

The 'draft' prepared by the Ministry of S&T formed the basis for discussion prior to the press release. While recognizing the need for 'integrating S&T' into one policy framework, it was also felt that India needed to evolve its own S&T policy that is 'deeply rooted in the Indian ethos of a holistic and interactive approach to human nature and development'. Requiring urgent attention were areas such as health, education, water sanitation, energy and employment, whilst drawing on the emerging technologies such as nano materials, genomics, MEM's, etc. The meeting also felt that S&T should serve as an instrument to bridge the divide between the urban and the rural, between agriculture, industry and services, and between genders. It was also felt that participation of women scientists, especially at policy levels needed to be enlarged.

The much neglected universities were now recognized by the participants of

the meeting to be 'nurseries of S&T talent'. Concern was voiced on the 'decline in governance of the universities and a need expressed to re-integrate the universities into the mainstream of S&T development activity'. Other topics that came up for discussion were the promotion of the culture of innovation, product and technology development, science education and attracting youth to make a career in science. A lacuna was seen in areas outside space, defence and atomic energy where investment in R&D is abysmally low. Examples of such areas are the railways, road, shipping, etc. where safety and building-up of the country's infrastructure are very much at stake.

There was a commonality in thought that India would continue to maintain its strong democratic and spiritual traditions, for it to remain secure not only militarily but also socially and economically. In spite of a broad con-

sensus on the framework, what appears to be a 'stumbling block' is the nitty-gritty of implementation, i.e. an action plan. However, highly placed sources in the Ministry have assured that with the appointment of two 'high-powered committees', the task ahead would be fulfilled in the 'next two months'. One point of direct interest to the S&T community is that this revised draft of the S&T Policy document and action plan would be placed on the World Wide Web to garner comments from all sections of the society. This, it is hoped will be in about three weeks from the 10th of September. The clock is ticking.

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RESEARCH NEWS

Dyslexia and intercultural comparisons

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I had raised two interconnected matters in a previous write-up in *Current Science*¹. If intensive training in phonics does indeed improve the reading skills of dyslexics (as the experimental work Richards, *et al.*² had shown), would there be lesser incidence of the condition in certain population groups in India since those literate in the major Indian scripts receive intensive phonic training anyway? In what manner can statistics be collected in India so that inter-cultural comparisons can be made with data available in the West?

Possibilities of getting some answers may be forthcoming from recent, very interesting, developments in the investigation of dyslexia. The new lines of research have shown that dyslexia can, indeed, be recognized as a neurodevelopmental disorder with universal incidence but, because it can have variable and culture-specific manifestations, certain strategies for its mitigation can be effective.

In a paper presented at the Annual Meeting of the American Association for the Advancement of Science, G. Eden and T. Zeffiro of Georgetown University Medical Center, Washington DC, reported that brain scans reveal that people with dyslexia have a much lower level of activity in one part of the brain compared with people who do not suffer from that condition (summary in homepage of BBC News/San Francisco/Brain scan aid to dyslexics, 16 February 2001). Another part of the brain is seen as being 'plastic'. It could be taught to compensate for the other region's weakness through a programme of intense reading training. This can be taken as confirming, in a way, the results from the study by Richards *et al.*².

In a second development, an international team of investigators addressed the question of cultural diversity of the incidence of dyslexia, looking into its relative prevalence among English, French and Italian speakers³. It had

been known that the condition is rare among speakers of Italian. By contrast, it is said to affect as many as one in six persons in the English-speaking world! (One estimate has it that between 5 and 15 per cent of Americans has some degree of dyslexia. The statement, 'dyslexia is a reading disorder found in about two per cent of school children in the West', appearing in ref. 1, is certainly very much off the mark, on two counts! Estimates vary because of a lack of an objective test. The soon-to-be-published results of Eden, from research supported by a grant from the International Dyslexia Association, may lead to an objective method for early screening for dyslexia using functional magnetic resonance imaging – fMRI.)

According to a comment in *Science*⁴, English is said to consist of '... just 40 sounds, but these 'phonemes' can be spelled, by one count, in 1120 different ways. French spelling is almost as maddening. Italian speakers, in contrast,

need to map 25 different speech sounds to just 33 combinations of letters ...'. While English and French are said to have 'deep orthographies' due to historical influences, Italian is characterized by a 'shallow orthography', having remained 'pure'.

