Chapter 4

The Universal Characteristic

1. In order to proceed, as it were, from the outside to the inside, or from the form to the essence, we shall begin by outlining the project of the universal characteristic. We have already seen how Leibniz defines this project in opposition to attempts at a universal language, and what he means by a *real* characteristic. He designates as *characters* all written, drawn, or sculpted signs, and he understands *real* characters to be those which directly represent not words, letters, or syllables, but things, or rather ideas. Among the real characters themselves, he establishes a fundamental distinction between those which serve only for the representation of ideas and those which are useful for reasoning.[1] To the first type belong Egyptian and Chinese hieroglyphs, as well as the symbols of astronomers and chemists; however, it is the second type of character that Leibniz desires for his characteristic, and this is why he declares those of the first type to be imperfect and unsatisfactory. As examples of characters of the second type, he cites arithmetical figures and algebraic signs.[2] Thus, he says in order to make his plan better understood and more acceptable, arithmetic and algebra are only samples of his characteristic, which show that it is possible and that it is even already partly realized.[3]

We see from this why Leibniz raised his project well above the various attempts at a universal language and why he insisted on radically distinguishing it from them.[4] There is, according to him, as much difference between Wilkins's universal language, for example, and his own characteristic, as between the signs of algebra and those of chemistry,[5] between arithmetical numerals and astrological symbols, or between the

[1] "Furthermore, signs are the more useful the more they express the notion of the thing signified, so that they can serve not only for representing, but also for reasoning" (*Phil*., VII, 204).

[2] Leibniz to Oldenburg (*Phil*., VII, 12; *Brief*., I, 101); Leibniz to Galloys, December 1678 (*Phil*., VII, 23; *Math*., I, 187).

[3] "I count both arithmetic and algebra among the specimens of my plan, so you see that even now we have examples of it." Leibniz to Oldenburg (*Phil*., VII, 12; *Brief*., I, 101). "The characteristic... of which algebra and arithmetic are only samples." Leibniz to Galloys, December 1678 (*Phil*., VII, 22; *Math*., I, 186). "This algebra, which we so rightly prize, is but a part of that general art." Leibniz to Oldenburg, 28 December 1675 (*Phil*., VII, 10; *Brief*., I, 145).

[4] See the beginning of his letter to Oldenburg (1675?): "Concerning [the real characteristic], I have a notion which is completely different from the plans of those who, following the example of the Chinese, have wanted to establish a certain universal writing, which anyone would understand in his own language; or who have even attempted a philosophical language, which would be free of ambiguities and anomalies" (*Phil*., VII, 11; *Brief*., I, 100).

[5] Leibniz to Haak, 1679-80 (*Phil*., VII, 16-17): "I see that that exceptional man [Hooke] greatly prizes the philosophical character of the Most Reverend Bishop Wilkins, which I too value highly. Nevertheless, I cannot pretend that something much greater couldn't be developed, which is more powerful than his to the same degree that algebraic characters are more powerful than those of chemistry. For I think that a certain universal writing can be conceived, by means of which we could calculate in every sort of matter and discover demonstrations just as in algebra and arithmetic." Cf. the note written by Leibniz in his copy of the *Ars Signorum* (Note III).

notation of Viète and that of Hérigone.[6] But the main advantage he attributes to his characteristic over all other systems of real characters is that it will allow arguments and demonstrations to be carried out by a calculus analogous to those of arithmetic and algebra. In sum, it is the notation of algebra which will, so to speak, embody the ideal of the characteristic and serve as its model.[7]

2. Algebra is also the example Leibniz constantly cites in order to show how a system of well-chosen signs is useful and even indispensable for deductive thought: "Part of the secret of analysis consists in the characteristic, that is, in the art of using properly the marks that serve us."[8] More generally, according to Leibniz, the development of mathematics and its fruitfulness result from the suitable symbols it has discovered in arithmetical numerals and algebraic signs. If, by contrast, geometry is relatively less advanced, it is because it has thus far lacked characters suitable for representing figures and geometrical constructions. If it can be treated analytically only by applying number and measure to it, this is because numerals are the only manageable and suitable signs that we have until now possessed.[9]

Thus Leibniz goes so far as to say that the advances he has made in mathematics arise solely from the success he has had in finding the proper symbols to represent quantities and their relations.[10] Indeed, he does not doubt that his most famous discovery, that of the

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[6] Leibniz to Oldenburg (*Phil*., VII, 12; *Brief.*, I, 101). Pierre Hérigone, a French mathematician, published a *Cours mathematique* or *Cursus mathematicus nova, brevi et clara methodo demonstratus per notas reales et universales citra usum cujusunque idiomatis intellectu faciles* (4 vols., French and Latin, 1634, 1644). He employed 2/2 as the sign of equality, 2/3 and 3/2 as signs of inequality (the 2 occurring on the side of the smallest term), B as the sign of relation; as a result, a proportion was written: 4 B 6 2/2 10 B 15. He also employed certain pictograms (rebuses) for representing ideas: for example, 5 < signified *pentagon* for him. He even had signs for expressing inflections: "...is the sign of the genitive, is the sign of plurality." We see from these examples that his notation was far from being clear and workable. It is only necessary to retain from it the principle or aim, which was to supply a "real" symbolism, namely one which is natural, ideographic, and universal, that is, international and independent of any idiom; it is in this alone that Hérigone merits being considered as a precursor of Leibniz (Cantor, II, 656; cf. Gino Loria, "La logique mathématique avant Leibniz," in *Bulletin des Sciences mathématiques*, 1894). Leibniz mentions Pierre Hérigone again in a letter to John Chamberlayn, 13 January 1714 (Dutens, VI.2, 198) in regard to real characters such as the signs of chemists and Chinese writing. He also proposed following him in the elaboration of a course of mathematics, which would comprise part of an encyclopedia (*Plan for a Thought-writing for the Encyclopedia of the Arts and Sciences in the Russian Empire* [about 1712], in Foucher de Careil, VII, 592).

[7] "The truest and most beautiful shortcuts in *this most general analysis of human thoughts* were shown to me by an examination of mathematical analysis" (*Phil*., VII, 199). Elsewhere, Leibniz favorably compares his characteristic to the method invented by Descartes: "I have found a method in philosophy which can bring about in all the sciences what Descartes and others did in arithmetic and geometry by means of algebra and analysis; it relies on the art of combinations, which Lullius and Fr. Kircher cultivated but into which neither saw very deeply." Leibniz to Duke Johann Friedrich, undated, but probably from 1671-73 (*Phil*., I, 57). This method, which he then indicates, consists in composing and decomposing concepts via their simple elements, by means of the art of combinations.

[8] Leibniz to L'Hospital, 28 April l693 (*Math*., II, 240). Leibniz adds, "And you see, sir, from this small sample, that Descartes and Viète did not yet know all the mysteries." The "small sample" is the numerical notation for coefficients (see Appendix III).

[9] Introduction to *On the Universal Science* (*Phil*., VII, 198). Concerning Leibniz's geometrical characteristic, see Chap. 9.

[10] Preface to *Inventory of Mathematics*: "In general, the instrument of human invention is suitable characters, since arithmetic, algebra, and geometry offer enough of an example of this... and I now declare

infinitesimal calculus, derives from his constant search for new and more general symbolisms, and that, conversely, the former may have contributed greatly to strengthening his belief in the fundamental importance of a suitable characteristic for the deductive sciences.[11] As Gerhardt very justly remarks, "it has been too little recognized that the algorithm which he chose, however fortunately, for higher analysis must be regarded simply as a result of these investigations; it is in the first place nothing but (and Leibniz himself designates it as such) a characteristic, an effective calculus."[12] The profound originality of the infinitesimal calculus in fact consists in its representing by suitable signs notions and operations which are no longer part of arithmetic, and in this way subjecting them to a formal algorithm.[13] It is this which constitutes the essential merit of Leibniz's invention and its principal advantage over Newton's method of fluxions.[14] We can therefore say that the infinitesimal calculus is only a sample, if the most illustrious and most successful, of the universal characteristic.[15]

3. It is precisely in connection with his infinitesimal calculus that Leibniz was led to develop and justify his ideas on the usefulness of a suitable characteristic in his interesting letter to Tschirnhaus of May 1678.[16] He had announced to his friend that he had a new calculus for obtaining quadratic equations, that is, for carrying out quadratures. Tschirnhaus responded that he did not see the usefulness of this invention and that by

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that this is what I have added to mathematical invention; from this alone it is born, since the use of symbols improves the representation of quantities" (*Math*., VII, 17).

[11] The invention of the differential and integral calculus is recorded in drafts dated 29 October and 11 November l675 (*Brief.*, I, 151, 161; cf. *Math*., V, 216). Some months later (26 March 1676), Leibniz wrote the following note: "Through these remarkable examples, I daily come to know all the arts of simultaneously solving problems and discovering theorems. In cases where the thing itself lies far from the imagination or is too vast, to return to the point, it may be subjected to the imagination by means of characters or shortcuts; and those things that cannot be depicted, such as intelligible entities, may nevertheless be depicted by a certain hieroglyphic, but at the same time philosophical, reason. With this done, we do not chase after pictures, certain mystic or Chinese images, but follow the idea of the thing itself. (*Math*., V, 216). One should note that this thought, suggested to Leibniz by the development of the infinitesimal calculus ("remarkable examples") is immediately extended to *intelligible* objects which escape the imagination; that is, it is transported from the domain of mathematics to that of metaphysics. He himself says later: "And as I have had the good fortune of considerably perfecting the art of invention or mathematical analysis, I began to have certain entirely novel ideas for reducing all human reasoning to a species of calculus...." Leibniz to the Duke of Hanover, ca. 1690 (*Phil*., VII, 25).

[12] *Math*., V, 5; *Phil*., IV, 5.

[13] Auguste Comte therefore commits a serious error when he assimilates differentiation and integration to arithmetical operations: he does not appear to have understood that these operations no longer apply to *numbers* but to *functions*.

[14] Gerhardt, in *Brief.*, I, xv. Cf. what Leibniz himself said of Newton while doing full justice to him (this was before their dispute over priority): "It is true that he uses different characters, but as the characteristic itself is, as it were, a large part of the art of invention, I believe that ours gives more of an opening." "Considerations on the difference between ordinary analysis and the new calculus of transcendents," in *Journal des Savants*, 1694 (*Math*., V, 307). See also Gerhardt, *Die Entdeckung der hoheren Analysis* (Halle, 1885) and Cantor, III, 160.

