

RNI No. 53166/92



ISSN- 0974-2433

BREAKTHROUGH

A JOURNAL ON SCIENCE & SOCIETY

Vol.22, No. 2, September 2021

SCIENCE says **No** to **Astrology**



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- * News of India March for Science 2021
- * The Stories That Numbers Tell
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B R E A K T H R O U G H
A Journal on Science & Society

A Quarterly Committed to the Cause of Science, Culture, and Scientific Outlook

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Contents

Breakthrough, Vol.22, No.2, September 2021

Editorial:

The emphasis on 'Indian Knowledge Systems' in the NEP-20204

Cover Articles

- **Our futures lie in ourselves, and not in the stars**

Partha P. Majumder 5

- **The Psychology of Astrology**

Sunil Mukhi7

- **Testing Astrological Claims**

Aniket Sule 10

- **Vedic Astrology or Jyotirvigyan Neither Vedic Nor Vigyan**

Jayant Vishnu Narlikar 14

Students' Section

- **The Stories That Numbers Tell**

Mayukh Chakrabarty20

- **Impact of age as a factor on Secondary Language Acquisition**

Srishti Ghosh27

Organizational News

- **India March for Science 202133**

- **Programmes organized by BSS40**

The emphasis on ‘Indian Knowledge Systems’ in the NEP-2020

The New Education Policy 2020 declares that *“the rich heritage of ancient and eternal Indian knowledge and thought has been a guiding light for this Policy”*. In Section 4.27 it states that knowledge from ancient India will now be included in modern subjects like mathematics, astronomy, philosophy, architecture, medicine, agriculture, engineering, etc. A course on Indian Knowledge Systems will be introduced at the secondary school level also. To facilitate this, Sanskrit will be ‘mainstreamed’ at all levels of the education system and will be linked with teaching the above subjects (section 22.15). Moreover, research on ‘Indian Knowledge Systems’ will be encouraged and funded. Thus, “Indian Knowledge Systems” is being promoted as a key plank of the NEP-2020.

But what is this ‘Indian Knowledge Systems’? The NEP document has left it undefined. However, an international webinar was held at IIT Kharagpur from 6 to 8 November 2020, in which the Minister of Education, Mr Ramesh Pokhriyal, and other government functionaries spoke and laid out the plan. Subsequently, the Ministry of Education asked government institutions to hold discussions on the implementation of NEP-2020 in collaboration with ‘Bharatiya Shikshan Mandal’, and these meetings further clarified the idea.

It transpires that the ruling dispensation perceives an imaginary glorious past of India in which science and technology had advanced far beyond what has been achieved in the 21st century. Aircraft flew around, the internet and television allowed running commentary of wars, development of plastic surgery enabled an elephant head to be planted on a human torso, engineers

could build a 48 km long bridge on the sea. This is what they want students to believe as the knowledge system that existed in ancient India. The Minister of Education announced on the floor of the Parliament that modern science was ‘a child’ compared to the ‘science’ of Vedic astrology and that his government would introduce it in the education system.

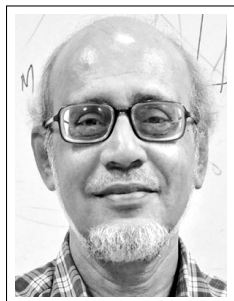
The results followed quickly. In June 2021, the Indira Gandhi National Open University (IGNOU) announced the introduction of a new master’s programme in astrology. While scientists across the country protested against it in unison, the IGNOU Vice-Chancellor, Prof Nageshwar Rao, defended the move by saying that the university has started the astrology course as part of its efforts to promote the Indian Knowledge Systems, as suggested by the New National Education Policy (The Telegraph, 30.06.21).

Breakthrough Science Society organized a number of state level and also a National Convention on July 24 to protest against the introduction of astrology and other unscientific ideas in the education system. The texts of the deliberations are included in this issue of *Breakthrough*.

The signs are ominous. If, behind the talks of overhauling the education system in keeping with the demands of the time, the real agenda is to introduce unscientific ideas systematically, it will mean the death knell for scientific secular and democratic education system in the country. It is the responsibility of the scientific community to come forward individually and collectively to resist these subversive attacks on science and scientific temper. We should be able to pass on science in its full vigour, science in thinking, in culture and in daily life, to our present and future generations if society, mankind and civilisation are to move progressively forward. □

Our futures lie in ourselves, and not in the stars

Partha P. Majumder*



We have assembled today (24th July 2021) to protest against the introduction of a Master's degree course in Astrology (Jyotish) by the Indira Gandhi National Open University (IGNOU). The introduction of this course confers legitimacy to astrology as a scientific discipline. Those who graduate from this programme will propagate astrological predictions with impunity and with legitimacy.

We are protesting because we strongly feel that astrology is not a scientific discipline as it does not follow the method of science. Pseudoscience is being legitimized. I am sure that none of us thinks that this action relating to astrology is a one-off action. Indeed, it is a small part of a concerted action that is aimed to instill a body of irrational thoughts and inaccurate data among citizens. Why this concerted action to promote irrationality?

There is a huge emphasis being placed on the antiquity of our civilization where philosophy, science and technology thrived

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and claims are being made that these migrated to other parts of the world from us. Some of this is true, but some of it is also untrue. Nevertheless, many are striving hard to make people believe that all of it is true. The problem is that initiating any discussion on the veracity of such claims implies automatically that the initiators have an anti-national agenda, that they are not proud of our glorious past and its achievements.

Of course, there is reason to be proud of the contributions of our ancestors in several fields like mathematics, medical science, etc., but to go so far as to say that the cosmetic surgery thrived in ancient India exemplified in Ganesha with an elephant head is surely an overkill. And, the claim that we flew airplanes long before the Wright brothers did is surely a flight of fantasy. But in the atmosphere prevailing, you have to believe what you are told; else, you are not proud of your ancestors and hence you are anti-national. You have to suspend your spirit of questioning.

Our buildings and living spaces have to be Vaastu-compliant. Celebrated as the "science of architecture" that originated in the Vedas, Vaastu has to be followed and a new breed of Vaastu-consultants have arisen to provide us with appropriate guidance.

In these pandemic times, we have seen proliferation of claims of the efficacy of Indian traditional medicines to ward off the SARS-CoV-2 coronavirus. The people who

are making these claims are saffron-robed businessmen who are capitalizing on our people being gullible.

What I am emphasizing is that providing legitimacy to astrology is a part of a larger agenda of pushing pseudoscience as science into the minds of citizens. Astrology has no scientific basis. It does not follow the method of science that comprises setting up of a hypothesis, making predictions arising logically from the hypothesis, collecting empirical data to test these predictions, and concluding whether the hypothesis is strongly likely to be true. Astrology does not follow this process. Therefore, Astrology should not be introduced as a degree course even if by the School of Humanities of IGNOU.

First, let me begin by stating that objections to astrology are not new. Almost fifty years ago, in 1975, a group of 186 scientists including many Nobel laureates (such as, Hans Bethe, Francis Crick, Paul Samuelson, Niko Tinbergen, Peter Medawar, Linus Pauling) published a signed objection to astrology. They wished *“to caution the public against the unquestioning acceptance of the predictions and advice given privately and publicly by astrologers. Those who wish to believe in astrology should realize that there is no scientific foundation for its tenets.”*

In the ancient times, the world view was magical. Planets and other celestial bodies were assumed to exert strong forces on the earth. These forces at birth were assumed to determine the course of our lives. Now that distances between planets and many stars have been calculated, we know that these forces are infinitesimally small to influence us. Shortly after this objection note was issued, the New York Times interviewed many astrologers and carried a news item on its first page on the

September 3rd, 1975, issue.

Diane Gusick of the Astrological Bureau in New York said *“An astrologer who has studied the subject can see planets in certain geometric arrangements and can predict or diagnose the kind of energy available to some humans that will be in effect at a specified time. We have studied the subject and the scientists who made the statement have not.”* Donald Papon, director of the Academy of Mystic Arts in New York, said, *“The debate has been going on for centuries. You can always get a number of scientists to sign a proclamation like this, but there are 50 million Americans very much involved in astrology ... and six universities have had academic courses in astrology.”*

In India, with the initiation of degree courses in astrology, we will soon have thousands of formal graduates. Our citizens will be able to embrace unscientific life-course predictions made by card-holding astrologers. Our citizens will become more irrational and our society more obscurantist.