Many difficulties, just of the sort I suggested would be relevant to the Indian context in ref. 1, can be anticipated when one tries to make intercultural comparisons. The international team led by E. Paulesu³ can be said to have gotten round them, partly at least, by selecting university students for the tests – 'people who have served plenty of time in classrooms and do not lack intelligence or will power'⁴. It was really difficult to find 'dyslexics' among Italians of this class – only 18 persons could be diagnosed as having aspects of the disorder from screening 1200 subjects! Positron emission tomography (PET) scans, when the subjects were performing select tasks such as reading strings of letters not recognizable as words, remembering numbers, etc. revealed that, those with symptoms of dyslexia showed less neural activity in a part of the brain vital for 'reading' regardless of the language (for an exact description in appropriate terminology consult ref. 3). All subjects having neurocognitive deficiencies recognizable by PET were equally impaired relative to their controls, in reading and phonological tasks. Compared to normal readers, dyslexics from all three countries showed less activation in parts of the temporal lobe when performing reading tasks. These observations clearly prompted a recognition that there does exist a *universal neurocognitive basis* for dyslexia.

Independent support may be seen in the results of an investigation by another international team⁵ which carried out a genome-wide search for linkages in the genetic make-up of a large Norwegian family (80 members) in which dyslexia 'is inherited as an autosomal dominant trait'. A region was identified as co-segregating with dyslexia. The authors remark that 'isolation and characterization of the newly reported gene (gene *DYX3* on chromosome 2) will provide new and exciting insights into the processes involved in reading and spelling'.

It was further reported in ref. 3 that Italian dyslexics, having the advantage

of a shallow orthography that facilitates reading, performed better than their English and French counterparts. Differences in reading performance appeared, then, clearly attributable to different orthographies. Further research⁶ has given evidence that English-speaking children lag behind Continental ones in acquiring reading skills (homepage of BBC News/Education/Children 'slow' at learning English, 4 September 2001). Paulesu opines that a case could be argued for reforming languages with complex orthographies like English and French, making them easier for people to read.

Such a proposal is not new, by any means. Various types of expansion and modification of the Roman (English) alphabet and spelling (as distinct from modifying the language to suit the orthography!) have been suggested from time to time, including some from India. Following early encouragement by the playwright G. B. Shaw, an 'Initial Teaching Alphabet' (ITA) was tried in the 1960s to 'aid dyslexics and end illiteracy by providing children with a logical spelling system' (homepage of BBC News/Education/Edukashanul lunacie or wizdom, 5 September 2001 and links).

That initiative got nowhere and, in a reaction to Paulesu's call, the British Dyslexic Association said, predictably enough, '... it was unrealistic and unlikely to be taken up ...' (homepage of BBC News/Education/Scientists find cause of dyslexia, 16 March 2001). ITA, hailed as pioneering in its day, never made it to the mainstream, at least partly because children trained in it failed to make the grade to 'correct' spelling as they grew up (they did pass secret notes to one another, however!).

A proprietary remediation method called the 'Lindawood Phonetic Sequencing Program' has been described as effective in 'increasing phonetic awareness among persons with learning disabilities'. Its website (www.lindawoodbell.com) states: 'The sequence of sounds and letters involved in reading and spelling can be verified through additional feedbacks to the brain. The integration of auditory, visual, and motor information enables children or adults to become self-correcting readers and spellers'. An example given in a lead article in *Newsweek* magazine (22

November 1999; text available as a link from the Lindawood–Bell website) illustrates one of the practices: consonants are given names according to the motions involved in making them. 'P' is a 'lip popper', because the lips start together and then come apart.

No doubt, vital concern with the widespread prevalence of dyslexia, especially among English learners/speakers, has caused a ferment deep enough to lead people to consider modifying the script in which English is written and simplifying its spelling as well. Sadly, those engaged in making such attempts have been unaware of or paid scant attention to principles evolved in ancient India some two and a half millennia ago. 'Popping' mentioned above was technically recognized as *sphota*, the 'first burst' that has to precede any utterance.

By the definitions given earlier, Indian methods of writing (orthographies) can only be considered as the 'shallowest among the shallow' or 'the most perfectly transparent'. Truly phonetic (not merely in the negative sense of their being not *representational* in the manner Chinese characters are), they amount, more or less, to setting down one symbol per syllable (e.g. 'beauty' with *five* phonemes, can be represented by just *two* symbols, one for each syllable). Ambiguity is virtually obviated by a method of combining letters in a logical and standardized way, unique to the major scripts of India, derived from principles enunciated in ancient times. These scripts share two important features: they separate the vowels (*svaras*) from the consonants (*vyanjanas*) and organize their 'alphabets' (*aksharamaalaas*) on the basis of anatomy of vocalization. There are different symbols for 'short' (*hrasva*) and 'long' (*dheerga*) vowels (e.g. the *a*'s in 'america') and the diphthongs (*ai*, *au*). The consonants, 'unvoiced' and 'voiced', are labelled and put in tabular form as gutturals (*kanthya*), palatals (*taalavya*), cerebrals (*moordhanya*), dentals (*dantya*) and labials (*oashtya*), with the nasals (*anunaasikas*) classified in the same way; there then are 'half-vowels': *ya* (*taalavya*), *ra* (*moordhanya*), *la* (*dantya*) and *va* (*dantyaushtya*), *three* sibilants: *s(h)a* (*taalavya*), *sha* (*moordhanya*) and *sa* (*dantya*) and the aspirate, *ha* and so on. Such phoneti-

