

HEURISTICS OF NUMERICAL AND CONCEPTUAL SYSTEMS. CHARACTERISTICA UNIVERSALIS

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ABSTRACT

We remember the historical vicissitudes, during more of thousand years -for simple intolerance and dogmatism- that had to pass until the efficient positional numerical systems could be implemented, but that in only four centuries have made possible the emergence of science and current technology. Three centuries ago LEIBNIZ analyzed these systems, such as the binary positional system for calculating (thus being a precursor of computer science), and was aware of the limitations of human languages, ambiguous and ambiguous, so he proposed the need for a "Characteristica universalis" common and integrative of all languages, which was analogous to the accuracy and intuitiveness of positional number systems. He sensed the difficulty of achieving it, but at the same time its ease of learning and use, as well as its communicative utility. At his death, after several failed attempts -and therefore the erroneous belief that it was not possible- this article explains that yes, it is possible such "Characteristica" and how it has been achieved. It was between 1984 and 1996 I analyzing the intrinsic characteristics of human thought and its languages on the basis of an innovative interdisciplinary methodology, integrating linguistics (semiology and semantics), psychology, neurology, mathematics and computer science. The possibility of defining concepts exactly, even the most virtual ones such as human psychic (i.e. mental) faculties, also makes it possible to bring order to the current ambiguities of psychology and pedagogy. A computer simulator, resulting from the same analysis, unequivocally demonstrates this tricentennial achievement regardless of whether or not its functioning is understood (a computer or a cell phone works, so no one doubts its complex technology and scientific basis). It has been transferred to the article "Children's Knowledge at the age of 2 years" (see Bibliography) several mathematical explanations about the analogy (permitted by the algebraic extension) of the exact positional numerical systems, to the conceptual system (exact and intrinsic) on which the "Characteristica universalis" is based. More than a thousand years had to pass before positional number systems became widely used (7th to 18th centuries). How long will it take to implement the Characteristica universalis (or Conceptual system [exact and intrinsic])?

NOTE: This article precede "Children's knowledge at 2 years of age". It will be followed by three others (3 years, 6 years and 10 years), all of which are a more understandable restatement of the initial 1996 writings on the 'Representation of knowledge'.

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Both annexes have been moved to "Children's Knowledge at 2 Years of Age"

.0 HEURISTICS OF NUMERICAL SYSTEMS

The first known representation of quantities by means of numerical systems dates back to more than 5,000 years ago (3,200 B.C., in Mesopotamia, Sumer). Roughly speaking and until very recently, including Roman numeration, these systems were based on the semiological transparency of hieroglyphic writing, i.e. signs ("palotes", the ancestor of "digits"), with a "palote" for each whole unit.

The problem is that, surprising as it may seem, human perception is very limited, and from 5 sticks on, it is not able to know unequivocally if there are five or six. Or worse if there are 6 or more. One must count consciously.

For this reason, and as an example because it is still in use, the Roman numeration does not even use 4 palotes, but only three, and the "IV" quibble, where "V" was a digit equivalent to 5 palotes. And then "VI" for the 6. And later other numbers for larger groupings such as "X", "L", "C", "D", "M". Despite this, the initial semiological transparency is soon lost, always resulting in systems that are difficult to manage beyond a few tens. It is not easy to "calculate". The 5/ 10 fingers of the human hands (20 with the feet) were also a resource in all the systems of antiquity, which is also evident in the Roman system ("V", "X", "C", "M").

.1 HEURISTICS OF POSITIONAL NUMBER SYSTEMS

The first positional strategy (i.e., giving a relative value referring to the position of the digit in the whole of what we now call number) appeared more than 2000 years ago in South India (Tamil and Malay culture) with 9 digits corresponding from 1 to 9.

Perhaps because the graphic origin of our numbers is inspired by semiological transparency (for example, the 5 is a polygonal line consisting of 5 strokes), it was very difficult for:

- the semiological strategy as a method of grouping/positioning was abandoned,
- the positional strategy will be refined, and
- zero will be incorporated!

It was in a treatise on Cosmology in India in 454 AD. The cosmologist BRAHMAGUPTA and the mathematician BAHSKARA already make a regular use in the year 628.