The objection note that I mentioned before stated a view that resonates well with me. Let me quote:

“Why do people believe in astrology? In these uncertain times many long for the comfort of having guidance in making decisions. They would like to believe in a destiny predetermined by astral forces beyond their control. However, we must all face the world, and we must realize that our futures lie in ourselves, and not in the stars.”

Science stands for rational thought. We as scientists must patiently promote rational thought and protest against irrational thought. But when irrational thought is promoted by the State the struggle becomes a monstrous challenge as it has now become in our country. □

The Psychology of Astrology

Sunil Mukhi*



The world is a difficult place to negotiate, and perhaps becoming increasingly so. Besides our mundane daily problems, all individuals are constantly grappling with eternal questions about human existence. In the latter

class, we all ask ourselves: How do we stay safe and in good health? How do we ensure meaningful relationships? How can we live happily?

Modern science offers some rational answers to these three universal questions. These answers have certain characteristics typical of scientific enquiry: they are complex, they have loose ends, they are incomplete and evolve with time, and they sometimes fail. Modern evidence-based medicine is exactly of this type. Statistically speaking, it is immensely successful and this is based on detailed analyses with proper tools to correct for bias and false interpretation. But as we know, sometimes modern medicine fails to provide a solution, or makes the problem worse, or gets corrected when new information comes along.

Rational answers of this type have to

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compete for the attention of the public with incorrect or irrational answers. These have characteristics that are not commonly found in science: They sound easy, they sound perfect (no loose ends are visible), they appear complete and eternal with no need to ever be corrected, and successes and failures are not properly documented in a bias-corrected way.

As an example from the media, a few months ago the Hindustan Times quoted a self-styled 'astrologer' who has claimed that the world is going haywire because of planet Jupiter. In his words, "Jupiter is not following the cosmic order for the last four years. It is in a fast forward mode." Of course there is no definition provided for "cosmic order", let alone how a planet can choose to follow or not follow it. The catchy phrase "fast forward mode" has been used although it is literally meaningless. The velocity of Jupiter has been studied since the dawn of modern astronomy and certainly there has been no unexplained or sudden change in it at any time.

Why do such absurd statements attract followers and merit publication in the mainstream press? One may surmise that it is a human tendency to pick easy answers and stick with them uncritically. This can variously be ascribed to ignorance—or a lack of education, or to laziness—a lack of genuine curiosity, or even to fear of complex mainstream knowledge and consequently a desire to trust 'outside' authorities.

Human psychology includes a feature

called 'confirmation bias'—the urge to support our initial beliefs by creating more 'evidence' for them¹. Suppose a group of people is shown a vague and generic statement, many in the group will tend to interpret it as being 'personal' and 'unique' about themselves. This is sometimes known as the Forer effect. Commonplace examples are statements like "You have a great deal of unused capacity which you have not turned to your advantage", or "While you have some personality weaknesses, you are generally able to compensate for them." We may be told that something good will happen today, then something good does happen and we take it as a confirmation. Something bad may also happen on the same day, but we conveniently ignore that.

Psychologists identify human personalities as falling between two extreme types: those with an external locus of control (who believe they are subject to forces outside their own influence), and those with an internal locus of control (who believe they are personally in control of their lives). Those closer to the former category tend to believe more in astrology. These are people who "want to fit in" and "believe in a divine order". These are also people who believe in a golden age, past glory etc. Their psychology is to seek external forces or events to which they can hand over control. Typically those at the other end are likely to try and influence their own destiny, and are not unrealistically excited about divine orders or past glories.

As to the motivation for the former personality type, the British philosopher Julian Baggini has suggested that "... people do want to feel they have some agency or control over the future, but on the other,

it's rather frightening to think they have too much". On the appeal of astrology, he points out that "an attractive world view is that there is some sense of unfolding benign purpose in the universe, in which you weren't fundamentally responsible for everything, but were given some kind of control ... and astrology gives us a bit of both, a balance."

A common view is that even if one doesn't take astrology very seriously, there is no harm in "believing a little bit of it". This view is misplaced on multiple counts. The first is that it causes disproportionate harm to the poor. In his book "Astronomy, Pseudoscience and Rational Thinking" eminent astrophysicist Jayant Narlikar has recounted an incident from the year 2000 when there was an unusual (but not unexplained) alignment of planets in the sky, some astrologers predicted tidal waves and other catastrophes. This led the inhabitants of a Gujarat village to abandon their homes, which in turn resulted in looting of their few possessions by opportunistic burglars. More generally, astrology and superstition are often used to manipulate the uneducated into actions against their own interest.

A corollary is that astrological beliefs are actively used to maintain power structures. Indeed, a self-styled 'astrologer' has been quoted as saying "... astrology is more for billionaires than for ordinary public because their stakes are too high." Though it may appear that many rich and powerful follow personages, follow astrological predictions, the word "follow" is rather misused here. Astrology never seems to cause them any genuine inconvenience. It is widely understood that if an astrologer advised against a desired marriage or business deal, a little extra money or change of astrologer can get the desired approval. So it is appealing largely for the appearance

¹I apologise for writing about psychology with no formal training in that field. This article is a series of everyday observations and should not be taken as a rigorous psychological analysis.

Cover Article

of humility and spirituality with which it endows the wealthy user than out of any genuine belief.

People with an “external locus” are an asset to politicians, who would like to control that external locus. Astrology (along with other fake-science beliefs) is a valuable tool for social manipulation by politicians. It also supports broad societal injustice, for example in views like “you are poor because your stars are wrong. I am rich because my stars were auspiciously aligned”. As a concrete example, a Wikipedia page on “Daridra Yoga” suggests that “Affliction caused by cruel planets, by the designated or functional malefics and the Marakas (death inflicting planets) to the 2nd house and its lord and to Jupiter results in poverty of varying degree.”

Finally, a “little bit of astrology” distracts a nation from the important tasks at hand.

India needs more scientists to expand human knowledge and bring about social benefit for all—particularly the most needy. But advertising false past events like “planes that flew backwards” does not actually inspire people to work hard and do good science. On the contrary it invites the lazy response “Our culture is great, therefore I am great, therefore there is no need for me to achieve anything.” Astrology has a similar effect.

It is important for the public to feel excited about the universe out there which holds many genuine mysteries—some already solved, but many yet unsolved and worthy of being studied by modern rational methods. But if the night sky evokes the thought of horoscopes and marriage, and of fear and trepidation at the anger of the Gods, then the motivation for genuine discovery will be lost and the nation will suffer greatly in consequence. □

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Testing Astrological Claims

Aniket Sule*



Whenever any of us try to explain the absurdity of astrology to our relatives or friends, one of the most common arguments presented by the believers of astrology is that not enough research has been done to test the validity of astrology. They feel that scientists are preemptive in their 'blind' opposition to astrology and if the astrologers are allowed time, space and resources, they would produce enough evidence to establish the validity of astrology. But this 'belief' is mistaken. The supporters of astrology are unaware of the research which has already taken place towards testing astrological predictions. In this article, we will review some of the major works in this area.

Before we begin the discussion of actual research, for the benefit of students and non-experts who are not familiar with the terminologies of statistical testing, we should clearly spell out the meanings of some commonly used phrases. In statistical testing, the researcher first defines a hypothesis which will be taken as a default position, unless the study throws strong evidence to reject it. This is called the 'null hypothesis' (H_0). Researchers also

define an 'alternate hypothesis' (H_1) which is typically opposite of H_0 and is likely to become the default explanation, in case the null hypothesis is rejected. Statisticians always present the result of their study as either 'reject H_0 ' or 'do not reject H_0 '. They never recommend to 'accept H_0 ' or 'accept H_1 ', because the evidence provided by any statistical study doesn't establish absolute truth value.

In the same vein, there is always a possibility that the statistical sample which the researchers analysed is freakishly different from the whole population and it can result in wrong conclusions. Thus, rejection or non-rejection of H_0 is recommended with a certain 'Level of Confidence'. Hence a typical conclusion will be framed as 'with the given evidence we recommend with 95% (or 99%) certainty that H_0 can be rejected'. That level of confidence is never 100%. Higher the level of confidence, stronger must be the indications from the data.

