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Description, Definition, Denomination and Explanation: The Bases of the Knowledge Process

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Abstract: Starting from Bateson's insight that our mind acts by identifying differences and filtering these through successive levels, a simple formal symbology is proposed to represent the basic elements of knowledge and communication – description, definition and denomination – in order to demonstrate how the cognitive process can be linked to a succession of acts entailing distinction, description, definition and recognition. After defining the notion of the Observational Universe as a vector of dimensions through which the observer filters reality, we construct a technical description (not yet adopting specific language) as a vector of the determinations of those dimensions for a specific object "O". Thanks to the innate process of analogy and analogical generalization, we start from descriptions repeated for a set of objects – held to be analogous, though different – in order to arrive at the technical definition of a "general object O", which in fact represents the concept (idea) of O* as well as the meaning (signified) of the signs that denote it. Gaining knowledge of the world means carrying out descriptions of "O", constructing definitions of "O*" through which the observer gains knowledge of "O*" as a class of all "Os" and recognizes the latter as elements (examples) of "O*". The same symbology is applied to define the basic elements of the process of linguistic denomination and the formation of languages through a signification process that couples a technical definition of "O*" – which represents the signified of the "general sign S*" – to the technical definition of "S*", which represents the signifier of "O*". Communication is the basis for the arguments made in the final part of the paper, where it is demonstrated that even the the Tarskian correspondence-truth «"the snow is white" is true if and only if the snow is white» requires processes of definition and description which are at the basis of knowledge.*

Keywords: Knowledge Process, Signification Process, Explanation Process, Technical Description, Technical Definition

Introduction. Bateson's Model. The "Mind" as a Calculator of Differences

IN HIS EXCELLENT book, Bateson proposes an epistemological theory of knowledge based on the capacity of a system to form a representation (map) of the world (territory) through the perception and ordering, even at successive levels, of differences.

> «1. Mind is an aggregate of interacting parts or components. 2. The interaction between parts of mind is triggered by difference and difference is a non-substantial phenomenon not located in space or time; difference. 3. Mental process requires collateral energy. 4. Mental process requires circular (or more complex) chains of determination. 5. In mental process the effects of difference are to be regarded as transforms (that is, coded versions) of the difference which preceded them. 6. The description and classification of these processes of transformation discloses a hierarchy of logical types immanent in the phenomena» (Bateson, 2002: 92).

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Bateson views the *mind* as the "processor" of knowledge that acts as a "machine" – with multiple inputs – capable of calculating differences, memorizing and comparing these, and finding analogies.

In short, Bateson – by adopting a simple metaphor – distinguishes between knowledge and what is known, comparing knowledge to a map, what is known to a territory: *«The map is not the territory, and the name is not the thing named»*. The map – that is, knowledge – is formed by taking account of the differences the observer perceives in the territory represented; these differences and their transforms are *«elementary ideas … and these differences are themselves to be differentiated»* (Bateson, 2000: 463).

Our "mind", as a "processor" of knowledge, carries out a continual process of discovering relationships in the patterns of differences, and this process leads to the emergence of a hierarchy of differences based on which all knowledge is constructed (Bateson, 2000: 454-471; 2002: 106).

In order to apply Bateson's model we must postulate that the "mind-processor of knowledge" must, as a minimum, be structured to carry out two basic operations, both of which are necessary:

1. *comparison*, which leads to the identification of differences (through some sense organ),
2. the *perception of analogies* (through some form of memory), which leads to the identification of *differences of differences*.

«In fact, wherever information – or comparison – is of the essence of our explanation, there, for me, is mental process. Information can be defined as a difference that makes a difference» (Bateson, 2002: 91).

Analogy is not simply the lack of differences but a judgment on the level of differences. Two objects, though different, are *analogous* if their differences are considered "too small" to reveal a *difference of differences*.

Only through *analogies* can we conceptualize classes, concepts, and thus knowledge.

