2016: YEAR RAMON LLULL

The *Ars Magna* by Ramon Llull*

Umberto Eco (1932–2016)

Summary. Beyond his general acceptance as a philosopher, theologician and religious man, Ramon Llull was also a scientist. In fact, he was a scientist in the way a scientist could be considered in the Middle Ages, with a society ruled by religion and by the absolute truth derived from the holy books (Bible, Koran and Torah). That truth, the "true Truth," was different for each religion, and that fact was the origin of many disputes among believers of these three religions. Llull as a scientist emerges from his attempt to explain the religious fact not by the mere faith but by means of the reason. That purpose embebed all his work and converted him into one of the most important figures of science and humanities of the European Middle Ages. [Contrib Sci 12(1):47-50 (2016)]

At the crossroads of three cultures

Ramon Llull (latinized in *Lullus*, italianized as Raimondo Lullo, and often anglicised as Raymond Lully or Raymond Lull), who lived from 1232 to 1315/16, was a Catalan born in Mallorca, and therefore grew up at the crossroads of three cultures: Christian, Jewish and Islamic. Not only did he become an interpreter of these traditions, but he was the first European philosopher to write doctrinal works in the vernacular, and some of them in rhyme, with very popular cadences, "so that one can demonstrate logic and philosophy to those who cannot understand Latin or Arabic" (Compendium 6–9).

First of all, however, the works of alchemy, which are all spurious, must be expunged from the Lullian *corpus*: the reputation of Llull had become such that various practitioners of occult sciences attributed their own works to him. Llull also wrote mystical, poetic, educational works, such as the novel *Blanquerna* and the *Llibre d'Amic e d'Amat (The Book of*

the Lover and the Beloved), but the works that had the greatest influence on later thought are those devoted to the *Ars Magna*.

Converting infidels

Llull, having become tertiary Franciscan after leading a dissipated life, wanted to unify Christianity, Judaism and Islam around a core of shared truths; but in fact he was interested in converting the infidels to Christianity. The idea of converting the infidels is present in the Franciscan world: think of the mission, during the Fifth Crusade, of St. Francis (1182–1226) in front of the Soldan of Babylon (i.e., the sultan al-Malik al-Kamil of Egypt [1177–1238]) in an attempt to convert him to Christianity, or of Bacon's appeal for the study of languages, so that it would be possible to talk to infidels and be able to learn from them treasures of wisdom that they had no right to possess.

Llull, however, wanted to invent a kind of universal language that could convince anyone of the truth of the Christian religion on the basis of rigorous mathematical calculation. To this end he devoted most of his life, while travelling throughout Europe and in the East. According to tradition, he would have been martyred by the infidels. In fact, he was attacked in Tunis, but he died later in Mallorca; however, he would be beatified as a martyr by Pope Pius IX (1792–1878) in 1850.

Permutation, computation, arrangement

To understand the Lullian project we must bear in mind the concept of "permutation": given n different elements, the number of possible combinations, in any order, is given by their factorial, which is represented as *n*! and is calculated as $1 \times 2 \times 3 \times \ldots \times n$. An example of a permutation is the anagram present in the Jewish Kabbalistic texts, which Lull probably knew. Except that in the case of anagrams, of the 24 possible permutations of the sequence ROME, for example, we use only the one that has a sense in our language, i.e., MORE, and discard those that we do not recognize as existing terms in the lexicon such as EOMR, OEMR, MREO and EROM.

In theory, however, all possible permutations could be considered as new words. As the number of elements increases, the number of permutations reaches amazing values. In addition, consider that the twenty-one letters of the Italian alphabet can give rise to more than 51×10^{18} 21-letter

sequences, with each letter different from the other; if we allow some letters to be repeated (as in the word "letter" with two "t" and two "e"), then the number of sequences is 5×10^{27} (i.e., a "5" followed by 27 "0").

Importance of the arrangement of the elements

There is not only the permutation but also the "arrangement" of the elements. For example, given four people, A, B, C, D, how can I arrange them in pairs, as done on an airplane that has seats two by two, but in a way that takes into account also the order (in the specific case, to define who sits next to the window, and who sits next to the aisle)? Our people could be arranged in twelve ways: AB AC AD BA BC BD CD CB CA DA DB DC.