Lastly, we should also remember that any test involving human subjects will involve conscious and unconscious mental processes of the volunteers as well as the researchers and this can affect the validity of that test. Even statistical tests are no exception to this. Thus, to minimise the human bias, good studies employ a 'double blind' strategy, i.e., neither researchers, nor volunteers, nor the intermediary persons facilitating the study are given access to full information about a participant's involvement in the study, while the study is in progress.

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Cover Article

To take the example of a vaccine trial, if half the volunteers are supposed to be given the real vaccine and other half just pure water, the volunteers won't know if they got the vaccine or water, the doctors and nurses administering injections will only know that volunteer with code number XXXX was administered injection taken from vial YYYY and the researchers planning the whole study will only know which vials had real vaccine and which ones had water but won't know which volunteer was injected with which vial. At the end of study, the different pieces of data are brought together and then the results are analysed.

If scientists are conducting statistical tests on astrology, they would define the null hypothesis as stating that astrological predictions are just random guesswork, or in other words 'the success rate of astrological predictions is not better than a random chance'. The alternate hypothesis would be 'the success rate of astrological predictions is better than a random chance'. We may define appropriate level of confidence needed to reject H_0 . If we define the level of confidence too low, then there is a high chance that we will interpret randomly occurring events as 'meaningful'. Thus, the level of confidence should be pretty high, which means the success rate of astrological predictions should be significantly higher than the random chance. It is common practice to put the level of confidence at 95% or 99%.

In India, the most famous statistical test of astrology was conducted in Pune (Narlikar et al. 2009). In this study, the researchers collected date, time and location of birth of 200 kids and used it to make birth charts for these kids. The kids were chosen in such a way that 100 kids were high achievers in their academics, whereas other 100 kids were deemed mentally re-

tarded. Thus the two groups could be said to be at opposite ends of the cognitive ability spectrum and no kid was in the middle of the spectrum. The researchers invited astrologers to take 40 birth charts (at random) from these 200 and correctly classify them in two groups, namely 'talented' and 'mentally retarded'. If a group of astrologers e.g. an association approached collectively, they were given the whole sample of 200 birth charts and were asked to classify them in the same way. The experiment was conducted in a double blind manner. Astrologers were given birth charts as well as birth date, time and location (in case they wanted to plot the birth charts independently) but identities of kids were not shared with them. Researchers were not told which birth charts were given to which astrologers, an intermediary facilitated the process.

The results of the study were very revealing. As there are exactly 2 outcomes, we expect 20 out of 40 answers to come out to be correct by pure random guess, e.g. by using a coin toss. The researchers set 99% level of confidence, which would mean that H_0 would have been rejected if any astrologer got 28 (or more) out of 40 answer correct. A total of 27 individual astrologers participated in the challenge. The best score was 24 out of 40 and the average score was 17.3 out of 40. An association of astrologer participated in the challenge as well. For them, the 99% level of confidence would mean they needed to get 116 answers correct (out of 200) to prove validity of astrology. A random coin toss experiment would roughly give you 100 correct answers. The association could only get 102 answers correct. Thus, it was conclusively shown that there is no evidence to reject our null hypothesis, i.e., 'astrological predictions are only as successful as random chance'.

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In western countries, similar tests for astrology have been conducted multiple times in last 70-80 years. One famous study was published in *Journal of Psychology* (Silverman 1971). Bernie Silverman collected horoscopes of 2978 happily married couples and 478 divorced couples and gave them to astrologers with a question 'which of these couples are no longer together?' The answers given by the astrologers were significantly different than reality.

The Carlson test conducted at Berkeley in 1977 is another famous example (Carlson 1985). Carlson was trying to investigate if birth charts indicate general personality or temperament. In the first part of his test, he invited two astrologers to write pen pictures of the personalities of some participants based on their birth charts. Then the participants were given their own pen picture (as written by astrologers) along with two other randomly selected pen pictures and were asked to rank them for match. By random guess you would be right 33.3% of the time. Before the start of the exercise, the astrologers had claimed that at least half of the participants would put their own pen picture at top. At 99% level of confidence as well, you need 48% participants to choose their own pen picture over others to prove the validity of astrology. However, in the actual experiment, only $(33.7 \pm 5.2)\%$ participants could pick the correct pen picture. In second part, the process was flipped. The participants were first assessed using a personality test. Then astrologers were given birth charts and three personality test profiles (one match and two random) and then were asked to rank them. In this case again, astrologers picked the correct personality profile only $(34.0 \pm 4.4)\%$ times.

The Carlson test was hailed for its results and robust process. It was the first double blind test of astrology. However, in later

years, some statisticians (e.g. Ertel 2009) pointed out that applying simplistic success rates criteria when participants were asked a ranked list would not be a good statistical strategy. The notion of 'success' or 'level of confidence' becomes too complex in case of ranked lists. Thus, results of Carlson test may not be as conclusive as he claimed them to be.

Another study conducted in USA (McGervey 1977) tried to investigate "Do Sun-Signs play a role in future career choices?" John McGervey tabulated the birth dates of 16634 scientists and 6475 politicians in New York state and tried to spot patterns, if any, in either of the groups. He noticed that in both group there were systematically more births in summer and less birth in spring. But further investigation revealed that the same pattern was seen in overall birth records of the New York state. Thus, it could be safely ascertained that any seasonal variation was not specific to a given profession. This study could prove that there is no additional likelihood of some child growing up to be a scientist or a politician if he/she is born in a particular sun-sign.

John McGrew and Richard McFall (McGrew & McFall 1990) gave birth charts and full case profiles (career charts, medical histories, photos, etc.) of 23 volunteers to astrologers and asked them to match the case profiles with birth charts. They were also asked to indicate their level of confidence in their match. The astrologer's success rate was again similar to random chance expectation. In addition, one non-astrologer was asked to read the case profiles and assign them a birth chart by guesswork and his success rate was similar to that of astrologers. It was interesting to note that the astrologers had expressed nearly the same level of confidence about the matches which turned out to be correct

and the matches which turned out to be incorrect. Further, matches proposed by any astrologer did not correlate with matched list of any other astrologer.

If astrological predictions are so often incorrect, why do people believe in them? Bertram Forer's study (Forer 1949) may hold an answer. Forer gave all the students in his class a short description of their own personality and asked them to rate it for accuracy. He got the average accuracy score of 4.26 out of 5. Afterwards he revealed that he had given exact same description to all the students in the class. Forer argued that if the statements are vague enough and they address the common complaints people have with the life (e.g. not being appreciated by others, being 'unlucky' etc.) most people will find resonance with at least part of the description and they would tend to believe the rest of it. Variations of this experiment have been tried in many countries and contexts and they have seen similar results. This Forer Effect tells you how astrologers make people think that they have correctly divined their past.

There are many more studies on Astrology. Manoj Komath (Komath 2009) reports that he could find 91 astrology analysis manuscripts online but he estimates that another few hundred studies were conducted between 1940s and 1970s and those manuscripts can only be accessed in print version. A meta-analysis of all these studies showed that most studies conclude that astrological predictions fail any statistical scrutiny. Interestingly, in a few studies a few situations were uncovered where high incidence of their occurrence couldn't be attributed to mere random chance. However, in all such cases, the situations observed were not consistent with the astrological predictions for those celestial combinations.

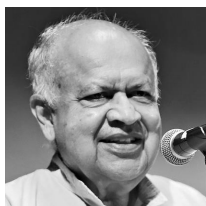
In conclusion, we can say that it is incorrect to say that astrology hasn't got a chance to prove itself. Over last several decades, scientists have tried to test it again and again and every time astrology has failed miserably. It is time astrologers accept this abject failure and concede that there is no scientific basis to astrology. □

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Vedic Astrology or Jyotirvigyan Neither Vedic Nor Vigyan

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In February 2001, the University Grants Commission announced that it was instituting departments of Vedic Astrology in Indian universities and subsequently renamed the courses as 'Jyotirvigyan', as if to underscore their scientific nature. The annexure to the announcement contains details on the objective, scope, courses and their durations. Allowing for the quality of English which would have made professor Higgins turn in his grave, the announcement promised that Vedic astrology is "not only one of the main subjects of our traditional and classical knowledge, but this is the discipline which lets us know the events happening in human life and in the universe on time scale".

