

LLULL'S ART AND MODERN COMPUTER SCIENCE

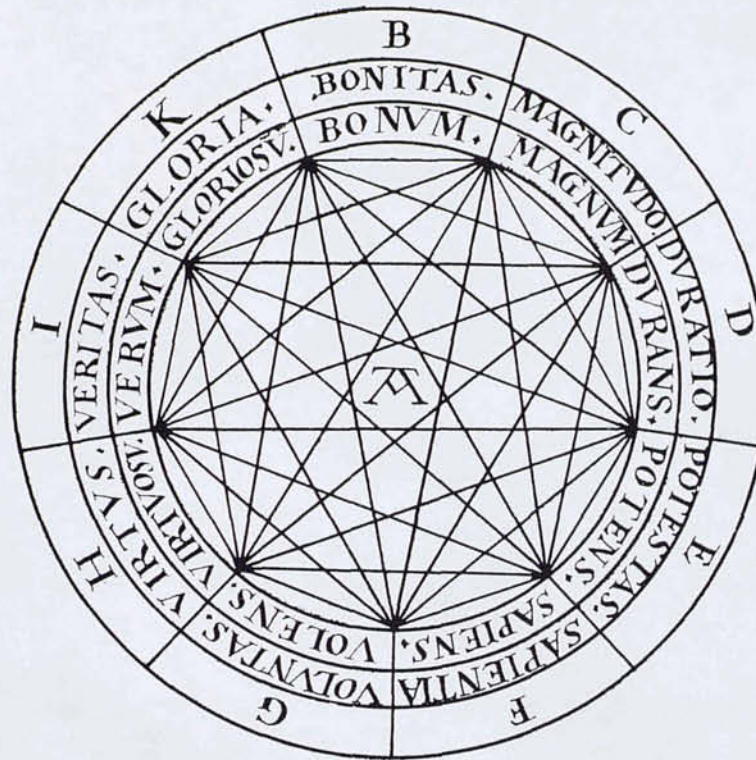


FIGURE 1. THE ABSOLUTE PRINCIPLES OR "DIGNITIES"

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The idea of the Art is Lull's most original and at the same time the most seminal. It also forms the nucleus of his metaphysical and religious thinking. The mystic in fact conceived his Art as an infallible means of acquiring knowledge and putting the truth of the Christian faith across to Jews and Muslims. It is not, however, purely a method of knowledge so much as a "system of science", in the sense that this word was to have among idealists: an organic set of conceptual structures in which there is no separation between container and content. If we look on it as the container, it is "art"; if we see it as the content, it is "science", but the two moments are inseparable: each one refers

to the other. Human knowledge is a long path which must be travelled step by step. The result of the journey is the science acquired and this coincides with the full range of Lull's Art. In other words, the rightful place of the Art comes before the branching apart of logic and metaphysics. In the Aristotelian tradition, logic was a training for effective thinking, whatever the content of that thinking. Metaphysics, on the other hand, dealt with the content of thought, of the being and its principles and causes. The Art arose from a refounding of logic and metaphysics. This is why, unlike Aristotelian logic, which is called "formal" precisely because it allows a separation between the form of the think-

ing and the content or subject matter, Lull's Art is the most polished medieval expression of a "material" logic which rejects any separation between the form of the thought and its real content. The unfolding of thought coincides with the unfolding of reality.

Having looked at the meaning of the Art, we must now try to understand its structure. It consists of three basic elements: the central concepts, the signs and graphic resorts that serve to express them and permutation. Let us start with the first element, the *central concepts*, and their key, the system of *absolute and relative principles*. Lull called the first of these "dignities". This word, related to the Greek term *axioma*, designates a series