Due to absurd reticence and above all religious censorship for centuries, this heuristic process did not progress. It was a very long and painful process of implantation:

- 3 200 BC, Indus (Sumerians, ...): first known number systems, base 60! (still valid for time and angle units), but **not** positional. Calculation was predominantly **sensitive** (pebbles, knots, abacus [2 000 BC?]).
- The later Attic/Roman numeration **also** did **not** allow for the development of a comprehensive/abstract calculus.
- 454 (5th century) Indian treatise on cosmology **including zero**.
- 628 (VII century) India, with BRHAMAGUPTA and BHASKARA: **Current positional decimal system**, with zero and **beginning of the comprehensive calculation** (multiplication). Later it was incorporated by the Arab sages (not by the people, because many powerful religious people fought against it).
- Pope Sylvester II, the Occitan Gerbert d'Orlhac [=Aurillac] 938 - Rome 1003, **was also unable to** implement the decimal positional system, which he had learned in Vic and Ripoll between 967 and 970.
- 1 202: "Liber abaci" by Leonardo da Pisa (FIBONACCI, 1 170 - 1 250)

- 1 299: **forbidden** by the Church as "the system of the infidels".
- 1 400: begins to be adopted by the scientific community.

It was not completed until Simon STEVIN (1548-1620) who in 1585 added the decimals (fractions of the unit) and thus was able to consolidate in the scientific field. It must be warned of the polysemy that this concept "decimal" supposes, of the homonymous concept "decimal" referred to the base 10, because it confuses and makes difficult to understand the concept of "Positional Systems". Thus, the positional number systems of any other base (2, 6, 12, 16, ...) also have their "decimals" (fractions of the unit).

But what makes it possible for a number like:

$$\mathbf{64\ 785\ 213\ (=6_{\times 10\ 000\ 000} + 4_{\times 1\ 000\ 000} + 7_{\times 100\ 000} + 8_{\times 10\ 000} + 5_{\times 1\ 000} + 2_{\times 100} + 1_{\times 10} + 3)}$$

that we have probably never seen before, is familiar to us and we can easily establish innumerable relationships with other equally unknown numbers (size, greater than, less than, multiple of, ...)? And even relatively complex mental operations. This is due to the appearance of another type of transparency, let's say "comprehensive", related to the processes of human psychomotor management, which is discussed specially in the Annexes of "Children's knowledge at age 2", resulting from various articles on how our psychic, i.e. mental processes work. See also "What is consciousness(-raising)?", "The kerygma of thought", etc.

It should be noted, therefore, that the base 10 is something anecdotal, derived from our ten fingers. The base can also be 12 (a system that would have been even more convenient), 16 (hexadecimal) or 2 (binary, the most convenient in a computer and calculation management). The important thing is the positional strategy.

With minimal progress for 4 600 years (until the 6th century), during the last 400 years alone (17th to 20th centuries) the development of mathematics has been spectacular due to the use of positional number systems. In algebra, geometry and topology. Without these positional systems, number theory (and statistics) would be unthinkable. And as a direct consequence, making possible the parallel development of science, technology and the globalization of the economy. As an anecdote, only a little more than 200 years ago, millions of wooden tablets that supported the information of the French treasury - tax authorities were burned in Paris, replacing them with written positional numerical documents. Today we add the computer and all that it entails, which would not be possible without the binary positional system (contributed by LEIBNIZ!). Undoubtedly, the wheel was a great technological advance, but restricted to transportation, far from what positional numerical systems have meant in all fields.

It is necessary to reflect on the centuries that these paradigm changes required (3,600 years, until the beginning of positional strategy), the beginning of its implementation in science (1,000 years more until the 17th century), and its popular use since the 19th century (200 years more).

Even a book as extraordinary as 'Histoire universelle des chiffres' (1994, by Georges IFRAH, !with 1996 pages!), which exhaustively covers the numerical systems existing in all civilisations, does not contain a single line that even minimally justifies the efficiency and intuitiveness of positional numerical systems (but, as I have said, the reader will find this explained in detail in the articles I mention). This is an example of the total ignorance of the psychology of mathematics.

