Indian Journal of History of Science, 50.3 (2015) 521-532 DOI: 10.16943/ijhs/2015/v50i4/48321

Features of Mathematical Sciences in India during the Second World War*

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(Received 23 November 2014)

Abstract

This study is focused on the development of mathematical sciences in India during the Second World War with reference particularly to India's indigenous tradition in mathematics, the ongoing freedom struggle in the country, and the crosscurrents of influences coming from all over the world. The subject acquires significance all the more as an entirely new branch of mathematics——Operational Research—came into being during this period, and revolutionary progress was made in other areas like artificial intelligence and computer science, and statistics. Since India was crucially involved in the war as a part of the British Empire, a look at the developments here may prove valuable, especially in the light of her own rich tradition in mathematics and its application in the postwar reconstruction. For, as the war escalated and postwar reconstruction became a national urgency in many countries, especially the Allied and the Axis powers, research in these areas unveiled their potentialities for peacetime development, too. What was the scenario in India? How and how far could the mathematical sciences develop during the war here, especially in comparison to the developed countries? Did the indigenous knowledge and talent prove of any help both with respect to the global war and post-war reconstruction?

Key words: Artificial Intelligence, India, Mathematics, Operational Research, Statistics, World War.

1. Introduction

Wars have universally catalysed science and technology throughout history; and the latter have shaped the means and methods of war. The greatest of them, the two World Wars (I: 1914-18, II: 1939-45), promoted science and technology, including mathematics, on an unprecedented scale. This study is focused on and around the Second World War with reference to the mathematical sciences in India. For, during this war, an entirely new branch of mathematics—Operational Research—came into being, and revolutionary progress was made in other emerging areas like computer science, and statistics[1]. Since India was crucially involved in the war as a part of the British Empire (Voigt, 1987), a look at the developments here may prove insightful, especially in the light of her own rich tradition in the field of mathematics (Sen, 1971, pp.136-212). Globally, research in these new areas had initially started for different purposes and in different perspectives; but the crisis of the Second World War streamlined their focus and increased their pace. As the war escalated and post war reconstruction became a national urgency in many countries, research in these areas unveiled their potentialities for peacetime development. As such, these new fields of science attracted attention as much of

* This is a fully revised version of my paper presented at the National Meet on History of Mathematical Sciences, 7-9 January 2010, organised by the Department of History, University of Delhi, Delhi. The author is beholden to its organisers for their encouragement and support.

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[1] See J.D. Bernal, *Science in History*, Vol. 3: *The Natural Sciences in Our Times*, Harmondsworth, 1954, especially pp. 831-48, and other pages; also see Vol. 4: *The Social Sciences: Conclusion*, esp. pp. 1139-44.

economists, politicians and the defence experts as of mathematicians. These developments took place in the developed countries like the UK, the USA and Germany and some activities were experienced in those allied with them, too (Bernal, 1954).

What was the scenario in India? What were the main factors responsible for the rise of mathematical sciences, and the problems they addressed, here? How and how far could they develop under the impact of the war, especially in comparison to the developed countries? Did the indigenous knowledge and talent prove of any help during the war, and what was the latter's impact on it? Here, it may be noted that under the colonial conditions, it is important not only to find out what happened in the past but also what did not. This study is essentially concerned with the social aspects of the subject, in the background especially of imperialism, nationalism, and indigenous tradition and response.

Unfortunately, the official secrecy maintained in the colonial policy concerning various aspects of life during the war and after, makes the task of the historian difficult (Sinha, 2008, pp.12-14). The fact that India did have a long tradition of mathematics, which did not disappear totally by this time (Sen, 1939-1950), makes it all the more meaningful to find out if the British made use of it, or of the new branches of mathematics, mentioned above, in their post-war reconstruction programme here. If not, why and how? And in that case, how did the Indian mathematicians react to that?

2. The Background

The conscious application of mathematics on organised level for collective human endeavours, like war and developmental activities, seem to have gained currency in the world much later, probably from the nineteenth century.[2]

India did have a very long and rich tradition of mathematics as a scholastic discipline. A survey of its early mathematics has been made by BB Datta, SN Sen and others. Some of the great names of the period are Āryabhaṭṭa I (b. 476 AD), Bhāskara I (c. 600 AD), Brahmagupta (c. 598 AD), Mahāvīracārya (c. 850), Āryabhaṭṭa II (950 AD), Śridharacārya (c. 991 AD), Śripati (c. 1000), Bhāskara II (c. 1114 AD), Nārāyaṇa (c. 1350), Mādhava (c. 1400), Nīlkaṇṭha (1500) and Jyeṣṭhadeva (1550). 'The Medieval period witnessed the growth of a sizable mathematical literature in Arabic and Persian and presented an opportunity for cross-fertilization of the efforts of two distinct cultures.'[3] From ancient times, the knowledge of Indian mathematics travelled to the West through the Middle East; and the concept of zero and place-value left their mark there, the influence of which may be noticed even in the European Renaissance of the sixteenth century (Gunatilake, 1999). This interaction influenced the developments in India, too (Gunatilake, 1999). By the eighteenth century, the astronomical knowledge of the West had started influencing the indigenous thinking on the subject. Sawai Jai Singh II evinced considerable interest in the developments in this area in the West (Ghori, 1980, Rahman, 1989).