[15] Cf. *Brief.*, I, vii and xv (Preface).

[16] Here are the principal advantages Leibniz attributes to his characteristic: "But that this combinatory or general characteristic contains far more than algebra has given cannot be doubted, for with its help all our thoughts can be, as it were, depicted, fixed, abridged and ordered: *depicted* so that they may be taught to others, *fixed* so that we may not forget them; *abridged* so as to be few in number; *ordered* so that all may be considered in thinking" (*Math*., IV, 460-1; *Brief.*, I, 380).

introducing new notations one only makes the sciences more difficult.[17] Leibniz replied that one could have made the same objection to those who substituted Arabic numerals for Roman numerals, and to Viète who replaced numbers by letters in algebra. Later he explained that Arabic numerals have the advantage over Roman numerals of better expressing the genesis of numbers, and consequently their definition, so that they are more suitable not only for writing, but also for mental calculation. He was thus led to define the usefulness he ascribed to signs and the conditions of this utility: “It should be observed that the greatest advantage for invention is to express the hidden nature of the thing in as few signs as possible and, as it were, depict it; in this way the labor of thinking is amazingly reduced.” He added that this is the advantage of his integral calculus: “Such are the signs that I have employed in the calculus of quadratic equations that by means of a few of them I often solve very difficult problems.”[18] And he noted that the same calculus allows him to resolve problems very different in appearance (namely, problems of quadratures and the problem of inverse tangents[19]) using a single method: “For I use the same calculus, the same signs, for the inverse method of tangents and the method of quadrature.”[20] This passage clearly shows how the invention of the infinitesimal calculus proceeded from the search for the most appropriate signs, and how in return it confirmed Leibniz in his views on the fundamental importance and marvelous fertility of a well-chosen symbolism.

In any case, in order to bring the unity of Leibniz’s philosophical and scientific work into prominence, it was important to show that his most celebrated and most fruitful mathematical invention, that which revealed his genius and consecrated his fame in the eyes of the learned, was connected in his thought with his logical investigations and was for him only an application or a particular branch of his universal characteristic.[21] But it is also appropriate to observe that this was not its only application, and that the same preoccupation suggested to him many other mathematical inventions, more or less successful, but always ingenious, certain of which, unknown or misunderstood at the time, have since found application in the sciences.[22]

4. We have already considered the requirements for a good characteristic: the characters must first be “manageable,” that is, of an abbreviated and condensed form which encloses much meaning in a small space, in such a way that one could form various combinations from them and take in complex formulas and relations at a glance. Next, they must

[17] *Math.*, IV, 455; *Brief.*, I, 375, and 523. This is essentially the same opinion Huygens long held on the subject of the infinitesimal calculus, until he was convinced by some striking examples. See Chap. 9, §2 and the texts cited there.

[18] There follows an example: Find the curve whose subtangent is constant; this is the *logarithmic* curve that Descartes had not been able to discover because it is transcendental.

[19] That is, to determine a curve by means of a property of its tangent, as in the case of the logarithmic curve cited in the preceding note.

[20] *Math.*, IV, 455; *Brief.*, I, 375. Later he states that the three methods of quadrature distinguished by Tschirnhaus reduce to particular cases in his: “But I consider these three methods all as parts of my general quadratic calculus” (*Math.*, IV, 458).

[21] In a letter to Baron Bodenhausen in which he presents a general theorem concerning quadratures, he writes: “It is pleasing to note that this theorem is undoubtably derived from my *characteristic*”; but the *characteristic* here is his infinitesimal calculus, which, as he remarks, contains all the theorems relating to quadratures (*Math.*, V, 114; cf. 87).

[22] See Appendix III.

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"correspond to concepts," by expressing, that is representing, simple ideas by signs which are as natural as possible and complex ideas by a combination of signs which correspond to their elements, so as to depict to the eyes their logical composition.[23] Thus the principal virtue of a system of symbols must be conciseness: they are intended to shorten the work of the mind by condensing thoughts in some way. From this comes their usefulness, or rather their necessity, in mathematics, whose theorems are, in Leibniz's words, only "abridgements of thought."[24] And, in fact, a theorem is generally expressed by a formula which represents a calculation done once and for all, and which consequently excuses us from repeating in each particular case the same reasoning by which it was obtained. A theorem, therefore, is not only a "tachygraph," or an abridgement of writing, but also an abridgement of reasoning which allows one to pass from premises to conclusion by a calculus or mechanical operation.

In an unpublished fragment already cited, relating to the universal language, Leibniz imposes a further condition on the characters: one must be able to deduce from their very form and composition all the properties of the concepts which they represent. He offers as a model the system of binary numbers, since it allows the elementary truths of arithmetic which make up the Pythagorean table (e.g. 3 times 3 equals 9) to be demonstrated by a calculus, while the decimal system of numbers is obliged to accept them as fact.[25] This is the second condition that the rule for the formation of characters satisfies: their combinations must portray to the imagination the logical connections of the corresponding concepts, such that the composition of signs corresponds to the composition of ideas according to an exact *analogy*, whose importance we shall soon see.[26] There is more: not only does the characteristic express the intuitive form of thought, but it also serves to guide it, to relieve it, and even to supplement or replace it.

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[23] *Phil*., VII, 198 (quoted in Chap. 9, §1). Cf. the following fragment: "I call a visible sign representing thoughts a *character*. The *characteristic art* is thus the art of forming and ordering characters, so that they may register thoughts or have among themselves the relation which the thoughts have among themselves. An *expression* is a collection of characters representing the thing which is expressed. The *law of expression* is this: just as an idea of the thing to be expressed is formed from the ideas of certain things, so an expression of the thing is formed from characters of those things" (LH IV 5, 6 Bl. 16; in Bodemann, 80-1).

[24] "All theorems are only tachygraphs or abridgements of thinking...; in this consists the entire use of words and characters, such as numerals in arithmetic and the signs of analysis...and accordingly the merit of the abstract sciences consists entirely of abbreviated signs for speaking and writing..." (LH IV 7B, 2 Bl. 53).

[25] "And it should be known that characters are the more perfect, the more they are sufficient, such that every consequence can be deduced from them. For example, the characteristic of binary numbers is more perfect than that of the decimals or any others, since in the binary system everything which is asserted of numbers can be demonstrated from characters, but in the decimal system this is not the case" (LH IV 7B, 3 Bl. 24). See Appendix III.

[26] "The *general symbolism* itself is the *characteristic art* united with the combinatory into one discipline, by means of which the relations of things are suitably represented in characters. And surely we must believe that the more we make the characters express all the relations which hold in reality, the more we will discover in them an aid to reasoning; so that as the poet Gallus elegantly said of writing, we give thoughts and reasons a substance and external appearance, not only for the benefit of memory in retaining those ideas which writing displays, but also for augmenting the power of the mind, so that it may touch the incorporeal, as if by hand." *A New Advancement of Algebra* (*Math*., VII, 159-60). The French poet alluded to is Brébeuf, whom Leibniz cites elsewhere: "Its true use would be to portray not speech, as M. Brébeuf says, but thoughts, and to speak to the understanding rather than to the eyes." Leibniz to Galloys, 1677 (*Phil*., VII, 21; *Math*., I, 181). The allusion is to a well-known verse in which Brébeuf defined writing as "that ingenious art / Of portraying speech and speaking to the eyes."

Moreover, just as combinations of ideas are represented by combinations of the corresponding signs, operations of the mind, that is, acts of reasoning which are carried out on these ideas, are expressed by concrete and sensible operations carried out on the symbols. The abstract laws of logic are therefore expressed by the intuitive rules which govern the manipulation of signs. These rules can be called "mechanical" in two senses: first, because they govern physical and material transformations; and second, because they become mechanical habits of the imagination which the hand of the calculator automatically obeys.

5. In this, Leibniz's method resembles the Cartesian method, of which it at first appears to be only a development.[27] Like it, it seeks above all to spare the power of the mind and to increase its capabilities, by acting as an aid to the imagination and in part as a substitute for the understanding, by relieving the memory with sensible signs and by facilitating deductive thought through the use of well-constructed formulas.[28] But this resemblance is easily explained by the fact that the two methods are both inspired by the example of mathematics and adopt algebra, albeit in two different senses, as their model.[29]

Indeed, given the meager capacity of the mind, which can embrace only a small number of ideas at the same time and carry out only immediate and simple deductions in one go, it is liable to become entangled in the maze of complex notions and lose its way in lengthy reasonings. In order to move forward and find its way back again without fail in the "labyrinth" of deduction, it requires a "thread of Ariadne."[30] By this favorite metaphor, Leibniz means a sensible and mechanical method which may guide and support discursive thought, eliminate its uncertainties and fumblings, and render its shortcomings and errors impossible.[31] He elsewhere calls it a "thread of thinking [*filum*

[27] We will see later that this is not at all the case (Chap. 6, §14).

[28] Cf. Descartes, *Rules for the Direction of the Mind*, especially Rules XII, XIV, XV and XVI.

[29] Leibniz wrote of his "method of universality": "it has this in common with the other parts of analysis, that it spares the mind and the imagination, the use of which it is especially necessary to conserve. This is the principal aim of that great science I am accustomed to call *characteristic*, of which what we call algebra is only a very small branch. For it is the characteristic which gives speech to languages, letters to speech, numerals to arithmetic, notes to music; it is this which teaches us the secret of fixing our reasoning and of requiring it to leave something like visible traces on paper in a notebook, which can be examined at leisure. Finally, it allows us to reason with economy, by putting characters in the place of things in order to relieve the imagination." *On the Method of Universality*, §4, ca. 1674 (LH IV 5, 10).

[30] Leibniz to Galloys, 1677: "The true method must provide us with a *thread of Ariadne*, that is, a certain crude and sensible means, which might conduct the mind like the lines drawn in geometry and the procedures one assigns to beginners in arithmetic. Without this our mind is unable to traverse a long road without losing its way" (*Math*., I, 181; *Phil*., VII, 22).

