Rome - July 11-th

On the interdisciplinary Roots of Aldo's scientific "Weltanschaung"

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THESIS ADVANCED IN THIS TALK:

- ALDO HAD STRONG (ALTHOUGH IMPLICIT) EPISTEMOLOGICAL INTERESTS

- THEY FROM ONE SIDE (IN THEIR ORIGINAL ROUGH FORM) PUSHED HIM IN THE CYBERNETIC HOTCHPOTCH AND ON THE OTHER SIDE, SUBSEQUENTLY, HAVE BEEN REINFORCED AND MOULDED BY THE STRONG INTERDISCIPLINARY SCIENTIFIC ATMOSPHERE HE BREATHED DURING HIS EARLY FORMATIVE YEARS

- THESE ARE AT THE BASIS OF HIS CAPACITY OF SUCCESSFULLY MOVING IN VERY DIFFERENT FIELDS

A summary

The content is, obviously, "incomplete"

And it is also doubtful whether the way in which these considerations will be presented can be useful (although, of course, I hope so)

So, comments and criticism welcome!

A summary

The main aim of these ruminations, in fact, is - starting from Aldo's ideas (and strongly reconstructing his "mental meanderings") - to see whether we can pick up some elements useful for driving the world of scientific research in the right direction

A Summary

Moreover:

Trying to understand a very successful scientific journey can also help us for judging whether the present day "governing rules" of research are "good" or inadequate

A summary

Let me say that - in my view - we are not here to praise Aldo but to see whether we can make a good use of some of his ideas

First QUESTION:

Did Aldo wrote explicit epistemological papers?

Before answering this question let me remember that for a few years starting from 1969 we discussed

- many crucial interpretative points of Quantum Mechanics
- questions related to the relationship between Physics and Cybernetics

Aldo's "leading idea" for the second set of questions was that we should consider "the mind as a mechanism of the brain"

Let's go back to our question

A paper with the provisional title

Remarks on some different (quantitative) approaches to the notion of information (1979?)

should have appeared in:

ITALIAN STUDIES IN THE PHILOSOPHY OF SCIENCE

Edited by

MARIA LUISA DALLA CHIARA
University of Florence, Italy

1981

D. REIDEL PUBLISHING COMPANY
DORDRECHT : HOLLAND/BOSTON : U.S.A.
LONDON : ENGLAND

However, if you look at the index of the volume, you will not find it.

Due to some misunderstandings about the deadline, we were not able to send the paper on time (in the form we deemed correct)

Luckily, Aldo had preserved the notes. So, subsequently, he was able to rework, update and transform them in the following paper:

Wilfried Brauer Hartmut Ehrig
Juhani Karhumäki Arto Salomaa (Eds.)

Formal and Natural Computing

Essays Dedicated to Grzegorz Rozenberg

A Survey of Some Quantitative Approaches to the Notion of Information

Aldo de Luca[1,2]

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Abstract. We survey some formalizations of the intuitive notion of information which have been formulated in different mathematical and conceptual frames. The existence of different formalizations reflects the different aspects of the notion of information which are strongly related to the mechanisms of information processing of the receiver. Finally, some considerations and remarks on information in Physics and Biology are made.

W. Brauer et al. (Eds.): Formal and Natural Computing, LNCS 2300, pp. 77–95, 2002.

1 Introduction

The concept of 'information' appeared first in Physics related to the physical entropy. It was observed by L. Boltzmann in 1896 [5] in the framework of Thermodynamics that physical entropy is a measure of the 'missing' information about a physical system knowing all the macroscopic information about it.

This concept of entropy was used subsequently by L. Szilard (1929) [49] for information in Physics and H. Nyquist (1924) [42] and R. V. L. Hartley (1928) [33] for problems of communication. A very fundamental contribution in this direction was due to C. E. Shannon (1948) [45] and N. Wiener (1949) [52].

However, 'information' and its measurement are intuitive concepts, or *explicanda*, which have a wide 'semantic halo' so that several formalizations, or *explicata*, are possible. Moreover, the formalization of the notion of information is related to the 'context'. Here, the term context is used in a wide sense. It depends on the 'receiver' and its characteristic features.

Intuitively, information means *minimum amount of 'data' which are required to 'determine' an 'object' into a given class.*

Several approaches have been proposed in order to formalize and quantify the notion of information. Any definition of information requires a suitable specification of the terms 'data', 'determine' and class of 'objects' used in the intuitive definition. These approaches, called *semantic*, *pragmatic*, *descriptive*, *algorithmic*, *logic*, *structural*, *etc.*, are conceptually very different in spite of some analogies, even though often only formal, between the considered quantities. Often some formalizations of the concept of information, even though meaningful and interesting, lack a solid mathematical frame in which one can evaluate the actual implications of these concepts or find deep theorems.

In this paper we shall give a brief general view of the conceptual more than formal aspects of the different approaches to a quantitative definition of the notion of information. For the sake of brevity, the presentation is necessarily incomplete and some important approaches, such as, for instance, the *semantic approach* of R. Carnap and Y. Bar-Hillel [8], have not been considered.

As we shall see in more details in the next sections there exist two main conceptions about the notion of information. The first, that we call 'entropic', is based on a global 'measure of ignorance' about the state of a system. This measure is called 'entropy' in analogy to the physical entropy. Any determination of the state of a system yields an information proportional to the entropy.

The second, that we call 'logic', is essentially based on 'formal logic'. In this case information is related to the minimal 'complexity', static or dynamic, required to compute or generate an object of a given class.

Finally, in the last section some considerations and remarks on information in Physics and Biology will be made.

This is the way in which, Aldo concludes the paper:

It seems that 'Life' is the only known case, in the great variety of phenomena of physical world, in which there exist some 'natural' coding mechanisms such as 'genetic code'. The natural origin of these mechanisms is very surprising and extraordinary since the codified objects are very different from the uncoded objects (for instance, genes and proteins) and codification is an operation which, in general, implies the existence of an 'intelligent' mechanism or an entity which makes the coding map.

In conclusion, 'information' is a concept which is not uniquely definable. Moreover, Biology seems to show that any definition cannot be independent from the 'semantic' and 'pragmatic' aspects of the information, which are strongly related with its utilization, i.e., with the characteristics of the mechanisms of information processing of the receiver.