Finally, there is "combination" if, of the four elements A, B, C, D, one wants to know in how many ways they can be paired, for instance, if they were soldiers to be sent on patrol. In this case, the order of selection does not matter (the pair consisting of A and B is the same as that composed of B and A), and the couples would be six: AB AC AD BC BD CD.
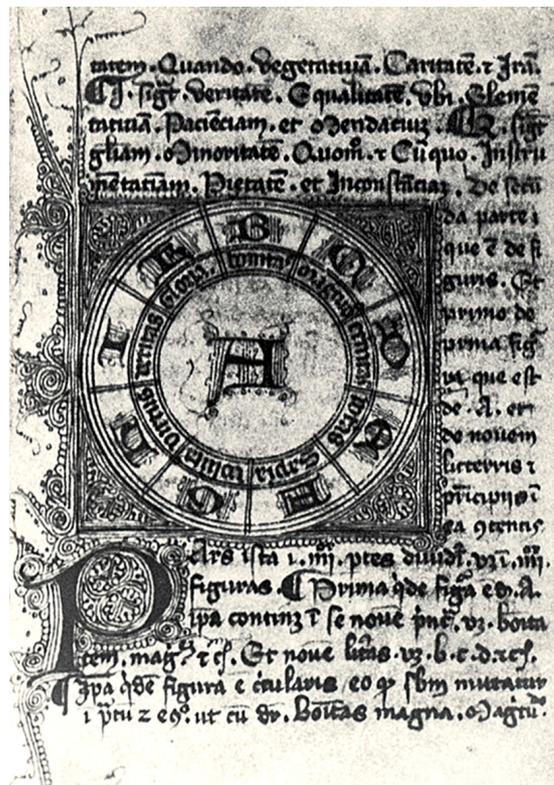
**Fig. 1.** *Ars brevis.* The First Figure. From Escorial Ms f-IV-12, fol.3.
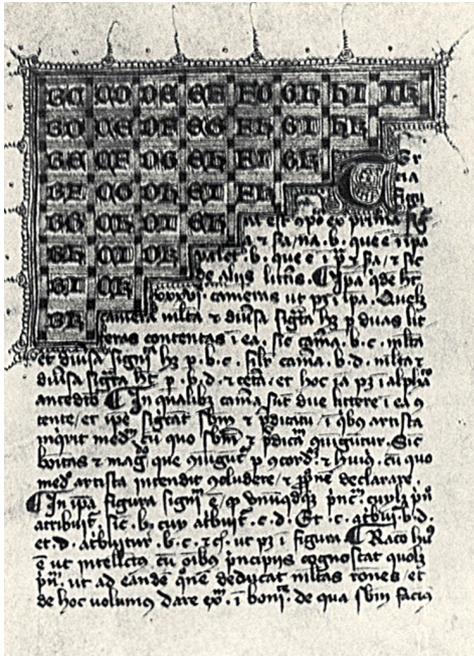
Fig. 2. *Ars brevis*. The Third Figure. From Escorial Ms f-IV-12, fol.6.

The *Tabula generalis* and the Figures

Llull was therefore implementing a combinatorial tool that nowadays is of great interest, mostly for researchers in computer science.

For combinatorics to work to its full capacity, it must be assumed that there are no restrictions in thinking about all the possible combinations. Otherwise external criteria appear that not only discriminate between the results of the combinatorics, but also insert restrictions within the same combinatorics.

For example, consider four people, A, B, C, D; there are six ways to combine them two by two, as we have seen, but if it is a combination intended to allow procreation, and if A and B are males, while C and D are females, then the possible combinations are reduced to four. In addition, if A and C are brother and sister and they would consider incest taboo, the possibility would be reduced to three. Now Llull had the truly revolutionary idea of combinatorics but at the same time he limited its possibilities.

The Lullian *Ars* considers an alphabet of nine letters, from B to K, representing nine absolute Principles (or Divine dignities), to which Llull attributes nine relative Principles that are predicates of his absolute Principles: nine types of Questions, nine Subjects and nine Vices and Virtues.

First Figure. The so-called First Figure of the Lullian *Ars* shows how, having assigned to the letters the nine absolute Principles, they can combine to form 72 propositions of the kind "Goodness is great," or reading it in the opposite direction, "greatness is glorious" (Fig. 1).

Third Figure. We skip the Second Figure, which does not refer to combinatorics. More interesting is the Third Figure, in which Llull considers all possible pairings between the letters. It seems as if he excluded the reversal of order, because the result is 36 pairs, but the virtually possible pairs number 72, because each letter can be either subject or predicate. Thus, the system allows questions such as "if goodness were great" or "what is great goodness?" The Third Figure allows, at least in theory, 432 propositions and 864 questions (Fig. 2).