There is a common confusion in the lay mind between astrology and astronomy. Let us reassure ourselves that the UGC circular means astrology and not astronomy. Certainly astronomy does not talk of events in human life, nor does it add "new dimensions for research in the fields of Hindu mathematics, vastushastra, meteorological studies, ..." as claimed in the UGC circular. Such claims are made by astrology, defined

by the pocket Oxford English Dictionary as "study of occult influence of stars on human affairs". The pocket OED defines astronomy as 'science of heavenly bodies'.

It is necessary to get this distinction clarified at the outset. For the contention of this article is that Vedic Astrology is neither Vedic nor a Vigyan.

Why Is Astrology Not Vedic

A few years ago, S G Dani had debunked Vedic Mathematics in the pages of this journal (see EPW, vol XXVIII, No 31, p 1577). A lesson to be learnt from that exercise is that one should be very wary of anything declared to be 'Vedic' or of ancient origin. Since India had an oral tradition of transfer of knowledge, there are very few reliable records of what knowledge existed at what ancient age. The situation is thus different from other cultures like China or Arabia or medieval Europe where written traditions existed. What written works we have may (and very well do) contain the 'prakshipta', that is later additions by others than the original creator(s) of the manuscript.

I myself had once been misled by this circumstance. I was very impressed by the verses in *Shukraneeti*, spelling out the employee welfare steps recommended to the employer, such as provident fund, help to the employee's widow, etc. "See how the ancients back in the fifth century had given thought to such modern issues like employer-employee relations" I wrote;

*In 2001, when the UGC sought to introduce 'Vedic Astrology' in the university curriculum, the eminent scientist Prof J V Narlikar wrote this article in the pages of *Economic and Political Weekly* (Vol. 36, No. 24, pp. 2113-2115, 2001). Now that a similar move is afoot, we reprint the article with permission.

only to be corrected by scholars that those verses were inserted much later by someone who simply followed the rules practised by the East India Company!

A survey of Vedic literature does nowhere reveal the notion of nine planets and their supposed influence on human destiny. There are references to omens and also to sacrifices to be performed at different times of the year as determined by the positions of constellations. The seven-day week came to India from the West, from the Greeks through the Arabs. This is related to 'planets' (the sun and the moon were part of these nine planets!). That the concept of occult influence of planets is of European origin is indicated by a shloka from the *Surya-Siddhanta* in which Surya (the Sun god) is telling the asura Maya "to go to Rome (which was symbolic of the Greco-Roman culture), your own city, where, because of a curse of Brahma I will reveal to you this knowledge in the guise of a Yavana (the name given to a foreigner or non-Indian)". The Sanskrit scholar C Kunhan Raja has stated in unequivocal terms: "There is no astrology of Vedic tradition ..." adding that there have been inputs outside the Vedic culture (Survey of Sanskrit Literature, Bombay, 1962, pp 275-277). Alexander's invasion of India in the fourth century BC opened the way for flow of ideas (good or bad!) from Greece to India.

In fact, authentic records tell us more about Vedic astronomy, which involved the observations of stars and constellations, vis-a-vis the Sun and the Moon and their use for time-keeping and calendar-making. There has been controversy here too; with some scholars claiming that all ancient Indian astronomy was essentially borrowed from the West, and other scholars denying this assertion and maintaining that Indian astronomy from the *Vedanga Jyotisha* to

the golden age ranging from Aryabhata I (fifth century) to Bhaskara II (12th century) had developed considerable originality. But all these claims are about astronomy and not astrology.

Indeed, the Greek word 'planet' means 'wanderer', a notion the Greeks had arrived at for planets by long-term observations which showed these heavenly bodies changing their positions relative to the stellar background somewhat arbitrarily. The response to these findings was twofold, one based on astronomy and the other on astrology.

The astronomy component sought to fit the apparently erratic planetary motion within the framework of Aristotelian hypothesis that all natural motions are circular and that the Earth is at rest at the centre of the universe. So here was a challenge to the astronomers of the day: explain the motion of a planet by assuming that the Earth is fixed and the planet moves in a circle. They met the challenge by introducing epicycles, that is a series of circles, each circle in the series having its centre moving on the preceding member in the series, with the planet moving on the last one. It was an ingenious but tedious exercise in what today's physicist would call 'parameter fitting', but was rendered redundant with the emergence of the heliocentric theory of Copernicus, Galileo, Kepler and Newton.

The astrology component, on the other hand, took recourse to assuming that the irregular motion of planets owed its existence to the special power the planets possess which allowed them to move at will. Then followed the next step of believing that this power extended its effect on humans also, by governing their destiny. So here we see some reasons for the origin of astrological beliefs. However, such is the human psyche, that even though today the

planetary motion is fully understood, and it is well established that far from possessing any special power to move at will, a planet moves in a completely predictable fashion bound by the Sun's gravitation, even though man is now able to send space-ships to observe the planets closely, all this factual information has not eradicated the astrological beliefs. In short, while one can understand some logic, howsoever convoluted, in the early beliefs in astrology, there is no logic at all in justifying that belief in the post-Newtonian (post-1685) era of today. Nevertheless later in this article, we will look at a reason as to why there are believers in astrology even today. And this brings us to the second of our questions: Is astrology a science?

Why Is Astrology Not a Science

The scientific community is up in arms against the UGC step not on the issue of its being Vedic or not, but on its projection as a science. Let us first examine the arguments that supporters of astrology make when astrology is rejected as a science. These are usually of the following kind:

- (A) Astrology makes use of the positions of planets obtained by scientific observations, just as astronomy does. So if astronomy is a science, why not astrology?
- (B) There is always someone who has heard of some astrologer whose prediction had come true. For making such correct predictions, shouldn't astrology be credited as being a science?
- (C) Look at meteorology and medicine. Weather forecasts go wrong, medical diagnosis is known to fail, and may vary from doctor to doctor. You regard these subjects as sciences, so why exclude astrology from science?

(D) Some astrologers fail because they are bad practitioners of the subject: it is unfortunate that there are charlatans in the field, whereas the subject itself is fully scientific.

(E) Scientists are an arrogant lot, who have rejected astrology without studying it or testing it.

To deal with these objections, it is necessary to spell out what is required of a subject to be called a 'science'. Science has evolved over the centuries through a process of theorising (T), experimentation (E) and observation (O). The process ideally is cyclical, rather like a winding staircase, where, one goes through the endless process

— T — E — O — T — E — O —

and the rise denotes progress towards a better understanding of nature. In practice, there are many hiccups and wrong turnings. The history of science is littered with falsified theories and misleading experiments or wrong observations. A scientist will be the first to admit this fact. He will also admit that at no time can science claim to have solved everything. Rather, experience has shown that when you progress up the staircase new questions come before you that you were unaware of previously simply because your understanding was not sufficient to grasp them as questions. So what is the strength of what we call science? It is its self-imposed discipline which works in the following way.

A scientific theory must clearly state its basic assumptions, and these must be consistent with the evidence to date. Based on these, it should present a logical framework of arguments leading to falsifiable predictions. The theory should not indulge in tautology, nor should it change its basic tenets each time it is called upon to make a prediction. In other words there

is a uniqueness about its assumptions. The predictions are subject to tests, which require experiments and observations. Now these have a built in objectivity ... it is not the case that only scientist X can find the required result, while scientists Y, Z, ... can't repeat his experiment or observations. The experiment and observations should be designed in a controlled fashion so that their findings can be interpreted by statistical analysis. And with all these safeguards, no theory can claim to be perfect. Newton's law of gravitation was improved upon by Einstein's general relativity; but only after a large number of controlled experiments could this claim be acknowledged. Despite these successes no scientist today believes that relativity represents the last word on gravitation. Quantum gravity lies as the next challenge to be surmounted by any theory claiming to improve on general relativity.

Let us now come to the above comments on behalf of astrology. Take (A) first. Astronomy follows the rigorous discipline of science described above; does astrology do so? Are there a unique set of basic rules for astrology? Is there a logical set of rules for interpreting data that is fully objective and not depend on a specific astrologer? Are failed predictions accepted as disproofs of the theory? The answers to all these questions is "No". Rather, the attitude of supporters of astrology has been that their subject is perfect, and if it fails, it is because it is wrongly interpreted. So does interpretation vary from person to person? How then would you design textbooks for the proposed course or find teachers who agree upon a uniform approach?