Also a previous passage is - in my view - extremely interesting:

As stressed in [22] in this type of information processing the 'coding mechanisms' play a crucial role. In the brain 'coding' is useful to 'compress' and adapt incoming information to the communication channels, namely to neurons. However, it plays a crucial role for the inner representation of 'metalinguistic predicates' by means of which the 'brain-machine' can 'see' itself in relation within a certain representation that it has of external world. Hence, the opinion of the author is that 'coding mechanisms' are essential in order to explain the 'consciousness' and the 'unconscious' present in the mechanism of human brain and, in a certain measure, of the major part of living organisms.

[22] de Luca, A.: The Mind as a Mechanism of the Brain. (1982) (manuscript)

Pay attention to the item quoted in the previous slide:

Aldo de Luca, The mind as a mechanism of the Brain (1982) (manuscript)

It is quoted also in his paper "SOME REFLECTIONS ON CYBERNETICS AND ITS SCIENTIFIC HERITAGE", Scientiae Mathematicae Japonicae Online, e-2006, 667–677.

I have never seen this manuscript, physically; however, as already remembered, this title is exactly the name heading our discussions in1969 and the beginning of the '70s of last Century about the development of Cybernetic ideas.

So, after all, I think we can say that Aldo had truly epistemological interests, (although of a peculiar style)

A summary

(we shall come back to this paper)

Now, let me remember Aldo's "vision" of quantum mechanics:

A very good "machine for predicting results" but something "not intelligible"

If someone (as myself) was affirming that it was intelligible that was due only to the fact that he (me!) has been previously undergone a brainwashing

What strange a position!

A SUMMARY

VERY STRANGE?

IT WAS SIMILAR TO THE ONE HERALDED BY RICHARD FEYNMAN.

A SUMMARY

“We have always had a great deal of difficulty understanding the world view that quantum mechanics represents. At least I do, because I′m an old enough man that I haven′t got to the point that this stuff is obvious to me. Okay, I still get nervous with it.... You know how it always is, every new idea, it takes a generation or two until it becomes obvious that there′s no real problem. I cannot define the real problem, therefore I suspect there′s no real problem, but I′m not sure there′s no real problem.

Richard Feynman, in Simulating Physics with Computers appearing in International Journal of Theoretical Physics (1982) p. 471.”

A position held also almost 20 years before:

A SUMMARY

There was a time when the newspapers said that only twelve men understood the theory of relativity. I do not believe there ever was such a time. There might have been a time when only one man did, because he was the only guy who caught on, before he wrote his paper. But after people read the paper a lot of people understood the theory of relativity in some way or other, certainly more than twelve.

On the other hand, I think I can safely say that nobody understands quantum mechanics. So do not take the lecture too seriously, feeling that you really have to understand in terms of some model what I am going to describe, but just relax and enjoy it. I am going to tell you what nature behaves like. If you will simply admit that maybe she does behave like this, you will find her a delightful, entrancing thing. Do not keep saying to yourself, if you can possibly avoid it, 'But how can it be like that?' because you will get 'down the drain', into a blind alley from which nobody has yet escaped. Nobody knows how it can be like that. (Richard Feynman, The Character of Physical Law, 1965)

Back to the previous paper

This is the SUMMARY

A SUMMARY

§3. allows me to tell the story of the "Measures of fuzziness"

INFORMATION AND CONTROL 20, 301–312 (1972)

A Definition of a Nonprobabilistic Entropy in the Setting of Fuzzy Sets Theory

A. DE LUCA AND S. TERMINI

Laboratorio di Cibernetica del C.N.R., Naples, Italy

A functional defined on the class of generalized characteristic functions (fuzzy sets), called "entropy", is introduced using no probabilistic concepts in order to obtain a global measure of the *indefiniteness* connected with the situations described by fuzzy sets. This "entropy" may be regarded as a measure of a quantity of information which is not necessarily related to random experiments.

Some mathematical properties of this functional are analyzed and some considerations on its applicability to pattern analysis are made.

by using only Aldo's words

Measuring fuzziness

Measuring fuzziness?

Is it possible to measure fuzziness?

Is it worthwhile?

For what?

Measures of fuzziness

a) Fuzzy Sets

Let X be a set and I the unit interval $[0,1]$. A *fuzzy set* in X is any map

$$f : X \to I \ .$$

The map f is called also *membership function* to the fuzzy set and for any $x \in X$, $f(x)$ is called *degree of membership*. The name fuzzy sets given to these maps arises from the possibility of interpreting them as a generalization of the characteristic functions of classic set theory [53]. A fuzzy set f is called *classic*, or *Boolean*, if for any $x \in X$, $f(x) = 1$ or $f(x) = 0$.

Measures of fuzziness

Let us denote by $\mathcal{L}(X)$ (resp. $\mathcal{B}(X)$) the set of all fuzzy (resp. Boolean) sets defined in X. It is possible to give to $\mathcal{L}(X)$ the structure of a distributive lattice with respect to the operations $\vee$ and $\wedge$ defined point-wise as: for all $f, g \in \mathcal{L}(X)$ and $x \in X$:

$$(f \vee g)(x) = \max\{f(x), g(x)\} \ ,$$

$$(f \wedge g)(x) = \min\{f(x), g(x)\} \ .$$

Measures of fuzziness

Moreover, with each $f \in \mathcal{L}(X)$ one can associate the fuzzy set f', that we call the *negate* of f, defined as:

$$f'(x) = 1 - f(x), \text{ for all } x \in X \ .$$

The operation of negation ($'$) satisfies the following properties: for all $f, g \in \mathcal{L}(X)$

$$(f')' = f \ ,$$

$$(f \vee g)' = f' \wedge g', \quad (f \wedge g)' = f' \vee g' \ .$$

The operations ($\vee$), ($\wedge$), and ($'$) extend to the case of fuzzy sets the operations of *union*, *intersection*, and *complement* of classic sets theory expressed in terms of characteristic functions. Let us stress that the operation ($'$) is not the *Boolean complement* since it does not satisfy, in general, the *excluded-middle* and *contradiction* laws. Hence, the lattice $\mathcal{L}(X)$ is not complemented. The only elements which admit a complement are the Boolean characteristic functions; in this case the complement of f coincides with the negate f' [27].

Measures of fuzziness

In $\mathcal{L}(X)$ one can introduce the following order relations:

i. *Inclusion order.*

We can partially order $\mathcal{L}(X)$ by the relation $\leq$, that we call *inclusion*, defined as:

$$f \leq g \Longleftrightarrow \forall x \in X \; [f(x) \leq g(x)] \; .$$

It is clear that this ordering of $\mathcal{L}(X)$ generalizes the classic inclusion relation expressed in terms of characteristic functions. If $f \leq g$, then we say that f is *included* in g.

ii. *Sharpening order.*

We introduce in $\mathcal{L}(X)$ the order $\preceq$, that we call *sharpening order*, defined as:

$$f \preceq g \Longleftrightarrow \forall x \in X \; [f(x) \leq g(x) \leq 1/2 \text{ or } f(x) \geq g(x) \geq 1/2] \; .$$

If $f \preceq g$, then we say that f is 'sharper' than g.

b) Entropy Measures

In the following we suppose, for the sake of simplicity, that the support X is a finite set even though almost all theory can be extended, with some slight change, to the case of infinite supports [36].