.2 THE "CHARACTERISTICA UNIVERSALIS" OF LEIBNIZ

With STEVIN's contribution, the genius of LEIBNIZ (1646 - 1716) made him go a step further and propose the "Characteristica universalis", an intrinsic semiology and semantics for language that would allow similar accuracy and calculation as that of numbers. That is to say, to make what today is called an "algebraic extension", in this case from mathematics to language. Strictly speaking, this would be the "natural language", because although it is said, our current languages are not at all "natural", they are only "usual". They are not "natural" because all languages have appeared and evolved in an arbitrary way, without taking into account the human mental faculties, that is to say the strictly natural ones, since they were totally unknown.

For example, the documentary filmmaker Melvil DEWEY (1851-1931) tried with his Universal Decimal Classification (UDC)*, but because he did not understand the transparency/psychic intuitiveness associated with positional systems, it did not lead him to anything useful to partition the concepts ten by ten. Like that Polynesian tribe, who, upon seeing the airplanes of the Second World War, built an analogous structure with trunks and branches, pretending that it would fly (without the most basic knowledge of fluids and aeronautics).

* For me, the most positive thing about DEWEY was his promotion of Lake Placid (USA) in 1895, because it was the venue for the Winter Universiade in 1972 in which I participated, held in preparation for the 1980 Winter Olympics.

From philosophy Ludwig WITTGENSTEIN (1889-1951) tried it with his "Tractatus Logico-Philosophicus", but without mathematics, cognitive psychology and information systems, he could not achieve it, and therefore he claimed later that it was impossible.... (the so-called "Second WITTGENSTEIN"), which has been erroneously believed until today.

.3 CLASSIFICATION AND RETRIEVAL OF INFORMATION: "THESAURUS".

I was commissioned by UNESCO's MAB-11 Program in 1982 to build the "Documentation Center" of the Barcelona City Council - Environment. It was the first fully computerized library-documentation center in Spain (1984), as well as other specific libraries that I also started up. But they were closed because they did not meet the then existing library protocols. It took 10 years before the usefulness of computerization was understood and all libraries began to be computerized (see the article "Classificació ..." at: <https://www.sistemaconceptual.org/pdf/Classificacio.pdf> 2008, 35 pages in Catalan).

Computerization aside, the greatest contribution was his "Thesaurus". The Thesaurus (from "Treasury") are "ideological" dictionaries, characterized by being structured in a hierarchical tree and being univocal (a single name and position for each concept), but with the disadvantage that it is a fixed and mostly subjective structure ("Each master has his own book"). They represent the lexicon of languages and, to a large extent, lines of thought that are inevitably subjective. They also serve to classify information ("Keywords") for retrieval ("Search").

Far from a structured list like the existing ones (the aforementioned CDU, that of UNESCO, those of the PASCAL, ENVIROLINE, NTIS, INSPEC, ..., already computerized), and their aforementioned limitations, I thought of a "Universal Algebraic Product" for the "Category" of Thesauri/languages". That is to say, one that encompasses and intercommunicates all the different existing Thesaurus. It is something analogous to

the "Tensors" as a Universal Product for Multilinear Applications (Gregorio RICCI-CURBASTRO 1853-1925), an integrating methodology that has made possible the current development of physics and technology.

Besides analyzing and respecting human cognitive processes, in order to have a universal Product that can integrate any Thesaurus and/or language, one of the needs is to solve the limitation of the "fixed" structure, allowing multiple inheritance with an explicit subjectivity, which objectifies and includes it without restrictions. This implies, therefore, the flexibility of being able to make changes of base/coordinates. Another condition is to have an exact definitional "Protocol" (the "Characteristica universalis" of LEIBNIZ). And finally an intrinsic relational structure (intrinsic with respect to human intuitive faculties) between concepts, so that elementary knowledge "**aRb**" (Cognitive Space) is generated, which can be combined among them to build progressively more complex concepts. And in turn operate such triads "**aRb**" as "First order logical propositions" (of the predicate logic), as will be seen.

