II-12. What Is Behind the Numbers?

Simply eliminating the beginning can dispense with God, the Creator.

- Stephen Hawking

Dealing with numbers requires panache and penchant for systematic thought. What has now come to be known as the decimal ten-based and the place-based numbering system was fully evolved and in extensive use by 300 BCE in the Ganga Valley. For example, in an inscription after the slaughter at Kaling (261 BCE) by Ashok, the edict engraved in stone says (L. Schulberg, Historic India, Time-Life Books, New York):

"......... 150,000 persons were thence carried away captive, 100,000 were slain and many times that number died. .... Today, if a hundredth or a thousandth part of those who suffered in Kaling were to be killed, or to die or be taken captive, it would be very grievous to His Sacred Majesty."

Besides the shock with the reality of war the passage clearly illustrates usage of a ten-based counting system to make the point. It also illustrates the concept manipulation of reality in terms of the 10-fold changes. Also the edict is for the general population who must have also been familiar with the numbering system.

The formalism for such systematic representation of quantities through distinct Brahmi symbols for 1 to 10 was initiated in the Ganga Valley sometimes around 3000 BCE. Possibly, it was an extension of the counting with ten fingers. All cultures had humans with ten fingeres. But it took a conceptual leap of abstraction to develop a ten-based system for counting. Singh (1991) has traced the evolution of modern number representation from Mauryan Brahmi after 300 BCE.

Conception of zero. A critical step in the number-based representation of the real world is zero or the absence of the reality that is to be represented. The concept of zero developed around 2000 BCE as a critical step for the evolution of the place-based system that uses 0 along side with the notations for 1 to 9. The system could not have evolved in one fell swoop. It requires considerable conceptual development of the ways to manipulate parts (numerals, digits, place based relationship) on the basis of defined criteria (*anugam*) as the convention that does not change.

The deeper conceptual basis of zero in the numbering system is that by itself zero has no value, and it has a place based value when placed in relation to other numerals 1 through 9 which have assigned values in the increment of 1. Large numbers are used in the *Brahmi* language inscriptions from around 1000 BCE. In Prakrit there are words for 1 to 9, 10, 100 and further with powers of 2 and 10 as well as the fractions and roots. The intermediate numbers are expressed with compound words. Establishment of the symbols for the numeral 0 to 9 was an important mile stone. Symbols for these numerals in Nagari as well in Arabic follow these conventions and script.

Ancient Mathematics in India. Several texts on astronomy and arithmetic from 500 CE are still available. These texts also mention the earlier texts that are not available now. The Dhavla (817 CE) has extensive mention of numbers and powers. The first textbook, for teaching algebra and geometry, is by Mahaveeracharya (written around 810 CE; first published in English in 1912. See Jain, L. 1963). Its opening passage reads:

Mathematics is useful in all worldly actions, including rituals and duties, such as sexual etiquettes, economics, music and dance, culinary arts, medicine, construction, literary work, logic, and grammar. It is also used for the astronomical and geographical measures.

Mathematics is also the basis for understanding the distribution and lifecycles of all inanimate and animate beings. In short, it is the basis on which one obtains a pearl from a shell.

It could not be said better. Clearly, the last reference is about realization of the hidden or latent potential of the observed reality on the basis of mathematics. Modern science and technology rooted in mathematics continues to support this assertion. This textbook systematically covers an extensive set of arithmetical, algebraic and geometrical manipulations. Such usages also show a deep understanding and applications of the zero, the place-based system, fractions, and the properties that emerge from such representations.

What is place-based numbering?

Reading from left to right in the number 305 each digit has a place based value, i.e. 300+0+5. Conceptually, the ten digit numbering system is a pure place value system. Zero plays two roles: Zero is nothing of everything, but depending on the place in a string it is also assumes the value of what that place represents. It is not unlike the difference between a large and small bowl which are said to be small or large (a value) depending on the space they contain, and not on the basis of the space that remains outside. We also call the contained space as place such as Earth is our place in the boundless space beyond.

By convention the status of zero comes from the fact that in a multi-digit (compound) number it has a value when placed to the right of any other numeral. By itself alone, or when placed to the left of a number, it has no value. In other words the place-value of zero emerges in relation to the context or the neighbors to the right and the left. The importance in the decimal system is that when zero is placed after a numeral, the value of the numeral is enhanced 10-fold.

Numbers move West. Possibly through the trade routes, knowledge of numbers (concepts and tools of the decimal system) moved to Central Asia and then to the Middle-East. Their symbols for numerals from the Central Asia region are virtually identical to those in *Brahmi*. As the concept of numbers moved farther west, notations for the numerals began to change around 800 CE to the current Arabic and European notations. The term *Arabic numerals* in the European vernacular acknowledges the fact that their source was Arabic. On the other hand, in the Middle-east these are called the *Hindu numbers*.