Following [26], an *entropy measure* h in $\mathcal{L}(X)$ is any map

$$h : \mathcal{L}(X) \rightarrow \mathbb{R}_+ \ ,$$

which satisfies the following three basic axioms:

A1. $h(f) = 0$ if and only if f is Boolean.
A2. If $f \preceq g$, then $h(f) \leq h(g)$.
A3. $h(f)$ takes its maximum value if and only if $f(x) = 1/2$, for all $x \in X$.

Measures of fuzziness

In other words an entropy measure is any map $h : \mathcal{L}(X) \to \mathbb{R}_+$ which is isotone with the sharpening order, takes its minimum value, equal to 0, if and only if the fuzzy set is classic and reaches its maximum value if and only if the fuzzy set takes the value $1/2$ in all the points of X. This last requirement is quite obvious since this fuzzy set is the more 'distant' from a classic one.

Two further axioms can be added which can be reasonable in some special cases:

A4. The entropy is invariant under the negation operation, i.e., $h(f) = h(f')$, for all $f \in \mathcal{L}(X)$.

A5. The entropy is a *valuation* in the lattice $\mathcal{L}(X)$, i.e., for all $f, g \in \mathcal{L}(X)$,

$$h(f \vee g) + h(f \wedge g) = h(f) + h(g) \ .$$

Measuring fuzziness

Examples of simple measures of fuzziness (besides the well known measure of Shannon) are the following ones:

$$\sigma(f) = \sum_{x \in X} f(x)(1 - f(x))$$

$$u(f) = \sum_{x \in X} min\{f(x), 1 - f(x)\}$$

The measure $\sigma(f)$ is formally identical to the sum of the variance of the random variables $\xi(x)$ assuming the values 1 and 0, respectively, with probability $f(x)$ and $1 - f(x)$. This measure has been used in statistical pattern recognition (already in 1977) for representing the information content of a given image.

The measures of fuzziness $\sigma(f)$ and $u(f)$, as well as the logarithmic one, satisfy all the first five axioms listed above.

An example of a measure which does not satisfy the valuation property (axiom e) is given by $[\sigma(f)]^2$.

Measures of fuzziness

Aldo and myself always thought that the richness of the theory was based on the fact that we could have how many measures we wanted, by suitably using the set of requirements (axioms) asked.

However, it was equally reasonable to ask which axioms could determine a unique measure

This was done by Ebanks in 1983

Measuring fuzziness

JOURNAL OF MATHEMATICAL ANALYSIS AND APPLICATIONS **94**, 24–37 (1983)

On Measures of Fuzziness and Their Representations

BRUCE R. EBANKS

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Submitted by L. Zadeh

The initiation of a theory of fuzzy sets by Zadeh [14] was an attempt to provide a framework within which to apply mathematical techniques to the cognitive sciences. This theory has been developed and applied in a number of fields. (See [2, 6, 8, 13, 15].) It seems clear that, if one wishes to define, analyze, and apply a mathematical idea of "fuzziness" meaningfully in an imprecise situation, one should have some means of comparing relative amounts of fuzziness. In other words, one should be concerned with measuring degrees of fuzziness. This is the topic of this paper.

Measuring fuzziness

In order to characterize families of measures of fuzziness, Ebanks in a 1983 paper has introduced a further axiom (*generalized additivity*):

(f) There exist applications $\delta, \tau : [0, \infty[\to [0, \infty[$ such that

$$h(f \times g) = h(f)\tau(P(g)) + \delta(P(f))h(g)$$

for each $f \in \mathcal{L}(X)$ and $g \in \mathcal{L}(X)$, being X and Y finite.

This axiom requires, then, that the measure of fuzziness of the direct product of two fuzzy sets f and g be equal to the weighted sum of the measures of fuzziness of f and g, the weights depending from their generalized cardinalities.

Let us, finally, introduce the operation of direct product $f \times g$ of two fuzzy sets $f \in \mathcal{L}(X)$ and $g \in \mathcal{L}(Y)$, defined for any $(x, y) \in X \times Y$, as:

$$(f \times g)(x) = f(x)g(y)$$

This is needed for introducing a further axiom which is instrumental for obtaining a classification of measures satisfying all or part of the axioms.

Measuring fuzziness

(P1) *Sharpness*: We have $d(f) = 0$ if and only if $f(X) \subset \{0, 1\}$ (i.e., f is "sharp").

(P2) *Maximality*: The value of $d(f)$ attains its maximum only when $f(X) = \{\frac{1}{2}\}$.

(P3) *Resolution*: We have $d(f) \geqslant d(f^*)$, where $f^*(x) \geqslant f(x)$ ($f^*(x) \leqslant f(x)$) whenever $f(x) > \frac{1}{2}$ ($f(x) < \frac{1}{2}$) (i.e., f^* is a "sharpened" version of f).

(P4) *Symmetry* (about $\frac{1}{2}$): We have $d(f) = d(1 - f)$, where $(1 - f) \in [0, 1]^X$ is defined by $(1 - f)(x) := 1 - f(x)$ for all $x \in X$.

(P5) *Valuation*: The functional d is a valuation on $[0, 1]^X$, i.e.,

$$d(f \vee g) + d(f \wedge g) = d(f) + d(g), \qquad f, g \in [0, 1]^X.$$

(P6) *Generalized additivity*: There exist mappings σ, τ: $[0, \infty[\to [0, \infty[$ such that

$$d(f \times g) = d(f)\, \tau(P(g)) + \sigma(P(f))\, d(g),$$

for all $f \in [0, 1]^X$, $g \in [0, 1]^Y$, X and Y any finite sets.

Measuring fuzziness

Ebanks presents then his:

THEOREM 3.2. *A measure d of fuzziness satisfies* (P1)–(P6) *if and only if d has the form*

$$d(f) = \sum_{x \in X} f(x)[1 - f(x)], \qquad f \in [0, 1]^X. \qquad (3.12)$$

The solution is the measure we have already met:

$$\sigma(f) = \sum_{x \in X} f(x)(1 - f(x))$$

Measuring fuzziness

Among many others meaningful results, a new way of affording the problem of measuring how much a fuzzy set **is far from** a classic characteristic function is due to Ron Yager.