Fourht Figure. The Fourth Figure is the one that will be the most successful in setting tradition. Here, the mechanism is mobile, in the sense that we have three concentric circles of decreasing sizes, applied one on top of the other and usually held at the centre by a knotted rope. Nine elements in groups of three allow 84 possible combinations (of the kind BCD, BCE, CDE). If in *Ars brevis* and elsewhere Llull speaks of 252 combinations, it is because to each triplet, the three questions designated by the letters that appear in the triplet can be assigned. Each triplet generates a column of 20 combinations (84 columns!) because Llull transforms
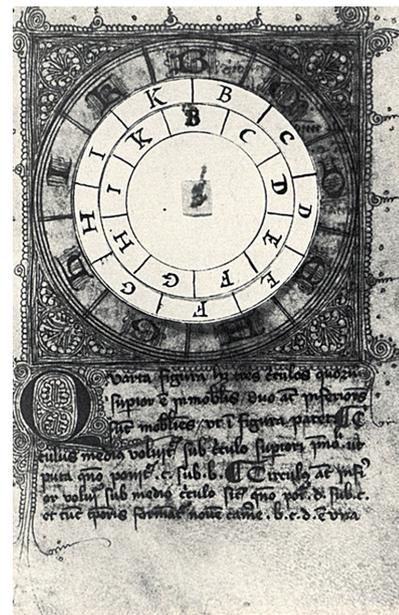

Fig. 3. *Ars brevis*. The Fourth Figure. From Escorial Ms f-IV-12, fol.7.
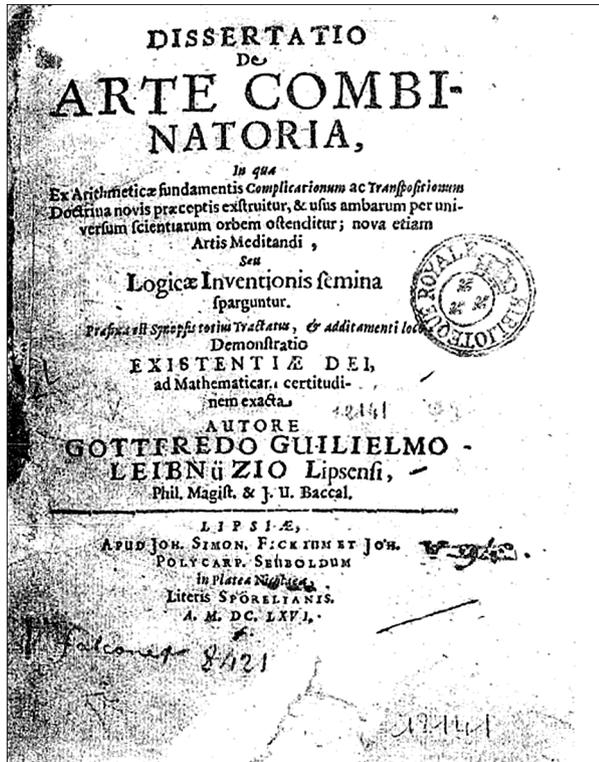
Fig. 4. *Dissertatio de Arte Combinatoria.* Gottfried Leibniz, 1666.

the triplets into quadruples by inserting the letter T. When a sequence such as BCTC is obtained, the letters preceding T should be read as absolute Principles, and those that follow it as relative Principles. Hence BCTC will be read as: "If B, the goodness, being C great, as it contains C in itself, then things are consistent." With this system, it is possible to obtain 1680 combinations (Fig. 3).

But here the first limit of *Ars* arises: many of the possible combinations must be rejected, based more on experience that on the truths of faith. For example, combinatorics would allow the question "if the world were eternal" and the answer that, if the world were eternal—we have already seen that goodness is so great that it is eternal—there should be eternal goodness and therefore no evil in the world. Llull objects, however, because evil exists in the world, as shown by experience. Therefore, it must be concluded that the world is not eternal. The answer is thus in the negative, but not based on what combinatorics would say, but according to what good Christians know, namely, that the eternity of the world is an Averroes heresy.

Thus, the 1680 sequences do not serve to generate new questions and answers, but provide only the proof of

arguments previously tested. The *Ars* is not a mathematical-logical tool, but only a dialectical tool, a means to identify and remember all good ways to argue in favour of a preconceived thesis.

The charm of combinatory art

The Lullian *Ars* would seduce posterity as if it were a mechanism to explore an infinity of worlds and of possible truths (and so will happen with Niccolò Cusano [1401–1464]); adopted by the Renaissance Christian Cabalism, it preceded the combinatorial dizziness with which mathematicians and philosophers of the 17th century played until the *Dissertatio de arte combinatoria* by Leibniz (1646–1716), who will think of a calculation based on empty symbolic forms, not anchored to any content. For Llull, however, both the principles of faith and a well-ordered cosmology must moderate the discontinuities of combinatorics. As Llull says in the Catalan version of his *Logica Algazelis*: "De la logica parlam tot breu tot / car a parlar avem de Deu" ("About logic let's speak briefly / because we must speak about God") (Fig. 4).

Rereading Llull today as if he would have invented computer science would be betraying his intentions. But certainly he was the forerunner of the subsequent boldness that he inspired. ◣

Competing interest. None declared.