We can recognize the capacity to identify *differences* and construct *analogies* in a mental experiment proposed by Bateson (2000, pp. 463, 464):

> «Let me invite you to a psychological experience, if only to demonstrate the frailty of the human computer. First note that differences in texture are different (a) from differences in colour. Now note that differences in size are different (b) from differences in shape. Similarly ratios are different (c) from subtractive differences. Now let me invite you... to define the differences between "different (a)," "different (b)," and "different (c)" in the above paragraph» (Bateson, 2000, pp. 463, 464).

We can translate this mental experiment into practice by observing the following objects (signs on a sheet of paper):

boy **b o y** BoY BO bo BoA BOa B O a boA A a b B b B B B.

In what way can we say that these objects are similar or different? The obvious response depends on our capacity to compare them and perceive differences or similarities (absence of "significant" differences) between the various letters or groups of letters. There are thus a number of ways to perceive differences or similarities between previously perceived objects;

this capacity depends on the mental organs (important here is memorization and the capacity to repeat the observations), but there is no doubt that this capacity consists in the perception of *difference that makes a difference* during the operations of comparison (observe the movement of our eyes when we compare the letters). Consider how reality has been expanded due to the invention of the microscope or telescope, instruments that, as we know, have increased the eye's capacity to perceive differences.

Once Bateson had affirmed his epistemological principle – the "mind" constructs knowledge through differences – he did not produce an operational-logical process to derive concepts, ideas and meanings from differences (of differences).

Strictly following the direction outlined by Bateson, I propose three objectives in this study: (1) above all, to make Bateson's definition of "mind" operative; by introducing simple symbols I show how it is possible for any "mind" – not necessarily only the human one – to construct *descriptions* of objects and *definitions* of concepts only by making use of "primitive" operations involving *comparison*, the *identification* of differences, and *analogy*; the symbols introduced give a meaning to the observation, identification and comparison of objects and concepts, which will allow me to formalize several models or moments that define the concept of knowledge; (2) to apply the same conceptual framework to define the process of *denomination* through which the "mind" manages to represent objects (descriptions) and concepts (definitions) through *signs* (descriptions of signs) and *signifiers* (definitions of signs), thereby forming *semes*; (3) to apply the symbols and the concepts of *description, definition* and *denomination* to operationally deal with the problem of *truth* as correspondence, making use of a reliable *process of determination*.

The First Step in Knowledge: The Process of *Description*. Objects

The first model-moment of knowledge is the *description* of an object (material or immaterial; individual, group or system; phenomenon, event, act, operation, process, etc.) or of a given part of reality (conceived in the broadest sense).

Using a simple formal notation, "describing" an object "O" by applying Bateson's difference-based epistemology means:

1. identifying or choosing a convenient number N of variables – or *scales of differences* – $D_1, D_2, \dots, D_n, \dots, D_N$, that denominate *observable dimensions*, (which depend on the structure of the "mind-processor". The ordered set of observable dimensions forms the *observed universe* adopted for that object:

$$UN = [D_1, D_2, \dots, D_n, \dots, D_N]; \qquad [1]$$

2. identifying the differences with regard to "O" by specifying the state, dn(O), that each Dn assumes in object "O", obtained through a precise process of qualitative or quantitative determination (according to the limits of the "mind-processor"). The vector of the determinations (differences) dn(O) for each Dn⊂UN forms the *technical description* of "O".

$$[\text{des } A] = [d_1(O), d_2(O), \dots, d_n(O), \dots, d_N(O)] \qquad [2]$$

We must assume that each object – for the “mind-processor” of a given subject – corresponds to a *description* achieved through the differentiation process indicated in [1] and [2].

This is always *relative*, since it depends on the *number* of dimensions considered and the *precision* of the specification of their state which the “mind” can produce through some process of qualitative or quantitative *determination*.

