (affective links between individuals):

$$n_j^i = f_{i,j}(n_1^1, \ldots, n_j^i, \ldots, n_{J_N}^N, x_1, \ldots, x_l, \ldots, x_L, t) \tag{2b}$$

The presence of the parameter representing time explicitly in relations (1) and (2), is a consequence of the fact that the needs determine the perception an individual gets of the quality of his life, through his <u>momentary</u> motivational state, the latter being dependent not simply on time but on all past time, in the sense of his entire individual history as well as the history of the species.

By intermission of relation (2), relation (1) can be written in the following equivalent form:

$$s^{(i)} = \phi_i(n_1^i, n_2^i, \ldots, n_j^i, \ldots, n_{J_N}^N, x_1, \ldots, x_l, \ldots, x_L, t) \tag{3}$$

One has tentatively established in Romalo[10] that the entire ethics of a human society should be based on only two general principles, the first of a moral nature, the second of a rational-ethical nature.

One shall observe that in the case of social collectivities, the moral-ethical conditionings (i.e., the two above principles) reduce through internal imperatives (in the sense of restraining the soft-path development alternatives normatively permitted) the degrees of freedom nature granted to the human society.

If we denote by

$$\{[n_1^1, \ldots, n_j^i, \ldots, n_{JN}^N, x_1, \ldots, x_l, \ldots x_L]\}$$

the set of representative vectors corresponding to all the social states which satisfy the moral principle and by $[n_j^i, x_l]_E$, i, j, l taking all permitted values, the representative vector which satisfies the principle of ethics also, then the two principles of morals and ethics may be written:

A. Principle of morals:

$$s^{(i)} = s^{(j)} = \bar{s} \tag{4}$$

i and j taking all permitted values and $\bar{s}$ representing the common value so obtained.

B. Principle of ethics:

$$[n_j^i(t); x_l(t)]_E = \arg(\max[\bar{s}([n_j^i(t); x_p(t)] \in M)]) \tag{5}$$

i, j, l taking all permitted values.

To describe in a more intuitive way the human-development problems one can use the following imagery: All possible states of a society may be represented by a number of points distributed in a multidimensional space, the numbers of dimensions of the space of representation being equal to the number of degrees of vector of position which, obviously, will be $[n_j^i; x_l]$, i, j, l taking all allowed values. The system being supposed dynamic, the vector $[n_j^i(t); x_l(t)]$ will change in time and the representative point of the system will move on a particular trajectory in the space of representation.

From what was said before, one deduces that, from all the trajectories permitted by the macroscopic laws of nature, in other words from the whole congeries of hard-path and soft-path development alternatives, the principle of morals (relation 4) reduces by normative imperatives the number of allowed trajectories. From the thus restricted set of trajectories, i.e., the set of moral evolutions, the principle of ethics (relation 5) selects a singular trajectory which represents the optimal evolution of the social system under study. Speaking in a metaphoric way, we shall call this particular trajectory an "ethodesic" (by analogy with "geodesic" which represents an extreme of a particular geometric function).

If so, one can affirm that human development may be aimed at a single goal, i.e., to engage and maintain human evolution on the ethodesic, passing through the point representing the momentary state of a society when it decides to go on an ethodesic.

One now tries to solve the following problem: Assume the whole set of factors determining human social evolution can be determined for the more or less distant future, how can the ethodesic for a given society be identified? At first glance one can believe that, starting with the state of the collectivity at a given moment t, and identifying all possible evolutions which will ensure that, at a closely following moment $t + \Delta t$, condition 4 is satisfied and that principle 5 is also satisfied for $t + \Delta t$, the new social state so obtained, corresponding to the representative vector $[n_j^i(t + \Delta t); x_l(t + \Delta t)]$, i, j, l taking all permitted values, will be situated on an ethodesic. Consequently, one could suppose that the whole ethodesic towards $t \to \infty$ could be obtained by proceeding iteratively in this way.

