Artificial Languages: Asian Backgrounds or Influences?

Research > General

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The growth of European science in the Renaissance and afterwards was influenced by contributions from the Islamic world and from India and China. This well established fact refutes three common prejudices: (1) Modern science originated from ancient Greece with the Arabs acting as translators; (2) Arabs, Chinese, Euro-Americans, and Indians inhabit separate cognitive worlds; and (3), the most preposterous: Science is 'Western'. The first prejudice is held by those whose history of science is outdated. The second is based upon an idea of political correctness, not upon facts. The third is the favourite of groups with a special agenda, sometimes hidden, for example, the superiority of 'Occidental Reason' or 'Oriental Spirituality'.

By Frits Staal

Participants in the workshop on 'Asian contributions to the formation of modern science: the emergence of artificial languages' did not take any of these prejudices as their vantage point. As specialists in the history of ancient and medieval science, they knew that this crucial period of human history can only be adequately understood if the Eurasian continent is treated as an undivided unit. That insight evolved over more than half a century, roughly speaking from Otto Neugebauer to Joseph Needham (who died in 1995), and is based upon the textual and historical study of source materials in the classical languages of science that include Arabic, Old-Babylonian, Chinese, Greek, Latin, and Sanskrit.

Much scientific content in these sources remains undiscovered but a few generalities appear to be valid. Mesopotamian science is earlier than any other and influenced China, Greece, and India, especially in astronomy. Chinese science reflects an organic philosophy of nature which manifests itself in her chemistry and life sciences. India's strength lies in abstract theory, as is evident from her mathematics and linguistics, and the Arabs stand at the geographical and historical centre of pre-modern science. Modern science developed when the classical languages were replaced by modern languages and the artificial language of algebra (Arabic *al-jabr*). The workshop looked for Asian backgrounds and influences with regard to the latter development.

Among the key speakers, Jens Høyrup (Roskilde) showed that Old-Babylonian ideograms do not constitute an algebraic symbolism (as had been suggested, with reservations, by Neugebauer), but are mnemonic abbreviations of geometric operations. Michio Yano (Kyoto) studied oral and written methods of transmission of expressions for numerals and numerical tables in Sanskrit. Kim Plofker (Providence) analysed al-Biruni's comparison of Indian and Islamic mathematical techniques and notations. Karine Chemla (Paris) demonstrated how permutations of characters in a Chinese mathematical text of the thirteenth century performed the function of brackets as used in modern notations. Charles Burnett (London) described the slow penetration of Indian numerals into Arabic, Greek, and Latin, which, by the time of Fibonacci in the thirteenth century, had led to a new way of using numerals. Frits Staal (Berkeley), convener of the workshop, argued that modern science is not a product of Europe or world history but the result of a major advance in human cognition through language. This topic – more speculative than any of the others – sheds light on the background of the workshop and I shall return to it.

The presentations were followed by lively discussions in which a crucial role was played by the chairs of the sessions; Kamaleswar Bhattacharya (Paris), Christoph Harbsmeier (Oslo and Peking), Jan P. Hogendijk (Utrecht), and Dominik Wujastyk (London).

The workshop was a resounding success with its high level of discussion and a fruitful exchange of ideas on fundamental issues. The proceedings will be edited by Staal and Yano and published in the *Journal of Indian Philosophy* and, perhaps, a volume of the *Synthese Library*.

Background of the workshop I:
The history of artificial language

I have been asked why I should have convened such a workshop with specialists in the history of ancient and medieval science. Its ultimate source lies in my interest in the origin of language and in its natural and artificial forms, perhaps the defining feature of human animals. Compared to natural language, the artificial variety is recent; its origins lie in antiquity. Is the artificial a mere extension of (part of) the natural? Or is it something entirely different? Natural language is constrained by the mouth and ears we share with other animals, and a computational system in the brain that may be uniquely human. The apparent paradox about artificial languages is that they are, in their ideal form, independent of natural language; but their origins and historical development have been inspired by it. Linguistics, logic, and mathematics provide examples.

The earliest known artificial language is the *metalanguage* of Panini's grammar of Sanskrit (fifth century BCE). A metalanguage is a language in which an object language is described and analysed. A grammar of Sanskrit – the object language – may be composed in English, French or Japanese – the metalanguages. Panini's metalanguage makes technical use of the sounds and case endings of Sanskrit. It results in artificial expressions such as: *// na lingi // indre ca // aatah // iko yan aci // a a //*. These formulas are not intelligible to Sanskrit speakers or scholars unless they are Panini specialists. Their explanation would fill a good part of an *IIAS Newsletter*.