With the rise and expansion of the European imperialism in the East, Western mathematics reached India in different ways—through trade, state-supported Western Education and science, Surveys, etc. The establishment of the European, especially the British, rule in the Indian subcontinent led to the crumbling of the

[2] J.D. Bernal, *Science in History*, 1954, provides an excellent general view of developments.

[3] S.N. Sen, 'Mathematics', 1971, p. 136. For contemporary sources, see A. Rahman, ed., *Science, Technology in Medieval India: A Bibliography of Source Materials in Sanskrit, Arabic and Persian*, New Delhi, 1982; also his *Trimurti: Science, Technology and Society*, New Delhi, 1972, esp. pp.235-39.

indigenous institutions of learning with the fall of the native states which patronised them. This cleared the road for the expansion of the Western science in India (Kumar, 1991). Yet, millions of people used the traditional mathematics in their day-to-day life, as they used the traditional measurements of weight, space, time and celestial activities which are still in vogue to an extent in India (Dharampal, 1971). Not long ago from the period of this study, India produced a mathematical genius in Srinivasa Ramanujan (1887-1920); (Kanigel, 1991) and there were scores of others who were impressively grounded in mathematics when the Second World War broke out (Seth, 1963, Jaggi, 1984, pp119-32). S Ramanujan was deeply rooted in India's philosophical tradition and spiritualism, and P C Mahalanobis (1893-1972), a physicists-turned-statistician, returned to *Sāmkhya* and the Jain philosophy of *Sadyvād* for his intellectual mooring just on the eve of the Second World War and worked through it (Rudra, 1996) to which we would return later for more discussion. The process was deeply influenced by the consequences of the colonial rule; and the Second World War added new factors to impact it.

3. Mathematical Sciences during the War

3.1 Pure Mathematics

As indicated above, modern mathematics had swayed over the indigenous mathematics during the colonial rule in India. Since general education was gradually deprived of its local content—both of the knowledge system, and of relevance and purpose of study—in preference for Western literature and sciences, and, later, for technical education, basic courses in mathematics seem to be simply a part of the educational curricula. During the Second World War, as the state budget was drastically cut, most of the basic subjects in the academics, including mathematics, lost priority to the urgent necessities of the war. Nothing significant seems to have been done by the government to promote pure mathematics.[4] Yet, the Indian mathematicians continued to do appreciable work in several branches of mathematics. Some of them were K Anand Rau (1893-1966), S S Pillai (1901-1950), S Chowla (1907-1995), T Vijayaraghavan (1902-1955), K Chandrashekharan (1920-1995), and S Minakshisundaram (1913-1968) (Seth, 1963). Whereas only 27 doctorates had been awarded in the 30 years between 1910 and 1940, the number rose to 42 in just 10 years between 1940 and 1950 (Jaggi, 1984, p.127). Why the colonial indifference to basic sciences could not deter Indians from working in this field merits some explanation. A close observation of the trend seems to suggest that their drive sprang essentially from their nationalistic urge to measure up their talent and capabilities with their masters who always underestimated their talent and discriminated with them. The indigenous interest and achievements in mathematics in the past must have fuelled their urge additionally. The palpable spurt in mathematical research during the Second World War may be ascribed to their awareness to the global developments to which the Indian scientists had become highly sensitive. It may be noted that the Indian Science Congress Association and the Mathematical Association had come into being in 1914; and in the years to come, they and all other professional organisations empathised with the freedom struggle and worked in concert with the national leadership, especially from the mid-1930s, in planning for India's national reconstruction. The mathematicians could not be an exception to this trend. The Indian Science News Association and its mouthpiece—the *Science and Culture*—brought the Indian scientists together; and the National Planning Committee (NPC) organised by the Indian National Congress

[4] For a general idea, refer to the *Progress of Education in India 1937-1947: Decennial Review*, Delhi, n. d.

for this purpose, in 1938, offered them a common platform to work with the national leadership from various walks of life in the country.[5]

3.2 Applied Mathematics

The official interest in mathematics during the Second World War was selective and ambivalent, although some of the areas of its interest did have considerable implications for mathematics. About this time, the government was faced with three major problems: the World War, the freedom struggle, and the material crisis aggravated by a famine and the Axis aggression from the east. While none of them could be overlooked, the government focused on the war crisis, and geared up its resources to meet its challenges.[6] It was in this context that mathematics promised to be of some help.

Operational Research: The devastation of the Second World War brought into limelight the importance and urgency of defence research. This led to research and experiment in various aspects of military preparedness and operations in Great Britain and in India, too (Sinha, 2008). In the midst of the global crisis, the Government of India invited Professor A.V. Hill of the Royal Society, London, to advise on postwar reconstruction in India. By the time he visited India in 1944, some work in Operational Research (OR) was already afoot on a modest scale. Hill showed keen interest in the subject and made detailed recommendations to organize and promote it in India (Hill, 1944, p.33).