Thinking so is however deceptive, because one cannot assume that reiterated use of the principle of ethics (relation 5) on consecutive short-term evolutions is equivalent to its use on the whole interval of time represented by the sum of the previously considered short intervals. It is, indeed, very well known that a maximization of satisfaction in the short run can lead to terrific dissatisfaction in the long run.

It follows from the above observations that one cannot apply the proposed principles to elementary intervals of time, but only to finite ones whose optimal length remains to be established by further investigation. At first glance it would seem that the longer the interval, the better the results.

A closer look at the subject shows it is not so, neither of the proposed principles being useful if applied for shorter intervals of time than some critical values.

The correct solution of the problem thus outlined results from considering the individual as an integrated part of the system. To do so one should note that the principle of equipartition of the VPQL has no real meaning if one attempts to apply it to strictly momentary values of the variables. So doing it would follow that all individuals in the society have to live in perfect synchronization – to do the same quantity of work, to rest, to watch a show, etc., synchronously – an obviously absurd solution.

It follows that the principle of equipartition of VPQL must be formulated in such a way as to permit comparison of individual VPQL averaged in a time interval ΔT. This interval must be long enough to permit the desynchronization of individual activities without, however, entering into the more complex domain of the distribution of VPQL over an individual's whole lifespan.

It seems that the interval of time ΔT so defined corresponds to one of the natural periods of activity of the individual, that is, days, months, or, perhaps more suitably, years.

So, the functions $s^{(i)}$, averaged over an adequate period of time

$$\overline{s^{(i)}}^{\Delta T_i} \equiv \frac{1}{\Delta T_i} \int_t^{t + \Delta T_i} s^{(i)} dt \tag{6}$$

should take, as a consequence of the principle of morals, the same value $\bar{s}(t)$ for all individuals, i.e.:

$$\overline{s^{(i)}}^{\Delta T_i}(n_l^i, t) = \overline{s^{(j)}}^{\Delta T_i}(n_k^i, t) = \bar{s}(t) \qquad (7)$$

for all i and j representing individuals belonging to the system.

It follows that under historically given development conditions $\bar{s}$ will depend essentially only on time and in a parametric way on a set of very general social variables, so that $\bar{s}$ is a function of $\bar{s}(t, \sigma_\omega)$, $\omega = 1, 2, \ldots, \Omega$.

A moral society thus becomes a kind of super-individual organism characterized from an ethical point of view by a specific function of VPQL, that is, by $\bar{s}(t, \sigma_\omega)$, a function defined as shown in relation (6).

So, if the principle of morals (relation 6) is normatively imposed, all

$$\overline{s^{(i)}}^{\Delta T_i}$$

must follow the evolution of the function $\bar{s}(t)$ which represents a quantity strictly linked to the evolution to be respected: any individual evolution must be strictly conditioned, in a normative way, by the optimization of the overall social evolution.

The next question to be answered is: How can the ethically recommendable evolution of a society be determined over a period of time longer than the mean lifespan of an individual?

To find the answer one should consider the indicator S, of an ethical nature, defined as:

$$S \equiv \frac{1}{TN} \int_t^{t+T} \sum_{i=1}^{N} s^{(i)} dt \qquad (8)$$

or equivalently, as a consequence of relation 6,

$$S = \frac{1}{T} \int_{t}^{t+T} s(t)dt \tag{9}$$

Indicator S shall be called the <u>specific VPQL</u> of the society of N individuals over an interval of time t to t + T.