Regarding (B), astrologers have probably not heard of Karl Popper, and if they have, they choose to ignore what he said about a scientific theory. The Popperian view is that a scientific theory has to be abandoned if it

fails on a single prediction. Thus successful predictions are necessary but not sufficient for the survival of the theory. If you ask that 'someone' how many unsuccessful predictions that astrologer made, he would not have the answer.

On (C), it is admitted that weather forecasts and medical diagnosis are not perfect; however, these subjects do follow the disciplines of science. In weather forecasting a complex calculation of the various conditions in the atmosphere and even on the ground are involved, with the forces controlling them getting better and better understood. So are the observations of the atmospheric conditions by man-made satellites. Even detractors of meteorology as a science will admit that the quality of weather forecasting has steadily improved because of more sophisticated theory and observations. Medical science also does not claim to be perfect, but as with progress in biology and biotechnology, we understand the human body better, its diagnosis and treatment have consistently improved. It is to be noted that whenever a new drug is put on the market, it is tested under controlled conditions, for several years if need be. Has astrology shown any improvement in its performance with inputs of science and technology?

(D) has already been considered. If the stand is that every time a correct prediction is made, astrology is a science, but a wrong prediction means that the astrologer is a charlatan, then there is no astrologer left who cannot be branded thus. Is it not time that the practitioners of the subject take a critical look at what they preach?

The last criticism (E) is unfair to the considerable body of work that already exists in literature about how scientists have studied and examined astrology and how each and every study conducted to verify the correctness of astrological predictions

has failed to give a positive result in favour of astrology.

Consider by way of example, the study conducted by Bernie Silverman, a psychologist at the Michigan State University to test the astrological claim that matching or compatibility of horoscopes of couples has any bearing on the success or otherwise of their married life. The study picked 2,978 couples who were happily married and 478 who were divorced. Their horoscopes were given to two established astrologers (who were not informed as to whom these horoscopes belonged), to agree between themselves as to which of the horoscopes were compatible and which were not. Their selection and the factual situation had no significant overlap as judged by standard statistical tests.

The statement against astrology issued by 186 distinguished scientists including 18 Nobel laureates in 1975 is explicit in declaring it as unscientific. The following extracts from what they said are self-explanatory:

We, the undersigned—astronomers, astrophysicists, and scientists in other fields—wish to caution the public against the unquestioning acceptance of the predictions and advice given privately and publicly by astrologers. Those who wish to believe in astrology should realise that there is no scientific foundation for its tenets ... In these uncertain times many long for the comfort of having guidance in making decisions. They would like to believe in a destiny predetermined by astral forces beyond their control. However, we must all face the world, and must realise that our futures lie in ourselves, and not in the stars (The Humanist, September/ October 1975).

Why People Like to Believe in Astrology?

The last part of what has been reproduced above explains partly why astrology has survived scientific debunking. It is looked upon as a psychotherapeutic exercise, which brings solace to human mind when confronted with moments of decision-making, sorrow, disappointment, etc. Rather than worry or brood upon difficult issues, it helps to delegate the responsibility to planets, or to someone who claims to interpret their effects. On such occasions logic is the last thing in one's mind.

There is another psychological aspect that goes under the name 'Barnum effect' according to which, from the astrological 'predictions' the human mind picks up selectively those items that apply to the individual and ignores the discordant part. And astrological predictions are frequently worded in such a way that almost everything applies to anybody. (When P T Barnum, the owner of Barnum and Bailey's circus was asked the secret of his success, he replied that his circus contained a diversity of acts and so even if different people in the audience liked different acts, everyone went away satisfied that he or she saw something worthwhile! Hence the name Barnum effect.)

The Barnum effect has been tested on believers and non-believers in astrology. In an experiment, each person from a group was given three word-profiles giving his/her character-sketch, one prepared by an astrologer based on that person's horoscope, another being a similar profile of some other person in the group and the third one a totally synthetic and vaguely worded (Barnum) profile, same one given to everybody. The Barnum profile runs somewhat along these lines; see how far it applies to you:

Cover Article

You have a great need for other people to like you and admire you. You have a tendency to be critical of yourself. You have a great deal of unused capacity which you have not used to your advantage. While you have some personality weaknesses, you are generally able to compensate for them. Disciplined and self-controlled outside, you tend to be worrisome and insecure inside. At times you have serious doubts as to whether you have made the right decision or done the right thing. You prefer a certain amount of change and variety and become dissatisfied when hemmed by restrictions and limitations. You pride yourself on being an independent thinker and do not accept other's statements without satisfactory proof. You have found it unwise to be too frank in revealing yourself to others. At times you are extroverted, affable and sociable, while at other times you are introverted, wary and reserved. Some of your aspirations tend to be pretty unrealistic. Security is one of your major goals in life.

Each group member was asked to rank on a scale of 1 to 5 how well each profile matched him or her. While the average ranking showed no significant distinction between the first two types, each was ranked well below the Barnum profile. This finding tells a lot about the 'authenticity' of astrological profiles and what makes people believe them.

It could be argued that astrology will continue to exist and flourish, just because people seek solace in it and find it an aid to decision-making. However, if man wishes to lay claims to the title of a 'rational animal', then one needs to worry; for there has so far been no rational justification

for astrological statements. Indeed promoting it as part of higher education and encouraging its decision-making process for architecture, weather forecasting, stock market investments, etc., is a giant leap backwards in time. In the West, belief in astrology is more by way of fun, and does not enjoy the stamp of respectability. In our country, it is taken seriously in all walks of society and transcends all divisions with respect to caste, education, income, politics, etc. People consult astrologers for fixing marriages, for inducting ministries, for starting new businesses... In a country, which is trying to catch up on the developed nations, a rational and efficient management of human resources is essential. This could hardly be achieved by making them more superstitious. □

Form 4 (vide rule no. 8)

Statement about ownership and other particulars about the magazine

1. Place of publication: Kolkata
2. Periodicity of publication: Quarterly
3. Printer's name: Ashok Lithographing Co.,
Nationality: Indian
Address: 128 Keshab Chandre Sen St., Kolkata-700009
4. Publisher's name: T. K. Naskar
Nationality: Indian
Address: 8A Creek Lane, Kolkata-700014
5. Editor's name: D. Mukhopadhyay
Nationality: Indian
Address: 8A Creek Lane, Kolkata-700014
6. Ownership: Debashis Ray
Nationality: Indian
Address: 8A Creek Lane, Kolkata-700014

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Date: September 2021 Publisher (T. K. Naskar)

The Stories That Numbers Tell

Mayukh Chakrabarty*

1. More ? Same ? Less ?

We start our story with a simple experiment. In Fig. 1, there are two images of crowded city streets. We want to see if we can answer two simple questions just by having a quick look at the images.

Q1. Which image has more number of people in it ?

Q2. How many people are there in each image ?

It appears that it is difficult to answer these questions. At best, we can say that there are '*many*' people in the images. So, even if we cannot exactly count, we have a sense of quantity. And up to a certain point we can actually recognise the change. So, we see that we possess a sense of quantity even if we are not able to do what we call 'counting'. Anthropological studies and linguistic evidence suggest that this visual sense of numbers extend to a maximum of four in human beings. Beyond four, we unconsciously resort to a technique known only to humans, called *counting*.

Before moving on to further discussions, let us take some examples from the primitive tribes. In Australia, very few from the tribes can distinguish '*four*' and none can recognize '*seven*'. In some African tribes, they have the number words '*one*', '*two*' and '*many*', and even these words



Figure 1: Images of crowds (taken from Google for the purpose of illustration)

are not very articulate. So, it is difficult to understand whether they actually attach some concrete sense to it. What differentiates them from the societies which moved towards '*civilisation*'? This can be attributed to two key developments—domestication of animals and agriculture. These led to the production of surplus and raised the question of who is entitled to the surplus, which, in turn, created the notion of *private property* (this happened over a long time, and it is a story in itself!). This would require the individual to keep precise measure of his private property. These emergent social conditions pushed towards

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Students' Section

the development of a complex counting system.