The *descriptions* can be:

1. *punctual,* if they concern a single object, or *general*, if they concern the dimensions common to the objects of a given set;
2. *static,* if the variables are observed at an instant in time, or independently of the time variable, or *dynamic*, if they also concern the variation in the state of the variables with respect to another variable that the “mind” conceives as “time”. The *dynamic punctual description*, with reference to period T, can assume the following structure:

$$[\text{des } A(t)] = [d_1(A,t), d_2(A,t), \dots, d_n(A,t), \dots, d_N(A,t)],\ t \in T. \qquad [3]$$

I have defined [2] and [3] as “technical descriptions” since they are independent of any linguistic representation; they are the result of a “mental technical process”. However, they can be translated into *linguistic* descriptions using a chosen language (section 7).

Comparing Objects

When the “mind” applies the process for recognizing the *differences of differences* to the technical descriptions it is then able to distinguish between objects that are *equal* or *different.*

We define *equality* by writing A = B in [UN] if, *for each* $D_n \subset [UN]$, we have: $d_n(A) = d_n(B)$; that is, if [des a] = [des b].
We define *difference* by writing A ≠ b in [UN] if, *for at least one* D_n, we have $d_n(A) \neq d_n(B)$; that is, if [des a] ≠ [des b].
It is important to observe that *equality* or *difference* in objects can be affirmed only after we have defined the observable universe, [UN].

Many errors of observation occur because a [UN] of reference is not specified.

Presumably we would say that two coins are equal which have the same “face value”, same shape, same weight, same diameter, same thickness, and are made of the same metal. If we widen the observable universe to include the dimensions “year of coinage”, “owner”, “number of component molecules”, etc., then it becomes difficult to perceive the *equality* those objects.

If we also included in the observable universe the dimension “spatial collocation” (the same spatial coordinates), then the two objects surely cannot be *equal* in the sense specified above.

Comparing the *technical descriptions* of objects also leads to distinguishing between *simple and composite objects.*

An object is *simple* if, for the "mind" and/or for a specific observation it is held to by *unitary*; that is, it cannot be broken up into other elementary objects (B, C, etc.) if there is no sense in holding that [des A] can be broken up into autonomous [des B], [des C], etc.

An object A is *composite* (or complex) if it can be considered to be composed of (or broken up into) parts, B and C, which can be independently described; that is, if it makes sense to obtain [des a] = [des b] + [des C].

Finally, the mind distinguishes between *united* and *separate* objects.

The objects A and B are *separate* if, *for each* $D_n \subset$[UN], [des a] can be formed through determinations independent of those necessary to form [des B].

If there is a d_n(A) such that we can observe only d_n(a+b), and it is not possible to observe d_n(A) separately from d_n(B), then the objects A and B are *united* in (for) that dimension.

Arm, hand and fingers are *united* objects but hand, wedding ring and watch are *separate* objects.

The Second Step in Knowledge: The Process of *Definition*. From Objects to Concepts

"Technical descriptions" represent the first step in acquiring knowledge; by means of analogy the "mind" transforms the "technical descriptions" into "technical definitions" through which we form *concepts* (ideas).

A "technical definition" is a *"general" description* that specifies the *limits* of variability in the "technical descriptions" of objects in order that these can be considered *analogous,* that is, all belonging to the same *open set* made up of the definition (genus, or species, type, class, etc.).

The *defining process* thus implies an *analogical generalizzation* through which the differences found in various "technical descriptions" of objects are evaluated by the "mind" (calculating differences of differences) in order to "conserve" the *analogies* and form a *general class of objects*.

Each "technical description" can thus be considered a "particular case", an "example", of a "technical definition".

In formal terms, if – for each $D_n \subset$UN – Δd_n(O*) indicates *the range of admissible variation* of the dimensional states in order for an *object* "O" to be part of the *concept* "O*" (idea, intuition, general significance, abstraction, generalization, image, etc.).), then the "technical definition" of "O*" is represented by the vector:

$$[\text{def O*}] = [\Delta d_1(O^*), \Delta d_2(O^*), \dots , \Delta d_n(O^*), \dots , \Delta d_N(O^*)] \subset U(N). \qquad [4]$$

We can then state that for the knowing "mind" the *object* "O" is part of the *concept* "O*" if [des O]$\subseteq$[def O*].