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Formalized logic and mathematics use variables (such as *x, y*), similar to pronouns which enable us to say: 'If anyone wants food, *he* should go to the kitchen; if *he* wants a drink, *he* should ask Johnny.' Christoph Harsbsmeier observed that, neither Plato, nor early Sanskrit or Chinese knew variables. They may use 'such-and-such' for an unnamed entity, but if they use it twice, it may refer to different entities. Aristotle discovered variables a little later and they occur in a roughly contemporary Chinese legal text: 'X (*chia*) and Y (*i*) do not originally know each other. X goes on to rob Z (*ping*). As he arrives, Y also goes along to rob Z, speaks with X', etc.

Aristotle and the Indian philosophers of the Nyaya-Vaiseshika evolved a logic of subject and predicate, based upon natural language and artificial in its European forms. Both erected on that slender foundation a metaphysics of substance and quality which is totally inappropriate to the study of the universe (*horse* or *water* are not substances and neither are *white* or *weight* qualities). It shows that artificial expressions may be as misleading as the natural.

When negative numbers were discovered (by Babylonians, Chinese, Indians, ...), there was fierce opposition. Even in the seventeenth century, John Wallis declared that it is impossible for a quantity to be less than nothing or a number less than zero. But we got used to them. Imaginary numbers are still puzzling. If we multiply any number by itself, the result is a positive number: 2 times 2 is 4 but so is -2 times -2. We may accordingly extract the roots of positive numbers only. However, an enterprising mathematician proposed to give a name to the impossible $\sqrt{-1}$ and call it i. We now know $i^2 = -1$, but do we understand it?

Background of the workshop II:
The power of artificial language

Historians of science agree that Newton's Latin was often unclear. All the formulas that are referred to as 'Newton's equations' were introduced later by Euler, Daniel Bernouilli and other mathematicians. C. Truesdell wrote in 1968: 'It is true that we, today, can easily read them into Newton's words, but we do so by hindsight.' David Park added in 1988: 'It took a century before Newton's work was made fully intelligible and others could do science without being a genius.' Formulas could trigger a scientific revolution because they were easy to understand and soon became intelligible to large numbers of people all over the world. But that simple hypothesis seems to have drowned in a flood of historical, economical, sociological, and political explanations that rarely touch the heart of science, which is knowledge.

India provides a telling contrast: infinite power series that are expansions of π and the trigonometric functions of sine, cosine, and so forth were discovered by Madhava in the late fourteenth century, almost three centuries before they were discovered in Europe by Gregory, Newton, and Leibniz. In Europe, infinite series were a powerful ingredient of the scientific revolution. Indian mathematics was equally strong in this respect and strong enough in any case to have similar consequences. But it was formulated in a complex form of Sanskrit, more obscure than Newton's Latin, and so nothing happened. I concluded in a 1995 article that the Sanskrit of science was formal, but not formal enough to trigger a revolution. It adds fuel to the idea that the so-called scientific revolution was really a mathematical revolution; and that mathematical revolution was really a revolution in language. Galileo had an inkling of it when he said that mathematics is the language of the universe.

The workshop confirmed that similar developments may have taken place elsewhere in Asia though there is no textual evidence for historical connections. However, at least since the Bronze Age, the traditional knowledge of practical professionals such as surveyors or 'reckoners', spread orally over wide areas, not unlike languages. Ibn Sina (Avicenna) learned Indian numerals not from books but from his grocer. Such facts strengthen the idea of the Eurasian continent as an undivided unit as well as the hypothesis that formalization is an advance in cognition, rooted in human nature, shown haltingly by the classical languages of science and, more fully, by artificial languages.

Let us return to imaginary numbers which illustrate the most mysterious power of artificial language; its inherent *knowledge*. Imaginary numbers are puzzling not just because we cannot understand them, but because they solve problems in mathematics and physics. It holds for other artificial expressions and seems to show that we are increasingly unable to understand the universe (which includes human language and the brain; in short, ourselves). It led to a slogan; our goal is intelligibility not of the world, but of *theories*. Quantum theory put an end to even that. Heisenberg had already written that we should free ourselves from 'intuitive pictures'. Richard Feynman declared: 'Nobody understands quantum theory.' Understanding seems to be a feeling generated by visual associations and/or natural language. Equations may convey knowledge and, as Stephen Hawking put it, 'Even if there is only one possible unified theory, it is just a set of rules and equations.'

Artificial language has been slow in freeing itself from its natural language background. It seems likely that it still has a long way to go. <

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