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# Mathematicians and the perfect language: Giuseppe Peano's case

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Attempts to create an International Artificial Language (IAL) have kept pace with the evolution of modern science. Ever since Galileo's time, scientists have been interested in how to create a perfect language (the adjective "perfect" takes on the meaning of "universal" or "unambiguous" depending on the period) capable of supporting communication at a horizontal level i.e. within the scientific community, and at a vertical level, i.e. between scientists and the public. The first goal of this article is to describe briefly how this need for a perfect language developed over the past years. Special attention will be spent on the mathematicians' role, especially Giuseppe Peano's. The second goal is to illustrate how Giuseppe Peano's contribution to this debate proved twofold and led to various conclusions. The Italian mathematician played a leading role in the creation of a perfect language, both at a horizontal and a vertical level. On the one hand, there is his successful attempt to introduce a standard logical and symbolic system of notation, which became essential for communication among mathematicians. On the other hand, there is the complete failure of his ambitious *Latino sine flexione* (Latin without inflection), a perfect language which died with its creator.

## Introduction

People have been interested in the creation of a perfect language for more than two thousand years. From ancient Greek philosophers to present PC programmers, the search for a universal language is ever present in the history of culture and, more specifically, of science.

The participation of scientists in this research has been mainly with regard to the creation of artificial languages. Following Umberto Eco's subdivision [1], these languages may have three fundamental functions: perfection in terms of structure, of universality and of practicality.[1]

The first approach resulted in formal languages whose use is limited to special scientific purposes, such as the languages of logic, algebra and chemistry. Similarly, mathematical linguistics, a particular branch of research in this field, developed around 1950 to analyse the structure of languages through mathematics.

There is abundant literature on this subject and no further historical information will be added here. The aim of this article is to find out what led scientists to systematically tackle the problem of language confusion, starting with the basic need to communicate research results. This need for communication has been rising fast since the beginnings of modern science and the subsequent end of alchemic obscurantism with its initiation through secrecy. The understanding of natural phenomena was no longer for the few and this increased the need for a means of communication of a larger impact among scholars and scientists. The rise of an international scientific community pushed scientists, especially mathematicians,[2] to seek a universal language, free from ambiguities. Most mathematicians were convinced that the formalism of their discipline was universal, or that, maybe, the logical methods of mathematics were the ideal means to correct imperfections in natural languages. This explains why they played such a leading role in this search for a perfect language which kept people all over Europe busy for most of their history.

## Brief historical outline of the perfect language

Two separate aspects continue to contribute to the problem of how to communicate science. On the one hand, at, what we might define, the vertical level, there is the need for intralingual translation. Concepts and models, which belong to the scientific community, need to be translated for the benefit of those who do not

[1] The first function refers to the power of a language to express univocally-defined concepts, by means of analogy between calculation and reasoning. The other two functions refer respectively to a language diffusion and ease of use.

[2] Most mathematicians believed they would have been able to export an artificial language, originally developed for communication within the scientific community, to a wider public. This would make their studies available for the rest of the world.

share the same cultural background.[3] It is a matter of vulgarising science in the noblest sense of the word, i.e. making science available to the general public. Thus the verb “to vulgarise” can no longer be considered as a synonym for “to make vulgar” because it lacks the implicit negative connotation. Secondly, there is the problem of science communication at a horizontal level, i.e. how to communicate within a multilingual scientific community. It is actually a much older problem, which the scientists themselves have tackled with ingenuity. The huge amount of knowledge developed and refined from the studies of three great men: Copernicus (Poland), Galileo (Italy) and Newton (England), marked the beginning of modern age. It resulted from an extraordinary international collaboration that had to find new ways to overcome the political and linguistic fragmentation, first in Europe first and then in the whole world.