.4 INTRINSIC AND EXACT CONCEPTUAL SYSTEM

What in 1984-87 I initially called "Interdimensional Thesaurus" was conceived as a geometric space in which:

- the intrinsicity search criteria of KLEIN's "Erlangen Program", the basis of modern geometry, were applied; and
- an algebraic structure based on the "endomorphism theory" was programmed to allow base/coordinate changes whereby:
 - represent multiple inheritance and make subjectivities explicit in order to objectify them;
 - analyze the intrinsic characteristics of the language.

Each change of base made by the computer in seconds could mean thousands of hours of documentalists managing their paper files. The changes brought to the surface the intrinsic characteristics that turned out to be the invariants, the "Relators" of the pairs of concepts (aRb), which from a psychological perspective are the most elementary cognitive faculties, which also appear progressively in the same way in all children. Thus the 1996 resulted in the "Conceptual System" (or "Cognitive System", they are equivalent), detailed in an extensive document, the basis of all subsequent ones.

Its definition could be: "a tree-like structure with multiple inheritance, of precisely defined concepts, all related to each other by a hundred or so relators representing the most basic human cognitive faculties".

The "Conceptual System" can be represented --and computer simulated-- as a three-dimensional space (which makes it intuitive by its analogy with the spatial environment, and strictly "navigable"). It is unique except for isomorphisms (the base changes). At the same time it is:

- a representation of human cognitive processes;
- the desired "algebraic extension" of the numerical systems to all concepts, whether numerical-quantitative or not (sensitive, virtual, ...), i.e., the "Characteristica universalis");
- a "Universal Product" (which, among other things, would make it possible for the first time to add comprehensive disambiguation and accuracy criteria to the voluminous, exclusively enumerative methods of current translations);

- a strict integration of mathematics, psychology and language (intrinsic semiology and semantics), this, in turn, implies discovering elements of the "Mathesis universalis" (Universal Science) also proposed by LEIBNIZ;
- a decomposition of all knowledge into simple "aRb" knowledge (first order logical propositions, ...), which in turn is plausible because it is a logical structure ("software") that is compatible with the basic structure of the brain (the neural interconnections, the "hardware"). On the contrary, semantic networks or neural networks are analogous attempts to Polynesian airplanes.
- integrates contributions from FREUD, BOOLE; PIAGET, MONTESORI, FREINET, MARTINET, ...

and mathematical concepts such as: "Short exact algebraic sequences" (SEAC), Cauchy sequences, limits, exactitude, systems of equations, diagonalization of matrixs, topological finesse, ..., or the aforementioned changes of base/coordinates, invariants and space, all of them usefully applied to language and knowledge.

So brilliant was LEIBNIZ's intuition 300 years ago, as absurd that today someone would have considered formulating his "Characteristica universalis" without fully integrating psychology and mathematics, and without elaborating an intrinsic semiology and semantics based on phenomenology (replacing the conventional and arbitrary grammars and syntax, along the lines of the "Mathesis universalis" also by LEIBNIZ), everything that is integrated for the first time in the "Conceptual System" giving a strictly "natural" substrate to the limited "usual" languages. Thus, for example:

- With FREUD's sensory "Facilitations" ("Bahnungen"), which children manifest from the age of 3 with sensory associations/relations (phonetically with rhymes/"Terminations"; psychomotorically with rhythms, ...), sensory relationality (which is prior to conceptual relationality, which is already cultural) is explained. It is made up of a score of phenomenologically based relationalizers (40 contemplating their inverses), which in turn explains the genesis of the grammatical morphology of all languages. From another perspective, it was analyzed by MARTINET with his "Articulations".
- BOOLE with his "Laws of thought" and undoubtedly under the influence of the psychological and pedagogical intuitions of his wife Mary EVEREST, are still today two psychologists ignored in providing the most basic conceptual faculties (union and complement, which manifest themselves spontaneously in children as young as 2 years old) that allow the child his first exact conceptual tree structures, but which, surprisingly, linguistics and mathematics ignore (BOOLE's Algebra and Set Theory are indirect and secondary contributions). But the child can only build small, disjoint, "local" trees, which over the years, and not always, the adult manages to partially integrate. The "Conceptual System" integrates all these structures into a single tree of exact concepts, which in turn resolves arbitrary disquisitions such as the millenary "Categories" (ARISTOTHELS, HUMBOLT, KANT, HEGEL, MARX, PEIRCE, POPPER, ...), or non-efficient strategies such as "Merons", "Taxons", ..., "Semantic Networks", "Neural Networks",

This also explains the "miraculous" emergence of language in children, which has nothing to do with hypotheses such as the genetically based "Generative Grammar" (CHOMSKY, who —very honestly— himself later abandoned it).