[31] *Inventory of Mathematics*: "For the mind is ruled, as it were, by a certain *sensible thread*, lest it wander in the labyrinth, and although it is unable to grasp distinctly many things at the same time, when signs are used in place of things the imagination is spared; nevertheless it makes a great difference how the signs are employed, in order that they may represent things more usefully" (*Math*., VII, 17). In the *Animadversions against Weigel*, Leibniz explains why it is more difficult to carry out rigorous demonstrations in metaphysics than in mathematics: "The reason for this is that in numbers and figures and the signs which depend on them, our mind is governed by a certain thread of Ariadne in imaginings and examples, and has at hand corroborations such as the *proofs* of arithmetic, by means of which fallacious arguments can easily be refuted. But in metaphysics (as it has until now usually been treated) we are without these aids, and we are forced to supplement the rigor of reasoning because it lacks proofs and tests" (Foucher de Careil, B, 150).

cogitandi],"[32] and most frequently a "thread of meditation [*filum meditandi*],"[33] that is, the guiding thread of reasoning and invention.[34] This procedure consists of representing ideas by signs and their combinations by combinations of signs, in such a way that the logical analysis of concepts may be replaced by the material analysis of characters.[35] Leibniz himself traces the discovery of this thread of Ariadne back to his adolescence and the composition of *On the Art of Combinations*,[36] which clearly shows that this method proceeds from his general ideas concerning the characteristic combinatory.

In fact, this assistance which the imagination lends to the understanding, through which it aids it and even replaces it, is the systematic use of signs and calculation, in a word, the characteristic: "If we had it such as I imagine it, we could reason in metaphysics and in ethics more or less as in geometry and analysis, since the characters would fix our overly vague and ephemeral thoughts in these matters, in which imagination offers us no help except by means of characters."[37] Leibniz desires above all to apply his characteristic to the sciences which surpass the imagination, in order to give them the rigor and certitude which seem (wrongly) to be the privilege of mathematics. It suffices to transfer to these sciences the method to which mathematics owes all its progress.[38] Doubtless this method is more difficult to employ in metaphysics than in

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[32] Cf. an unpublished fragment containing one of the first plans for an encyclopedia: "What I call the *thread of thinking* is an easy and certain method. By following it we may proceed without agitation of the mind, without disputes, without fear of error, no less securely than one who in a labyrinth possesses the thread of Ariadne" (LH IV 7C Bl. 88).

[33] Leibniz to Oldenburg: "But what I call the *thread of meditation* is a certain sensible and, as it were, mechanical guide for the mind, which even the dullest person could recognize" (*Phil*., VII, 14; *Brief.*, I, 102). A little later he compares his method to the parapet of a bridge that one would have to cross at night (see below n. 49).

[34] Still elsewhere, Leibniz speaks of a "sensible thread" (*filo palpabili*) which must guide investigations (*Phil*., VII, 57), or of *sensible* demonstrations: "You produce sensible demonstrations in the calculations of arithmetic or the diagrams of geometry" (*Phil*., VII, 125); or, finally, of a *sensible* criterion of truth: "in the sensible signs by which truth is to be decided and in the certain thread of the art of invention" (*Phil*., VII, 59). Cf. n. 67.

[35] *The Analysis of Languages*, 11 September 1678: "For the invention and demonstration of truths an analysis of thoughts is necessary; and since this corresponds to the analysis of characters..., it follows that we can render the analysis of thoughts sensible, and guide it, as if by some mechanical thread, since an analysis of characters is something sensible" (LH IV 7C Bl. 9). Cf. Leibniz to Tschirnhaus, May 1678: "For there will be at hand a mechanical thread of meditation, as it were, with the help of which any idea may be easily resolved into those from which it is formed; indeed, when the character of any concept is carefully considered, the simpler concepts into which it can be resolved at once occur to the mind: ...the resolution of concepts thus corresponds exactly to the resolution of characters" (*Math*., IV, 461; *Brief.*, I, 380).

[36] Leibniz to Tschirnhaus, 1679: "At the age of eighteen, while writing a little book *On the Art of Combinations* which was published two years later, I discovered a sure thread of meditation, wonderful for the analysis of hidden truths, a corollary of which is a rational language or characteristic" (*Math*., IV, 482; *Brief.*, I, 405-6).

[37] Leibniz to Galloys, 1677 (*Phil*., VII, 21; *Math*., I, 181). Cf. *Animadversions against Weigel*, cited in n. 31, and *The Analysis of Languages*, 11 September 1678: "But with the help of characters this becomes easier than if in no respect did we approach the thoughts themselves through the characters; for our intellect must be governed by some mechanical thread on account of its weakness, since in those thoughts which display things not subject to the imagination they are shown in characters" (LH IV 7C Bl. 9).

[38] In his *Elements of Reason*, after having praised the logical perfection of mathematics and the means of verification that it possesses, Leibniz adds: "This genuine advantage of continual testing through experience and a sensible thread in the labyrinth of thought, which could be perceived by the eyes and, as it were, felt by the hands (to which the increase in my mathematical knowledge is owed) has until now been

mathematics, but this only makes it all the more important to apply it with rigor: "For in mathematics it is easier to succeed, since numbers, figures, and calculations make up for the shortcomings hidden in speech; but in metaphysics, where one is deprived of this assistance (at least in ordinary ways of reasoning), the rigor employed in the form of reasoning and in the exact definitions of terms might make up for this deficiency."[39] The assistance that the imagination and intuition lend to the understanding in mathematical reasoning is precisely what Leibniz wants to furnish himself with in deductions of every sort by means of his logical calculus.[40] Moreover, he notes that mathematics finds in experience a guide, a control and a verification which is missing in the reasoning of philosophers, so that the latter can only be saved from error by a scrupulous attention to the *form* of deductions.[41] But this form could not be better guaranteed than by the characteristic, which renders it sensible and palpible.[42]

6. It is precisely this method which philosophers—most notably Descartes and Spinoza—who claimed to treat metaphysics and ethics in the manner of geometry have been lacking. According to Leibniz, Descartes did not possess the perfect method and the true analysis;[43] he "did not know the true source of truths, nor this general analysis of notions which Jungius, in my opinion, understood better than him."[44] This is why he always failed in his attempts at metaphysical demonstrations, particularly when he wished to establish them formally, as at the end of the Replies to the Second Objections.[45] From where, then, does the insufficiency of Descartes's logic arise,

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missing in other human reasonings" (LH IV 7B, 6 Bl. 3 verso). Later he recalls the invention of his adolescence, that is, his combinatory (Bl. 7 recto).

[39] *Remarks*..., 1711 (*Phil*., VI, 349n.). Cf. Leibniz to Burnett, 1699 (*Phil*., III, 259); *On the Use of Meditation* (*Phil*., VII, 79n.); *New Essays*, IV.2.xii; and *Animadversions against Weigel*, cited above n. 31.

[40] It is to this that the reservation in parentheses makes allusion.

[41] This is why he puts forward as models of logical rigor, first geometers and then legal experts: "One can even boldly advance a pleasing, but genuine paradox, that there are no authors whose manner of writing more resembles that of geometers than the ancient Roman lawyers, fragments from whom are found in the Pandects, and who, according to him, might put philosophers to shame even in the most philosophical matters that they are often obliged to discuss" (*Phil*., VII, 167; cf. *New Essays*, IV.2.xii). Cf. the preface to *A Specimen of Political Demonstrations*, 1669 (Note VIII); Leibniz to Arnauld, 14 January 1688 (*Phil*., II, 134); *On Universal Science* (*Phil*., VII, 198), in which Leibniz recalls his essay *On Conditions* (see Note V); Leibniz to Gabriel Wagner, 1696 (*Phil*., VII, 526).

[42] Leibniz to Tschirnhaus, May 1678 (relating to the posthumous works of Spinoza): "In the *Ethics*... there are logical fallacies, owing to the fact that he departed from rigorous demonstration; I certainly think that it is useful to forsake rigor in geometry, since in this it is easy to keep clear of errors, but in metaphysics and ethics I think that the highest rigor of demonstrating must be followed, since in these it is easy to slip up; nevertheless, if we should have the characteristic established, we could reason with equal safety in metaphysics and mathematics" (*Math*., IV, 461; *Brief*., I, 381). Cf. Leibniz to Galloys, 1677 (*Math*., I, 179); Leibniz to Arnauld, 14 January 1688 (*Phil*., II, 133); *On the Emendation of First Philosophy*, 1694: "It seems to me that illumination and certainty are needed more in these matters than in mathematics itself, since the facts of mathematics carry with them their own test and corroboration, which is the most important cause of success, but in metaphysics we lack this advantage. And so some special means of expression is needed, and as it were a thread in the labyrinth, with whose help, no less than by Euclid's method, problems might be solved in the manner of calculations" (*Phil*., IV, 469).

[43] Leibniz for Molanus, 1677: "Descartes lacked the perfect method and true analysis" (*Phil*., IV, 276).

[44] Leibniz to Philipp, 1679 (*Phil*., IV, 282); cf. Leibniz to Malebranche, 13 January 1679: "He is still very far from the true analysis and the art of invention in general" (*Phil*., I, 328).

[45] Leibniz to Malebranche, 22 June 1679 (*Phil*., I, 337); *Remarks on the Summary of the Life of Descartes* (*Phil*., IV, 320; cf. the texts cited in Chap. 6, §45).

especially concerning things not subject to the imagination? Leibniz frankly asserts: "If he had followed exactly what I call the *thread of meditation*, I think he would have perfected first philosophy."[46]

Leibniz thus criticizes rather severely the famous rules of the Cartesian method, which he declares useless or insignificant: "Those who have given us methods undoubtedly supply some fine rules, but no way of observing them. They say that it is necessary to understand everything clearly and distinctly; that it is necessary to proceed from simple things to complex things; that it is necessary to divide our thoughts, etc. But this is of little use if nothing further is said."[47] We will see later (Chap. 6) the detailed criticisms Leibniz directs at Descartes's various rules and the precepts he substitutes for them. For the moment, it is enough to note that although they may be valid and correct, they have in his eyes the defect of being only general and vague, and consequently ineffective recommendations, with the result that in order to follow the Cartesian method confidently and apply it correctly another method would be needed.[48] This other method is precisely the characteristic, which supplies the mind with a guiding thread and a concrete support and assures its regular and orderly advance, not through useless advice, but through practical and mechanical rules similar to rules for calculation.[49]

7. For the same reason, Leibniz does not accept the hyperbolic doubt that Descartes had conceived concerning the value of mathematical reasoning and the certitude of deduction in general, under the pretext that memory necessarily intervenes in it and can deceive us. Leibniz replies that memory is involved in every state of consciousness and that to doubt memory is to doubt consciousness itself. Nor can he seriously accept the hypothesis of an evil genius by which Descartes attempts to justify his hyperbolic doubt; and the reply Leibniz directs against him is quite remarkable: he simply argues from the fact that we can in our demonstrations assist, and even replace, the memory with writing and signs.[50]

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[46] That is, metaphysics. Leibniz to Foucher, 1678? (*Phil*., I, 370-1).