In an attempt to extend the validity of the second principle stated in Romalo,[10] one shall assume that the ethically recommendable evolution of a society shall correspond to the condition:

$$S_E = \max S \tag{10}$$

More precisely: assume the social evolution is described by the set of variables $\{n_j^i, x_l\}$ as function of time l, j, l taking all permitted values, the principle of ethics in a generalized form shall be written as:

$$[n_j^i, x_l]_E = \arg\ [\max\ (\frac{1}{NT} \int_{t}^{t+T} \sum_{i=1}^{N} s^{(i)}(n_j^i, x_l)\ dt)] \tag{11a}$$

$$j = 1, 2, \ldots, J_i$$
$$l = 1, 2, \ldots, L$$

or, equivalently if the principle of morals is respected:

$$[n_j^i, x_l]_E = \arg\ [\max\ (\frac{1}{T} \int_{t}^{t+T} \bar{s}(t, \sigma_\omega)dt)] \tag{11b}$$

$$\omega = 1, 2, \ldots, \Omega$$

Maximization has to be understood as accomplished by the varying of all the parameters representing social or socio-economic interactions <u>upon which one can act by normative means</u>.

One has now to decide: How great should the interval of time T, over which the integration is extended, be?

A natural response seems to be: As long as possible, the only limit being that imposed by our incapacity to accurately evaluate the future.

But if T is greater than the average lifespan of an individual, a very sensible question may be asked: How should the VPQL be distributed between contemporaries and descendents so that the sacrifices necessary to make possible human development should be equitably shared by the successive generations? Actually, most people who lived a century ago may have asked: Is it right that I have to work so hard now not only to make a living but also to make it possible for other individuals of the future to have a much easier life than myself?

The question is not trivial, nor has it an obvious or immediate answer. On the contrary, it is of a fundamental nature.

At the level of theoretical analysis, the answer to this question may be sought as follows: One has to imagine an impartial observer who watches the evolution, over successive generations, of a society made up of similar individuals. For him, a particular individual in a particular generation is absolutely no different from another individual from another generation. Therefore, he may consider that, in theory, any two individuals could be interchanged without producing, from his point of view, any significant ethical or moral change in the observed society (axiom of non-privilege). Consequently, the observer might think that since high values of VPQL are recommendable for one individual, they are also recommendable for a series of successively living individuals. Not having criteria for privileging a particular individual or a particular generation, he might conclude as he looks at the supra-individual organism living first through a difficult period then through an easier one that, consequently, optimization must be applied to the whole super-organism thus identified. That means that the criterion of maximum VPQL has to be extended over the society's entire evolution.

Any one of the individuals looked at may find, however, this reasoning absolutely unsatisfactory because it is a fact that individuals cannot be moved from one generation to another. Every individual lives only through those sensations arising from the life he lives in the generation he belongs to, and only those sensations.

So he is justified to assume the right of all individuals living in successive generations of the same well-defined society to be normatively situated on the same ethodesic (as expressed in a very mechanistic formulation).

But these observations constitute the principal clue to finding the answer to the question. Indeed, one observes that it is the affective links between individuals belonging to successive generations, especially the older to the younger, which are responsible for the presence in social cybernetics of a component of automatic control, in a sense favourable to future generations. This phenomenon was already accounted for in the previously established mathematical relations by considering the functions $s^{(i)}$ in the general form of relation (2b), which takes into account the affective interrelations between individuals, whatever generation they belong to. This causes the correct normative solution to result automatically, by application to the set of relations 2b of the principles of morals and of ethics.

Social cybernetics, if further developed as an analytical science, will principalize a second component of this phenomenon, motivated by a sense of responsibility of those now living towards those who are to live in the future. We refer specifically to the principle of Meadows, which states that no man or organization has the right to make a decision which would diminish the liberty of decision of those coming afterwards. This principle, if formulated as above, establishes a not easy task for the social administrators, because it requires a balancing, over a number of generations, between the liberties generated by development and the restrictions due to consumption.

In our opinion Meadows' principle is less general and expressed in a less precise form than the system of two principles proposed in this study as the theoretical base for ethics. If these two principles are satisfied, then the principle of Meadows will automatically be satisfied in its intent.