Numbers, as we see today, could not be the first form. Why do we say this? Take for example the English language. We have words like “pair”, “duo”, “brace”, “couple”, etc.,—each of them describes a collection of size *two*. If there was a well-established idea of *two*, these many variants need not have propped up in our languages. So, clearly, counting could not have begun in the way we are used to count today. The initial idea of counting must have been a crude idea of what we call *one-one correspondence*. To understand this, we need another experiment :

Suppose we have two bags containing some chocolates each. Without counting, we are supposed to compare the number of chocolates. Is it possible? We can simply take a chocolate each from each bag and pair them off. You can easily understand that if a bag had more chocolates, then it will have some chocolates left while the other bag will be empty.

This form of counting lets one have a sense of *same*, *more* or *less*. Let us use this basic idea and see if we can establish the idea of numbers. We shall use the symbol = to mean the two collections are of the same size. We start with the simplest relation :

legs of a crow = hands of a human

The idea is simple. We express the size of the collection on the left hand side as the size of a different collection. In doing so, we forget the physical differences of these objects and treat them as equivalents due to the size of the collections. Suppose, you have no idea what a crow is. The above statement tells you that this thing, called a crow, has as many legs as you

have hands. We must be careful here. The two sides of the = symbol play different roles. The entity on the left side is an entity (here, crow) whose physical features are unknown. On the right side, we have an entity (here, human) whose physical properties are known. So, we are trying to visualise an unknown entity in terms of a known one. The abstract is seen in terms of the concrete. The Bangla language still follows this notion for teaching numbers to kids : “*ek-e chondro, dui-e pokkho, [...] dosh-e dik*” (translation : one moon, two sides, [...] ten directions). Now, we can have as many such simple relations as we want.

The next development would be to find all collections of the same size. So, we will get something like:

$$\text{legs of a crow} = \begin{cases} \text{hands of a human} \\ \text{sides of a river} \\ \dots \end{cases}$$

Let us understand what we have done. We have *determined many collections whose size is same as that of one given collection*. In other words, we have described a certain feature of an unknown entity in terms of known entities. Once again, we can have as many such relations as we want. By now, you should have a question: Is this stage even necessary? Or is it just a futile exercise? Why would one describe a single entity in terms of multiple entities? It is difficult to answer “why” but we do have evidence that this was, in fact, it still is, a practice. Recall the words ‘pair’, ‘duo’, ‘brace’, ‘couple’, etc.—each of them describe collections of equal size.

Our next step would be to recognise a representative from all the collections that would represent the size of all the collections of a given size. We must not think this development was very simple. To quote Bertrand Russell: “*It must have required many ages to discover that a brace*

Students' Section

of pheasants and a couple of days were both instances of the number two". So, we will get something that looks like this :

$$\left. \begin{array}{l} \text{legs of a crow} \\ \text{sides of a river} \\ \dots \end{array} \right\} = \text{hands of a human}$$

At this stage primitive counting begins to develop into a '*counting system*'. And often, this representative is a heap of pebbles, marks on a tree, etc.—a practice still prevalent in some tribes. In fact, the word 'tally' comes from the Latin word *talea*, meaning twig-cutting. The word 'calculate' comes from the Latin word 'calculus', meaning small pebbles. Another common practice is counting on fingers.

So, what we have done is that from all the collections, we have chosen a particular collection. This choice is not special in any way, it is, at most, a convenient choice. So, we may as well choose some new name for this particular collection. In doing so, in representing the concrete by the abstract, we get rid of the limitations imposed by the physical properties of our representative. Moreover, we need no longer explain why we choose that particular representative. We have given a new name, a '*number-word*' to describe the size of the collection. So, at this stage, we have something like

$$\left. \begin{array}{l} \text{legs of a crow} \\ \text{sides of a river} \\ \text{hands of a human} \\ \dots \end{array} \right\} = \text{two}$$

What we have developed so far is an idea of correspondence (cardinal system¹). To create a counting system, we will also need a rule of ordering and succession (ordinal system²). But this development

¹A Cardinal Number says how many of something, such as one, two, three, four, etc.

²An Ordinal Number tells us the position of something in a list, like 1st, 2nd, 3rd, and so on.

happens along with correspondence, the rudimentary qualitative ideas of *more* and *less* matures into very specific quantitative questions "*how much less?*" and "*how much more?*" At this point, we have overcome the need of a concrete model collection. Our abstract system is capable enough to count and shed off all its connection with its concrete origins. And as we shall see in its development over millennia, this abstract system is capable of developing complicated systems that its modest beginnings could never have imagined.

A curious observation is that wherever such a system came up, it was accompanied with finger counting. For the fingers are incredible tools for counting—they can cover both the cardinal and ordinal aspects of the system. It is safe to claim that all these happened much before written history. The modern number words have lost traces of their original meaning, while the words themselves have remained relatively stable. This can happen only if the concrete objects which motivated these number-words have been lost in time without any written records.

2. Much Ado About Nothing

The above discussion has tracked how the idea of *natural numbers* developed. Numbers like zero, negative integers, fractions etc. could not have arisen similarly. In this section, we will discuss the development of the concept of the abstract *zero* that has its concrete roots in *nothing*. We will also see its role in the development of arithmetic from a number system.

It is claimed that written numeration is as old as private property, and it originated from an imperative to keep record of the goods and flocks owned by a person. This was done by means of notches on a tree or marks on clay, etc., and there are archaeological evidences that this was practised

Students' Section

1	I	11	XI	50	L
2	II	12	XII	100	C
3	III	13	XIII	500	D
4	IV	14	XIV	1000	M
5	V	15	XV		
6	VI	16	XVI		
7	VII	17	XVII		
8	VIII	18	XVIII		
9	IX	19	XIX		
10	X	20	XX		

Figure 2: The Roman number system.
Source : Google

by pre-historic humans. Let us not go into specific details of the different number systems developed in the world but let us discuss two specific number systems as representative of the general idea. In the Roman system of numbering (see Fig. 2), we shall see the reflection of the cardinal system. The Roman system uses alphabets to represent larger numbers but it lacks the sense of ordering.

Notice that there is no sense of ordering in the symbols, they merely reflect the size of the collections. Let us take some examples on how to write the numbers :

- $90 \rightarrow XC$
- $299 \rightarrow CCXCIX$
- $1945 \rightarrow MCMXLV$

But now, we ask, what is the following number?

$$XCIX + CCCV$$

In fact, we should ask what is the rule to find the sum of two numbers? it is not at all a trivial exercise to find the sum with these symbols. So, it is clear that this type of number system cannot give rise to arithmetic.

	Units	Tens	Hundreds
1	α alpha	ι iota	ρ rho
2	β beta	κ kappa	σ sigma
3	γ gamma	λ lambda	τ tau
4	δ delta	μ mu	υ upsilon
5	ϵ epsilon	ν nu	ϕ phi
6	f digamma	ξ xi	χ chi
7	ζ zeta	\omicron omicron	ψ psi
8	η eta	π pi	ω omega
9	θ theta	9 koppa	\AA sampi

Figure 3: The Greek number system.
Source : Google

On the other hand, in the Greek system (Fig. 3), we see the reflection of ordinal system. The numbers are represented by alphabets in the order they are spoken.

Notice the ordering. We see the ordinal system at work. The numbers are labelled by letters of the alphabet in the order of succession of the letters. So, you directly know that $4 < 5$ because δ comes before ϵ in the alphabet. How would you write a number? The idea is the same as what we do today. Let us see some examples:

- $60 \rightarrow \xi$
- $400 \rightarrow \upsilon$
- $347 \rightarrow \tau\mu\zeta$

And we notice that we have arrived at a similar problem: We are not able define a set of efficient rules of arithmetic operations. One has to remember a lot of rules to do

Students' Section

the most basic operation of addition, even those that do not require carry over.

But arithmetic operations are necessary during trade. So that cannot be avoided. So what was the way out? We need some other way to do these calculations. And we found the way out by the use of counting boards or abacus. We find such devices almost everywhere where an adequately developed counting technique existed. The construction and counters may vary. For example, in the Indian subcontinent, dust boards were used on which markings were made and then erased, whereas in China, they used perforated beads sliding on bamboo rods, while the Greeks used loose counters, but the working principle remained the same.