[47] Leibniz to Galloys, 1677 (*Phil*., VII, 21; *Math*., I, 181). Cf. *New Method of Learning and Teaching Jurisprudence*, 1667 (Note VII).

[48] Later (around 1690) Leibniz satirized the Cartesian rules in these caustic terms: "And it is little different than if I were to say things similar to these for an unknown rule of chemistry: assume what you ought to assume, proceed as you ought to proceed, and you will have what you desire" (*Phil*., IV, 329). This is why Descartes's discoveries appeared to him to be "rather an product of his genius than his method" (*Phil*., VII, 22; cf. *Phil*., IV, 329, 331).

[49] This is the point of the analogy Leibniz draws to a bridge in his letter to Oldenburg: "I can prescribe this rule for crossing a bridge at night, that if one loves his health he should proceed in a straight line, veering neither right nor left; by this rule he should achieve great safety and lose little effort; but if there is a parapet on both sides of the bridge, the danger and the remedy will be absent" (*Phil*., VII, 14). The precept in question represents Descartes's method, whose rules Leibniz cites immediately after; the parapets of the bridge signify the characteristic. The comparison seems to be inspired by the precept Descartes gives for getting out of a forest in which one is lost (*Discourse on the Method*, Part III, second rule of provisional morality).

[50] "Consciousness is the memory of our actions. Thus Descartes wanted to be able to trust no demonstration, since any demonstration requires a memory of the preceding propositions, in which the power of some evil genius could perhaps deceive us. But if we produce pretexts of this sort for doubting, we also ought not to believe things present to our consciousness. For memory is always involved, since, strictly speaking, nothing is present besides the moment. Writing or signs assist the memory in demonstration, but no evil genius is allowed who might trick us into those falsities" (LH IV 1, 4i Bl. 42; in

Thus it is the characteristic which, undermining the ruses of the evil genius, protects us from any error of memory and supplies us with a "mechanical" and "palpible" criterion of truth.[51]

By expressing concepts and their relations by means of characters, it allows every stage in a deduction to be fixed on paper: the logical rules will be represented by the sensible and mechanical rules for the transformation of formulas (as they are in algebra), and, consequently, an argument will be reduced to a combination of signs, to a game of writing, in a word, to a calculation.[52] Leibniz thus rediscovers, in a more exact and profound sense, the thought of Hobbes: "reasoning is calculation."[53] Not only does the calculation follow the deduction step by step, but it directs it in an infallible manner and replaces reasoning by a mechanical manipulation of symbols conforming to fixed rules.[54]

8. Thus the characteristic must serve as the foundation for a genuine logical algebra, or *calculus ratiocinator*, applicable to every category of knowledge in which reasoning can be exercised.[55] Among the numerous uses of this logical calculus Leibniz praises one in particular: that it will put an end to disputations,[56] that is, to the interminable discussions of the Schools in which all the resources and subtleties of scholastic logic were displayed, generally in utter waste and without ever reaching agreement.[57] In fact, the fruitlessness of these disputes proves above all, according to him, the lack of rigor and precision in ordinary language, which causes verbal reasoning to give rise to equivocations and logical fallacies that are often involuntary and unobserved.[58] By contrast, with signs

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Bodemann, 58). Cf. *Phil.*, IV, 327, and LH IV 1, 4d Bl. 4: "M. Descartes behaved like a charlatan..." (Foucher de Careil, B, 12; Bodemann, 52).

[51] Leibniz to Oldenburg, 28 December 1675 (*Phil.*, VII, 9-10); cf. the fragment LH IV 5, 6 Bl. 19, quoted in n. 67, and Chap. 6, §14.

[52] "For a *calculation* is nothing else than an operation on characters, which has a place not only in quantitative reasoning, but in every other sort as well." Leibniz to Tschirnhaus, May 1678 (*Math.*, IV, 462; *Brief.*, I, 381).

[53] "All our reasoning is nothing other than the connection and substitution of characters, whether the characters be words, signs, or finally images.... It is further clear from this that any reasoning amounts to a certain combination of characters" (*Phil.*, VII, 31). Cf. *Phil.*, VII, 204.

[54] "For if writing and thinking go hand in hand, or as I say in a straight line, the writing will be a *thread of meditation*." Leibniz to Oldenburg (*Phil.*, VII, 14; *Brief.*, I, 102).

[55] "Calculus Ratiocinator, *or an easy and infallible instrument of reasoning. A thing which until now has been ignored*" (LH IV 7B, 2 Bl. 8). Leibniz later called it: "A certain *characteristic of reason*, by whose aid it is possible to arrive at truths of reason, as if by a calculation, in all other matters insofar as they are subject to reasoning, just as in arithmetic and algebra" (Leibniz to Rodeken, 1708; *Phil.*, VII, 32).

[56] Cf. the following titles: *Discourse Concerning the Method of Certitude and the Art of Invention, so as to end disputes and make great progress in a short time* (*Phil.*, VII, 174); *Project and Essays for Arriving at Some Certitude, in order to end a good number of disputes and advance the art of invention* (LH IV 6, 12e).

[57] We recall the words of Casaubon that Leibniz cites in several passages: "Someone showed Casaubon the hall of the Sorbonne and said to him: here is a place in which disputations have been held for so many centuries. He replied: What has been concluded from them?" (*New Essays*, IV.vii.11). See a scathing satire of these disputes in a German fragment entitled *Words*, in Bodemann, 81 (LH IV 5, 6 Bl. 17). Cf. *Phil.*, VII, 188.

[58] "Natural languages, although they may offer many things for reasoning, are nevertheless guilty of innumerable equivocations and cannot perform the work of calculation, such that errors of reasoning could be uncovered from the very form and construction of words like solecisms and barbarisms. And until now only the signs of arithmetic and algebra have offered this wonderful advantage, whereby all reasoning

possessing an univocal meaning and well-defined sense, and with the rules of an invariable and inflexible calculus, one must inevitably arrive, like it or not, at the true conclusion, at the correct and complete answer, just as in the solution of an equation.[59] One could no more contest the result of a formal deduction than of an addition or multiplication—all the more so as Leibniz thought he could invent techniques for the verification of logical calculations analogous to that of "casting out nines" employed in arithmetic.[60]

Leibniz thus describes his characteristic as the "judge of controversies,"[61] and regards it as an infallible art. He paints a seductive picture of what, thanks to it, philosophical discussions of the future will be like. In order to resolve a question or end a controversy, adversaries will have only to take up pens, adding when necessary a friend as arbiter, and say: "Let us calculate!"[62]

9. But this, as it were, polemical utility is just a particular application of the characteristic and only makes the infallibility of this method obvious in a dramatic form. It will be no less useful to the lone investigator, for apart from the fact that, as we have seen, it will lead him as though by the hand in his deductions and inventions, it will also spare him errors of reasoning by rendering them *sensible* to him. In fact, every logical fallacy will be expressed by an error in calculation and will therefore be self-evident; for it will violate an intuitive and mechanical rule that has become a habit of the eye and hand. It will be as shocking to us as a solecism or barbarism, as an error of orthography or syntax.[63] In addition, any calculator with a little experience will be almost incapable of

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consists in the use of characters and any error of the mind is the same as an error of calculation" (*Phil*., VII, 205).

[59] "But, that I may return to the expression of thought through characters, I thus think that controversies can never be ended nor silence imposed on the *sects* unless we reduce complex reasonings to simple *calculations* and words of vague and uncertain meaning to determinate *characters*" (*Phil*., VII, 200).

[60] "I can even show how, as much in the general calculus as in the numerical calculus, *tests* or criteria of truth can be devised, corresponding to the casting out of nines and other similar proofs, just as I have adapted this casting out to algebra by using common numbers" (*Phil*., VII, 201; cf. VII, 26, and the *Animadversions against Weigel*, cited in n. 31). To see how Leibniz applied casting out nines to the algebraic calculus, see Appendix III, §9.

[61] "Men would find in this a truly infallible judge of controversies." Leibniz to the Duke of Hanover, 1690? (*Phil*., VII, 26). Cf. his letters to G. Wagner, 1696 (*Phil*., VII, 521); to Placcius, 19 May 1696 (*Dutens*, VI.1, 72); to Eler, 1716 (Note XVIII), and LH IV 7B, 3 Bl. 24. In an unpublished plan for the encyclopedia we read: "On the judge of human controversies, or the infallible method, and how it could be brought about that all our errors would be only errors of calculation and could be easily discerned through some test" (LH IV 7A Bl. 26 verso). Cf. his "method of disputing," which he earlier proposed to the Elector of Mainz (see Chap. 6, §22).

[62] "From this it follows that whenever controversies arise, there will be no more reason for dispute between two philosophers than between two calculators. For it will suffice for them to take pens in hand and, when they are seated at their abaci, for another (calling on a friend, if they should wish) to say: Let us calculate!" (*Phil*., VII, 200). Cf. *Phil*., VII, 26, 64-65, 125; Leibniz to Placcius, 1678 (*Dutens*, VI.1, 22); and LH IV 5, 6 Bl. 19 (fragment quoted in n. 67).

[63] "But sophisms and logical fallacies will become nothing more than errors of calculation in arithmetic, and solecisms and barbarisms in language" (*Phil*., VII, 205). "This in fact would be achieved: that every logical fallacy be nothing more than an *error of calculation*, and that *sophisms*, expressed in this new kind of writing, actually be nothing more than a *solecism* or *barbarism* that would be easily refuted by the very rules of this philosophical grammar" (*Phil*., VII, 200). What Leibniz here metaphorically calls the

committing errors, even if he wanted to.[64] His hand will refuse to record what is not a consequence, or if not, his eye will reveal it to him as soon as it is written. One could not even formulate an absurd or false proposition: for in attempting to do so the author immediately will be alerted to it by the incongruity of the signs (as the reader would be also); or else it will be corrected in time and the rules of the calculus will dictate to him the unknown or unrecognized truth in place of the error he had recorded.[65] This admirable calculus therefore will serve not only to refute error, but also to discover the truth. It will be not only the art of demonstrating or verifying known truths, but also the art of invention.