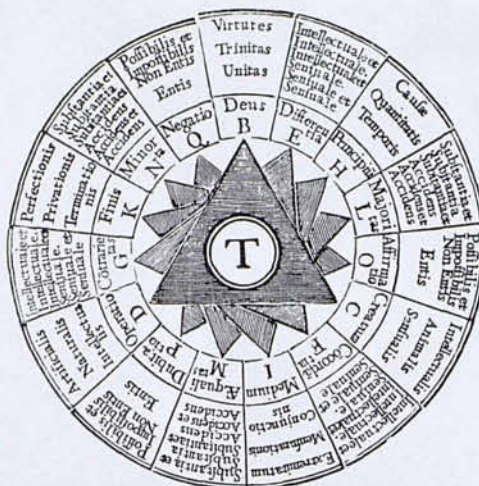


FIGURE II. THE RELATIVE PRINCIPLES

of God's names accepted by the three monotheist religions, which, because they each mean one of the Creator's perfections reflected in created things as in a mirror, also provide a knowledge of God and of the world. In the definitive version of the *Ars ultima* (1308) the nine names are as follows: goodness, greatness, eternity, power, wisdom, will, virtue, truth and glory. The "secret" of the dignities, in short, lies in the theologization of Platonic apriorism and example: God has created everything in the image of his own perfections. The dignities, like Plato's "ideas", then become *principia essendi et cognoscendi*—that is, fundamental structures of the being and structural forms of human knowledge. In creatures, the dignities differ one from the other, whereas in God they coincide and identify with one another: goodness is greatness and vice versa.

To the dignities or absolute principles must be added the nine relative principles, as follows: difference, concordance, contrariety, beginning, middle, end, majority, equality and minority. They are called relative because they establish the various possible modes of relation between the absolute principles. Note, however, that not all the relative principles have the same extension; for example, in God there is no place for contrariety or minority. The new series of principles gives the Art the sense of a comparative logic or general doctrine of relations tying the world's beings to one another and to God. Llull conceives reality as interrelated; ultimately, everything is connected to everything else. What is more, the fact that in the relative triads the central position corresponds to the concepts of concordance,

BC	CD	DE	EF	FG	GH	HI	IK
BD	CE	DF	EG	PH	GI	HK	
BE	CF	DG	EH	FI	GK		
BF	CG	DH	EI	FK			
BG	CH	DI	EK				
BH	CI	DK					
BI	CK						
BK							

FIGURE III. THE "CHAMBERS"

middle and equality shows that the mystic does not simply set things off against each other, but looks for mediation and reconciliation, so to speak.

The second element of the Art are the *signs* and *graphic resorts* with which Llull represents the central-trunk concepts and their relationships. The main ones are the alphabet, the figures and the table. The *alphabet* arises from the assignation of the nine letters of the Latin alphabet B,C,D,E,F,G,H,I,K to the two successive series of absolute and relative principles. Thus for example, B = goodness and difference; C = greatness and concordance, etc.

The *figures* connect the meanings of the letters of the alphabet into a coherent logical language. In the final version of the *Ars ultima* there are four. The first (figure A) represents the absolute principles. It consists of a circle divided into nine sectors corresponding to the nine letters of the alphabet. Inside the circle a series of straight lines lead from one sector to another signifying that the concepts represented by the respective letters are permutable. The letter A which occupies the centre represents, in Llull's own words, "the Lord, our God". The first figure is therefore a theological figure. The second figure (figure T) corresponds to the relative principles. It is made up of three superimposed triangles, inscribed in a circle, around which the letters of the alphabet appear again. The angles of each of the triangles refer back to the corresponding trio of relative principles. These first two figures provide the logician with the terms of the prayer. The third figure, on the other hand, is directed at forming the judgement. It has