The first example of a pseudo-universal language was Latin, codified between the late Roman Empire and the early Middle Ages. Latin was the only “vehicular” language that could keep pace with the rapid development of this innovative method of research though its use had been restricted to a small group of scholars for many centuries. The shift then quickened from Latin to French and from French to *basic English*, which is the language in use in the business field for multicultural reasons. These shifts were interspersed with countless attempts, some of them bizarre, to replace national languages with new, artificial and universal idioms capable of producing an effective and unambiguous exchange of information among scientists.

Beyond the scientific community’s specific needs, the search for a universal language resulted above all and for long, in the quest for Adam’s tongue: a single and divine language in which everything was called “by its own name”. This was the state before the cruel God of the Genesis destroyed the ambitious Tower of Babel and people dispersed in the chaos of conventional languages. Despite the importance of this episode in the Old Testament, at that time, the multiplicity of languages was not a real problem either for the Church Fathers or for rest of the people. As already mentioned, Latin was still used as vehicular language among people from different cultural backgrounds even though it was a dead language [1].

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[3] We take the popularisation of science in the noble sense of the term i.e., that of making science available for all. The fact that it has become subject of study only in recent times results mainly from the allocation of more resources and from a wider awareness of the non-specialist public. Similarly, difficulties have also increased due to the fragmentation of disciplines and the introduction of indirect and rather obscure methods to describe reality.

However, it is only since the 11th century that the number of representations of the Tower of Babel grew enormously. The birth of vulgar tongues drew European attention to the linguistic and political fragmentation, which they tried to overcome through this utopia of a unifying perfect language. Some looked backwards for possible solutions: ancient Hebrew had been considered as the primordial language until the end of Renaissance. Others looked ahead, aiming to fabricate a new, rational language resulting from the universality of fundamental logical concepts. Thus, in the Middle Ages, the influence of Kabbala grew stronger. Kabbala was a school of Hebrew mysticism that regarded creation itself as a linguistic phenomenon. Underneath the letters in which the Torah (the books of Pentateuch) was written, the Kabballist sought to descry the eternal Torah created by God before all worlds, and consigned to his angels. It is clear that there is a strong implicit nominalism in this theory: semiotic elements, in the Kabbala, were not "signs" of pre-existing things, but the very "form by which the elements of the universe are moulded"[4] [1].

The search for the perfect language still persists in more recent times although it underwent some radical changes. The monogenetic hypothesis, which assumed that all languages, descended from a unique mother tongue lost part of its previous importance but it still has a strong appeal. [In fact, the theory has been recently taken up again by Cavalli-Sforza [2] within the field of genetic research to discover the origins of man.] The faith in the power of the human mind led linguists, but above all, scientists and scholars to stop looking at the past for a perfect language. Their attention was taken by the idea of a new artificial language, based on philosophic principles, which could establish the perfect harmony between content and form through rational methods.

Scientific communication had been strictly horizontal for a long period, until the beginning of the 20th century. A small amount of vertical communication did take place among scientists and the political and economic leaders of the time but it was clearly local and hierarchic though no less problematic. Thus, with the beginning of the evolution of scientific methodology which heralded the dawn in Modern Age, the

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[4] According to their tradition, Kabbalists completely disregard how things are expressed, for the material text itself. They strive to retrieve the exact divine message through three fundamental techniques. *Notariqon*, acrostic, the initial letters of a series of words generate new words. *Gematria*, based on the fact that, in Hebrew, numbers are indicated by letters; this means that each Hebrew word can be given a numerical value, calculated by summing the numbers represented by its letters. Adding up the letters in YHWH, we get 72, so the kabbalistic tradition searched for the 72 names of God. Then there is *temurah*, the art of anagram, based on the interpolation of vowels allowed in Hebrew.

history of scientific communication was intertwined with the search for a perfect, universal language. According to Galileo “the twenty letters” [3] of the alphabet were “the seal to all marvellous human inventions.” Galileo was convinced that nature was written in a mathematical language and he was also extremely attracted by the possibility offered by language to transmit ideas to other people in different places and epochs.