With the perception of movement ("Explaining the movement", IMIPAE, 1985), from the age of 5 or more, the child can enter a strict, relational cognitive phase, but in a conscious way. With the global perception of dynamics derives the strict conceptualization of "Phenomenon" (for a child, previously, something like fire is a

material object like any other, regardless of the associated ignition process). With the relation between "Matter" (static) and "Phenomenon" (dynamic) the child begins to manage an elaborate concept of differential geometry, the "Star operator" of the "Algebraic duality" (between the base space E and the dual space E^* of the functions of E on E of the Variety). It is surprising that something so "elevated" is one more of the cognitive and intuitive "Relators", but it is not so much if one notices that it is a generalized methodology (and is therefore part of the "Mathesis iniversalis"), widely present in nature (quantum, genetics, ..., grammar, syntax, economy, ...) that has been transferred between systems until it has been recently made explicit in the field of mathematics with the Bourbakian perspective. Another natural and not only human phenomenon, which mathematics has recycled without even recognizing it.

MONTESORI or FREINET highlighted the importance of the contextual, of the environment, which is represented by semantic relationality (the only one contemplated, — and still partially— by linguistics). Etc., etc., etc., etc. A progression of ignored intuitive faculties, which show what pedagogy still has to incorporate with the contributions and improvements of the "Conceptual System" as a representer of human cognitive processes.

As it has been said, the Universalis Characteristic, or what is the same the intrinsic and exact Conceptual System, is strictly an algebraic "Universal Product". Nothing to do, then, with another new language (Esperanto), or the current inefficient Thesaurus and Dictionaries (including Wikipedia).

Five papers or the Bibliography present in detail this novel mathematical-psychological integration of language from both perspectives: [1](#)), [2](#)), [3](#)), [4](#)), [5](#)).

In order not to interfere with the brevity of the presentation, the annexes include some significant parts of these documents, as examples.

.5 SOME CONSEQUENCES

The aforementioned scientific and technological advances are due to the fact that numbers are exact and allow exact calculations. And to the intuitiveness of their representation. Even in a store, today no one tries to cheat in the sum of a domestic purchase.

Similarly, today's widespread demagogy would be hindered/prevented if ambiguous and interpretable words were replaced by concepts taught in childhood through a conceptual system intrinsic to our basic and intuitive faculties, relational, exact and objective. A thought constructed with this structure of representation would hinder subjectivity and self-deception, due to the unconscious action of feelings. It would make it possible to feel fully (feelings, affections, tastes, hobbies, ...) as well as to think and reason rigorously, but without reciprocal conditioning factors, each thing in its place and at its moment. Undoubtedly this must have been LEIBNIZ's aspiration when he conceived his "Characteristica ...".

Children's learning would be much faster, more efficient, quality (comprehensive) and playful. It is possible to demonstrate this with the current simulator by means of various available examples. With this methodology, the cognitive causes of school failure would disappear, only different learning speeds would appear, depending on the intelligence and motivations of the student. Teachers could comfortably and exclusively perform their guiding/guiding function.

Although Wikipedia has eradicated historical encyclopedias, it is still something enumerative, literal and with "manual" links (traditional hypertext). And, undoubtedly, with an expiration date. With the support of a conceptual system such as the one mentioned above, it would be transformed into a space of knowledge in which to navigate and enjoy as in an aerial simulator, in a comprehensive hypertext that still does not exist today.

In addition to the above-mentioned efficient unambiguous translations, information retrieval processes ("Search") would also add comprehensive criteria to the exclusively enumerative, recognition and statistical methods (Google), with enormous hardware requirements and energy consumption.

Etc., etc., etc., etc. A definitive cultural change if the current media (Internet) overcome the strong reluctance to paradigm shifts of this type.

.6 SOME FINAL REFLECTIONS ON THE POSSIBLE USEFULNESS OF THE "CHARACTERISTICA UNIVERSALIS".