It was in the context of defence research that Operational Research drew the attention of the authorities. It was born out of the urgency of managing resources to achieve definite goals in war operations with limited resources and in a given time span. It was an entirely new branch of war research that originated during the Second World War itself. It assumed great importance in the Allied countries,[7] and some efforts in this direction seem to have been made in India, too. The Operational Research groups here were under the South East Asia Command, one each for the Army and the Royal Air Force (RAF); the Royal Navy did not have any Operational Research unit in India. By September 1943, the Commander-in-Chief had a Director of Research, Brigadier Welsh, together with an Operational Research Section commanded by Lt. Col. Leitch. There are indications that Operational Research activities were going on at different places and at the levels of the armed forces, and the personnel concerned were active even at such war fronts as in Assam (Sinha, 2008, pp127-28).

Hill was quick to appreciate the value of operational research for post-war reconstruction. So, he advised in his report that it would be wise for India to ensure that the experiences of these Operational Research groups were not lost in the future, and they were made use of even after the hostilities were over (Hill, 1944, p.34). Sources indicate that importance of Operational Research for the country after the war was deliberated upon in certain colonial circles, too.[8] In spite of such concern, however, the achievements in this field of research are little known. Official secrecy regarding war operations, defence research, and the exclusion of Indians from information in this

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[5] Jagdish N Sinha, 'Science and the Indian National Congress', in Deepak Kumar, *Science and Empire*, 1991; idem, 'Origin of India's National Science Policy: M.L. Sarkar to M.K. Gandhi, 1975-1935', *IJHS*, XXVII, 2, Apr. 1992. For the NPC, see its *Report*, 25 vols, Bombay, 1945-49.

[6] For contemporary conditions, refer to Johanne H. Voigt, *India in the Second World War*, New Delhi, 1987.

[7] J.D. Bernal, *Science in* History, 1954, pp. 833-34. Also see *The Origins and Development of Operational Research in the Royal Air Force*, London, 1963.

[8] 'The Post-War Importance of Operational Research, with Particular Reference to India', by Dr C.N. Waddington, then with O.R.S., Coastal Command, R.A.F. (typescript) in E.H.T.L.A. A.V. Hill 2/8 [?], 15 Oct. 1943, Hill Papers, Churchill College, Cambridge

regard was conspicuous.[9] In the circumstances, what we know about are the less sensitive subjects like signals and electrical equipment, wireless communication, meteorological forecasting, mines and body traps; and food preservation and health appear to have been taken up by Operational Research groups in the armed forces (Sinha, 2008, pp.127-28). Defence and Operational Research were the areas in which India lagged far behind the UK [10] and its allies like the USA, Canada and Australia;[11] and she was blatantly excluded from their principal war research efforts.

For example, the Tizard Mission, launched by Britain to coordinate scientific research amongst the Allies for the war, bypassed India. It visited America during August-September 1940 and took in representatives from both the USA and Canada (Zimmerman, 1996). The cooperation that followed introduced Canada to the secret war research projects of the United Nations and made her an active partner with the UK and the USA. This offered Canada an opportunity to participate in advanced research and make significant contributions to one of the greatest inventions of the Second World War—the radar and atomic energy (Eggelston, 1950,pp. 17-19; Hartcup, 2007). The momentum thus gained in scientific research activities soon encouraged Canada to extend efforts in several other areas that would be crucial for the development of the country in peacetime, too. They included aviation, medical science and public health, industry, agriculture, etc.[12] Nothing of this sort happened in India even though she was a part of the British Empire, while Canada was by now independent and only a member of the Commonwealth.

***Statistics*:** Statistics was another area wherein mathematics was profoundly involved. It was already developing as an applied branch of mathematics before the Second World War; and some work was being done in it in India as well. The World War added some importance to it, thanks not exactly to the military crisis but to the economic and material emergencies that aggravated during the war. In India, statistics as a statecraft did have a long antiquity. Its beginning can be traced to the *Arthaśāstra* of Chanakya in the 3rd century BC; in the medieval times, its best example can be found in the *Ā'in-i-Akbari* (1590) of Ab'ul Fazl in the reign of Akbar. In modern India, a comprehensive statistical survey of the Bengal Presidency was undertaken by Francis Buchanan under the East India Company in the early nineteenth century (Buchanan, 1930). In 1862, the Government of India set up a committee for the preparation of standard statistical forms for a uniform system of compilation of statistics on trade, education, population, agriculture, finance, etc. Later, this led to the publication of the *Statistical Abstract of British India* in 1868. The *Imperial Gazetteer* and the *District Gazetteers*, published by the government throughout the British rule in India, were another example of statistical exercise (Mahalanobis, 1989, pp.31-32). In spite of all this, statistics was not considered an independent subject and never included in the academic courses until the Second World War.

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[9] Unidentified person to A.V. Hill, Secret, 22 Sep. 1943, J55/BJS, in A.V. Hill Papers, Churchill College.