One considers it useful to underline here that the thus derived social-cybernetic, long-term solutions could be normatively unimplementable if they contradict strongly motivated natural rules of behaviour of the individual in the short term. To quantify and theoretize this phenomenon one should observe that, the intensity of motivation being directly related to the degree of satisfactions of needs, one may imagine that the theoretic normative solutions are implementable only if they are not based on values of the variables n_j^i (representing the degree of needs satisfaction) smaller than some yet-to-be-determined threshold-values n_{jo}^i. By considering as inadequate evolutions in which $n_j^i < n_{jo}^i$ for some interval of time, i and j taking all permitted values, one may be able to eliminate the aforementioned difficulties.

Finally, one observes that the general social evolution so determined can assume two aspects, each quite different according to the length of time chosen for T. If T is greater than an individual's average lifespan, T_{al}, then the ethical evolution is represented by a continuous ethodesic and, if correct prognoses are made, individuals belonging to the future generations will be the main beneficiaries of development.

If, on the other hand, a value close to T_{al} is chosen for T and the procedure of maximizing function S is repeated from one interval to the next, a continuous evolution curve is obtained, but it will be composed of a series of disconnected arcs of partial ethodesics.

It is the second case which, in our opinion, represents the more prudent solution, favourable to the individual living at a particular time, because it bears in mind the rights of the individuals of each generation to benefit from the results of the effort expended to bring about progress.

From the above analysis it results that the set of norms able to ensure, if implemented, an ethically adequate evolution of human society could be established by using an algorithm of the following sort (all symbols have the above-established significance and the indices taking all permitted values).

1. Determine the set of individual needs significant for solving the social problems of the observed society at the desired level of accuracy.

2. Determine the mappings $s^{(i)} = f_i(n_k^l)$ for all individuals belonging to the society under study, indices l and k taking all permitted values.

3. Determine the whole set of representative vectors $\{[n_j^i(t), x_l(t)]\}$ built on the values n_j^i representing the degree to which the individual needs are satisfied in different alternatives of possible futures, each vector $[n_j^i(t), x_l(t)]$ representing a particular alternative evolution. These alternatives have to be imagined as scenarios for a foreseeable future implementable by normative means.

4. Determine the ethically recommended evolution of the system by applying both principles of morals and of ethics (relations 6, 7, and 11). This means that from the whole set $\{[n_j^i(t), x_l(t)]\}$ of possible evolutions one single ethically adequate evolution $[n_j^i(t), x_l(t)]_E$ is identified. By this all the time-dependent values of the variables $n_j^i(t)$ and $x_l(t)$, for all permitted values of the indices, should become known.

5. Considering the thus determined values of the variables $n_j^i(t)$ and $x_l(t)$ as desirable values of indicators, one should be able to derive adequate norms of behaviour in society so as to control the actual social evolution towards the indicated, desirable one.

The thus established recommendable social behaviour will aim the social processes towards recommendable ones and, if successfully implemented, towards a desirable future world.

Conclusions

The present study is a generalization of an earlier published study[10] concerning the theoretical bases of morals and ethics. The validity of the principles established in Romalo[10] have been extended here to dynamic social systems also. The proposed principles, formulated in their general form, constitute, in our opinion, a theoretic kernel which may not be neglected in any significant study of social cybernetics, because it represents the human aspect of the problem.

To the conclusions drawn in Romalo,[10] one may add:

The original contribution of the study is not very much related to new significant aspects of life in society but rather to a severe systematization in social analyses.

The whole study is a mechanistically oriented approach reflecting a very strong deterministic philosophy. This kind of approach has been chosen because, in our opinion, understanding of complex and still partially unknown phenomena is sometimes easier to achieve with the aid of a very simplified first-approach model than by looking from the very beginning for a more elaborate but also more complex one.

The intent of the above study is to propose a coherent set of values, indicators, and principles by the aid of which human individual interests can be evaluated and compared. On such a base the co-ordinates of the optimal evolution for an organized human society may be identified.

In our opinion two not quite trivial results emerge from this study.

In the first place is the observation that the problem of equity between individuals belonging to different generations is not of an obvious solution.