The definition can be formulated using two processes:

1. *denotative* or *extensive*, if the process identifies the set (denotation or extension) of the descriptions [des O_1], [des O_2], [des O_3], etc. that can be included in [def O*];
2. *connotative* or *intensive,* if it identifies the *dimension* and *range of variation* within which the *states* identified in the objects (in their descriptions) must be included in order

for them to be indicated by the definition (connotative or intensive). The connotative definition is provided in [4].

The Three Paths of Knowledge in a Two-Dimensional Universe

Following Bateson's assumptions, we can now verify how the mind-processor can gain knowledge by developing *three* minimal cognitive processes at both the conscious and unconscious levels (Fig. 1):

1. *distinction*: adopting the mental processes of *perception* and *comparison,* and employing constitutive memory, the mind forms *descriptions* of objects – [des O_1], [des O_2], [des O_3], etc. – distinguishing these from their *background*;
2. *understanding*: after having described several objects, the mind uses analogical abstraction to develop [def O*]; that is, it finds in the *observational universe* a *zone* that corresponds to [def O*];
3. *recognition*: in the presence of an object "O" the mind carries out the [des O] and determines in which [def O*] [des O] is included. The object "O" then becomes a *point* in [def O*].

If the *recognition* is successful, the mind *recognizes* (*knows*) "object O" as belonging to "concept O*". In the opposite case it determines a new [def O*].

Referring to our experience, the cognitive process is the basis for understanding, allowing us to form the [def O*] of various objects through an analogical process applied – at times unconsciously – to various technical descriptions; often the initial [def O*] coincides with a simple [des O].

"Knowledge" is acquired through a continuous cycle of "distinction", "understanding" and "recognition", which together form our *thoughts*.

Let us consider a "minimum mind" which is only able to distinguish differences belonging to only two dimensions, D_1, D_2, representing a minimal universe: U(2) = [D_1, D_2], shown as the axes in Fig. 1.

The area determined by the segments of such dimensions which are knowable to the observer through the available instruments represents the *observable universe*: UO(2) = [ΔD_1, ΔD_2].

Each point of UO(2) represents the technical description of an *observable object*.

The areas A*, B*, etc., represent *technical definitions*.

An object "X" is A* if [desX] $\subset$ [defA*]; B* if [desX] $\subset$ [defB*], etc.

The surface of UO(2) occupied by the technical definitions forms the *known universe*; the set of points that corresponds to objects included in the known universe forms the *observed universe*.

If [desX] does not belong to any of the definitions in UO(2), then a *new definition* arises represented solely by the point indicating the object: [defX*] = [desX].

Knowledge is increased because the known universe is enriched by the new definition.

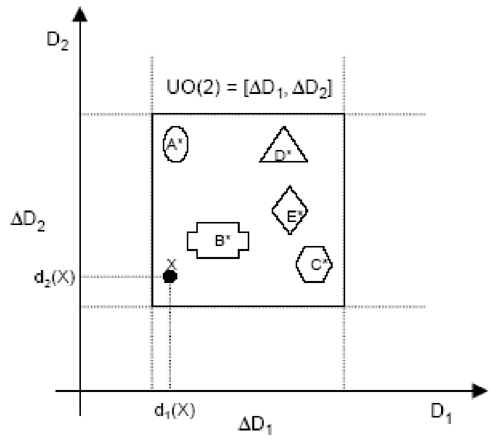

Fig. 1: Observable Universe, Descriptions and Definitions

As an example, assume we want to scrutinize the sky using modern technology and to distinguish "something new".

"X" indicates the "new object" that has to be recognized; how does the cognitive process unfold?

The first step is to compose the [desX] using the dimensions that normally characterize well-known celestial objects. Subsequently we search for a *technical definition*, already set forth, that allows us to *recognize* the object X as analogous to others already observed.