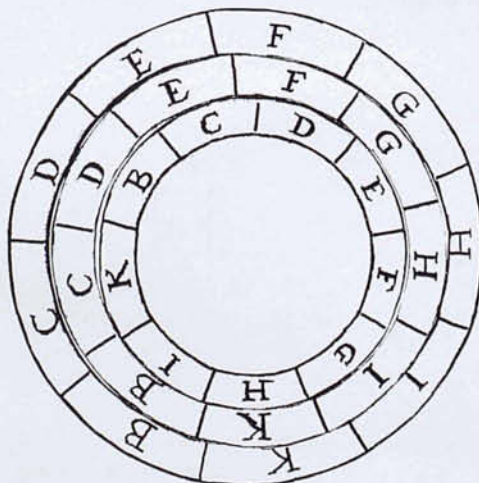
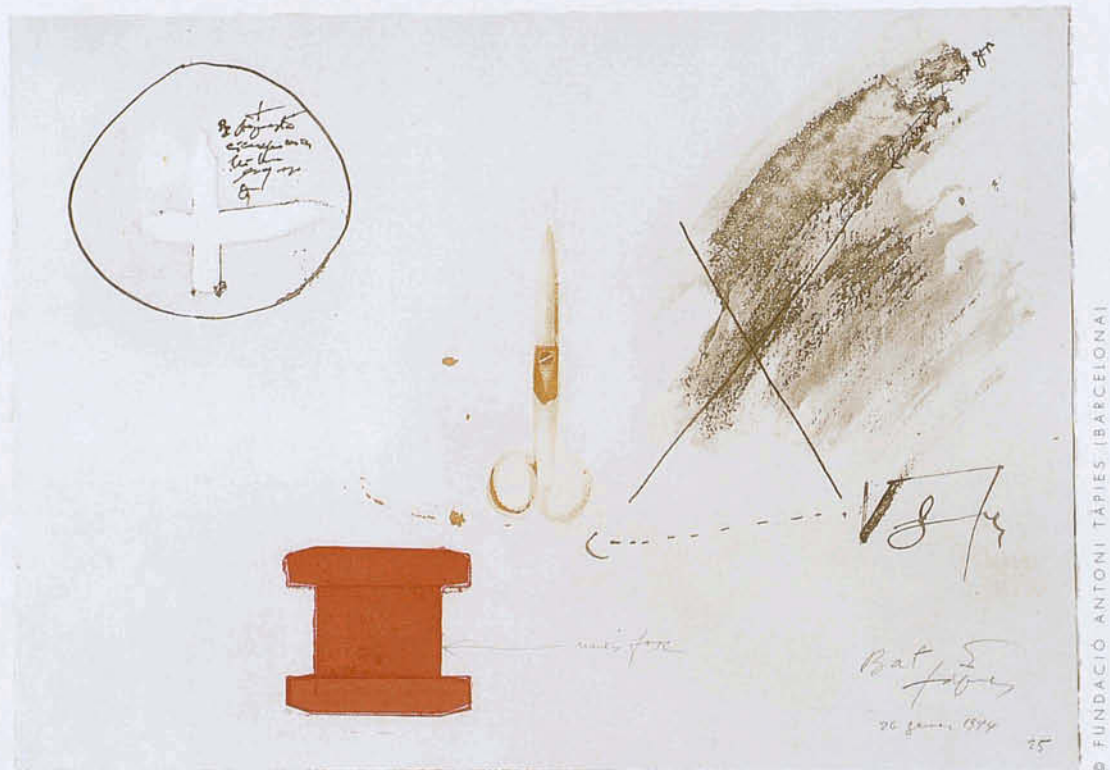


FIGURE IV. THE FIXED CIRCLE AND THE MOVABLE CIRCLES



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thirty-six compartments—or “chambers”, as Lull calls them—, each with two letters which supply the subject and the predicate of the possible sentence. The role of the logician is now to find the middle term that can join them. This is the job of the fourth figure, which consists of three superimposed circles, one fixed and the other two movable. Each one consists of nine chambers, containing respectively the nine letters of the alphabet. To “operate”, the two movable circles must be turned on the fixed circle. The first movable circle then provides the middle term.

The general *table* arises from the rotation of the two movable circles of the fourth figure. This is made up of eighty-four columns, each of which contains eight chambers or combinations of three letters (for example, BCB, BCD, etc.). Since the procedure occasionally involves a mixture of absolute and relative principles, Lull introduces a T into the combinations (for example, BCTB, BCTD, etc.) to distinguish the first from the second. The letters preceding the T must be ta-

ken as absolute principles and those following as relative principles.