Despite Galileo’s strong interest in linguistic problems, he did not leave any important writing on the subject. Descartes, on the contrary, proposed some practical modifications in grammar to let language resemble the “True Philosophy”, of clear and separate ideas. Even though Descartes’ suggestion was never put into practice and was actually considered utopian if not absurd [4], his basic ideas belonged to the philosophical languages. Descartes, however, should be remembered for his attempt to give birth to a language based on a mechanistic and numerical conception of human thinking, rather than a language based on communicative requirements. In other words, he was thinking of a language to make science rather than to communicate it. Later on, Leibniz resumed this idea. He was persuaded that the development of a perfect language should keep pace with the evolution of science. His perfect tongue was universal and would automatically lead the speaker to formulate true prepositions. Any given term needed to be resolved into its formal parts (man=rational animal). These parts could not themselves be defined since they are primitives. By this method he could give any concept a specific numerical value (animal=2; rational=3; man=2x3=6). For a proposition to be true (all men are animals), the fraction subject-predicate (6/2=3) must be an integer, that is one of the previously defined prime terms.

The main problem with these rationalistic attempts to create a perfect tongue lies, as Umberto Eco noted, in the fact that they are incapable of combining a universal inventory of human knowledge (according to which all the parts must unequivocally express the characteristics of the given object) with the principle of *total effability*, that is a verbal language capable of rendering the totality of our experience, mental and physical. This statement, however, is not completely true. Verbal languages are the semiotic systems with the highest degree of effability, but imagine, for example, of having to describe what rosemary tastes like. On the other hand it is also undeniable that, ever since Aristotle, nobody has managed to find an effective criterion to create Leibniz’ “Alphabet of Thoughts”. Though Leibniz eventually came to doubt the possibility of a list of original terms, he believed that the two tasks could be worked on separately in order to create not only a perfect language, but also a perfectible language capable of evolving with human knowledge. Despite the inevitable difficulties, attempts to create *a priori* philosophical languages followed one another until the beginning of the $20^{th}$ century. From that moment on, the revolution in communications and transport heavily influenced research in this field. The new objective, having discarded the old pretensions to produce an unequivocal classification of primitive thoughts, now consisted in the creation of a practical universal language capable of overcoming the world linguistic Babel.

If the idea of choosing a living language as an international medium was utopian as well as the idea of returning to a dead but neutral language such as Latin was impossible. It simply displayed too many homonyms and irregularities. The obvious solution, in an increasingly small world, seemed to be the invention of an International Auxiliary Language (henceforth IAL). The criteria for this new language would be a simple and rational grammar (as proposed by the philosophical languages, but with a closer analogy with the existing tongues), and a mixed lexicon whose terms recalled as closely as possible words in natural languages. Volapük was perhaps the first IAL. It was invented, in 1879, by Johann Martin Schleyer and was actually the first example of a mixed system. Regarding the phonetic spelling, the model language was English, though loan words were constantly deformed to appear unrecognisable; its grammar was based on a Latin-like declension system and many prefixes and suffixes were added to reduce the number of radicals. In fact these criteria were used with a degree of arbitrariness: why is *flitaf* (which literally means any "flying animal") used to denote a "fly" and not a "bird" or a "bee"?

Similar to Volapük, Esperanto is perhaps the most famous example of IALs. It was invented in 1887 by Ludwik Zamenhof. The twenty-eight letters of the Esperanto alphabet are based on a simple principle: for each letter one sound, and for each sound one letter. Zamenhof coined his own terms according to a distributive principle, privileging Romance languages, followed by the Germanic and Slav. In this case too, the regular use of prefixes and suffixes as well as compound words, following the principle of optimisation, allowed maximum exploitation of a small number of radicals. Esperanto abolished all case endings, except the accusative, which allows one to invert the syntactic order of the sentence without misinterpretation. As we shall see, the *Latino sine flexione* (Latin without inflection) of the great Italian mathematician and logician Giuseppe Peano was inspired by the same principles. It was applied to a well-known language rather than IAL and was originally designed as a written lingua franca for international scientific communication, though Peano tried to use it also during his lectures.