One has assumed earlier that human development, if it is to satisfy the moral and ethic desiderata, should grant to all individuals belonging to the same society the right to live along one and the same ethodesic. This is a quite precise statement. But what "the same society" means is rather fuzzy. Clearly it should mean human society as a whole. But, at this hour, the means capable to realize a one-piece, normatively unified human society are rather foggy and, as a consequence, also in the mist is when will human society decide to follow an ethodesic path.

Even if no practical answers have been given in the present study concerning the means to realize an adequate human development, one hopes however that the "what is the problem" was, at least, put under a stronger light.

In the second place is the proposed concept of "ethodesic." This concept was introduced with the hope of obtaining, by using a geometric analogy, a clearer look at the very complex and intricate phenomenon of social development under moral and ethical normative constraints.

In our opinion the essential thing in studying human development is to observe that the ethodesic cannot be determined like its geometric cousin, the geodesic, by identifying a path between two given or known points. Specific to the ethodesic is that only its starting point is determined at any given moment. Starting with this point, its configuration has to be found by linking successive elementary processes so determined as to satisfy an overall imposed condition between the initial moment and an arbitrarily chosen final moment. This, indeed, is a very arduous task considering that every elementary process in building the ethodesic transforms not only the structure of the system but also the structure of the elements of the system and, by so doing, introduces new processes into the future evolution of the system. Thus it is clear that the arbitrarily timed point in the future of an ethodesic has to be determined by the very process of building the ethodesic, the only a priori (the given parameter of this point being the end-time) being chosen at will (no catastrophe being taken into prior consideration).

Using the thus established human-development/ethodesic analogy, one may point out that any a priori definition of a desirable world, or society, or even of a type of man, is an act of temerity which should be very carefully studied and weighed, with the utmost prudence, before any far-reaching statement is made. This is so because man is the essential element of the social system and because he is himself transformed by the evolving of the system just as he transforms, at every moment, the structure of the system. (Man makes the road, the road makes the man.) So, to look at a desirable world and/or society as an arbitrarily to-be-chosen goal is to oversimplify the reality. One should look first at the desirable processes capable of joining the human development to an ethodesic path. In our opinion, this is the now-essential problem for adequate human development. As was said in Romalo,[10] our strong belief is that the very first step for a better dynamics of human development is to implement, first on a national, later on a worldwide scale, the above proposed principle of morals with the aim of realizing a normatively unified, one-piece human society.

References

1. Bossel, H., "Information Processing, Cognitive Dissonances and Basic Needs: The Modelling of Behaviour," in Bossel et al., eds., System Theory in the Social Sciences, Birkhäuser, Basel, 1976.
2. Calude, Cr., Marcus, S., and Paun, G., "Empirical Information and Theoretical Constructs in the Study of Needs," Part II, GPID meeting, January 1979.
3. Galtung, J., "Human Needs as the Focus of the Social Sciences," WIP paper, University of Oslo, 1977.
4. Galtung, J., "Alternative Ways of Life Project: Preliminary List of Basic Human Needs," Preprint, Geneva, January 1978.
5. Halle, J. Mc., Basic Human Needs: A Framework for Action, University of Houston.
6. Lederer, K., "Reflections About Needs," 3rd draft, September, 1978.
7. Mallmann, C., and Marcus, S., "Empirical Information and Theoretical Constructs in the Study of Needs," Part I, GPID, January 1979.
8. Massini, Eleonora Barbieri, "Motivation and Proposal for a Research Study Project on Basic Needs and Changes of Values," World Future Studies Federation, Rome, 1975.
9. Paun, G., "Possibilities and Limits in Reducing Social Indicators Complexity," GPID, Bucarest, January 1979.
10. Romalo, D., "Needs Satisfaction and Behavioural Rules," GPID,

Bucharest, January 1979.

11. Sicinski, A., "The Concept of Need and Value in the Light of the System Approach," Polish Academy of Sciences.

12. Wirak, A.H., "Human Needs as a Basis for Indicators Formation: A Tentative Approach," World Indicators Programme No. 13, University of Oslo.