Thus the characteristic is capable of instructing the ignorant, for it already virtually contains within itself the encyclopedia.[66] It is this which constitutes the mechanical and sensible criterion that Leibniz opposes to the empty criterion of Descartes,[67] and which must render the truth sensible and irresistible.[68] Its scope is equal to that of reason and its domain encompasses all rational and *a priori* truths: all that an angelic mind can discover and demonstrate is accessible to the logical calculus.[69] This is how, by abridging and condensing reasoning, it increases tenfold the forces of the mind, expands the range of intellectual intuition and extends indefinitely the power of the understanding. In a word,

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philosophical grammar are the rules of the logical calculus. Cf. *Foundations of the General Science* (Erdmann, 85a), and Leibniz to Oldenburg: "I seem to be describing an amazing grammar to you, but in fact I know it to be philosophical and not unrelated to logic" (*Phil*., VII, 13; *Brief.*, I, 102). See n. 58.

[64] Leibniz to Oldenburg, 28 December 1675 (see n. 3): "Nevertheless it shows that we could not err even if we wanted to, and that the truth is perceived like a picture, as if expressed in a chart by mechanical means" (*Phil*., VII, 10; *Brief.*, I, 145).

[65] Leibniz to Galloys, December 1678: "The chimeras, which even those who advance them do not understand, couldn't be written in these characters. An ignoramus couldn't make use of it, or in trying to do so he would become wise in spite of himself" (*Phil*., VII, 23; *Math*., I, 187). Leibniz to Oldenburg: "But it will have as much value as it could have, for in this language no one will be able to write about an argument that he does not understand. If he attempts to do so, either he himself will recognize that he is talking nonsense, and the reader also, or in the course of doing so he will learn what should be written" (*Phil*., VII, 13-14; *Brief.*, I, 102). Cf. *Phil*., VII, 205.

[66] "Anyone who learns this language will at the same time learn the encyclopedia as well, which will be the true gateway into things.... To whomever desires to speak or write about any argument, the very genius of this language will supply not only the words, but also the things." Leibniz to Oldenburg (*Phil*., VII, 13; *Brief.*, I, 101, 102). The expression "the gateway into things" is the title of a work by Comenius: *Janua rerum reservata,or, the Original Wisdom (which is Commonly Called Metaphysics),* composed in 1640-1 and published in Leyden in 1681. Cf. *Judgment on the Writings of Comenius* (Note XIII).

[67] "If, therefore, these [elements of truth] are dealt with in some sensible way, so that it will be no more difficult to reason than to count, it is obvious that all errors will be like errors of calculation and will be avoidable with a moderate amount of attention. And if any controversy or dispute should arise, taking pens in hand and being summoned to calculate, the contestants will immediately, despite their ingratitude, become conspirators in the truth. I therefore propose a sensible criterion of truth, which will leave no more doubt than numerical calculations..." (LH IV 5, 6 Bl. 19; in Bodemann, 82). The rest of this fragment is a critique of the rules of the Cartesian method (see Chap. 6, §14).

[68] "That criterion... which, as if by a rational mechanism, renders the truth fixed and visible and (as I should then say) irresistible." Leibniz to Oldenburg, 28 December 1675 (*Phil*., VII, 9-10; *Brief.*, I, 145). At issue here again is the Cartesian criterion of obviousness (as is apparent from the context).

[69] "But whatever can be investigated by reason alone, even by that of angels, I tell you again that it is especially through the characteristic that these things have been investigated so far and that the investigation to be established will proceed; and the further we reveal the characteristic the more we will perfect it." Leibniz to Cluver, August 1680 (*Phil*., VII, 19). Cf. Chap. 6, nn. xx and yy.

it is an exaltation of human reason.[70] Thus Leibniz frequently compares it to the telescopes and microscopes which extend the limits of vision in the direction of distance or smallness, just as the logical calculus increases the reach of the eye of the mind.[71] He also compares it to the compass, which allows the sailor to venture out on the open sea and to carry out long journeys without risk of losing his way or lengthening his route by useless detours.[72] Finally, he summarizes in a word all these metaphors by calling his characteristic the organ or instrument of reason.[73]

10. But the characteristic is still more, namely the embodiment of reason and its substitute: not only does it assist reasoning, it replaces it. In effect, it excuses the mind from thinking of the concepts it handles, by substituting calculation for reasoning, the sign for the thing signified.[74] One no longer pays attention to the actual content of ideas or propositions; it is enough to combine them and transform them according to algebraic rules. Deduction is thus transformed into a play of symbols and formulas; and Leibniz is not afraid to reduce it to a purely formal mechanism. In a sense, the characteristic thereby realizes the ideal of *formal* logic. With all the operations of the mind reduced to completely formal combinations of signs whose sense remains unknown or undetermined, one is assured that the consequences one derives result from the form of the logical relations alone, and not from their matter or content, or from the ideas which constitute their terms.

But, in another sense, does it not seem that the mind pays very dearly for the advantages of formal rigor by giving up the control it has over calculations through attention to the content of reasoning, and that reason, so to speak, abdicates in favor of a blind mechanism? In fact, Leibniz shows that this is what happens in every sort of reasoning, and that there is no lengthy or complex deduction save at this price. Neither the calculator nor the geometer could proceed if he constantly had to think of the sense of the words or signs that he employs and to substitute throughout, according to the recognized rule, the definition for the defined.[75] On the contrary, this could only impede them and needlessly encumber their minds; it would slow their deductions enormously or even arrest them completely. They are obliged to place their trust in the mechanical

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70 "It should be known that by this art just these things can be obtained (when the appropriate effort has been employed): *whatever can be elicited from what is given by however great a intellect*.... However much reason is capable of in all those things (and it is capable of much indeed), so much and much more can this art do, which is nothing other than the highest exaltation and *the most profitable use through symbols or signs* of human reason" (*Phil*., VII, 201; cf. 205).

71 *Phil*., VII, 14, 17, 20, 27, 187, 202; cf. 174, and Leibniz to Bourguet, 1709 (*Phil*., III, 545).

72 *Phil*., VII, 187; cf. 174.

73 *Phil*., VII, 17, 20, 27, 32, 187, 202, 205; and Leibniz to Bourguet, 1709 (*Phil*., III, 545).

74 Cf. a fragment already quoted: "All theorems are nothing but tachygraphs or abridgements of thought, so that the mind is excused from thinking distinctly of the things themselves, but nothing thereby arises less correctly..." (LH IV 7B, 2 Bl. 53); and *Plan for a New Encyclopedia*, June 1679: "For just as arithmetical training provides us with a variety of shortcuts or formulas for calculating which give accurate results, so men trained in speaking and thinking have devised for us many shortcuts for reasoning and expressing ourselves, which no less than the modes of the schoolmen give conclusions that follow as a consequence of form..." (LH IV 5, 7 Bl. 3-4). It is just these non-syllogistic consequences that the rational grammar must justify by the analysis of words and particles (see Chap. 3, §15).

75 *Phil*., VII, 204: "All human reasoning is carried out by means of certain signs or characters. For not only the things themselves, but also the ideas of things cannot and should not always be observed distinctly in the soul; and so, for the sake of brevity, signs are used in place of them." See the passage that follows.

associations of words and signs (for example, in the Pythagorean table learned by heart and in so many other such formulas known solely by memory). This surrender of the mind to a verbal or symbolic mechanism is responsible not only for the quickness but also for the formal validity of arguments and calculations, since one is then sure that a consideration of content cannot come to compensate for or mask the insufficient rigor of the logical form.

In sum, Leibniz only generalizes and regularizes this systematic process of the mind, by everywhere substituting algebraic signs which possess a well-defined sense and are governed by fixed rules of combination for verbal signs whose sense is vague and whose relations are indefinite.[76] Without a doubt, he thus appears to reduce all of logic and all the deductive sciences to a pure *psittacism*, or to what modern psychologists call after him, symbolic thought.[77] But he does not shrink from this apparent consequence of his theory. He willingly recognizes that *in fact* this is just how most men think and reason, and that *in principle* symbolic thought is useful and even indispensable most of the time, and that the sciences owe their development and progress to it.[78]

11. Does it then follow that Leibniz is a nominalist (in the modern sense of the word), that he sees in general ideas only simple names, in the sciences only "well-formed languages," and in scientific truths only arbitrary propositions depending solely on the conventions of language and the definitions of words? Not in the least. On the contrary, from his youth he very clearly declared himself to be against this radical nominalism, which was that of Hobbes,[79] and he produced a succinct but decisive critique of it in a short dialogue dated August 1677.[80] He begins by granting that truth and falsity reside solely in our thoughts and not in things. But nominalists mistakenly infer from this that they depend on our will. They advance two reasons for this. On the one hand, all rational truths (in mathematics, for example) derive from definitions, and since the latter are arbitrary, the truths are equally so. On the other hand, our reasoning cannot proceed without some words or signs;[81] but the choice of these signs is arbitrary; therefore, the conclusions, which rest on these signs and depend on their choice, are also arbitrary.[82]

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[76] *Phil.*, VII, 205 (passage quoted in n. 58).

[77] See *Meditations on Knowledge, Truth, and Ideas*, 1684 (*Phil.*, IV, 423).

[78] This thesis is in agreement with the well-known Leibnizian doctrine according to which men, insofar as they are empirics, that is in three-quarters of their actions, only act and think like beasts, that is mechanically. *Principles of Nature and of Grace*, §5 (1714); cf. *Monadology*, §28; Preface to the *New Essays*; and the texts quoted in Chap. 6, §37.

[79] See Appendix II on Leibniz and Hobbes.

[80] *Dialogue on the Connection Between Things and Words, and on the Reality of Truth* (*Phil.*, VII, 190-3).

[81] "B: Thoughts can occur without words. A: But not without some other signs. Please see whether you can begin any arithmetical calculation without numerical signs.... On the contrary, if the characters were missing we would think of nothing distinctly, nor would we reason" (*Phil.*, VII, 191). Thus Leibniz is far from contesting the necessity of signs, not only for the expression of thought, but for internal thought such as mental calculation: "We have need for signs, not only for making our opinions known to others, but also for assisting our own thought." *Some Modest Thoughts Concerning the Practice and Improvement of the German Language* (*Dutens*, VI.2, 7).