**Mathematicians and the perfect language**

With the development of science, the search for a perfect language became almost exclusively a matter of interest for mathematicians. As already illustrated, two separate currents arose: on the one hand there were those, such as Leibniz, who promoted the creation of an IAL based on the classification according to logic or the invention of a language capable of expressing the mechanistic and numerical aspects of human thoughts. On the other hand, there were those, such as Galileo, Newton and then Peano, who privileged a more communicative approach.

During the summer of 1900, two important international conferences were held in Paris. The philosophers first (August, $1^{st}$-$5^{th}$), and then the mathematicians (August, $6^{th}$–$12^{th}$) debated the state of their disciplines and attempted to discern future developments. The problem of a perfect language crossed both conferences and, in front of many important scholars such as Russel, Peano and Hilbert, Charles Maray, a Belgian mathematician, triggered an intensive debate. Maray was an active supporter of Esperanto and was firmly convinced that Zamenhof's IAL project was the only one capable of solving the problems of an international scientific communication at a horizontal level. The mathematicians had different opinions on the subject and decided to accept the proposal of the Russian Vasil'ev to reduce the number of natural languages to be used in scientific communication to avoid the "Babel effect".

The idea to choose a natural "vehicular" language seemed to prevail over the artificial, even though its supporters did not give up. At the Paris conferences, there were also two scholars at the forefront of the IAL movement: Leopold Leau, a mathematician, and Luis Couturat, a philosopher-logician. Leau and Couturat were firmly convinced that scientific progress and the overcoming of all linguistic barriers were inextricably bound together. Couturat [4] maintained that science and industry were essential to the cultural development of that time; the only obstacle to the spread of this scientific and technical knowledge was constituted by the diversity of languages. Leau and Couturat were both very active in this field and, within a few years, they stimulated the debate on the subject and organised committees to increase people's interest. They also wrote *Histoire de la Langue Universelle*, which contained the description of projects which had been undertaken up to that time to create an artificial language. Leau and Couturat played a leading role at the Paris conferences and, though they failed to impose their will, in firmly dismissing other scholars' conclusions they were able to draw the mathematicians' attention to the creation of an artificial language[5] of universal acceptance. If Leau and Couturat seemed engaged in a humanitarian mission, Peano aimed to improve communication among mathematicians.

**Peano and the problem of unification**

To understand the role that Giuseppe Peano played in the international debate on artificial languages, we should first sketch his personality. Peano was a brilliant mathematician, an eclectic scholar and stubbornly carried out his ideas in his everyday life, in spite of anybody or anything, and not least, evidence. His commitment to science had two fundamental stages: his *Formulario Mathematico* and his axiomatization of natural numbers. Both projects originated from his specific will to universalise mathematics and to make its contents, rudiments, system of notation and language more comprehensible. Between 1895 and 1908, Peano devoted himself to the development of one of his six projects of universal interest:[6] the *Formulario Mathematico*. This book, which counts five subsequent editions, was originally designed to contain all mathematical principles (or, more modestly, the principles discovered up to that moment) with all their propositions, demonstrations and methods. The book gathered propositions and demonstrations of 4,200 theorems as well as a detailed biography and bibliography on more than 300 mathematicians. The whole *Formulario* was, of course, written in *Latino sine flexione*.

To grasp the fundamental meaning of Peano's *Formulario Mathematico* which introduced a new logical symbolism, it is essential to underscore that this work was the first of a long series of similar attempts which included Russell's *Principia*

[5] Couturat (Cf. [4]), in particular, made it clear that it was impossible to choose five or six natural languages to be used in scientific contexts because of the expected opposition from those excluded and of the inevitable arbitrariness and partiality of the choice.