If we are successful in our search, knowledge is acquired and we can conclude: "since object X has dimensional states that we already know, we can conclude, for example, that it is a *pulsar*". If our search for the *technical definition* is not successful, in the sense that "X" continues to remain a "mysterious object", we can create a new *technical definition* and conclude: "in that zone of the sky a *new* celestial object was observed for the first time that presents these dimensional states [des X] = [d_1(X), d_2(X), … , d_n(X), …] ; since it is not analogous to any of the celestial objects already known (defined), the new celestial object (and any others that have similar characteristics or dimensional states) will be *called* (for ex.) "MC12"".

The new *technical definition* (which in this case coincides with only a single technical description) has added an additional element to the *defined universe* and raised our capacity for understanding and recognition.

Meaningful Technical Definition

In formulating descriptions or definitions human beings tend to ignore many dimensions of the observable universe, since their inclusion would make the descriptive and definition process so complex and redundant as to render it inefficient.

For this reason there is an attempt to reduce to a minimum the number of dimensions considered in the descriptive and defining activities in the knowledge process in order to form *minimal* descriptions and definitions, which we shall call "*meaningful descriptions and definitions*" (or basic concepts).

Many meaningful descriptions and definitions even include a single dimension held to be particularly representative; these are called *elementary*. We mention the following, expressed, for simplicity's sake, in a linguistic form (the typology is also valid for descriptions):

a) *ostensive* definition: this lets the observer form the analogy by merely indicating several examples of the object of the analogical abstraction ("what is an ant?"; "any insect similar to those you see on the tree!");
b) *extensive* definition: this lists "all" the objects (extension) that must be contained in the definition ("what is a sisar?"; "any stellar object listed on p. 22 of the Atlantis of the Sky");
c) *genetic* definition: this highlights the origins of the objects to be included in the definition ("an American is any individual born in USA");
d) *historical-geographic definition*: this considers the place and time the objects can be observed;
e) *structural* definition: this brings out the structure of the defined objects ("a hand is a limb composed of the following elements ...");
f) *modal* definition: this indicates the composition of the objects contained in the definition (materials, color, shape, etc.);
g) *functional* definition: this brings out the function of the objects in the definition;
h) *instrumental* definition: this brings to light the possibilities for using the defined objects;
i) *teleological* definition: this considers the objectives of the objects of observation;
j) *operational* definition: this specifies the operations needed to identify or recognize the objects of observation in the definition. Operational definitions are particularly effective in defining abstract or composite objects;

The meaningful definitions commonly used in human knowledge derive from combinations of a limited number of the preceding types.

The Signification Process. Denomination and Languages

Recalling Bateson's motto: «The map is not the territory, and the name is not the thing named», and also Saussure, for whom a linguistic sign is not a link between a thing and a name, but between a concept and a pattern (Saussure 1983, 66), I shall define *denomination* as the process by which a *sign* (a conventionally accepted name, in particular) is assigned to a concept.

Proper denomination matches a *sign* to a *technical description* [2] of a single object "O", and that sign becomes the *proper name* of the *described* object, the only one which can be denoted by that description and which represents the *signified* of S.

Proper denomination of the sign [S denoting "O"] = [des O] [5]

Common denomination matches a sign to a *technical* definition [4] (intensive denomination). That sign becomes the *common name* of all those objects denotable by that definition, which constitute the *signified* of S.

Intensive common denomination of [S denoting O*] = [def O*] [6]

Extensive common denomination of [S denoting O_i] = [des O_1, … , des O_N] [7]

The *meaning* is conventional for a group (or social context) and refers not to the *objects indicated* but to the *indicator signs.*

The set of all signs having the same *signified* is the *signifier of the sign* and corresponds to the *technical definition* of the sign:

Signifier of the sign [S] = [def S*] [8]

The correspondence (denoted by ↔) of the *signifier* [8] to what is *signified* [6] represents a *seme,* in Prieto's sense of the term (1966), and the convention adopted by a collectivity to achieve this correspondence is the *semic code*.

Seme = [def S*] ↔ [def O*]. [9]

The *sememe* of a sign is defined as the set of all *interpretants* of the significance of the sign in that language (Prieto, 1966).