Certain features of the use of numbers did not change with the migration. Even in Arabic the digits of the larger numbers have decreasing value from the left-to-right of the numeral string i.e. the same way as in all other languages. In contrast, the order of the alphabets in words, and also for the string of the words in the Arabic an Hebrew text on a page is read from right-to-left. In fact, Arabic Books are printed in such a way that the first page also opens from rightmost page of the stack. Also an Arabic book is read by turning the pages such that the next page is to the left. Note that although Chinese write from top to bottom, the count on abacus is from left to right.

Systematization of sound for vocalization

The panache of the ancient Indian mind for systematization is also apparent in the way alphabets are arranged as vowels (*swar* or sounds emanating from different resonance cavities of the body) and consonants (*vyanjan* or the sounds modified with the movement of tongue) in Prakrits to modern Hindi. For example the range of the vowels “a” "i", "e", "o" or "u" follows from the different regions of the human respiratory system. The organs used for resonating the phonemes of *a*, *aa*, *i*, *ii*, *u*, *uu*, *e*, *ei*, *o*, *ou*, *am*, *ah* move from abdomen for *aa* to the nasal chamber for *am-ah*. These sounds can be modified with the movement of the tongue to generate sounds of consonants like *k*, *ch*, *t*, *p* and *s*. Thus the phonemes build on the physiology and anatomy of the human sound producing system. In most other languages alphabets are assigned and arranged without such considerations.

In the yogic practices the range is integrated in the sound of "***aaoum***" – the primordial vocalization of all sounds (knowledge)! Such combinations of phonemes and lexemes are like formula for mental reality (*mantr*(a)) that enables, amplifies and configures conscious patterns of thought and behaviors. It is not too different than the limits to the use of a formula by a chemist to synthesize a desirable chemical agent.

Through the Arabic writings after 800 CE the Hindu numbers were disseminated farther West. The trade routes of Moors brought the numbering system to North Africa and then to Spain. Al-Khouarizmi's *Arithmetic* (ca. 850 CE) is the first Arabic work in which the decimal place value system and the computing operations based on it are explained in great detail. He showed how the value of the numeral changes when it is put in another place. He was also aware of zero.

In the 12th century CE when *Arithmetic* by Al-Khouarizmi was translated into Latin, his name was used in its Latin form *Algorithms* to denote the new Arithmetic. It applied the place value system for elementary computing operations. Apparently the European merchants did not understand the place value system. Initially, the system was banned in parts of Europe. In most places they did not see the advantage for several centuries, just as many Americans do not see the advantages of the metric system. The numbering system gained full acceptance when the European use of a dot to represent zero was changed in a hollow circle.

Two world-views: numbers versus lines. While the abstraction of numbers going out of India was being adopted in the East, in Mesopotamia, Babylon and Egypt the thrust was on more practical aspect of mathematics for architecture and surveying. With the conquest of Greece by the Persian Empire (ca. 580 BCE), the Greeks began to move out and interact with other cultures and traditions. The Hellenistic culture in the Greek colonies to the South and East integrated the local knowledge. As the colonial Greeks came into possession of a vast number of arithmetical algorithms they began to wonder if there is some order in the way of solving such problems. They did not have their own mathematics. But they were not inhibited about asking poignant and skeptical questions. Their job was made easier because at least initially the Persians, Babylonians and Egyptians were all too eager to share information with the colonizers. Once the Greeks and later Romans entrenched into power, they used force and deceit to build a remarkable collection of books on parchment and papyrus scrolls. This fabled library of Alexandria, at its peak in 400 CE had a collection of over 200,000 books "*containing all the available knowledge of the world.*"

Tradition of Greek scholarship began with Thales (624-545 BCE) of Miletus (a port near Turkey). It was a busy trade harbor on the Western edge of the Persian Empire and on the eastern edge of Mediterranean. It attracted merchants and visitors from far and wide. Thales started a tradition of scholarship when he asserted that the Earth is round on the basis of the observation that the mast of a sailing ship appears first for an incoming ship, and disappears last for an outgoing ship. This was a remarkable insight: *Based on certain facts interpreted in certain ways one could infer about what is well beyond the reach.*

Thales argued against superstition and sloppy thinking. It is not clear if he was reacting to the Persians, or was inspired by some of the thoughts he had heard from the merchants. Before him there was little by way of the tradition of scholarship in these parts. The Greek mythology was as garbled with ridden with imageries and hyperboles as the Persian and Egyptian.

Although the two never met, Pythagoras (581-497 BCE) was inspired by the reputation of Thales. It is said that Pythagoras traveled as far as India. He managed to become a priest in an Egyptian temple. With access to the temple library for 13 years, he came across the way in which area of a right angled-triangle is calculated. He explained the results in terms of the properties of numbers that he had picked up during his stay in Babylon before coming to Egypt. His proof came to be known as the Pythagoras theorem. Based on the available documents it is clear that the Egyptians had other systematic ways of finding the square roots and ascertaining the validity of the calculation. Probably, their method was far too complicated, or the steps in Babylonian validation were loaded with memories of the centuries.