*Mathematica* (1913), Hilbert's *The Foundations of Mathematics* (1934) and Bourbaki's *Elements of Mathematics* (1939-1967). This book contained Peano's attempt to collect all mathematical principles and to introduce a new system of notation capable of unifying the variety of symbols then used. It should not appear exaggerated to state that Peano's unifying *Formulario* and his system of notation deeply influenced the mathematicians' community of the 20$^{th}$ century and that these works were perhaps far more important than his axiomatization of natural numbers and his famous curve.

The end of the century saw the evolution of a process which would arithmetise mathematics. From Gauss in geometry, to Cauchy and Weirstrass in analysis, mathematicians strove to reduce mathematics first to algebra and then to arithmetic.

Pythagoras would have found this global reduction to arithmetic so very gratifying. The situation presented was clear: arithmetic was considered not only as sufficient, but also obviously necessary, to found mathematics. Some scholars managed to find ingenious shortcuts, such as Leopold Kronecker's well-known statement "God made the natural numbers; all else is the work of man." Others managed to find a more orthodox approach. Peano clearly stood by those who did not believe in the divine origin of numbers; he searched for a new and strictly mathematical approach. Peano who had already attempted to create a new language, to design a new calendar, to provide mathematics with a logical language, could hardly ignore this challenge to discover the origin of natural numbers.

He postulated three basic notions (zero, number and "successor of") from which he obtained, what we know today as, his, *Peano's axioms*. Thus he was able to demonstrate that natural numbers, arithmetic, algebra and mathematics could all be based on these few *a priori* rules.

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[6] Peano's six projects were: the *Formulario Mathematico*, concentrating all mathematical principles into one single book; his proposal for a new mathematical notation (this is his most famous project since his formalism was adopted by Russell and then by the whole scientific community); the proposal of five postulates, such as the Euclidean, to describe the system of natural numbers on axiomatic basis; the *Latino sine Flexione* and *Interlingua*; the "Vocabulario de Latino internationale, comparato cum Anglo, Franco, Germano, Italo, Russo, Graeco et Sanscrito" which was Peano's answer to Vasil'ev's challenge; a perpetual calendar to be used up to 2599 (on behalf of the *Academia delle Scienze*).

**Latino sine flexione**

Apart from the earlier mentioned general attempt at unification, Peano's interest in the perfect language originated from a letter about elliptic functions that he received at the beginning of 1903 from Japan, on behalf of M. Kaba [5].

The letter was really disconcerting to him, not because of its technical content, but simply because it was written in Japanese. Those incomprehensible oriental signs led him to believe that the linguistic situation was similar to a new Tower of Babel.

He realised that linguistic confusion risked compromising scientific progress. That was the reason why he became convinced that a new language was necessary. This new tongue was called *Latino sine flexione*. In typical Peano style, though, he did not advertised his idea until he was perfectly sure that it could be implemented. When the moment came, he demonstrated to the world the methodological approach of his project. Peano's new auxiliary language was presented to the general public in an article [5], in which he playfully shifted gradually from traditional Latin to his *Latino sine flexione*. In this way he illustrated how official Latin could be simplified to make it clearer, more functional and universal. It was basically a simplified form of Latin, almost completely deprived of declensions, conjugations and gender.

Peano also honestly admitted how and where Leibniz' work inspired many of his ideas, although his final results were actually different and *Latino sine flexione* actually enjoyed a high degree of popularity within the scientific community.

In October 1903, the first article fully written in this new language appeared in *Rivista di Matematica*, a journal founded by Peano himself. His mathematical and linguistic interests were tightly linked and Peano himself explained [5] that his linguistic proposal was closely related to his research in logic. Thus a strong coherence was at the basis of his project on communication among scientists from different countries.

Peano and his disciples began an intense campaign to promote *Latino sine flexione*. It was used to write articles, minutes of conferences and the results of their researches. Their undertaking proved successful and, after few years, two journals, written almost completely in *Latino sine flexione*, were published.