Sememe of [def S*] = interpretants of [def O*]. [10]

The sign "dog" can indicate different specific animals that the mind recognizes as dogs: ["Fido", "Buck", "Smurf", "Ball", "Black", "Samson", etc.] = *extensive* meaning of the sign "dog".

The same meaning can also be evoked by the signs:

[dog, *dog*, *dog*, DOG, *dog*, DOG, **dog**, DOG, dOg, DoG, d o g , D O G, **D o G**, etc.] = *signifier* of the sign "dog".

["our most faithful friend", "the faithful guardian of our home", "the most intelligent of pets", in addition to other expressions that designate dog] = *semema* of [def S*].

Following Prieto, *semeiology* is the science that studies human behaviour regarding the attribution of *semes*; in this sense the original meaning attributed by Saussure is widened.

We can define *language* as a system of *intentional semes* and *sememes*, codified by a collectivity, through which we can attempt *linguistic communication* of:

1. *expressions* of judgments, understood also as expressions of evaluations, such as the expression of impressions, indications of kindness, beauty, amazement, and so on;
2. *orders*, understood as manifesting a desire to a subject that he behave in a certain way;
3. *questioning*, expressed as requests for thought content, for answers;
4. *information*, or *specific data* useful in carrying out operations or activities;
5. *descriptions*; that is, the results from observing objects and portions of reality;
6. *argumentation*, through which we try to judge the truth of certain statements (information or descriptions)

Factual Truth and Falseness

Following Copy and Cohen (2004), we shall define a *declarative proposition*, or *statement*, in any language as a sequence of basic signs capable of expressing a thought content that can be ascertained to be "true" or "false" using some *conventional procedure*.

Verification and *falsification* are the cognitive operations that *verify* whether or not a *statement* regarding differences, descriptions, definitions or cognitive procedure (par. 5) has an observable or derivable meaning.

As *truth* derives from a *mental process* of verification or falsification it is always relative, at least as regards the instruments for observation and the language used.

Let us consider how the "Batesonian mind" can ascertain the truth.

Let us suppose that a declarative proposition E, transmitted from Alfa to Beta in a given language, asserts that the difference: $d_n(A) \in$[des a] is *true;* for ex. "Snow is white".

The proposition is *true* for Beta if he can, using a similar procedure to that used by Alfa, construct [des a], thereby determining $d_n(A)$ and verifying it belongs to the description; otherwise the proposition is *false*.

Formally – we can translate Tarshi's rule for truth: *"'Snow is white' is true if and only if snow is white"* – by writing "Snow is white" is *true* for Beta if he observes that, in objects where [des snow] ⊆ [def snow], the dimension D_{COLOR} always assumes the state d_{COLOR}(snow) ∈ [def white].

According to the procedure examined in par. 5, *truth* thus depends on the processes of *distinction* (white?) *understanding* (snow? color?) and *recognition* ("this" is snow and its color is white?) and assumes a reliable *process of determination* (what does "white" mean in a chromatic scale?).

Personally I cannot affirm whether the proposition "Πιερο ε υν δοχεντε" is *true* or *false* since I cannot understand its meaning, as it is given in an unfamiliar language; neither am I able to recognize the *signifier* of signs nor to identify a *signified* and thus determine any *descriptions* and *definition*.

The enunciation whereby Alfa states to Beta that [d_n(O*)]⊂ [def O*] – for ex. "men are mortal" – or that O_m ⊂ [O*] – for ex. "Piero is a man" – is *true* if Beta is able to undertake a cognitive procedure that can construct [def O*] – that is, "man" – and can recognize that [Δdn(O*)] – that is, "mortal" – belongs to it and identify Piero="O_m" as an element of "O*".

In conclusion, the statement "Piero is a man" is *true* if [des PIERO] ⊂ [def MAN].

The statement "The square root of 9 is 3" is true if the [def SQUARE ROOT] includes a calculation procedure that, when applied, provides the declared value.