The conjunction of all these elements gives rise to the *combination*. The mystic sees this as an efficient instrument for forming the sentence and the syllogism. To this end, he must solve the following questions: first, given a subject, find all the possible predicates and vice-versa; and second, find the middle term that allows the previous judgements in a syllogism. Lull therefore started to assign letters of the alphabet to the two series of principles. Afterwards, using binary and ternary combinations of letters, he established the necessary relations between the terms of a judgement or of several judgements. To facilitate this task, he assigned the fourth figure and the table as an instrument. By turning the middle movable circle of the fourth figure over the higher fixed circle and the lower circle over the middle circle—but not letting letters coincide—, one gets 252 ternary combinations. The table is the result of turning the two movable circles of the fourth figure in alphabetic order. One

thereby gets 84 ternary combinations which in turn become the heads of new series of 20 combinations, so as to make a total of 1,680 (84 x 20) combinations. The whole mechanism has a very definite objective: to find the right terms to form the judgement and the syllogism and thereby constitute reasoning almost mechanically. E. Bloch is therefore quite right when he describes Lull’s Art as “technically manufactured thousand-league boots of the deductive concept”. Not very many years ago, most logicians considered the Art nonsense and its author an eccentric, to say the least. Today, with the boom in new mathematical logic and modern computer systems, the situation has changed completely. Although the formalist procedure central to computer systems is not suited to Lull’s more “material” intention, there is no question that the Art also contains a series of formal aspects that can rightly be seen as a distant forerunner of mathematical logic and of the complex world of our computer systems. First of all, there are similarities



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of an external nature but with unforeseeable consequences for the future: the formalization of language –that is, the outline of an artificial and of a secondary system of signs to replace the concepts of the common language.

There are also internal similarities. Modern logical calculus is based on the equivalence of the elements it intends to combine. Whatever we are dealing with –whether concepts, words, numbers or real objects–, the essential condition is that it can be asserted as an equivalent. This is what happens with the principles in the first figure. The letters designating it are strictly equivalent. Each of them can follow the others, replace them or be combined with them irrespectively. The combinations of the first figure, therefore, exactly satisfy the laws of logic for substitution and permutation.

The other elements of Llull's combinatorial art do not respond to the demands of a strictly formal logic. Standing as they do for different principles at the same time, the signs of the alphabet cease to be equivalents. Nevertheless, the

idea of a logical calculus and the techniques used by Llull to carry it out go further than he thought and contain the seed of a daring attempt to mathematize and mechanize thought, an attempt which at that time must have seemed crazy, but which today we can begin to understand in all its genius. Anthony Bonner recently pointed out that to graphically represent binary relations of the sort “b is interchangeable with c” or “d is opposite or greater than e” (to take two examples from Llull), logicians and mathematicians use a series of vertices connected by lines, which is exactly what Llull does in the first figure. Another way of representing a network of relations is with a matrix, which is precisely what we have in the third figure. The table shows us the complete set of possible relations and thus becomes a forerunner for the mathematical concept of the function of a function. Furthermore, the fourth figure has the appearance of a rudimentary calculating and even thinking machine. Llull sometimes gives precise instructions about the material, preferably brass,

from which to construct the moving circles. And the table, for its part, represents a first attempt at tabulating calculus results.

By an irony of history, the mystic's mathematical “dream” –which Leibniz later formulated in a famous statement: “According to this, when some controversy arose, there would no be more need for discussion between philosophers than between calculators. It would suffice for them to take up a pen, sit down at a table and say to each other, ‘let us calculate!’”– has ceased to be a logical and scientific “heresy” to become, according to Bloch, “an industry of thought which professes speed as a heresy”. There is, in this respect, a significant fact it would not be out of place to mention here. By introducing a certain key-word into the Siemens electronic calculator in Berlin, a training program starts up whose title is “*Ars Magna*. Author: *Raimundo Lullus* (c. 1300)”. Llull's logical model has been translated into Cobol and Assembler computer languages by a programmer. And the program works! ■