[82] "Some learned men think that truth arises by human decision and from names or characters" (*Phil.*, VII, 191). By these "learned men," whom he later calls, in the singular, "as clever as a secretary can be," Leibniz clearly means Hobbes, whom he habitually describes as the cleverest. Cf. *On Knowledge, Truth,*

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To this Leibniz replies decisively that if signs are arbitrary, the relations between signs which express or constitute propositions are not for that reason arbitrary, and that they are true or false according to whether they correspond to the relations of the things signified. Thus truth consists in the connection of signs insofar as they correspond to the real and necessary connection of ideas or objects, which does not depend on us. Or more accurately, truth consists in this similarity of the relations of signs and the relations of things, which constitutes an *analogy*, in the strict and mathematical sense of the word, that is, a proportion or equality of relations.[83] The choice of signs and the definition of words can therefore be arbitrary without the connection of words and signs being so, and it is in this connection alone that truth or falsity resides. One can even change the system of signs at will without the truth thereby changing or depending on our fancy, since regardless which symbols are chosen there will be an arrangement of these symbols, and one alone, which will be true, that is, which will correspond to the real order of things or to the facts. There is therefore an analogy not only between signs and objects but between different systems of signs insofar as they express the same reality.[84]

This necessary and non-arbitrary order which exists in things is the objective, though unknown, foundation of all truth. Once some system of arbitrary signs or some collection of conventional definitions is adopted, it no longer lies with us that one combination is true and another false; and this proves that truth, although resident only in our mind, has its principle outside of us and symbolically expresses some reality.[85]

12. Leibniz illustrates this argument with examples borrowed from mathematics. He shows that algebraic formulas are independent of the letters and signs employed in writing them, because their truth rests on certain general and formal transformation rules, and not on the "material" nature of the characters which appear in them. Likewise, arithmetical truths are independent of the symbols employed and even of the system of

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and Ideas, 1684 (*Phil.*, IV, 425); *On Universal Synthesis and Analysis* (*Phil.*, VII, 295); *New Essays*, IV.v.2; LH IV 7A Bl. 26 verso; LH IV 8 Bl. 3: *G. Pacidii Plus Ultra*, sec. 3.

[83] "For although characters may be arbitrary, their application and connection have something which is not arbitrary, namely some analogy between characters and things, and the relations which different characters expressing the same things have to each other. And this analogy or relation is the foundation of truth. For it happens that whether we employ these or other characters, what is produced is always the same or equivalent or corresponding in proportion" (*Phil.*, VII, 192).

[84] As an illustration of this analogy, Leibniz cites the words φωσφόρος and *lucifer*, whose etymological makeup is the same, although derived from different, yet corresponding, roots in Greek and Latin.

[85] This thesis is also connected with the deepest and most general principles of the Leibnizian philosophy, namely the idea of universal harmony, which translates the maxim so often cited by Leibniz: "Σύμπνοα πάντα, all things conspire." To the *logical analogy* of signs and ideas is related the *metaphysical analogy* of ideas and things: knowledge does not consist in the identity of thought and being, but in their correspondence or parallelism. "It is not necessary that what we conceive of things outside of us be perfectly similar to them, but that it expresses them, just as an ellipse expresses a circle seen from an angle." Leibniz to Foucher, 1686 (*Phil.*, I, 383). In a fragment entitled *What is an Idea?*, which probably dates from 1678 (see *Phil.*, VII, 252), Leibniz says that an idea *expresses* an object; but there are different *expressions*, some arbitrary, some founded in the nature of things; now it is not necessary that what expresses is similar to what is expressed, it suffices that there be some *analogy* or connection among their properties and their relations. He gives as an example the relation of a circle and an ellipse through perspective, and he concludes: "And so, although the idea of a circle is not similar to a circle, nevertheless from it truths can be deduced, which experience would undoubtedly confirm in a real circle" (*Phil.*, VII, 263-4).

numeration adopted.[86] For example, between the number *ten* and the digits '10' there is only an arbitrary relation, which derives from the entirely conventional choice of the number *ten* as the base of our (decimal) numeration.[87] Consequently, every translation of numbers into symbols is arbitrary and depends on the choice of the base of numeration. Yet this does not prevent the properties and relations of numbers from being absolutely independent of the system of numeration.[88] Moreover, the very properties of numbers which are relative to the system of numeration and which, as a result, have an accidental and non-essential character are not at all arbitrary, but are necessary and eternal truths.[89] Such, for example, is the rule of verification known as "casting out nines." It is of course relative to the system of decimal numeration, but it does not for that reason have a less general value or less absolute truth.[90] In sum, every deduction is hypothetical, that is, relative to premises which include definitions of words. But whatever these premises may be, once they are assumed, we are no longer masters of the consequences which necessarily follow from them, and we can no longer change them, except by changing the premises themselves. Thus as wholly hypothetical as it is, the logical necessity which relates consequences to premises is absolute.[91] It is pointless to say that we are free to choose our premises or our hypotheses, or our symbolic conventions or our definitions of words, and consequently also to change all the consequences which follow from them. By the very fact that the latter change at the same time as the former, in a related and rigorously determined way, there exists between the two a constant connection which does not depend on us and which corresponds either to the intelligible order of ideas or to the real order of phenomena and objects.

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[86] Cournot has very plausibly distinguished the essential properties of numbers, which are independent of any system of numeration, from the, so to speak, artificial properties, which provide them with their translation into symbols. He has noticed that they merge in arithmetic to the point of being confounded, although they have an unequal logical value and philosophical importance. For example, the practical *rules* of addition and multiplication rest on the system of numeration, while the sum and product of two numbers are independent of it. Likewise, the divisibility of a number by 9 does not depend on the decimal system of numeration, although the practical criterion does depend on it; and so on. See *Correspondence entre l'Algèbre et la Géométrie*, especially chap. 5 (Paris, Hachette, 1847).

[87] In general, in every system of numeration, the number taken for the base is written 10.

[88] "Just as in numbers, whose signs and decimal ordering have been established by the will of men, it appears that the calculations drawn from these signify absolute truths, namely the connection among the assumed characters and the formulas derived from these, in which the connection of things (which remain the same whatever characters are assumed) are also signified" (*Phil*., VII, 219). Leibniz had already had this idea in 1670: *Preface to Nizolius* (*Phil*., IV, 158), passage cited in Appendix II, §10.

[89] "Therefore, although truths necessarily presuppose some characters, especially when they speak of the characters themselves (as in practical theorems about casting out nines), they nevertheless depend not on what is arbitrary in them, but on what is eternal, namely on the relation to things; and the truth is always independent of our will, since with such-and-such characters supposed, such-and-such reasoning will be produced..." (*Phil*., VII, 193).

[90] (*Phil*., VII, 295). The divisibility of numbers is independent of the system of numeration. Moreover, the same rule holds true in a system of base n, on the condition that 9 is replaced by $n-1$.

[91] "Although certain propositions, like the definitions of terms, are assumed on account of the choice of names, nevertheless there arise from them truths which are not at all arbitrary, for it is an absolute truth that conclusions immediately arise from the definitions accepted; or what is the same, the connection between theorems or conclusions and arbitrary definitions and hypotheses is absolutely true" (*Phil*., VII, 219; cf. 295).

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13. We now understand why Leibniz attributes such an extraordinary importance to the choice of characters: it is not at all because they take the place of ideas, as the nominalists believe, but rather, on the contrary, because they must translate and express those ideas in the most precise and adequate way.[92] Thus, although in principle the choice of signs is arbitrary, in practice it must be guided by a host of delicate and complex considerations. Undoubtedly, every symbol is more or less conventional; nevertheless, Leibniz urges us to adopt symbols which are as natural as possible, that is, which are the most appropriate for the notions they must represent. Thus for sensible or imaginable things the best signs are, according to him, images.[93] In order to express abstract ideas, which obviously cannot be depicted, we will at least try to preserve a sort of agreement and analogy between the sign and the idea, such that the sensible sign displays the same relations as the notion and, as it were, recalls it by its constitution.[94] Far from eclipsing the idea and causing it to be forgotten, the sign renders it more immediate and more vivid, because it will be its exact and complete portrait.[95] But for this it is necessary that the symbol for each idea expresses its composition, and this presupposes that every concept has been completely analyzed and reduced to simple ideas.[96] Thus the *real* characteristic, founded on the analysis of notions and the "alphabet of human thoughts," is also the *natural* characteristic, that is, the one which furnishes the simplest, clearest, and, so to speak, most transparent signs for complex ideas; the one which best portrays and reveals their constitution, properties, and relations. Such are the rules Leibniz follows in applying his characteristic to the mathematical sciences, which moreover have already presented him with models or samples of it. As he recognized that the expression of numbers in a system of numeration always involves an arbitrary and conventional element that masks some of their properties, he dreams of a more natural notation that would display these relations explicitly. For example, the characters for the divisibility of numbers would become clear if we expressed the latter by their decomposition into prime factors.[97]

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[92] Cf. the fragment LH IV 5, 6 Bl. 17: "*Words*. To intelligent people, words are like tokens, but to unintelligent people they are like money. For with intelligent people, they serve as signs, but with unintelligent people, they pass for reasons and rational arguments" (Bodemann, 81), with this (unpublished) marginal addition: "Signs are enough for us, you require idols." See the commentary on this passage in Appendix II, §12.

[93] Leibniz to Tschirnhaus, end of 1679: "Nevertheless there is need for some other signs, under which I include images and words. The best signs are images; and words, insofar as they are adequate, should represent images accurately" (*Math*., IV, 481; *Brief.*, I, 405).

[94] "If characters have been well-constructed, there is some relation or order impressed in them which is in things" (*Phil*., VII, 192).

[95] "No one should fear that the contemplation of characters will lead us away from things; indeed, on the contrary, it leads us into the secrets of things. For today we often have confused notions on account of badly-ordered characters, but in the future with the help of characters we will easily have those which are most distinct." Leibniz to Tschirnhaus, May 1678 (*Math*., IV, 461).

[96] "But it is useful for knowledge that characters are assumed in this way, so that from a few assumptions many things can easily be deduced; and this would occur if characters were assigned to the simplest elements of thought" (*Phil*., VII, 219). Cf. LH IV 7B, 3 Bl. 24.