Scientific Laws and Theories as Definitions and Conjectural Models of the World

Various types of observation repeated with *regularity*, such as *technical descriptions* of events, phenomena and objects, including their dimensional states, even under different observational conditions, lead the "mind-processor" to *legalization* – that is, to *generalizing analogical abstraction* – which results in those regularities that constitute valid models of knowledge for all the observed objects being *defined* as *empirical laws*.

For an *empirical law* (*norm* or *generalization*) to be defined as *scientific* it:

- must be presented as the following type of statement: "if [desA] then [desB], always"; (x) (y) ([des x] → [des y]); [desA], we observe [desB], always; we don't have [desB] without [desA], etc.;
- must have empirical content; without empirical content it can at most be a formal law;
- must present relations between objects belonging to *open sets* that are connotatively defined and whose extension is not finite or entirely known; this is thus valid not only for observed objects but for all those objects that have the connotations that define a set, even if they have not yet been observed;
- must not present a relation that derives from conventions or the application of a procedure;
- must be *verifiable* or *falsifiable*; that is, confirmed by favorable cases, or positive examples, or confuted by unfavourable cases, or contrary evidence;
- must be *coherent* with other accepted scientific laws and permit *deductions* when included in deductive argumentation.

Having identified regularities and laws for a given observed universe, the observer/mind then tries to understand the *reason* for their existence.

He thus states *theories* – that is, hypotheses or conjectures (systems of hypotheses) – that could justify the affirmed regularities.

The theories (as well as the single laws) can be interpreted as *formal hypothetical definitions* of the *observed universe* presented by man to completely *describe* that universe.

Theories, as *explanatory hypotheses*, must not only contribute to *explaining observed* facts but also permit *forecasts* about *observable* facts.

Conclusion. The «Mind» System and the Mental Activity of Cognitive Systems

A *conscious cognitive system* is an *autopoietic system* (Maturana-Varela, 1992) that through the "mind" is able to distinguish differences (section 1) and develop knowledge.

Following Bateson, the basis for the functioning of the "mind-processor" system is difference; a difference used to produce other differences becomes information, and the mind develops knowledge by processing differences and transforming these into information.

In this paper I have attempted to show, relying solely on the concept of *difference* and the operations of *comparison* and *analogy*, that the "mind" – as conceived of and defined by Gregory Bateson – represents a computational system that is perfectly capable of constructing knowledge and transforming the autopoietic system into an *observer system* that can describe objects (section 2) and produce definitions (section 3) of concepts from which a knowledge process can be derived (sections 4 and 5); «The world is not informative [...] information is that which we construct» (von Foerster, 1987: 33).

The *cognitive system*, through the "mind", not only "constructs" the world but also produces a codification process of the differences-information, creating a system of *semes*, a *language* (section 7) through which the *cognitive system* links up with other *cognitive system* in a formal communications process that allows it to form *scientific laws* and develop *argumentations* (sections 7 and 8).

It thus follows that a necessary and sufficient condition for a *cognitive system* to also be *intelligent* is that it is at the same time *autopoietic* and capable of developing a formal communications behaviour with other systems it is linked to.

In the end, this is the ultimate meaning of Turing's Test (1950), which we are all familiar with.

References

[As this paper deals with the knowledge process from various points of view, the bibliography may appear to be boundless. Here I have only listed the works cited in this paper]

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About the Author

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Born in Pavia, graduated in March 1969 with a first class degree in Industrial administration, in 1985 I won a chair as a full professor and lectured in Business Economics and Administration at the Faculty of Economics of Pavia. In 1986 I was elected Head of the Department of Business Research at the University of Pavia. From 1987-88 to 1992-93 I was Dean of the Economics Faculty at the University of Pavia. Since it was founded in 1990 I have been the scientific Director of the Masters in Accounting, Budget and Financial Control in profit organizations, set up by the University of Pavia. In 1997 I became Co-ordinator of the Doctorate in Business Research at the University of Pavia. In 2000 I created the scientific web site www.ea2000.it. My interests also deal in the fields of Complex and Holonic Systems and of Networks. In 1997 I have proposed the Combinatory System Theory, described at the web site: www.ea2000.it/cst.