[10] See *The Origins and Development of Operational Research in the Royal Air Force*, London, 1963; and M.M. Postan et al., *Design and Development of Weapons*, London, 1963.

[11] Wilfrid Eggleston, *Scientists at War*, London, 1950, pp. 17-19, 24ff, 82ff.; and Guy Hartcup, *The Effect of Science on the Second World War*, Basingstoke, 2000, esp. chap. 6. For Australia, D.F. Mellor, *The Role of Science and Industry*, Canberra, 1958.

[12] *History of the Department of Munitions and Supply: Canada in the Second World War*, vol. I: *Production Branches and Crown Companies*, 1950; *Report of the Minister of Agriculture for the Dominion of Canada for the Year Ended March 31, 1945*, Ottawa, 1945; *First Annual Report of the Department of National Health and Welfare for the Fiscal Year Ended March 31, 1945*, Ottawa, 1945.

What is however, worthy of note is the growing interest of Indians in modern statistics right from the beginning of the twentieth century. Prasanta Chandra Mahalanobis (1893-1972) took the lead in it, and developed it to an international standard (Rudra, p. 996). He began his interest in the subject in the second decade of the last century. Interestingly, Mahalanobis and statistics (with the work of Karl Pearson) were born in the same year, i.e. 1993. In his effort, Mahalanobis received the help and encouragement from such eminent persons as Brajendra Nath Seal (scholar and philosopher), Rabindranath Tagore (literature and Nobel Laureate), and internationally known scientists like R A Fisher (noted British statistician) and Walter A. Shewhart ('father' of the Statistical Quality Control from the USA) (Mahlanobis, 1989, pp. 24-29, 33) Initially, Mahalanobis was impressed by the journal *Biometrika* when he was in England (Mahlanobis, 1989, p.12). He discovered the utility of statistics to the problems in anthropology and meteorology, and began working on them as soon as he was back to India.

By 1931, he was able to establish the Indian Statistical Institute (ISI) in Calcutta, which later developed, after 1959, into a deemed university. By 1933, its journal, *Sānkhya: The Indian Journal of Statistics* was founded on the lines of Karl Pearson's *Biometrika (*Mahlanobis, 1989, pp. 37-38). While Mahalanobis was initially introduced to the concept of statistics through the works of the West, he was quick to discover its roots in the traditional indigenous knowledge and philosophy. This was amply demonstrated by his choice for '*Sānkhya*' as the name of his journal. In his editorial in the first issue published in June 1933, he explained the reason why he called it '*Sānkhya*':

> 'We believe that the idea underlying this integral concept of statistics finds adequate expression in the ancient Indian word *sankhyā*. In Sanskrit the usual meaning is 'number', but the original root meaning was "determinate knowledge". In the *Atharva-veda* a derivative form *sankhyāta* occurs both in the sense of "well-known" as well as "numbered'. The lexicons give both meanings. *Amarkoṣa* gives *sānkhya* as *vicarana* (deliberation, analysis) as well as "number"; also *sankhyāyana* as *panditaḥ* (wise, learned).

'The same dual sense is attached to its derivative from *Sānkhya* which is the name of the most famous analytic philosophy of ancient India. ...The root meaning is also met with the *Mahābhārata* in the *Gīta* portion where the *Sānkhya* system of philosophy is classified with the Vedānta as being based on *jñāna* (or intellectual cognition) as distinguished from the yoga systems. Śridhara, in his commentary on the *Gīta*, explains *Sānkhya* as *samayag-jñān*, that is, "proper cognition" or "adequate knowledge".[13]'

Mahalanobis believed that the idea underlying the integral concept of statistics found adequate expression in the ancient Indian word *sankhyā* and referred to the *Atharva-veda*, the *Gīta*, the *Sānkhya* system of philosophy, and to the *Amarkoṣa*, to elaborate his point. He concluded:

> 'The history of the word *sānkhya* shows the intimate connexion which has existed for more than 3000 years in the Indian mind between "adequate knowledge" and "number". As we interpret it, the fundamental aim of statistics is to give determinate and adequate knowledge of reality with the help of numbers and numerical analysis. The ancient Indian word *sānkhya* embodies the same idea, and this is why we have chosen this name for the Indian Journal of Statistics.'[14]

Mahalanobis was so charmed by the subject that he could not wait for any state patronage to promote it. He identified the areas

[13] Editorial in *Sānkhya*, June 1933.
[14] Editorial in *Sānkhya*, Jun. 1933.

for its application and went ahead to promote it with his personal initiative and resources. Without being aggressive towards the colonial government like M N Saha, Mahalanobis quietly tried to apply statistics to some of the basic problems of the country, such as those connected with agriculture, flood and population; and instead of depending on the British expertise, he gradually turned for it to other countries like the USA and Japan, and, later, to the USSR (Mahlanobis, 1989, pp.24-28, 32-33, 40-41, 44,47) .

