The Generosity of Artificial Languages

A revolution in language heralded the birth of modern science. Latin was replaced by formal languages, such as algebra, born of artificial notions and practical devices like new numerals. Fritz Staal argues that some of the roots of that revolution lie in Asia.

Fritz Staal

Still ignored by the majority of Asian scholars who should know better, the Euro-American idea that “science” is ‘Western’ has long been discarded. Long before the modern period, Asian contributions to ancient and medieval science were expressed through classical languages such as Old-Babylonian, Chinese, Sanskrit, Greek, Arabic, and Latin. In their scientific uses, some of these languages were formalised to some extent, but they were not designed to express abstract relationships in a systematic manner. They were intimately linked to different civilisations and lacked universality. What happened next and culminated during the 17th and 18th centuries was a revolution in language. The construction of formal languages grew out of natural language, artificial notions and special devices such as numerals. The replacement of Latin by such universal languages, in particular the languages of algebra, was a greater revolution than the so-called European scientific revolution.

The birth of artificial or formal languages
Some of Newton’s laws provide simple examples. They were not, at first, written in an artificial form. Newton formulated his law of motion in cumbersome, and it took nearly a century to simplify it.

Brendan Gillon’s “Panini’s Ashbydhayya and Linguistic Theory” gave a brief overview of Panini’s grammar, showing that it was a work with an important missing piece: a historical survey of grammar applicable to Arabic and European languages. Startlingly, in the 18th century, the mathematical system used to formalise verbal solutions of equations, it reached a symbolic form in the 18th century in the western part of the Islamic world.

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The above essay is based on a workshop “The Generosity of Artificial Languages in an Asian Perspective”. The workshop was part of a series of academic events on the history of science in Europe and Asia, organised by IAS, organised by IAS in May and June 2006. With thanks to Marloes Rozing.

Over-generosity
Jens Hoyng examined several examples of over-generosity. One is the extension by a century of Italian mathematician of rules like:

\[ \frac{a^4}{a^2} = a^2 \]

Add or subtract alternately the diameter multiplied by four and divided in order by the odd numbers like three, five, etc., or to the diameter multiplied by four and divided by one.

The result is an accurate circumference. If division is repeated many times, it will become very accurate.

Infinite Series Expansion of the Circumference of a Circle

\[ 4D - \frac{4D}{3} + \frac{4D}{5} - \frac{4D}{7} + \ldots \]

the plural

trees we can make the plural plants.

Children pick it up soon but may go too far in mass or sheeps. Philoso-

phers, Kantians as well as Indians, have always done it — claiming, for exam-

ple, that the world may be explained in terms of substances and qualities because sentences consist of subjects and predicates.

Panini’s grammar is very generous. The techniques he uses to refer to groups of sounds, called “consonation” (praty-

hara), are also used to refer to groups of nominal and verbal endings.

John Kadvany’s “Positional Notation and Linguistic Recursion” compared ancient relationships between linguis-

tics and mathematics to modern ones. He showed how the early Ayurvedic terms and the formal techniques of Panini’s grammar to explain how modern mathematical computation is con-

structed from linguistic skills and lan-

guage structure.

The distinction between natural and artificial
Joachim Kurtz supplemented Jeffrey Oaks’ contribution with an account of the surprising adventures of the European Syllogistics - medieval re-

formations of Aristotelian logic in the late Imperial China. Since it involved the introduction of some 8000 Chinese characters, it relied on Kanji characters found in logic textbooks imported from Japan.

Martin Stokhof’s “Hand or Ham-

mer?” discussed ‘grammatical form’ and ‘logical form’ in early 20th century Euro-American analytical philosophy. Adding linguistics and the philosophy of language, he wondered whether the distinction between natural and formal languages can be maintained.

In “Can the world be captured in an equation?” Robbert Dijkgraaf discussed a variety of examples, some of them suggesting that physics benefits from the generosity of mathematics, others (especially in the quantum theory of strings) that they develop simultaneously, others again that reductionism plays a role or that a sense of playfulness or beauty is decisive.

The Indic contribution
The Indic approach to the exact sciences has generally preferred computation to theory, and so assigns a role to language, natural or artificial, different from that in European science. Roddam Narasim-

ha showed how the best example of this approach is the Bhāskara Manuscript of around 800 CE. Here computational tasks are displayed in an artificial lan-

guage that is written with the help of symbols for arithmetical operations that foretell the algebraic equations of modern science. These displays did not lead to equations like the Newton/Euler f = ma, but their spirit survives in the famous diagrams that the self-confessed Babylonian Richard Feynman invented for doing calculations in quantum physics.

Most of the works of the Kerala school of mathematics are in Sanskrit, but one is composed in a Dravidian language. In “The First Textbook of Calculus: Yuktibhasa,” P.P. Divakaran examined a Malayalam work of the 16th century which describes the development of infinitesimal calculus for the geome-

try of the circle and the sphere, together with all proofs. These proofs are written almost entirely in natural Malayalam, without the help of a formal notation or even diagrams. Divakaran presented translations of two passages to illustrate the point that the lack of an artificial language did not hinder the communica-

tion of the subtle reasoning involved in this new mathematics. He then argued that, nevertheless, an efficient artificial language is a prerequisite for abstrac-

tion and greater generality and that its absence may have played a role in pre-

venting the Kerala work from realizing its potential.

The story of generosity has not come to an end. One afternoon in Bangalore, at the time of writing this report, the author had a long conversation with Robdam Narasimha and P.P. Divaka-

ran, both primarily physicists, and Vidyanand Nanjundiah, who started out as a physicist but is now respon-

sible for Molecular Reproduction and Development Genetics. He declared and illustrated that “Every structure is generous.” It’s a good place to stop and think again.

Robbert Dijkgraaf referred to “the great little meeting in Amsterdam” and added “it was a gem.” The event owed much of its success to the lively rulings of the chairs who included Henk Baren-

regt, Kamaladeswar Bhattacharya, Dirk van Dalen, Fenrong Liu, Kim Plofker and Bram de Swaan. Like the Proceed-

ings of the first, the papers will again be published in the Journal of Indian Philo-

osophy. The present report owes much to conversations with Roddam Narasim-

ha and P.P. Divakaran, strengthened by emails from Kim Plofker. The author thanks all them and expresses his sincere gratitude to Shri K.S. Rama Krish-

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