cally sound classification could have been developed only from deep observation aided by analytical ability. Compounding of consonants (forming *samyuktaaksharas*) is achieved in *Devanaagaree* (and *Devanaagaree*-based North Indian) *lipis* (orthographies) by 'uniting' two or more truncated forms of the full symbols and, in some cases, by special representations. In major southern Indian scripts, standardized symbols are employed above and/or below the line of writing (Tamil and Malayalam use a combination of such a procedure and juxtaposition). Vowel 'values' are added by what can be called 'standard extensions'. The merits of this method of phonetic representation (and the grouping and arrangement of the letters that historically preceded it) have been discussed excellently well by both A. L. Basham⁷ and M. Monier-Williams⁸. Evolution of the principles backing it can be dated to a time no later than about 8–7th Century BC, the approximate time of Yaska, the composer of the *Praathishaakhya*s ('explanatory notes' on the oral *Vedic* texts). It deserves nothing less than being ranked as a signal contribution from ancient India, second in importance only to the invention of the decimal place-value system and a symbol (or position) for zero.

An Associated Press item noticed and transmitted to me by V. Gargeya, quotes C. D. Frith, a member of the international team of ref. 3, as saying Spanish, Finnish and Czech are 'dyslexia-friendly'. Japanese, he said, is also easier for children to read because of *its consistency of sounds and symbols* (italics mine). In a personal correspondence, Michio Yano, Director, International Institute of Linguistic Sciences, Faculty of Cultural Studies, Kyoto Sangyo University (Kamigamo-Motoyama, Kita-ku, Kyoto 603, Japan), has informed me that the influence of the Indian system on arranging the letters on the basis of modes of vocalization in the phonetic part of the Japanese alphabet can be dated to about the 8–9th Century AD and traced to a Chinese Buddhist monk who learnt Sanskrit. Something similar is said about the Korean alphabet (*Hunglê*) but datable only to the 14th Century. Such history holds true also for Southeast Asian scripts, especially Thai, from even earlier times.

There cannot be much doubt that, because of its universal incidence, neurocognitive deficiency that leads to the dyslexic condition is present in the Indian population to the same extent as elsewhere, just like red-green deficiency in colour vision. A 17-year-old boy from Mumbai, Jason Fernandes, diagnosed as having dyslexia but realizing he 'wasn't stupid and could do something to help', has set up a prize-winning website to help 'kids with learning disabilities' – 'ldkids' (<http://www.ldkids.f2s.com/index1.html>; see BBC News/South Asia/Net triumph for dyslexic boy, 24 January 2000). I have not been able to determine whether Jason is literate *only* in English and not so in any of the Indian languages (Marathi/Hindi?). The relationships of multilingualism, dyslexia and the learning of 'modern foreign languages' (mostly European) are matters of much intensive investigation (see ref. 6 and vol. 6, issue 1).

The international team of ref. 3 has shown how intercultural comparisons can be made (in a limited way at least) by identifying comparable groups belonging to different cultural settings. However, it remains uncertain whether factors like cultural/economic/status disparities and differences in home environment can be 'smeared out' in the Indian data by selecting some 'neutral' groups like school students or college-goers, those taking technical courses, etc. Groups like these may be expected to have undergone literacy-training, but those lacking it must be removed from other groups like unskilled/skilled workers, trainees for manual jobs, in not particularly intellectually demanding positions. Data gathered from dyslexia tests on subjects selected from such groups (assumed to be physically fit and having normal growth, good health, etc.) may serve immediately for intercultural comparisons within the Indian context. Evolving criteria appropriate for making valid comparisons with Western data may be possible only after interpretations of preliminary data are in. It is necessary to segregate samples unilingual in a given language from multilingual ones. It is a matter of great interest if we find ourselves able to compare an Indian sample unilingual in English with another Indian sample bilingual in English and a major Indian tongue (*with* literacy training in *both*).

Descending from our colonial past and having no choice but to accede to present-day economic realities, we may expect English to displace, over a period of time, even those languages with hoary literatures, extant in India. A majority of young people tends nowadays to remain illiterate in the mother tongue. The deficient and ambiguous method of transliteration of Indian words into the English–Roman alphabet is leading to horrifying mispronunciation of even common 'Indian' words. Increasing use of that alphabet, together with English-type spelling and pronunciation, will surely enhance the 'cultural component' of the incidence of dyslexia, bringing it close to what is found now in the English-speaking world (one person in six, we should remember!).