This part is extremely interesting and must be observed carefully. Let us talk in terms of the dust board. For every number upto nine, we mark a line in the column. As soon as we reach ten, we mark a line in the next column, and so on. Note how similar this idea is to the modern system of mathematics—to every number we attach a face value and a place value. For example, in 23, 2 has a face value of 2 but a place value of 20, whereas the place value and the face value of 3 is 3. What is more interesting is that it took us more than a thousand years to realise this and to abstract this practice into a system capable of performing arithmetic. Now, in the dust board, a number like 132 will be represented by one, three and two marks in the columns, respectively. But what about 120? We get an *empty column*. If we do not have a symbol for the empty column, 12, 120, 102 will have the same representation. While the Greeks, seeing a new column, defined a new symbol for it, the mathematicians in the subcontinent saw an empty column, and gave it a symbol of its own. This would be adopted

by the Arabs in tenth century and taken to Europe in thirteenth century. There it would start a long fight with the existing counting systems for centuries before being accepted as the norm.

Thus, zero began its journey as *shunya*, meaning empty, merely as a notation of the empty column. In its journey through Arab into Europe, it retained this meaning throughout. It took centuries for zero to get rid of its concrete roots in the empty column and finally become *nothing*. And now, when we ask the question : what is

$$97 + 235,$$

the question can be answered by a six-year old kid of today without the help of any computing devices. Moreover, we have very elementary and specific rules that lets us add any two numbers.

The representation of the empty column thus became the key to the genesis of modern arithmetic which found applications in almost every field of knowledge. But as we have seen, this only happened just five-six hundred years ago. But by this time, human society had already made great progress in geometry as well as number theory. We will devote the next section to how the mysticism surrounding numbers gave rise to the science of mathematics.

3. Rational and Irrational

Many branches of knowledge were born out of mysticism and practices bordering on superstition. For example, alchemy preceded chemistry, numerology preceded mathematics, etc. The mysticism around numbers can be seen in almost cultures. Lucky 7 and unlucky 13 are perhaps the most common examples in the present day. The Babylonians considered 60 and its multiples to be most auspicious numbers. Their number system was in base 60; their gods were associated with numbers upto

Students' Section

60, representing their place in a divine hierarchy. Another practice arising out of this mysticism was the practice of *gematria*. To each letter, a number is associated. The number of a word is given by the sum of the numbers of its constituent letters. Gematria finds extensive use in various Jewish and Christian texts.

The Pythagoreans, perhaps, took the mysticism to the highest known degree. They believed that the entire universe can be seen through number and form. The natural numbers $1, 2, \dots$ formed the core of this mystical system. They attributed human qualities to numbers. The number 1 was considered the symbol of unity and the origin of all things, because all numbers can be constructed by repeatedly adding itself. Even numbers, being easily divisible, were considered feminine while the odd numbers above 1 were considered masculine. 4, the first perfect square, was considered to symbolise justice. 5, being the union of the first feminine and masculine numbers, was considered the symbol of marriage.

They described friends as the numbers 220 and 284. The factors of 220 are 1, 2, 4, 5, 10, 11, 20, 22, 44, 55 and 110, which add to 284. The factors of 284 are 1, 2, 4, 71 and 182, which add to 220. They called such numbers as amicable numbers. Legend has it that there was a certain prince whose name had the gematric sum 284. He wanted a bride whose name would have the gematric sum 220, for it would mean a match made in heaven.

They had the idea of relation of form and numbers. They had the idea of triangular, square, pentagonal and other polygonal numbers. This meant representing the numbers as dots and arranging them into the polygonal shapes. Except for *square* and *cube* others do not have significance in modern mathematics.

They described *perfect* numbers. In modern terminology, these are numbers which are equal to the sum of its proper divisors. For example, $6 = 1 + 2 + 3$ and $28 = 1 + 2 + 4 + 7 + 14$ are perfect numbers. Other numbers are either *excessive* or *defective* if they are greater or less than the sum of their proper divisors, respectively. These two numbers—6 and 28—play a significant role in biblical references as well : 6 days of creation and 28 days of the lunar cycle. St. Augustine goes as far as to say :

"Six is a number perfect in itself, and not because God created all things in six days; rather, the converse is true. God created all things in six days because the number is perfect."

But the Pythagoreans did not stop here. They further hypothesised that the perfect numbers are even and always end in 6 or 8. Euclid also showed that an even perfect number may be written as $2^{n-1}(2^n - 1)$, when $2^n - 1$ is a prime. The existence of odd perfect numbers were never disproved, nor has any counter-example been provided yet. The other claims have been proven to be true.

In their mysticism, they found that certain numbers, called composite numbers, can be broken down into smaller factors, other than itself and 1. Others which cannot be broken down thus are known as prime numbers. The technique of sieve, attributed to Eratosthenes, is an elementary method to separate the primes and composites. We have a brilliant proof, due to Euclid, that *there is no greatest prime*. The problems on the distribution of primes, or a generating function for primes are still open questions.

But the practice of treating each number as individual and special prevented abstraction and hence hindered the development of a *theory of numbers*.

Students' Section

The Pythagorean geometry saw points as beads on a string. The ratio of lengths of two segments was thought of as the ratio of number of points on the lines. In the dot notation, 1 would be represented by a point. Thus, the *number* and *form* can be translated into one another. Thus, here we can think of the word '*rational*' in two ways—both as ratio of integers and as something logically consistent. This worldview was further strengthened by the import of the 'golden' triangle—the right-angled triangle whose sides are in the ratio 3 : 4 : 5. Later, more such triangles like 5 : 12 : 13 and 8 : 15 : 17 were discovered. And from this triangle, we have the classical theorem: *"In a right-angled triangle, the area of the square drawn on the hypotenuse is equal to the sum of squares drawn on the other two sides"*, which still bears the name of Pythagoras. It is doubtful whether the Pythagoreans had a general proof of the theorem, perhaps they obtained it as an empirical observation. But this observation established an intricate relation between *number* and *form* and further strengthened the Pythagorean worldview of understanding nature through numbers.

The first challenge to this view is credited to Hippasus, a disciple of Pythagoras. He observed that the diagonal of a square could not be expressed as the ratio of two integers. We have an interesting story from Proclus :

"It is told that those who first brought out the irrationals from concealment into the open perished in shipwreck, to a man. For the unutterable and the formless must needs be concealed. And those who uncovered and touched this image of life were instantly destroyed and shall remain forever exposed to the play of the eternal waves."

We have a proof due to Euclid that $\sqrt{2}$ is

irrational, an example of proof by contradiction. The proof is very elegant and, in fact, can be generalised for larger numbers and higher powers. Thus was discovered the *irrational*. Once again, we see that this word carries two senses: a number which cannot be expressed as the ratio of integers and something inconsistent with the Pythagorean logic. But this contradiction led to a great development of geometry in the classical age.

Greek geometry developed around three problems (among others), which remained unsolved for a long time :

- squaring the circle
- doubling the cube
- trisecting an angle

The straight-edge and the compass were considered the instruments of the Gods and these problems had to be solved using these two tools only. The methods and tools of the artisan were considered vulgar and worthy of contempt of the philosophers, who belonged to the aristocracy. This restriction made it impossible to solve these three problems. Each of these problems present us with different irrational numbers which cannot be constructed using these devices, which has been proved by modern mathematics using the tools from field theory. However, these could not be proved by the Greeks, and these appeared as merely *limitations* of their knowledge and intelligence, and not as the *limits* of their methods and tools. This motivated many developments in Greek geometry.

In the Indian subcontinent, we see mathematics take a different route. While the Greeks were obsessed with the concrete, in the subcontinent, we will see an approach more into the abstract, with the use of symbols and the genesis of algebra. But that's a story for another time ! □

Impact of age as a factor on Secondary Language Acquisition

Srishti Ghosh*

Introduction

Psycholinguistics is defined as the study of the relationship between human language and the human mind [1]. It is an interdisciplinary branch of inquiry that spans the fields of linguistics, psychology, neurology, and education.

SLA (second language acquisition) is mostly associated with the production and comprehension of another language after a native tongue has been established. Most children in India are raised in a multilingual environment; however, in certain cultures, it is very common for them to be raised by monolingual parents. Therefore, the question arises, how does language learning and processing differ in these individuals because of the age at which they were introduced to a language that was different from their mother tongue?