The important thing of any "innovative" proposal or scientific research is (that of "Problem solving"):

"What can you do with **it**?"

In the field of teaching and learning, it is very easy to evaluate any proposal for "innovation" or scientific research, if five parameters are used:

- Is it possible to verify/assess that one learns more quickly than without **it** (quantitative parameter)?
- Is it possible to verify/evaluate that one learns more comprehensively than without **it** (qualitative parameter)?
- Is it possible to verify/assess that one learns more autonomously than without **it** (including, therefore, the attractiveness/transparency of its use, which are motivational parameters)?
- Can its use be generalized to any person (social and economic parameter)?
- Can this improve interpersonal and collective communication ("civilizational" parameter, a parameter that is not even considered, due to its exceptionality)?

When one sees any "scientific" article or any proposal of supposed innovation in this field, rarely is any clearly evaluative answer to any of these questions provided as a conclusion, simply because the article it is rarely useful.

Given the above, we can ask whether would be possible:

- So you can learn many times more quickly?
- Much more comprehensively, more intuitively and avoiding memorization efforts?
- Much more "playfully"?
- Without any population limitation (other than having a networked computer), without significant *per capita* cost?
- That will clearly improve interpersonal and collective communication?

and the answer is affirmative: the "Characteristica universalis". From the reflections that he bequeathed us, this is what LEIBNIZ already considered more than 300 years ago when he proposed them.

"It will be **very difficult to** form or invent this language or this *Characteristica [universalis]*, but **very easy to learn** without any dictionary."

"I don't know if I will ever be in a position to carry out this project, which needs **more than one hand** [interdisciplinarity], and it even seems that humanity is **not yet mature enough** to claim the advantages that this method could provide."

"The Leibniz project is not [only] a matter of logic, but of the **representation of knowledge**, a field that is **largely unexplored** in epistemology and the philosophy of science, which are currently oriented towards logic." (P. JAENECKE, 1996).

More than a thousand years had to pass before positional number systems became widely used (7th to 18th centuries). How long will it take to implement the *Characteristica universalis* (or Conceptual system [exact and intrinsic])?

.7 BIBLIOGRAPHY

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Recent translations to English:

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- 2) "What is consciousness(-raising)?" 2007, 87 pages: <https://vixra.org/abs/2507.0023>
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- 5) "Mathematical Basis of the System..." <https://www.sistemaconceptual.org/pdf/MatematicaSC.pdf> 2015, 79 pages in Spanish (Translation to English in progress)
- 6) "El kerigma del pensament..." <https://www.sistemaconceptual.org/pdf/Kerigmapensament.pdf> , 2007, 52 pages in Catalan (Translation to English in progress)

.8 ANNEX (2024-08-13) THE SO-CALLED "ARTIFICIAL INTELLIGENCE" (AI)

Recently, ChatGPT languages have appeared whose performance has led to consider that after more than 30 years of attempts, computers have already reached the point of simulating human "intelligence".

In the 90's I already had the opportunity to build and use profitably a "DataWareHouse" (in the Barcelona City Council) and to learn about "Data mining" technologies. The progressive availability of hardware and the improvement of software allowed to give way to "BigData". And now to GPT languages. But between all of them there are only quantitative differences, more data and more speed of calculation and more refined (with relations, in the latter case). There are no quantitative differences, nothing strictly new "emerges".

That is why some discerning people rightly speak of "parrot". They just repeat, associating the immense data that is there, but without any comprehension, let alone any hint of consciousness. GPTs are "functional illiterates" (listening-reading or speaking-writing without understanding what is being communicated). If understanding is understood to be the most elaborate level of knowledge, and knowledge is a faculty that is far removed from the complex faculty of intelligence, it is clear that today's AI (and "e-learning") has nothing to do with intelligence.

The only thing that can be reached today to simulate our psychic faculties is "Artificial Reasoning" (which would already be a lot), but provided that the *Characteristica Universalis* (or "Intrinsic and exact conceptual system") is used as a basis, and that from the traditional mathematical logic based on words, we give way to a new mathematical logic that is built on exact concepts and logical propositions of the first order to relate them.