The ISI created a Statistical Publishing Society in 1935 which published its journal and other publications. In the post-colonial era, the ISI entered into international collaboration with the USSR for publication. Mahalanobis was taking the subject as a mission, and he organised the first Indian Statistical Conference in 1938 at Calcutta, and invited R A Fisher to preside over it. As the Indian Science Congress did not agree to start a section on statistics, the ISI started holding statistical conferences independently every year at the Science Congress sessions. Ultimately, the Science Congress decided to have a section for mathematics and statistics in 1942; and a separate section on statistics was started from 1945 onwards.

Mahalanobis identified certain areas for work, and interacted with both the experts in the field and the colonial authorities concerned. In the 1938 conference, Fisher strongly supported the development of sampling methods in India, and declared the ISI as the most suitable place for that. A little earlier in December 1937, Viceroy Linlithgo had visited the Institute, probably on Fisher's initiative. These events induced the Indian Central Jute Committee to go for a large-scale sample survey of the areas under jute cultivation in Bengal, which was undertaken in 1940, in association with the ISI and Mahalanobis who wrote several reports thereafter. Thus, sample survey of agricultural crops and, later, large-scale economic and social surveys became a very important activity of the Institute, leading to the inauguration, in 1950, of the National Sample Survey, being the largest of its kind in the world. This technique was immediately acclaimed internationally.[15] The two-stage sampling procedure suggested by Mahalanobis in his book *Sample Census of Area under Jute in Bengal, 1940*, may, in a way, be regarded as a forerunner of sequential analysis technique (Mahalanobis, 1989, p. 41).

Way back in 1931, Mahalanobis had been impressed by Walter A Shewhart's ideas on quality control in industrial production and had written to the authorities concerned to make their use in India. He once again, in 1942, wrote to Sir Frank Noyce, Member of the Viceroy's Executive Council, pleading for the use of statistical quality control methods particularly in industries manufacturing military supplies. However, nothing happened till Professor A V Hill visited India in 1944. On his recommendations, the CSIR appointed a committee on statistics, standards and quality control with Mahalanobis as its Chairman. During 1945-46, a special training course in statistical quality control, the first of its kind in India, was arranged at the ISI. Mahalanobis foresaw tremendous possibilities of its use in industry, and it was at his instance that Shewhart was invited to India in 1947. This visit created a widespread interest amongst industrialists, and a conference on standardization and quality control was held in Calcutta in February 1948. Shewhart maintained a very long and close relation with Mahalanobis and the ISI, and donated his entire collection of books to the ISI. His visit to India was followed by visits of a number of experts in quality control from the USA, UK and Japan (Mahalanobis, 1989, p. 41).

[15] Professor Harold Hotelling of the Columbia University, who visited the ISI in 1939-40, acknowledged the originality and novelty of this technique of random sampling.

Broadly speaking, Mahalanobis' interest in statistics was focused on anthropological studies and population, agriculture, flood, metrology, etc. His main contributions to sampling methods were: pilot surveys, inter-penetrating network of sub-samples (IPNS), and the concept of optimum design of surveys (Mahalanobis, 1989, p. 41). He received the Weldon Memorial Medal and prize from Oxford University in 1944, and was elected a Fellow of the Royal Society, London, in 1945, for his fundamental contributions to statistics and particularly in the field of large-scale sample surveys. In 1946, he was appointed a member of the Statistical Commission of the United Nations Organisations (Mahalanobis, 1989, p. 41-42).

As a visionary and the one determined to promote statistics in India, Mahalanobis could not be indifferent to the value of the education and training in statistics. Soon after its establishment, the ISI started short training courses in statistics from 1932, which were attended by officers on deputation from the government and other organisations from all over India. With initiative of Mahalanobis and active support of Dr Shyama Prasad Mukherjee, then President of the Councils of Post-Graduate Teaching in Arts and Science in the University of Calcutta, a course in statistics was introduced there at the postgraduate level in 1941, with Mahalanobis as its Honorary Head. The first examination for Master's degree was held in 1943 and C.R. Rao topped the list. Rao became a close associate of Mahalanobis at the ISI for many years to come; and brought great laurels for his work in the future.[16] Mahalanobis did have a special ability for locating talents. He discovered outstanding mathematicians in Subhendu Sekhar Bose, Harish Chandra Sinha, Raj Chandra Bose, Samarendra Nath Roy and others, who raised the Institute to an international stature, earning global recognition (Mahalanobis, 1989, pp.38-39). Along with his intellect and a creative mind, Mahalanobis had also a personal charm that endeared great personalities and scholars from all over the world, which helped him develop the institute. Thanks to him, J B S Halden joined the ISI and lived in India for ever (Clark, 1988). After Independence, Mahalanobis became a trusted member of Nehru's team instrumental in India's national reconstruction through planning and industrialisation (Chandra, Mukherjee and Mukherjee, 2000, pp.341-44).