His proposal allows to look at the problem of intuitive ideas *versus* formal results from another point of view.

His **challenging** idea is that of **measuring the "distance"** (or the "**distinction**") between a fuzzy set and its negation and the technical tool to do so is provided by the lattice theoretical notion of "**betweeness**".

Measuring Fuzziness

Int. J. General Systems, 1979, Vol. 5, pp. 221–229
0308-1079/79/0504-0221 $04.50/0

ON THE MEASURE OF FUZZINESS AND NEGATION
Part I: Membership in the Unit Interval

RONALD R. YAGER

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(*Received February 16, 1979; in final form July 6, 1979*)

We investigate the meaning of the concept of fuzziness. It is suggested that fuzziness can be related to the lack of distinction between a set and its negation. Using fuzzy subsets with grades of membership in the unit interval, measures of fuzziness are suggested. First, a class of measures based on metric distances is used to derive numeric measures of fuzziness of a fuzzy set. Finally, the concept of compatibility is used to develop linguistic measures of fuzziness.

Measuring Fuzziness

We have introduced what we feel is a holistic idea of the measurement of fuzziness. This idea being that fuzziness is related to the lack of distinction between a concept and its negation.

Measuring fuzziness

It is possible to provide a formal connection between Yager′s approach and the axiomatic one.

In fact, it can be shown that in all the cases in which it is possible to define Yager′s measure it is also possible to define a measure of fuzziness in the more general axiomatic sense. Moreover these measures form a proper **subclass** of all the measures.

The point of view of Yager, then, provides a **new very interesting visualization** although it **does not allow to extend** the class of measures, as one would expect, due to the conceptual difference of the starting point.

Measuring fuzziness

Measures of fuzziness have been introduced also in in the case of the L-fuzzy sets envisaged by Joe Goguen

GOGUEN, J. A. (1967), *L*-Fuzzy sets, *J. Math. Anal. Appl.* 18, 145–174.

We consider maps whose range is a poset L (in particular, a lattice)

Measuring fuzziness

This was done in the paper

INFORMATION AND CONTROL 24, 55–73 (1974)

Entropy of *L*-Fuzzy Sets*

ALDO DE LUCA AND SETTIMO TERMINI

Laboratorio di Cibernetica del Consiglio Nazionale delle Ricerche, Arco Felice, Napoli, Italy

The notion of "entropy" of a fuzzy set, introduced in a previous paper in the case of generalized characteristic functions whose range is the interval [0, 1] of the real line, is extended to the case of maps whose range is a poset *L* (or, in particular, a lattice).

Some of the reasons giving rise to the non-comparability of the truth values and then the necessity of considering poset structures as range of the maps are discussed.

The interpretative problems of the given mathematical definitions regarding the connections with decision theory are briefly analyzed.

published in 1974, but discussed with Aldo when I was serving the Army. There is another story to remember.

Measuring fuzziness

For general surveys one can see:

- A. de Luca, S. Termini, 1979, 'Entropy and Energy Measures in Fuzzy Set Theory'. Advances in Fuzzy Set Theory and Applications (Eds., M.M. Gupta, R.K. Ragade, R.R. Yager): 321-338.

- A. de Luca, S. Termini, 1988, 'Entropy Measures in Fuzzy Set Theory'. Systems and Control Encyclopedia (Ed., M.G. Singh): 1467-1473.

Applications in unusual fields have also been proposed.
See, for instance:
- M. E. Tabacchi and S. Termini "Fuzzy set theory as a methodological bridge between hard sciences and humanities," International Journal of Intelligent Systems, 2013.

Consequences

1. - Many applications

2. - A relation with an innovative point of many valued logics:

3. - A crucial observation by Enric Trillas:

It makes the notion of fuzziness a true scientific notion (rendering it "measurable")

Other consequences:

1. - more than 2200 citations

2. - interest of the USA Department of Defense which granted me a permission of one month when I was serving the army. Aldo - in the same period succeed in avoiding it.

Measures of fuzziness

Fuzziness in Italy – Traces of a scattered history

Gianpiero Cattaneo[1], Giulianella Coletti[2], Antonio Di Nola[3], Mario Fedrizzi[4], Giangiacomo Gerla[3], Gabriella Pasi[1], Marco Elio Tabacchi*[5,6], Settimo Termini[5], Aldo Ventre[7]

3 Antonio Di Nola: Fuzzy Logic as a Logic: the wisdom of fuzzy sets

At early stage of fuzzy sets' age soon some interesting ideas arose. We like to mention the idea due to De Luca and Termini ([25]) of *entropy of a fuzzy set*, idea which, later on, was developed by Mundici, [26], in a theory of states of algebras of Lukasiewicz Logic, as formalization of the concept of averaging truth values. Belluce in the paper [27] linked fuzzy sets with Lukasiewicz Logic, and

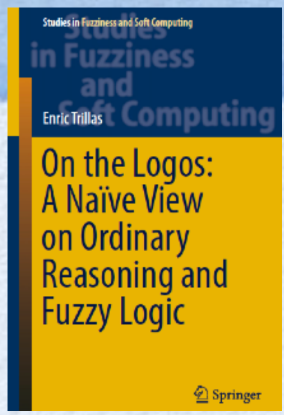
26. Mundici D: Averaging the truth-value in Lukasiewicz logic. *Studia Logica* 1995, 55:113–127.

Measures of Fuzziness

Daniele Mundici, **Averaging the truth-value in Lukasiewicz logic**, *Studia Logica* 1995, **55**, 113-127

Abstract. Chang's MV algebras are the algebras of the infinite-valued sentential calculus of Łukasiewicz. We introduce finitely additive measures (called states) on MV algebras with the intent of capturing the notion of 'average degree of truth' of a proposition. Since Boolean algebras coincide with idempotent MV algebras, states yield a generalization of finitely additive measures. Since MV algebras stand to Boolean algebras as AF C^*-algebras stand to commutative AF C^*-algebras, states are naturally related to noncommutative C^*-algebraic measures.

Measuring fuzziness (and meaning as a quantity)



22.3. Concerning the model of meaning as a quantity, it came from the Aldo De Luca and Settimo Termini idea of a nonprobabilistic "fuzzy entropy", that is, on the measuring of fuzziness, with which this concept appeared as a strengthening of the wider philosophical concept of vagueness, namely as a measurable part of it. With their fuzzy entropies, De Luca and Termini reached a new view of vagueness that, although referring to only a part of it, meant an advance towards its still incomplete scientific domestication.