Pythagoras and Thales began the tradition of theorizing from the selected parts. The ancient traveling Greeks were at their best in such rationalizations and illustrations that common people could understand. In their colonies Greek were not burdened. At home they had little ancient knowledge that could become a baggage. In their playfulness to develop a quantitative worldview, the Pythagoreans tried to visualize the numbers. By the following arrangements of pebbles, he "showed 1, 4 and 9 as the square numbers:"

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  o        o   o        o   o   o
           o   o        o   o   o
                        o   o   o
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Similarly, “1, 3 and 6 are triangle numbers:"

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  o        o        o
         o   o     o  o
                  o  o  o
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The numbers represented in such "geometrical notation are even." Clearly, 5 and 7 are "odd" in the sense that they do not succumb to such simple representations. The number 1 is both, which is a minor annoyance that can be explained away. Of course, absence of pebble was *nothing* to worry about. Beyond this the concept of zero did not bother or made sense to the Greeks or to the European Mind for another 2000 years until the merchants from the East brought it.

Two hundred years after Pythagoras, Euclid (ca. -300c) also living in Egypt managed to consolidate most of the available information about architecture and surveying in about 470 theorems. Without discovering any new law or making any original observation, he was able to consolidate virtually all the known observations in theorems that were based on the explicitly stated assumptions, and “nothing else” (except for some definitions). His book, titled *Elements*, has been a model textbook for the last 2000 years. As convoluted and marginal as many if not most of his proofs were, it did bring home a point: **spell out what you say and imply**. In this sense, in extending the vision of Pythagoras and Thales, *Elements* is believed to be the single most influential device in shaping expression of reason in and by

Western Mind. In spite of such a thorough scrutiny and usage, scores of serious errors of logic and limitations of the theory and hidden assumptions continued to be discovered even until the last century.

The last shining light of the Pythagoras tradition of the traveling Greeks was Hypatia. On a spring day in 415 CE she was dragged from the street in Alexandria and lynched by Christian monks in a Church. For this "contribution" of his stooges, Cyril was ordained as Pope. That day the dark ages descended with the ascendance of Christianity. Soon afterwards the fabled library of Alexandria was destroyed because its content were affront to the Christian world-view. The Roman Empire fell in 476 CE. This was followed by the rise of Islamic scholarship that also reorganized and preserved the scattered material from the East and West.

As they assembled a remarkable body of insights from the prior accumulated knowledge of the Middle East the Greeks spread thalassimmia, a genetic disease, Colonial authorities support the high ideals as long as they did not have to live by such *nonsense*. A traveler often muses about the local traditions as implicit in the term museum as the place where scholars muse themselves. Even to this day uninformed travelers are seen bemusing about the local cultures. Traditions rooted in the Greek colonies did not find home in Greece. Resources and the critical mass were missing. As the colonial Hellenistic Empire gave way to Romans, mathematics turned from sublime thought to an instrument for warfare and architecture. Even the Roman intellectuals like Cicero detested abstract mathematics and logic.

Rise of Europe: With the fall (ca. 1480 CE) of the Moor kingdom of Granada in Southern Spain, their libraries were transferred to different parts of Europe. This effort by the Jesuit monks catalyzed the rise of Northern Europe, where quickly the knowledge and information became a property and commodity to be traded (Burke, 2000). This undermined the traditional institutions that thrived on the local resources, crafts and markets. Rise of technology and control of mass-markets encouraged extensive industrial espionage and propaganda campaigns. Before the dawn of 15th Century little indigenous culture had developed North and West of Alps. These people had contributed little knowledge for human progress (Essay III-15). The imported steel technology from South India via Assyria was adopted for making stronger swords and ships. By the middle of 15th century, the Chinese art of making black-powder was adopted into the technology of gunpowder for cannons. It unleashed indiscriminate slaughter and relentless Wars on one pretext or the other.

Learning as trade. Confluence of accumulated knowledge and tools has quickened the pace of innovation. A cross-cultural comparison and critical examination of the past has accelerated the pace of the technological progress during the last few centuries. Means and tools of technology, coupled with a modern scientific understanding of the physical reality, accomplish in years what used to take centuries and millennia by the isolated tribes. Control of larger territories and markets has also unleashed newer forces of change and innovations. It has also led to the revision of social and cultural values, albeit expressed through the same biological instincts. Therefore it is not surprising that at times, and certainly in many places, the forces of greed and grab seem to reign unchecked and freely, but with much more at stake.

Fascination with the visible order. The approach of Pythagoras of the searches for the ordered universe has fascinated many (Plato, Descartes, Poincare). Simply put, the difficulty with such representations is that our brains can visualize only three dimensions. Why does this matter? In effect we are dynamically blind towards virtually all nonlinear systems with more than a few variables. Although computer simulations now provide a way out, such solutions pose an age-old problem about the choice in the future. Do we want to be part of the proof and decision-making, or remain bystanders flabbergasted by a machine that knows best and can do no wrong? We have had enough problems with omniscience before. How can we stop what we cannot not see?

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