[97] "Still, it is discovered in general that we do not have the sort of characters for numbers that we ought to have and that others are needed for the perfection of knowledge, so that it certainly would not be necessary to derive the fact that 5 + 3 makes 8 and 2 x 8 makes 16 from memory or a table, but it would follow from the characters themselves.... The resolution of numbers into prime factors and the discovery of fixed signs for fractions, by which simple ones could be distinguished from complex ones without tables or the bother of calculation—this matter has not yet been satisfactorily dealt with by anyone." Leibniz to

Moreover, this notation would be, as we know, the exact analogue of that by which he wishes to depict concepts; only it would not be practical, for it would require an infinity of different signs to represent *all* the prime numbers.

This is therefore only a passing fancy. But even if one cannot dispense with a system of numeration—that is, at bottom, with an artifice which allows for the representation of an infinity of numbers by means of a finite number of signs (numerals)—it would be best, Leibniz thinks, to employ as few signs as possible, in order to reduce the artifice to its simplest form. Such is the origin of his binary arithmetic (base 2 system of numeration), in which all numbers can be written using only two numerals (0 and 1).[98] The idea for this system was undoubtedly born from the desire to strip numbers of the artificial and accidental properties that the system of numeration imposes on them, or at least to reduce these properties to their simplest expression. Moreover, the mere comparison of two different systems of numeration makes it obvious how contingent these properties are and allows them to be separated from the others by abstraction.

It is once again the search for a clearer and more expressive symbolism that led Leibniz to invent his numerical notation for algebraic coefficients, which was destined to perfect algebra using the combinatory and to allow the construction of tables for the resolution of algebraic equations.[99]

14. However, these were still only very specific applications of the characteristic, and the general system of signs that would express all simple ideas was yet to be invented. The more the choice of these signs became important and of great consequence for the progress of science, the more it must have appeared to Leibniz a difficult and serious matter. He seems to have hesitated for a long time over even the type and nature of the signs to be adopted.[100] In *On the Art of Combinations* (1666), he imagined its "characters" as geometrical figures, drawings, or hieroglyphs, which would represent the object in a concise and schematic way—in a word, as signs that would be as *natural* as possible.[101]

Later, the analogy he established between the composition of concepts and that of numbers (from prime factors) led him to conceive of an arithmetical symbolism: simple ideas, which are the elements of all the others, would be represented by prime numbers,

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Detlef Clüver, 18/28 May 1680 (*Phil*., VII, 18). The search for a characteristic property of prime numbers which could be used to define them occupied Leibniz considerably during this period (see Appendix III, §19).

[98] He cites this as an example of a perfect characteristic (LH IV 7B, 3 Bl. 24). Cf. §4 of this chapter and Appendix III.

[99] Leibniz makes allusion to this symbolism in *New Essays*, IV.vii.6: "And just as Viète substituted letters for numbers in order to gain a greater generality, I have wanted to reintroduce characters for numbers, since they are more suitable than letters even in algebra... as I have shown elsewhere, having discovered that the correct characteristic is one of the greatest aids to the human mind." Concerning this symbolism, invented in June 1678 (at the latest), see Appendix III and the texts cited there.

[100] Cf. Kvet, §40.

[101] "But it will be appropriate for the signs to be as natural as possible, e.g. for one, a point, for numbers, points.... The whole of the writing will therefore be made as if of geometrical figures and like pictures, just as the Egyptians once did and as the Chinese do today" (§90; *Phil*., IV, 73; *Math*., V, 50). There is a curious and naive fragment of these hieroglyphs in a letter likely addressed to Boineburg, in which riches are represented by a square, honors by a circle, and pleasures by a triangle (LH IV 5, 6, Bl. 11).

and complex ideas by the product of the prime numbers corresponding to their elements.[102] The "alphabet of ideas" would be translated by the series of prime numbers, and this translation would have the advantage that if the number of simple ideas were infinite, there would be sufficient symbols for them in the infinite series of prime numbers, provided that one could assign them an order which gave them a one-to-one correspondence with the prime numbers.[103] It is on this system of "characteristic numbers" that the April 1679 essays on the logical calculus are based.[104]

Yet the more Leibniz developed it, the more he came to realize how difficult it is to choose symbols appropriate for all ideas, given that each of them must be represented by two *mutually prime* numbers, and that these numbers must in addition satisfy rather complicated conditions of divisibility with respect to the characteristic numbers of other ideas.[105] Furthermore, in virtue of the close connection of all the ideas among themselves, it is nearly impossible to assign numbers to a small number of isolated ideas so as to create a partial characteristic relating to a particular subject or science. Thus Leibniz resolves to go on: he will assume that the characteristic numbers have been found and in the meantime will establish the rules of the logical calculus using hypothetical numbers,[106] or better still using letters, as in algebra.[107] In any case, these numbers obviously could not be natural signs; and in fact Leibniz foresees that it will be necessary to prepare a dictionary,[108] although the language dreamed of in *On the Art of Combinations* would be understandable without a lexicon.[109] In the end, Leibniz does not seem to have opted for either of the two systems; he prefers to wait for the very progress of his logical calculus to show him the type of sign that will be the most appropriate for the application of this calculus.[110]

Finally, in the *New Essays* (1704), Leibniz seems to return to the project of his youth when, after having referred to the characters of the Chinese, he says: "We could introduce a very popular universal character and one better than theirs, if in place of words we employed small diagrams which represented visible things by their traits and invisible things by the visible things which accompany them, joining to these certain additional marks suitable for playing the role of inflections and particles."[111] What follows shows clearly that what is in question here is no longer an international language but a genuine

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[102] Cf. Chap. 2, §§6, 7, 12; Chap. 3, §7.

[103] *On Universal Synthesis and Analysis* (*Phil*., VII, 292).

[104] LH IV 5, 8a, b, c, d, e, f; LH IV 7B, 4 Bl. 18; cf. *A General Language*, February 1678 (LH IV 7B, 3 Bl. 3). See Chap. 7, §§2ff.

[105] *Rules by Whose Observance the Validity of Consequences Can Be Judged Using Numbers* (LH IV 5, 8f). See Chap. 8, §5.

[106] *History and Praise of the Characteristic Language* (*Phil*., VII, 187, 189). This essay appears to be contemporary with the logical essays of 1679. In it one sees manifested an absolute confidence in the symbolic power of numbers: "Number allows for anything. And so number is like a metaphysical nature and arithmetic a sort of universal statics, by which the powers of things may be explored" (*Phil*., VII, 184).

[107] *Foundations of the Calculus of Reasoning*: "But since it would not yet be right to lay down how signs should be formed, in the meantime, for the sake of forming them in the future, we will follow the example of mathematicians and use letters of the alphabet or any other arbitrary signs, the most appropriate of which progress will supply" (*Phil*., VII, 205).

[108] *Phil*., VII, 187.

[109] §90 (*Phil*., IV, 73; *Math*., V, 50), quoted in Ch. 3, n. 16.

[110] *Phil*., VII, 205 (quoted in n. 107).

[111] *New Essays*, IV.vi.2. These "additional marks" recall those of Wilkins (Chap. 3, §5 and Note IV).

characteristic having a logical and didactic purpose.[112] On the other hand, this writing would be so dependent on what were, strictly speaking, drawings that Leibniz objects to himself that "not everyone is familiar with the art of drawing"; he responds to this objection by saying that "in time everyone would study drawing from his youth in order not to be deprived of this picture-character which would truly speak to the eyes." Everything Leibniz says about it shows that this is not a mere fancy, but a mature and well-established plan of whose possibility and utility he is convinced. This proves again that he returned to the idea of employing natural signs or, as he says, "figures meaningful in themselves... in place of our letters and Chinese characters which are meaningful only through the will of men."

15. In this constant search for suitable characters, Leibniz was led to try one by one all the symbols one can imagine.[113] After algebraic signs, or alongside them, he employs geometrical diagrams in order to depict for the eyes the relations of ideas and to support reasoning by means of intuition.[114] We have seen (Chap. 1, §16) that he had invented a very ingenious schematism for representing syllogisms and, if need be, for verifying them. We know that he composed an (unpublished) essay in which he treated in great detail "the verification of logical forms by the drawing of lines."[115] It is to this essay that he made allusion in a letter to Koch on the principle of the syllogism,[116] and again in the last year of his life in responding to Lange, who had sent him a "logical square" he had invented.[117] Leibniz himself had written that all the rules of the syllogism could be established by means of a geometrical figure such as a square, representing the dichotomous divisions that give rise to many concepts by combining some with others and partitioning them with respect to each other.[118]

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[112] "The use of this way of writing would be a great help for enriching the imagination and giving us thoughts which are less blind and less verbal than those we have now," says Theophilus; and Philalethes replies (§3): "It seems that this would be of no small importance for increasing the perfection of our mind and making our ideas more real." We may note Leibniz's constant tendency to free thought from symbolism and psittacism by means of the signs themselves.

[113] In the *New Essays* (III.i.1) he indicates in passing that one could construct a (obviously conventional) language using musical tones. He had already mentioned this idea in the fragment *A Universal Language* (LH IV 7B, 3 Bl. 4).

[114] For example, he proposed representing multiplications by means of lines running between the factors (arranged in a table), and to distinguish these lines he imagined that they would be of different colors, or even that they would be solid and movable so as to be positionable (LH XXXV 4, 13c: "The art of evaluating analytic calculations").

[115] LH IV 7B, 4 Bl. 1-10; cf. LH IV 7B, 2 Bl. 18.

[116] Leibniz to Koch, 2 September 1708: "Nevertheless, a kind of line-drawing can be conceived through whose help the invalidity of illegitimate moods would be apprehended by means of certain observations. For there is in the syllogism something resembling mathematics" (*Phil.*, VII, 479). See Chap. 1, §17.

[117] Leibniz to Lange, 1716 (Note XIX). In an unpublished fragment containing some linear logical schemata, we read: "Giess recently (I write this in 1715) published something concerning a logical triangle" (LH IV 6, 15).

[118] *Addenda to a Specimen of the Universal Calculus*, a fragment left unpublished by Gerhardt (LH IV 7B, 2 Bl. 21 verso). This figure is similar to the diagrams of Venn (*Symbolic Logic*, Ch. V; 2nd ed., London, Macmillan, 1894).