The basic problem for measuring vagueness lies in the difficulties appearing for counting with a clear form to recognize when "this is less vague than that", in part due to the appearance of vagueness in a multitude of different contexts, with intermingled situations in a given context and coming from the different sources from which vagueness arises.

Measuring fuzziness

More about these questions can be found in the paper by Enric Trillas

FUZZINESS: TOWARDS A SCIENTIFIC DOMESTICATION OF VAGUENESS?

which will appeared in

Archives for the Philosophy and History of Soft Computing

(http://aphsc.org/index.php/aphsc)

Coming back to our three questions

- is it possible to measure fuzziness?
- Is it worthwhile?
- For what?

We can answer that not only it is possible to do that but we remain always in the same axiomatic framework, also starting from different visualizations

It seems moreover that it is worthwhile for doing what one expect from them, but also for founding the notion of fuzziness on a more solid base if one wants to develop a notion of meaning based on quantitative evaluations

Other Epistemological(?) Papers

Other Epistemological papers

Aldo de Luca, Settimo Termini, ***Algorithmic aspects in the analysis of complex systems***, *Scientia* 106 (1971) 659-671

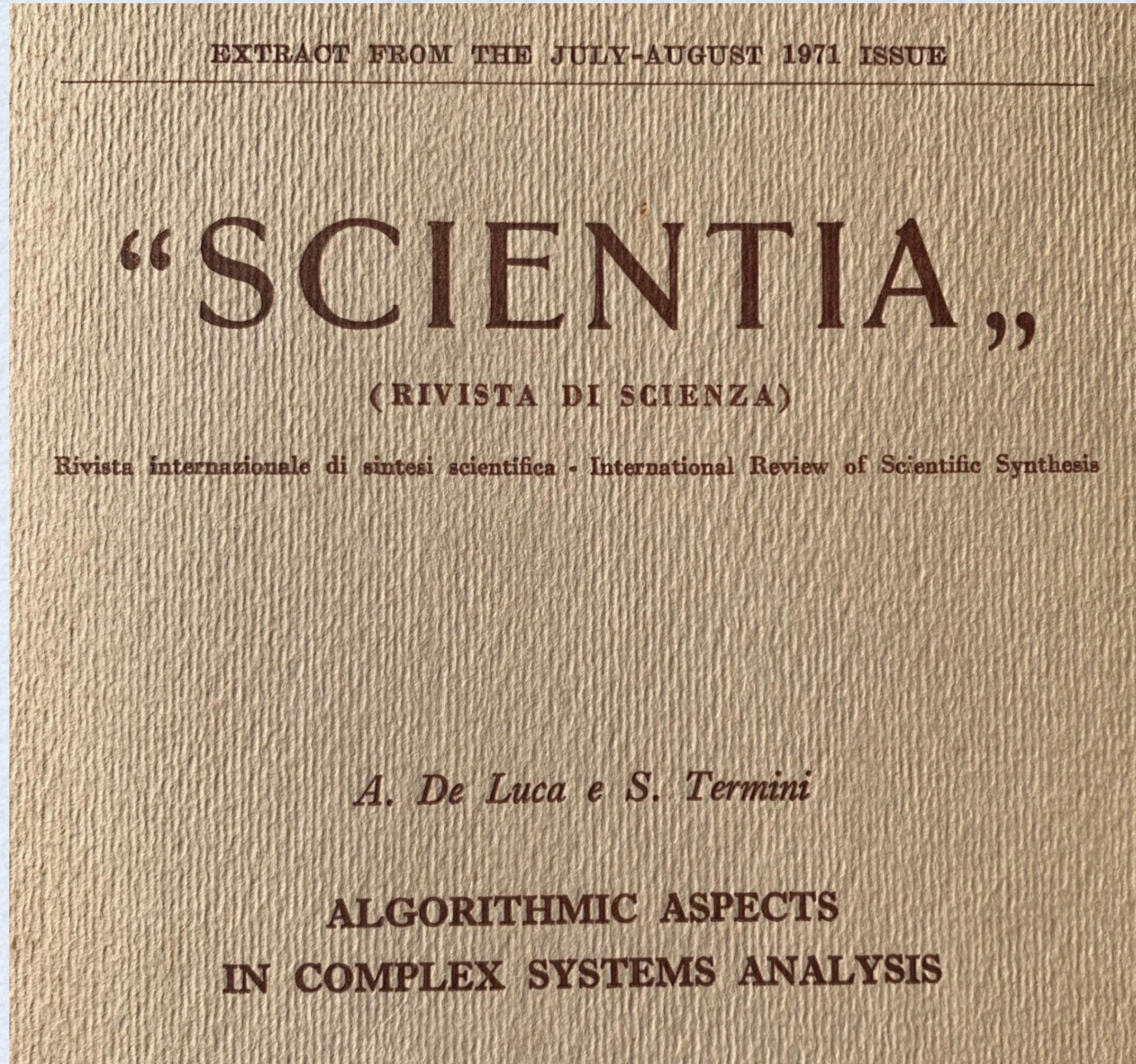
Aldo de Luca, ***Some reflections on Cybernetics and its Scientific Heritage***, *Scientiae Mathematicae Japonicae*, 64 (2006) 667-677.
Convegno Biocomp 2005 (Vietri sul Mare) organized by Luigi M. Ricciardi, Special Session **"Not to forget"**

Aldo de Luca, ***Structure, combinatorics, and complexity of "words"***, in S. Termini (Ed.) *"Imagination and Rigor". Essays on E. R. Caianiello's scientific heritage ten years after his death,* Springer-Italia (Milano 2006) pp. 71–92.

Aldo de Luca, ***Eduardo Caianiello e la nascita a Napoli di una ricerca interdisciplinare***, in *"Memoria e progetto - Idee per lo sviluppo del Mezzogiorno come modello per un Progetto Paese"* (a cura di Pietro Greco e Settimo Termini), Edizioni GEM, 2010, pagine 33-36.

Epistemological papers

The most coffee soaked of our common papers:


EXTRACT FROM THE JULY-AUGUST 1971 ISSUE

"SCIENTIA"

(RIVISTA DI SCIENZA)

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A. De Luca e S. Termini

ALGORITHMIC ASPECTS
IN COMPLEX SYSTEMS ANALYSIS

Epistemological papers

A short story about this paper:

these purely "technical" aspects we felt that, having encountered a "qualitatively new" notion, a few epistemological reflections were unavoidable [123].

The first papers appeared, so to say, in the "most adequate" journals.