*Academia pro Interlingua*, *Discussiones* in 1909, and above all *Schola et Vita*, founded and edited by Nicola Mastropaolo, were the most important examples of the striking success of Peano's project. Many brilliant mathematicians and enthusiasts of this new language (a modified version of which appeared later and was called by Peano "interlingua") gathered around Peano.

Despite the fact that many important Italian mathematicians, such as Tullio Levi-Civita, wrote for Mastropaolo's journal and that *Latino sine flexione* was one of the official languages, with French, English and German, at the congress of mathematicians held in Bologna, in 1928, the popularity of Peano's idea faded almost immediately after his death in 1932.

It was because of the lack of a charismatic promoter of great scientific reputation that *Latino sine flexione* fell gradually into decline and eventually vanished. Political reasons probably also played a crucial role: Peano never accepted Fascism. He was of socialist and democratic ideas and his linguistic project was based on a democratic conception of society.

His own political tenets led him to undertake some personal struggles, especially within the university. Peano refused to hold exams. He maintained that they should be abolished since they were only an instrument of torture and were a totally inadequate means of assessment. Exams were not the reason why people studied mathematics. So, failing somebody who did not reach the required standard was absurd, Life would fail them anyway.

He was such a strong supporter of this theory that in 1912, i.e. twenty years after the beginning of his career as a university lecturer, he wrote an article for a local newspaper, *Torino Nuova*, with the very un-academic title: "Contro gli Esami" (Against exams). The following sentence sums up clearly Peano's opinion on this subject: "It is a crime against humanity. Students must not be tortured with exams to assess whether or not they know notions which are unknown by most of the educated public". Language was another distinctive feature of his decidedly alternative teaching. Ever since he devoted himself to his *Latino sine flexione*, he used it without hesitation during his university lectures. In 1925, Peano had actually become an embarrassment to his university. He was the most important Italian mathematician of his time but, as a teacher, he had long since gone too far. One could gloss over the fact that he refused to hold exams. It shocked most of his colleagues but - times don't change – his students didn't complain. However it was entirely unacceptable that he taught logic (starting from the fundamentals he himself had defined) instead of analysis [6]. Moreover Peano went on holding his lectures in his own type of Latin, which sounded totally ungrammatical to the majority of people. This was the last straw.

The university board could not dismiss him; all they could do was to create a tailor-made university course at least as far as mathematics, not language, was concerned. A new course significantly called, *Complementary Mathematics*, was instituted for Peano. He was so happy with this solution that he even accepted teaching in Italian, thus restricting the use of *Latino sine flexione* to his scientific papers only.

In 1932, with Peano's death the process that had started at the Congress in Paris was eventually brought to an end. The Italian mathematicians had unquestionably played the leading role. Results, however, were surprising: in thirty years, Peano had paved the way for an easier form of communication among mathematicians, but in doing so an enormous obstacle was also created in "vertical" communication. Peano's logical symbolism turned out to be a powerful "vehicle" of communication among experts, but was also totally obscure to the general public. In addition, *Latino sine flexione* proved pointless to the first and unfathomable to the latter.

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# Bibliography

1. Cavalli-Sforza, L. “Genes, People and Languages.” *Scientific American*. 265(1991):104-110.

2. Couturat, L. *Per la lingua internazionale.* Coulomnieers: Imprimerie P. Brodard, 1906.

3. Eco, U. *La Ricerca della lingua perfetta nella cultura europea*. Bari: Laterza, 1993.

4. Kennedy H. *Peano. Storia di un matematico.* Torino: Boringhieri, 1983.

5. Kline, M. *Storia del pensiero matematico.* Torino: Einaudi, 1996.

6. Odifreddi, P. *Dar alas ad mente de homo (peana per un matematico)*, http://www.vialattea.net/, gennaio 1999.

7. Peano, G. “Il latino quale lingua ausiliaria internazionale.” *Opere Scelte vol. 2*. Roma: Ed. Cremonese, 1958: 448.

8. Roero, C. S. “I matematici e la lingua internazionale.” *Bollettino U.M.I.*, (8), 2A(1999):159-182.