Artificial Intelligence & Computer Science: Artificial intelligence and computer science, developed largely with the help of the principles and methods of mathematics, were the areas that made tremendous advance in the West during the Second World War. However, one is surprised to find no evidence of any R&D in this field in India. This is conspicuous all the more because India did have a good pool of mathematicians and physicists (many of whom contributed to the development of statistics in the country and outside it),[17] India was the greatest centre of Allied military operations in the East, and activities in the fields close to this subject (as statistics, operational research, radio and wireless, and electronics) were taking place in the 1940s, here. Moreover, the country possessed a rich heritage of philosophy and logic that would aid the development of the subject in the future. But I am blank in information on the existence of any activity in this regard in India. A thorough research should find out the truth, or explain why even the Indians could not think on these lines, and why Pāṇiṇi was not remembered in this connection.[18]

[16] A MA of the University of Andhra (1940), Rao soon excelled in statistics and was decorated with the Shanti Swarup Bhatnagar Award of the CSIR in 1963, and the Guy Medal of the Royal Statistical Society of London in 1965. In 1967, he was elected a Fellow of the Royal Society, London, for his contribution to statistical theory, multivariate analysis and biometric method; and lastly was decorated with Padma Bhushan Award in 1968.

[17] J.N. Kapur, 'Development of Mathematical Sciences in India during the Twentieth Century,' *Indian Journal of History of Science*, vol. 27, no. 4, 1992, gives a general picture of the developments and the mathematicians involved with them.

[18] In recent years, effort is being made in the West to make use of Pāṇiṇi's grammatical model and skill to develop a universal language for computer.

For, in the recent years, Indian and American researchers have successfully used the approaches of the fifth-century grammarian Panini to develop computer software for machine translation, transforming knowledge representation techniques in grammatical Sanskrit to the field of Artificial Intelligence.[19] Likewise, after half of a century or so since the Second World War and development of computer, India's traditional skill of computing prevalent among the artisans and businessmen in the non-Europeanised sectors in south India has been successfully used by Professor Ashok Jhunjhunwala of the Madras IIT to enhance and speed up the computing power of the computer.[20] 'Francisco Valera, a leading theoretical biologist and student of cognitive science and artificial intelligence, and co-workers have used Buddhist insights in extending the limitations of both the neo-Darwinianism adaptation in biological evolution and of the current paradigm in cognitive sciences (Varela, Thompson and Rosch, 1991)'. The conventional understanding about the nature of man and machine (computer in our context) often meets a road block and stalls the prospects of development of computer beyond a limit. Drawing from their understanding of the symbiotic relation between the living and non-living, the Buddhist philosophers hint at the existence of an intrinsic mutuality and co-dependence between the two that does not limit the prospects of some type of autonomous growth in machine. Further understanding and use of this insight is likely to bring breakthroughs in cognitive sciences and artificial intelligence, and help develop computers and robots that may act independently.[21] Not only that, Raja Ramanna (responsible for India's first atomic explosion) has used insights obtained from Buddhist concepts of conditioned reality, *kṣana* (short time) and 'Nothingness' and its logic to derive some of the characteristics of elementary particles using the mathematical theories of Cantor (Ramanna, 1993).

***Other Areas*:** The enhanced interest of the Indian scientists, concerned with mathematics, in calendar, weights and measures in the 1930s and 40s deserves some attention; so does their interest in the chronological study of India's antiquity, and of demography and eugenics. The noted journal *Science and Culture*, the mouthpiece of the Indian scientists around the Second World War, published scores of articles on these subjects, many of them authored by M.N. Saha, the editor and a leading Indian scientist of the time.[22] Interestingly, the interest in these areas was shown not by the British but by the Indians. While the genesis of this trend can be partly traced to a cross current of factors and forces from all over the world, their nationalistic roots cannot be overlooked.[23]

5. In the Vortex of Imperialism & Nationalism

Broadly speaking, however, pure mathematics was sidelined as an academic subject, like most of the basic sciences, during the war.

[19] Rick Briggs, 'Knowledge Representation in Sanskrit and Artificial Intelligence', *AI Magazine*, 6, 1 Spring, 1985. The machine translation efforts at the IIT at Kanpur are the most comprehensive in India. Already a basic system as a working model has been demonstrated for translation between Hindi and Kannada using the technique (See Akshar Bharati, Vineet Chaitanya, Rajeev Sangal, A *Computational Grammar Based on Paninian Framework*, Department of Computer Science, IIT, Kanpur, 1993, pp. 67-74).

[20] Susantha Goonatilake, 'Coming Intellectual Shifts to Asia: The Indic Possibilities,' a revised version of paper presented as the opening address at the Eighth East-West Philosophers Conference, Hawaii, Jan. 2000.

[21] This passage is exclusively based on Susantha Goonatilake 'Coming Intellectual Shifts to Asia,' 2000.

[22] See M N Saha, *Collected Works of Meghnad Saha*, edited by Santimay Chatterjee, Vol. 3, Calcutta, 1993.

[23] For the nationalistic factors, see Jagdish N Sinha, 'Technology for National Reconstruction', in MacLeod and Kumar, eds., *Technology and the Ra: Western Technology and Technical Transfers to India,1700-1947*,New Delhi, 1995, ; idem, 'Freedom Movement and the Scientists: Problems and Prospects of Historical Research', *Journal of Indian History and Culture* (Madras), Mar. 1997.