For the third one, we declined Lotfi's invitation to publish it in "Information Sciences". We were deeply convinced that the "right" journal, in this case, was the old Italian Scientia founded at the beginning of the XX century with the specific mission of presenting analyses of new scientific concepts. We were not sure that our paper would be accepted in this venerable journal in which the greatest scientists - including Einstein - had presented conceptual general comments on their own technical work , and so were very proud when it, finally, appeared.

Subsequently, however, we asked ourselves whether, by accepting Lotfi's invitation, the paper could have been read by a wider audience. I think that nobody read it also due to the fact that a few years later Scientia was no more published.

EPISTEMOLOGICAL PAPERS

ALGORITHMIC ASPECTS IN COMPLEX SYSTEMS ANALYSIS

The importance of algorithmic procedures in physical models and generally in the study of complex systems is stressed. An informal account of some general techniques for the analysis of such systems - in particular Watanabe's and Zadeh's approaches - is given and a new proposal is made. In conclusion, some possible relevant implications of the previously discussed proposals are remarked.

I. - INTRODUCTION. — The purpose of this paper is to give a general, even if not exhaustive, account of some general techniques in the study of complex systems that have been very fruitful in their specific fields of application, suggesting at the same time their possible extensions in fields different from the original one.

During the exposition we will bear constantly in mind the theory of algorithms even if, sometimes, this connection will not appear at first sight; we, in fact, retain that many conceptual problems can be greatly clarified if we look at them from the theoretic-computational point of view.

It seems to us that a true and genuine dialogue between the new formalisms of physics and the group of new theories generally collected under the name of Cybernetics, in which the theory of algorithms plays an essential role, will be, no doubt, useful for both. It is not casual, we retain, that von Neumann and Wiener have been interested both in the foundations of Quantum Theory and the main problems of Cybernetics [1-5]; there is, in fact, a common conceptual background and a very strong relation between the new epistemological problems raised by Cybernetics and Quantum Mechanics.

classical Physics. The concept of completeness is relative to the fixed set of meaningful variables used in a theory and a theory which is incomplete with respect to a certain set may become complete with respect to another set of suitable variables. This generally changes the interpretation of the the theory without necessarily modifying substantially the mathematical formalism.

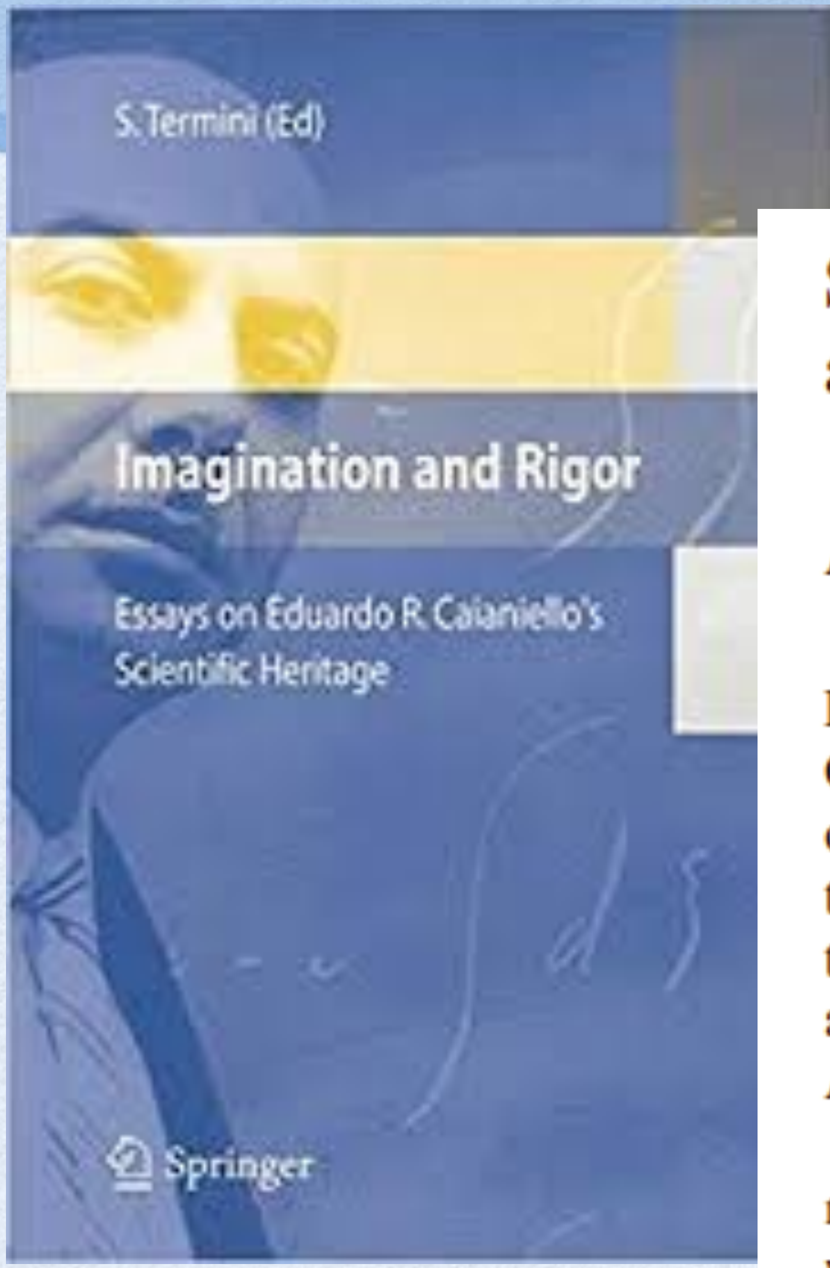
In the analysis of complex systems we may be forced to give up some concepts used in previous models; the attempt to adapt them to new situations may not be relevant. As pointed out in the fourth Section, there are systems such that their descriptions in terms of classical variables are too complex to be usefully handled. In these cases an alternative convenient description may be obtained by means of a suitable language very much related to the empirical data even if it does not ultimately make use of Boolean logics. We therefore presume that a careful examination of the algebraic structures which are the mathematical representatives of classes of such complex situations is worthwhile and may, perhaps, give some contributions both in the direction of a conceptual clarification and in the finding of new concrete mathematical techniques.

Epistemological papers

The need for simple algorithms naturally leads one, for instance, to « linearize » problems that are highly non-linear; this often happens, however, with a loss of information about the system. Such attempts are linked, from a philosophical point of view (as has been clarified by Böhm [6]) to a « Weltanschauung » in which the systems are analyzed in separate parts, more and more simple, mutually interacting. This implies a sharp separation between observer and observed object.