Can such a dire manifestation be forestalled? The general use of a new script, created by specifically modifying and expanding the Roman script for correct phonetic rendering of written forms of Indian words, could and should be promoted. One may adopt the symbols, designed in the Roman style, already available from ITA, but some additional ones have to be invented (ITA has only 44 symbols, while the need could be 55 or more). Examples of some special requirements for meeting the demands of Indian languages are the Dravidian (*Elamite*) consonant usually rendered as 'zh' (as in '*Tamizh*') of Tamil and Malayalam; the short and long forms of 'e' (as in '*then*' and '*they*') and of 'o' (as in '*one*' and '*bone*'), common in languages of Dravidian origin (short forms are absent in Sanskrit and North Indian languages); the 'f' and soft 'k' (or 'q') of Urdu (as in '*faqeer*' and other words of Arabic/Persian origin), etc. Inversely, a separate symbol needs to be created for *a* in *cat* or *bank*, there being no representation for it in any of the Indian *lipis* (many English words containing that sort of *a* are now in common use in India). There may be other needs. The 'alphabets' of this script (let us call it Indo-Roman *lipi*) *must* be arranged in the manner they are in the major Indian scripts (as described above for *Devanaagaree*) and nothing like 'proper names'¹ should be given to them.

Why should the proposed Indian common script have a basis in the Roman script? That script is serial in

structure, with nothing above or below the line of writing and there are no special representations for adding vowel 'values' or for forming compound consonants. It is easily adapted for cursive writing (the ability to write without lifting the pen off the paper, except for dotting the i's and j's, crossing the t's and adding diacritical marks).

The principles of Indian *lipis* make it nearly impossible to do cursive writing. One is often forced to resort to the use of diacritical marks to represent Indian words properly in the Roman script. If true cursive writing is the goal, the use of diacritical marks must be avoided.

Why should an expansion/modification of the 26-letter alphabet be tried when a similar attempt with ITA did not succeed? The purpose is arriving at a scientific script that combines the merits of *both principles* – juxtaposition, as in the Roman or Semitic script, with the logicity, transparency and exactitude of truly phonetic representation, possible with the Indian scripts. It is easy to create new ASCII (computer) codes for the new extra, non-modifiable, symbols suitable for

keyboards. The primary intention should be the easing of communication among the different linguistic regions of India, without the burden of having to learn different scripts. The Roman-based but expanded alphabet (*Universal Indo-Roman*) would be culturally, linguistically, religiously, regionally neutral.

A highly interesting and important purpose in new research is to compare the efficacy of the two principles of phoneme-formation mentioned above in mitigating the symptoms of dyslexia.

The intention in proposing a new script can never be that scripts distinctive to the various major Indian languages should be displaced. It should be to propagate the use of Universal Indo-Roman as a guide to correct pronunciation, *an adjunct* to the many different scripts in current use in India. A wider recognition of the ancient Indian contribution should be an aim. A widespread manifestation of dyslexia, compounding the already prevalent high rate of illiteracy, may yet be avoided.

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Back to basics: Reflections on refraction

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The first writings on the nature of light date back to Greek philosophers and mathematicians. The law of reflection of light was known to the Greeks.

Elementary textbooks of physics sometimes deal with a simple observation, related to a pencil of light incident on water in a glass tumbler. The pencil of transmitted light looks bent in a direction away from the incident line and the phenomenon is known as refraction. The behaviour of light that gives this image, depends on a property of the medium (water), namely its index of refraction. The higher a material's index, the slower light travels through it, and the more it 'bends'. A beam of light passing from air into a glass slab is deflected by a greater amount in the same direction, as the refractive index of glass is larger than that of water.

This puzzled the ancients for a long time. According to Feynman¹, Claudius Ptolemy (the Greek natural philosopher) made a table of the angles in water (from the normal to water surface) for each of a number of different angles in air. The table was made in 140 AD, but it was not until 1621 AD when finally Willebrord Snell, a Dutch mathematician, found a rule connecting the two angles, although he did not make it public. Referring to Figure 1, the rule is

$$n_1 \sin\theta_1 = n_2 \sin\theta_2, \quad (1)$$

where θ_1 and θ_2 are angles (made by the beam of light with respect to normal to the interface between the two media) in the first and in the second media, respectively. Snell's law states that the sines of the incident and refracted an-

gles θ_1 and θ_2 , should be in the same ratio as the velocities of the light beam in the two media. In other words,

$$(\sin\theta_1/\sin\theta_2) = (v_1/v_2) = (n_2/n_1). \quad (2)$$

We define 'an absolute refractive index' n of a medium; it is the refractive index for refraction from vacuum into that medium. If n_1 and n_2 are absolute refractive indices of the two media, the 'relative refractive index' n_{12} is given by,

$$n_{12} = n_2/n_1 = v_1/v_2. \quad (3)$$

If the speed of light in vacuum is denoted by c , the speed of light in any material will be

$$v = c/n, \quad (4)$$