On the contrary, in the developed countries, its applications were found in newer areas that developed as statistics, operational research, and artificial intelligence and computer science. But their development in India was selective, uneven and lopsided. Generally speaking, the government evinced interest in operational research because it was vital for the war; whereas, the Indians were interested in statistics, because they visualised in it a useful tool for rebuilding the nation out of the debris of decay caused by the colonial rule. Moreover, Indians had an intrinsic inclination and acumen for it. This is why even though initially Mahalanobis was inspired by the concept of statistics being developed at the time in the West, he was immediately impressed by the exposition of the traditional indigenous thinking in this regard. During his stay in England, he had opportunity to know the views of Ramanujan on the subject. Apparently, the mathematical genius was intuitive in the matter but his ideas did have close affinity with India's philosophical tradition. About forty years later, a somewhat similar philosophical thinking led Mahalanobis to 'trace certain interesting resemblances of the ancient Jain philosophy to the probabilistic and statistical view of reality.' He found that the Jain logic of *syadvad* (assertion of possibilities), which was current over two thousand years ago, seemed to have close resemblance to the concept of probability, and that all predictions, according to *syadvad*, had a margin of uncertainty which was somewhat similar to the concept of uncertain inference in modern statistical theory.[24]

Indeed, there was the clash of two interests—the imperialist and the nationalist. The Second World War put Britain in a position that could not sustain imperial control over India, allowing Indians to liaison with the experts from countries other than Britain, such as the USA which had a liberal and egalitarian outlook sympathetic towards India's problems and her freedom. Not much long after, anti-imperialist and anti-capitalist socialist Russia came to India's help when the Indian Institute of Statistics received a substantial aid from the Russian Government in 1967.

Although, by this time, some British scientists (J D Bernal, A V Hill and P M S Blakett and others) had a friendlier attitude towards India, the British Government was still hesitant to share wartime secrets concerning strategic and military preparations, a point best explained by the secrecy maintained on operational research (Sinha, 2008).Colonial discrimination with the Indian scientists and the lack of opportunities for research and career development in India forced many Indian mathematicians to leave India and go abroad, especially to democratic America. S. Chandrashekhar (later a Nobel Laureate), Sarvadaman Chowla, Harish Chandra Mehrotra, Raj Chandra Bose and S.N. Roy were some of them.

6. Conclusions

To conclude, in and around the Second World War, the mathematical sciences had an uneven and deflected progress in India. The academic courses in pure mathematics received a setback as the resources of the educational institutions were diverted to meet the demands of the war; and cut in the budget drastically reduced the scholarly interaction through conferences and considerably stopped the publication of, and subscriptions to, scholarly journals. In fact, right from the beginning, the development of mathematical sciences in colonial India was essentially thanks to the indigenous initiative—individual efforts, groups and associations.[25]

In the fields of applied mathematics, the pattern of development was queer: Interestingly,

[24] P.C. Mahalanobis, 'Foundations of Statistics', *Dialectica*, 8, 95-111; *Sankhya*, 18, 183-194, 1957.

[25] J.N. Kapur, 'Development of Mathematical Sciences in India during the Twentieth Century,' 1992, gives a general picture of the developments and the individuals and associations involved.

the latest offering of mathematics—Operational Research—was worked upon in India under purely governmental authority, fully focused to meet the challenges of the war, and in complete secrecy from the Indians. On the Indians' side, considerable interest was shown in statistics and international recognition was achieved in it by scholars like P.C. Mahalanobis. Not unexpectedly, the Indian scholars did not address the problems of the war but basically of India's reconstruction, focussing on agriculture, flood control, industrial production and so on. Needless to say, by the 1940s, India was fast approaching the gates of liberty, and a strong urge for national reconstruction was very much in the air. This amply shows how the social needs shape the nature and path of sciences, and how ideology and the state can promote, deflect or retard their progress.

But why neither the British nor Indians took interest in artificial intelligence and computer science that was fast developing in both the Allied and the Axis countries, is surprising. It is really an irony that one of the founding fathers of computer science—Alan Turing (1912-1954) — was born in India; and India did have a long and rich tradition of mathematics, logic and philosophy needed for developing this science. After about half of a century since the Second World War and development of computer, as we have noted earlier, India's traditional skill has been successfully used by scientists like Ashok Jhunjhunwala to improve the processing speed of computers.[26] Today, the Indians constitute the largest part of the pool of computer scientists in the world; and an approach based on the Buddhist philosophical insights is likely to revolutionise the way the computers work (Varela, Thompson and Rosch, 1991). But then, why mathematics and the mathematicians of India in modern times are one of the least researched subjects? Having said all this, I must confess that mine is just a preliminary probe into the subject; further research, especially into the war archives, should be able to present a clearer picture of the developments in the field.

Bibliography

Bernal, J D. *The Origins and Development of Operational Research in the Royal Air Force*, London, 1963.

Bernal, J D. *Science in History*. Vol. 3: *The Natural Sciences in Our Times*. Harmondsworth, 1954.