Such a conception of the world works well at a macroscopic level and in some areas of microphysics but nevertheless seems to break down at different levels of organization. Quantum Mechanics, for instance, would represent at the same time the last step of a conception of this kind and the first attempt toward one in which such a separation into actually distinct parts does not take place. If, in fact, it maintains the classical division between observed object and measurement apparatus, it breaks, nevertheless, with classical conceptions for it is assumed (according to the orthodox interpretation) that there is a strong and uncontrollable interaction during the measuring act: under these conditions it seems not very meaningful to go on speaking of separate systems.

Epistemological papers



Structure, Combinatorics, and Complexity of "Words"

Aldo de Luca

Eduardo Caianiello was an eminent scientist in various fields including Physics and Cybernetics. I met him for the first time at the beginning of the 1960s as a student of his course on Theoretical Physics and I was tremendously impressed by his towering personality. In 1964, I became a member of the Group of Cybernetics at the Institute of Theoretical Physics of the University of Naples directed by Eduardo and, subsequently, my scientific activity continued at the Institute of Cybernetics of Arco Felice (Naples) founded by him in 1969.

I had the privilege of collaborating with Eduardo for some years on the theory of neural networks. We wrote a joint paper on this subject [1] in 1965 and, subsequently we published, together with my friend and colleague L. M. Ricciardi, two more papers on the dynamics of neural networks [2, 3].

Even though with the years my scientific interests became more and more oriented towards Automata and Information theory, my research activity was very much influenced by his teaching, his interdisciplinary vision of science, and his love for the *ars combinatoria*, of which Eduardo was a great master (see, for instance [4]).

As regards steps (2) and (3) of decipherment we shall not enter into details. Indeed, these steps are based on semantic aspects and philology arguments. Here we mention that step (2) was achieved starting with the natural assumption that names of towns like Knossos or Amnisos in Crete island survived up to the classic period probably pronounced in a very similar way. These names were easily recognized in the Linear B script found in Knossos. In this way the phonetic values of some symbols were obtained. Completion of the decipherment was described in a superb way by Chadwick in [13] as follows: "Cryptography is a science of deduction and controlled experiment; hypotheses are formed, tested and often discarded. But the residue which passes the test grows and grows until finally there comes a point when the experimenter feels solid ground beneath his feet: his hypotheses cohere, and fragments of sense emerge from their camouflage. The code 'breaks'. Perhaps this is best defined as the point when the likely leads appear faster than they can be followed up. It is like the initiation of a chain-reaction in atomic physics; once the critical threshold is passed, the reaction propagates itself".

2.2 Sturmian words

Sturmian words have been extensively studied for at least two centuri
many applications in different fields such as Algebra, Theory of Nun

01	*da*	30	*ni*	59	*ta*
02	*ro*	31	*sa*	60	*ra*
03	*pa*	32	*qo*	61	*o*
04	*te*	33	*ra*$_3$	62	*pte*
05	*to*	34		63	
06	*na*	35		64	
07	*di*	36	*jo*	65	*ju*
08	*a*	37	*ti*	66	*ta*$_2$
09	*se*	38	*e*	67	*ki*
10	*u*	39	*pi*	68	*ro*$_2$
11	*po*	40	*wi*	69	*tu*
12	*so*	41	*si*	70	*ko*
13	*me*	42	*wo*	71	*dwe*
14	*do*	43	*ai*	72	*pe*

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SOME REFLECTIONS ON CYBERNETICS AND ITS SCIENTIFIC HERITAGE

Aldo de Luca

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Abstract. The scientific research program of Cybernetics, originated by Norbert Wiener, was mainly concerned with the communication and control whether in living organisms or machines. The main aim was to get useful and essential information on the functioning of the brain on which to construct later a science of the mind. This requires methods and knowledge borrowed from different disciplines including Physics, Biology, and Humanities. The great novelty of Cybernetics was the introduction of a new entity called 'information' of fundamental importance in the theory of communication. However, several different formalizations of the intuitive notion of information exist which depend on the 'context', i.e., the characteristic features of the 'source', of the 'channel', and of the 'receiver'. The context is of a particular relevance in the study of biological systems where there exist sophisticated coding mechanisms which are essential to the information processing, and underlie the high level functions of human mind. At present, still lacking is a theory of information and coding that could be usefully employed for the study of complex biological systems. This was the main reason for the decline of Cybernetics.

[23] de Luca, A., The mind as a mechanism of the brain, unpublished, 1982

Epistemological papers

"The Institute of Cybernetics was a sort of an incubator that allowed, starting from the initial program of Cybernetics, to create and develop within itself much more specialized research related to the new emerging disciplines. There was in a short time the transition from an interdisciplinary research to a multidisciplinary one … Subsequently, especially following the presence in the Institute of Marco Schützenberger for over a year, the scientific interests of some of us were oriented towards theoretical computer science." (pages 35-36)

Aldo de Luca, Eduardo Caianiello e la nascita a Napoli di una ricerca interdisciplinare, in "Memoria e progetto - Idee per lo sviluppo del Mezzogiorno come modello per un Progetto Paese" (a cura di Pietro Greco e Settimo Termini), Edizioni GEM, 2010, pp. 33-36.

Eduardo's Warning

"Aldo has the tendency to fly off along the mathematical tangent"

(Eduardo R. Caianiello)

Was Eduardo right?

Someone could, perhaps, answer: "We do not know what Eduardo had in mind, but since Aldo was a mathematician it is natural that he would have followed this path.

My point is that Eduardo was wrong, since Aldo was a very peculiar mathematician

Eduardo's warning

He behaved as a "normal" mathematician only when he had arrived - through various paths - at a question he deemed interesting for different reasons

Eduardo's Warning

Faggin's ideas on consciousness

Federico Faggin, the italian physicist, inventor of microprocessor and the touch pad, has expressed arguments against some "common" views on AI and "consciousness as an emergent property", proposing an alternative (monistic) view based on the assumption that "awareness" is a basic constituent of the world. We can study it, trough Quantum Mechanics, a particularly suited version being the one proposed by D'Ariano (Quantum Theory from First Principles - An Informational Approach, Cambridge University Press, 2017) which is derived starting from purely information theoretic assumptions

Faggin's ideas on consciousness

La realtà informatica è realtà virtuale

Nel momento in cui l'informazione è stata definita indipendentemente dal suo significato, abbiamo imboccato una strada che ci ha portato a descrivere soltanto una realtà informatica astratta, dove non c'è ontologia. In questa realtà virtuale la consapevolezza non può esistere, né nelle macchine né negli organismi viventi.