In a general way, Leibniz never ceased to insist on the usefulness of geometrical schemata for illustrating abstract speculations.[119] Undoubtedly, it is not necessary to reason using figures and to replace deduction by simple inspection; it is even good to learn to reason without any figures. On the other hand, however, schemata (like signs in general) greatly aid the understanding by giving it the imagination as a teacher and guide. The validity of a demonstration must not depend on the diagram: but the diagram serves to make its validity sensible by means of the analogy between its construction and the intelligible relations whose connection it portrays.[120] Thus, just as Leibniz in a way reduced logic to arithmetic using the symbolism of characteristic numbers,[121] so he also reduced it to geometry using a linear schematism in which deductions would be expressed through constructions "by drawing lines."[122]

16. Leibniz went still further and dreamed of reducing logic to mechanics. This will not be surprising if we recall, on the one hand, all the passages in which he compares reasoning to a mechanism or the characteristic to a machine,[123] and if we consider, on the other, that he had invented in his youth an arithmetical machine for carrying out the four basic operations[124] and an algebraic machine for solving equations.[125] It was natural that after having reduced reasoning to a calculus, he should want to reduce it, like numerical calculations, to a material mechanism. His *On the Art of Combinations* had suggested to Albert von Holten the idea of constructing a "cylindrical grammar," whose structure we can guess at from what is said in that work concerning the attempts of Harsdörffer.[126] This instrument would be similar to a combination lock: the different drums that compose

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[119] See *New Essays*, IV.iii.19-20, where Leibniz recalls the figures that had been conceived by his teacher Erhard Weigel of Jena for representing moral matters, under the title *A Moral Sphere* (recalled in the *The Universal Atlas*, LH IV 7A Bl. 30). Cf. *Draft of a Certain Table of Government* (*Klopp*, V, 308). On Weigel, see LH IV 1, 6 and Foucher de Careil, B, 146.

[120] *Plan for a New Encyclopedia*, June 1679 (LH IV 5, 7 Bl. 2 verso). Cf. the fragment LH IV 8, Bl. 79: "It is necessary to reduce all the sciences to figures and formulas. For many things not capable of being expressed through figures (except by analogy, which is not scientific) could at least be subjected to formulas which take the place of figures and serve to restrain the imagination. See the remark I have made elsewhere on the usefulness of constructing commands for the operations of the navy, artillery, architecture, carriages, and dances, similar to the formulas and commands for the management of arms and military maneuvers (Klopp, V, xxxvii; Bodemann, 117). The latter in fact exists as an unpublished fragment classified under LH XXXVI Bl. 224-5, entitled: "Formulas for Commands in all the Mechanical Arts According to the Example of Military Commands Governing the Management of Arms and Maneuvers" (Bodemann, 321-2).

[121] *A General Language*, February 1678 (LH IV 7B, 3 Bl. 3), quoted in Chap. 3, §17.

[122] See an undated and unpublished fragment: "*Characteristic*. Just as a philosophical language could be expressed through numbers or arithmetic, so a philosophical writing also could be displayed through line-drawings or geometry, with the result that all the problems and theorems of science would become no more than theorems of arithmetic and geometry in which all other things can be signified. Just as in numbers truth can always be tested through casting out nines, so with lines it can be tested through attempted constructions" (*Phil*., VII, 41).

[123] Leibniz to Oldenburg, 28 December 1675 (*Phil*., VII, 10; *Math*., I, 85; *Brief*., I, 145).

[124] Leibniz's arithmetical machine was invented, as well as constructed, in 1673. See Chap. 7, §6.

[125] The algebraic machine was invented in Paris in December 1674, as is reported in an unpublished fragment entitled *Constructor*, which contains a description of the instrument (LH XXXV 2A, Bl. 20; cf. Bl. 26a). Cf. Leibniz to Huygens (*Math*., II, 15); Leibniz to Oldenburg, 12 June 1675 (*Math*., I, 73; *Brief*., I, 126); Leibniz to Arnauld (*Phil*., I, 81); *Math*., VII, 215.

[126] *On the Art of Combinations*, §95 (*Phil*., IV, 74; *Math*., V, 52). See Chap. 2, §4.

it would take, respectively, the roots, prefixes, and finally the different suffixes and endings necessary for declensions and combinations. Leibniz expressed at this time the idea that one could construct in the same way a cylinder[127] that would supply every theorem, that is, all the possible relations among certain given terms. For this it would suffice for these terms to have been reduced to simple elements by means of their definitions.[128] Always we rediscover the master idea of *On the Art of Combinations*. Leibniz immediately derives from it an artificial language by proposing to assign a distinct and unique name to each combination, and he adds that one could apply this logical instrument to legal questions.[129]

From all this it appears that Leibniz admitted several parallel and equivalent symbolisms for his logic, in which the relations of concepts would have been expressed, respectively, by calculations, equations, figures, and motions. He thus conceived the logic several times over in the form of an arithmetic, an algebra, a geometry, and even a mechanics—all symbolizing and constituting so many concrete "expressions" of the same abstract science. The idea of transposing logic in this way and reclothing it in mathematical, that is, imaginative forms was in agreement with, on the one hand, his constant desire to make reasoning sensible and tangible, and on the other, his profound views on the analogy and harmony of all the rational sciences, which must, according to his favorite expression, "symbolize" each other.[130]

17. Nevertheless, until the end of his life Leibniz seems to have hesitated and drawn back from the invention of a complete and definitive symbolism, for he wrote two years before his death, on the subject of his *spécieuse générale* (or as we shall call it, his universal algebra): "I would have had to have supported it by some obvious use, but for this result it would be necessary to construct at least part of my characteristic."[131]

In addition to the intrinsic difficulty of a comprehensive work of such magnitude,[132] there is another obstacle that must have stopped Leibniz every time he made an attempt at it: it is that the establishment of the characteristic presupposed the elaboration of the

[127] The word he employs, *cista*, strictly speaking designates a deep cylindrical basket.

[128] *Excerpt from a Letter of Leibniz to a Friend on the Usefulness of the Grammatical Cylinder of Albert von Holten* (Note XI). We have conjectured that this letter dates from around 1671, and all the details it contains (especially the preoccupation with questions of law) confirm this conjecture. Leibniz said moreover of the period prior to 1672, in which he was by his own admission "superbly ignorant" of mathematics: "I extracted more pleasurable things from *mathesis*, being especially fond of investigating and inventing machines; for my arithmetical machine was also born at this time." Leibniz to Jacob Bernoulli, April 1703 (*Math*., III, 71-72n.). See Chap. 5, n. 4.

[129] We know that several modern logicians have invented logical machines: Stanley Jevons, "On the Mechanical Performance of Logical Inference," in *Philosophical Transactions*, 1870, vol. CLX; John Venn, *Symbolic Logic*, Ch. V (1st ed., 1881; 2nd ed., 1894); Allan Marquand, "A Machine for Producing Syllogistic Variations," in *Studies in Logic* by members of the Johns Hopkins University (Boston, 1883); "A New Logical Machine," in *Proceedings of the American Academy of Arts and Sciences* (1885).

[130] *Preliminary Key to the Secrets of Mathematics*: "Now, therefore, we will discuss the elements of geometry.... Thereafter, by joining a calculus to geometry, we will show, first, how those things which are considered through geometry and line-drawings or through determinate motions can be *expressed* through a calculus; then, in turn, how those things which are determined by calculation can be *constructed* through line-drawings" (*Math*., VII, 12). Cf. the texts quoted in §15.

[131] Leibniz to Remond, 14 March 1714 (*Phil*., III, 612). See Chap. 9, §§2-3.

[132] Pointed out by Leibniz himself (see above, §14).

encyclopedia,[133] or at the very least a set of logical definitions of all the fundamental concepts of the different sciences. And this, as he himself notes, presupposed the "true philosophy."[134] Now if, by his own admission, it was only in 1697 that he might have dared to undertake such a work, this suggests that the enterprise might have been rash and premature twenty years earlier at the time when he drew up the first plans for the encyclopedia. However, this does not explain why, in the last twenty years of his life, when he was in possession of the "true philosophy,"[135] he should not have succeeded in seeing it through, or at the very least in sketching it out.[136] In order to resolve this issue, we must study the different plans for the encyclopedia that Leibniz conceived during the course of his career and the reasons for the failure of this vast enterprise.

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[133] *History and Praise of the Characteristic Language*: "Nothing else is needed for the characteristic which I wish to see... established... than that there be founded what is called a philosophical and mathematical handbook [that is, a manual for teaching]. And it would require no more work than we already see expended on any handbooks or encyclopedias, as they are called" (*Phil*., VII, 187).

[134] "It is true that these characters would presuppose the true philosophy, and it is only now that I would dare undertake to create them." Leibniz to Burnett, 24 August 1697 (*Phil*., III, 216). Nevertheless, Leibniz maintained against Descartes that the universal language does not presuppose the completion of philosophy and the sciences, but only the establishment of principles and definitions; but that is half the work, especially in philosophy (LH IV 5, 6 Bl. 8). See Chap. 3, §4.

[135] The same year he wrote: "Most of my opinions have finally been fixed after a deliberation of twenty years; for I began to think when I was very young, and I was not yet fifteen when I sometimes spent entire days walking in the woods in order to decide between Aristotle and Democritus [cf. Leibniz to Remond, 10 January 1714; *Phil*., III, 606]. However, I have changed my views again and again concerning some new insights, and it is only for about the last twelve years that I have found myself satisfied and have arrived at some demonstrations of matters which did not appear at all capable of demonstration." Leibniz to Thomas Burnett, 8/18 May 1697 (*Phil*., III, 205). This chronological reference leads us to the year 1686, the date of the *Discourse on Metaphysics*, which marks the establishment of the system (cf. Stein, *Leibniz und Spinoza*, 143n.). He adds: "Nevertheless, in the way in which I set about it, these demonstrations can be made sensible just like those involving number, even though the subject outstrips the imagination"; this is an obvious allusion to the characteristic. Cf. *Phil*., IV, 469.

[136] He said again in 1706: "It is true that in the past I planned a new way of calculating suitable for matters that have nothing in common with mathematics; and if this type of logic were put into practice, all reasoning, even in matters of probability, would fall to the mathematician: if need be, the least minds who possessed the industry and goodwill, although they could not accompany, could at least follow the greatest. For one could always say: let us compute, and judge as required in this way to the extent that the givens and reason are able to supply us with the means for doing so. But I do not know if I will ever be in a state to execute such a project, which requires more than one hand; and it seems that the human species is not yet mature enough to claim the advantages which this method could bring." Leibniz to the Electress Sophie (Klopp, IX, 171).

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