Bharati, Akshar, Chaitanya, Vineet, Sangal Rajeev. *A Computational Grammar Based on Paninian Framework*, Department of Computer Science, IIT, Kanpur, 1993.

Briggs, Rick. Knowledge Representation in Sanskrit and Artificial Intelligence. *AI Magazine*, 6, 1 Spring, 1985.

Chandra, Bipan, Mukherjee, Mriduala & Mukherjee, Aditya. *India After Independence 1947-2000*, 1999; New Delhi, 2000.

Chatterjee, Santimay (ed.). *Collected Works of Meghnad Saha*, Vol. 3, Calcutta, 1993.

Clark, R. *The Life and Work of J.B. S. Halden*, Oxford, 1988.

Datta, B B and Singh, Awadesh Narayan. *History of Hindu Mathematics*. Motilal Banarsi Das, Lahore, 1935.

Dharampal, P, *Indian Science and Technology in the 18th Century: Some Contemporary European Accounts*, Delhi, 1971.

Eggleston, Wilfrid, *Scientists at War*. London, 1950.

Ghori, S A K. The Impact of Modern European Astronomy on Raja Jai Singh. *IJHS* 15.1(1980).

Goonatilake, Susantha. *Towards Global Science: Mining Civilizational Knowledge*, 1998; New Delhi, 1999.

Goonatilake, Susantha, 'Coming Intellectual Shifts to Asia: The Indic Possibilities,' a revised version of paper presented as the opening address at the Eighth East-West Philosophers Conference, Hawaii, Jan. 2000.

Hartcup, Guy, *The Effect of Science on the Second World War*. Basingstoke, 2000.

Hill, A V. *Scientific Research in India*, Simla, 1944.

Jaggi, O P. *Science in Modern India*, Vol. IX. Delhi, 1984.

[26] 'Coming Intellectual Shifts to Asia', Jan. 2000, sited from the web. Also see his *Towards Global Science: Mining Civilisational Knowledge*, 1999; New Delhi, 1999.

Kanigel, Robert. *The Man Who Knew Infinity: A Life of the Genius Ramanujan*, Toronto, 1991.

Kapur, J N. Development of Mathematical Sciences in India during the Twentieth Century, *IJHS*, 27.4 (1992).

Kumar, Deepak (ed.). *Science and Empire*. New Delhi, 1991.

Mahalanobis, A. *Prasanta Chandra Mahalanobis*, 1983; Delhi, 1989.

Mellor, D F. *The Role of Science and Industry*. Canberra,1958.

Oldham, C E A W. (ed. with notes) Buchanan, Francis, *Journal of Francis Buchanan Kept During the Survey of The District of Bhagalpur* [also other districts] in 1810-1811, Patna, 1930.

Postan, M M et al., *Design and Development of Weapons*, London, 1963.

Rahman, A. *Trimurti: Science, Technology and Society*, New Delhi, 1972.

Rahman, A. (ed.). *Science, Technology in Medieval India: A Bibliography of Source Materials in Sanskrit, Arabic and Persian*, New Delhi, 1982.

Rahman, A. 'Maharaja Jai Singh II: Purposes and Contributions,' paper presented at the Seminar on Sawai Jai Singh, New Delhi, Oct. 1989.

Ramanna, Raja. 'Concept of Discreetness, continuity and the Cantor continuum theory as related in the life-time and masses of elementary particles', *Current Science*, Vol. 65, No. 5, 25 Sept. 1993.

Rudra, Ashok. *Prasanta Chandra Mahalanobis*, New Delhi, 1996.

Sen, S N. 'Mathematics', in D.M. Bose, S.N. Sen and B.V. Subbarayappa, eds., *A Concise History of Science in India*, New Delhi, 1971.

Sen, N R. (ed.). *Progress of Science in India. Section I: Mathematics [Including Geodesy and Statistics] (1939-1950)*, New Delhi, n. d.

Seth, B R. Fifty Years of Science in India: Progress of Mathematics, Indian Science Congress Association, 1963.

Sinha, Jagdish N. *Science, War and Imperialism: India in the Second World War*. Leiden/Boston, 2008.

Sinha, Jagdish N. Science and the Indian National Congress, in Deepak Kumar, *Science and Empire*, 1991.

Sinha, Jagdish N. 'Technology for National Reconstruction', in MacLeod and Kumar, eds., *Technology and the Raj: Western Technology and Technical Transfers to India,1700-1947*, New Delhi, 1995.

Sinha, Jagdish N. 'Freedom Movement and the Scientists: Problems and Prospects of Historical Research', *Journal of Indian History and Culture* (Madras), Mar. 1997.

Varela, Francisco J, Thompson, Evan and Rosch, Eleanor, *The Embodied Mind: Cognitive Science and Human Experience*, MIT, 1991.

Voigt, Johanne H. *India in the Second World War*, New Delhi, 1987.

Zimmerman, David. *Top Secret Exchange: The Tizard Mission and the Scientific War*. Stroad, 1996.