Le strutture materiali create dall'uomo per rappresentare informazione astratta non possono rappresentare l'informazione viva, che si esprime con simboli vivi coerenti inseparabili dal loro significato e controllati da un sé dotato di libero arbitrio. Non c'è nulla di sbagliato a far questo, purché non si creda che queste strutture artificiali possano essere consapevoli.

Faggin's ideas on consciousness

I simboli astratti, da soli, non possono dare coscienza al computer, perché non sono connessi in nessun modo con i simboli vivi, che sono i soli portatori di significato. Pertanto le proprietà cruciali di un sé cosciente non sono accessibili al computer, non importa quanto complesso esso sia.

Solo gli organismi viventi, per quanto ne sappiamo al momento, possiedono la speciale organizzazione materiale che può rappresentare un simbolo vivo coerente controllabile da un sé unico. Un organismo vivente si comporta come una gigantesca macromolecola costantemente ricreata dalla materia che passa dentro e fuori di essa. Questo li-

Such an approach should be compared with what Aldo "loosely" indicated in his "A survey of some quantitative approaches to the notion of information".

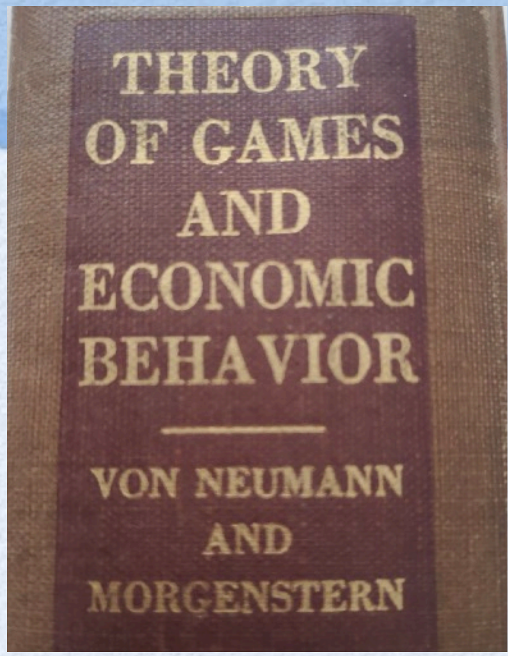
(And what new material is still contained in the 1982 manuscript?)

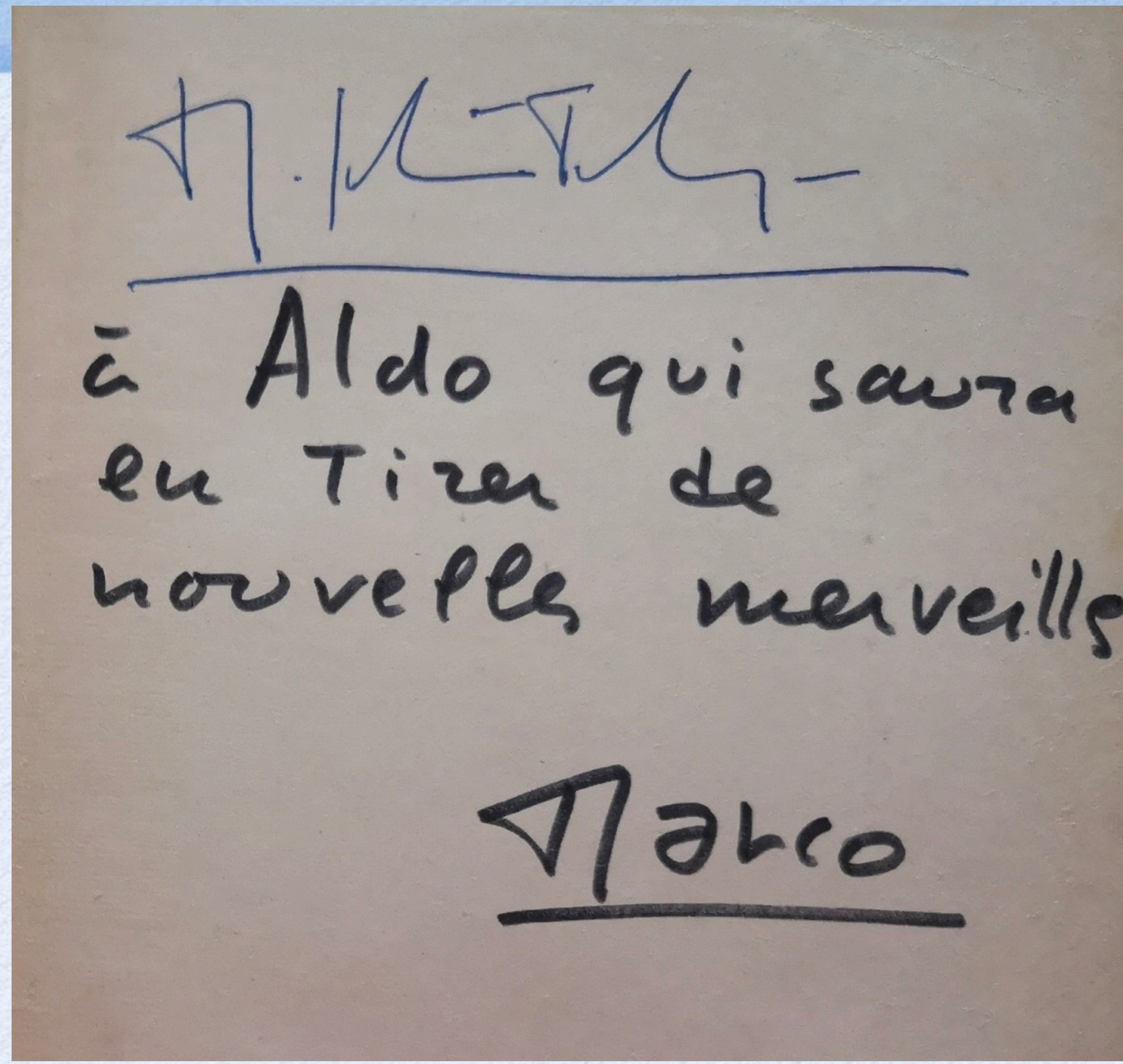
Now, WE MUST STOP

As I said before, we are **not here to praise** Aldo

and, in fact, I am not sure that he really deserves to be praised:

… A BOOK





Marco Schützenberger's dedication:

"To Aldo who will be able to extract from it new wonderful things"

Marco was right.

It is **Aldo's fault not having worked** on The Theory of Games.

GRAZIE, ALDO