Undeniably there is a link between age and language learning. Children are usually considered better at picking up symbolic associations that are required for learning whereas adults easily pick up syntactic rules¹.

However, all humans retain the innate ability to learn a language. According to Noam Chomsky [2], the speed and accuracy with which children comprehend

and generate language must come from a preexisting language apparatus. The idea of “language acquisition device” and “universal grammar” suggests that language is evolutionarily hard-wired into the human brain. Children seem to just “pick up” their first languages without any formal training. This in turn depends on the frequency of a certain linguistic input, which includes phonology², semantics³, syntax⁴, and pragmatics⁵.

Many linguists use the terms language acquisition and language learning interchangeably but they hold different meanings in this context. Language learning occurs through explicit education and training. The individual has to actively and consciously seek to understand the language. Similarly, language acquisition refers to the ability to distinguish a language as a separate entity and pick it up subconsciously through immersion. When formal educational institutions offer courses for languages, it is done to promote language learning, however, when children are raised

²The science of speech sounds including especially the history and theory of sound changes in a language or in two or more related languages.

³The historical and psychological study and the classification of changes in the signification of words or forms viewed as factors in linguistic development.

⁴The way in which linguistic elements (such as words) are put together to form constituents (such as phrases or clauses).

⁵A branch of semiotics that deals with the relation between signs or linguistic expressions and their users.

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¹These rules determine how words are ordered in a sentence in any specific language for it to make sense to the receiver.

Students' Section

in a multilingual culture and “pick up” bits and pieces of all the languages they come in contact with, that’s language acquisition at play.

Age is not the only factor that influences language acquisition. The learner’s affective state, perception of the language, learning techniques, and culture also has an impact on how quickly or efficiently a language will be learned. An individual’s normative script and the frequency with which L2 (second language) is used in their native culture influences the way they learn. It is always more efficient to understand language through applied practice; therefore, the sociocultural element of immersion is very important to encourage fluency in any language.

In this article, we will focus on age and the nature of its influence on linguistic acquisition. The Critical Age Hypothesis claims that there is a fixed, optimal age for learning a language. Before and after this particular period, the rate and efficiency of language learning drastically drops. Accordingly, a critical period is a maturational time period during which some crucial experience will have its peak effect on development or learning [3].

However, since the theory’s initial foundation was established in 1959 by Wilder Penfield and Lamar Roberts, it is crucial to test how relevant it is in modern society. Due to globalization, the rate of acculturation has drastically increased, leading to an increased level of familiarization with other cultures. Since people have more opportunities to first-hand experience different cultures at the same time, it is easier for them to familiarise themselves and pick up certain languages.

Moreover, in recent studies, results indicate that there is a possibility that there are multiple critical periods, i.e., individuals have multiple optimal periods of language

learning that vary on a spectrum. It is also implied that the decline in the ability to learn a language is gradual and happens throughout the individual’s life, in which case, the concept of critical age becomes redundant.

The exploration of age as a factor is particularly important because age affects the socio-cultural associations, education, experience, and the individual’s definition of learning rate and success. Therefore, it affects the way learners approach the whole process of accumulating knowledge when they are young.

The kind of social opportunities and frequency of such events vary with age, which means that the chances of learning the language are also differentiated. The initial exposure to L2 primarily happens within the first few years of a person’s life, usually, when they start going to school; because of this the individual becomes attuned to the language and integrates it into their normative script.

Nature of influence

The theory of a critical period for language acquisition is an exceedingly difficult one to operationalize. Although there is considerable evidence that there is a strong link between age and acquisition of L2, it is hard to establish causality since there are multiple instances where adults can reach native-like language skills and pronunciation if certain conditions are met before they were introduced to the language. In 2019, Dollman, Kogan and Weibmann [4] conducted a study to demonstrate that acquiring an accent-free foreign language becomes less likely after the critical age. The data was taken from a large-scale data set of the sixth wave of the German extension of the Children of Immigrants Longitudinal Survey. Each participants’ German accent was evaluated. As immigration and cultural

Students' Section

integration are at an all-time high, it is important to consider how language acts as a driving force for assimilation. For a lot of immigrants, it becomes essential to sound like the native population to feel any sort of belongingness. The researchers found that children who immigrated to Germany before 10 years of age, could speak fluently and relatively devoid of a foreign accent. Their results supported the critical period hypothesis with respect to the phonological aspects of a language [4]. They also mentioned "exceptional outcomes" in which certain individuals did achieve the same expertise after the age in question. Language aptitude, talent, high verbal ability, general cognitive skills, and language environment were thought to influence and enhance their learning process.

As discussed earlier, the decline in learning ability is gradual and perhaps does not affect all elements of a language; for example, the ability to understand syntactic rules is theorized to remain steady till the age of 18 after which it too declines. Hartshorne, Tenenbaum and Pinker [5] conducted an experiment in 2018 to estimate how grammar learning ability changes with age. The participants had to take an online grammar quiz and a computer algorithm calculated the Euclidean distance between the vector of the subjects' responses and the vector of mean responses for each language and dialect. Results indicated that grammar learning is consistently present throughout childhood and the ability drastically falls after late adolescence [5]. This study is important in the scope of this discussion because it highlights a key problem in the generalization of the Critical Period Hypothesis. According to the researchers working with German immigrant children the critical age for language learning is 10, however, these researchers found that the age of offset came much later.

This contradiction highlights the main issue with the hypothesis itself, measuring language prowess cannot solely be used to study the innate learning ability of an individual. Especially in situations where individuals have different motivations to approach the language, maybe their desire and necessity to learn have more to do with how fluent they will be rather than any inherent presence or absence of talent.

That being said, it is hard for experts to explain the non-nativelike achievement in language acquisition by adults living in areas densely populated by L2 speakers, in some cases when they are married to a native L2 speaker. Length of residence does not seem to correspond with successful learning for people after a certain age even without the consideration of the age of offset. This indicates a clear biological constraint. The maturation of neural pathways in an individual has a direct relationship with their ability to learn and integrate L2 in their life. Granena and Long (2013) identified the timing and scope of maturational constraints on 3 linguistic domains [6]. The first domain was phonology and they found that on an average read-aloud task there was a sharp decrease in the ability of speakers who started learning L2 at the age of 7-15 as compared to speakers who started between ages 3-6. 65 Chinese learners of Spanish and 12 native Spanish speakers were tested using a language aptitude test (LLAMA test). The results indicated that after the critical period, language acquisition became less effective [6].

The second and the third domain (Lexis and collocation, and morphosyntax respectively) followed similar trends of decline in learners who were introduced to the language later, however, domain 2 seemed to have a different timeline for the critical period declining before morphosyntactic ability and after domain 1. This lends

Students' Section

further credence that people have variable propensity to learn elements of our language systems at different ages. One way to understand it would be to break down the different components that contribute to the learning and understanding of any language; the ability to grasp the phonological aspect of it sharply decreases before the ability to understand syntax and grammar does. Therefore, in the previous study by Dollman et al., where fluency and pronunciation were used to narrow down the critical period they found the age of offset to be much earlier than later studies that measured critical periods through the grammatical understanding of language.

The criteria used to evaluate when an individual reaches the age of maturation along with the complexity of the language they are trying to learn plays a huge part in how well they will be able to pick it up. Moreover, phonological similarities with L1 also contribute to a more native-like understanding of the language.

From Theory to Practice

With respect to the research mentioned above, the general trend seems to support the claim of a critical period. If not hard-bound by age restrictions at least a sensitive period where retaining information pertaining to a specific language is easier.

The studies conducted were often cross-cultural and researchers did not consider the effect of cultural variables on the subjects; even the type of learning technique and the teacher available makes a huge difference. One of the major differences between adult learners and children was that they had different perceptions of success and different goals. This affects the way they treat the language. Adults focus on perfecting it so initially, they learn faster than children because they have the drive and the desire to do better. They are better

at picking up grammar and syntax. Children however show considerable potency for phonological elements. They retain the ability to sound like a native speaker throughout because they don't focus on the technicalities for "success".

Research in this area revolves around a particular sample, which decreases its generalizability. Most studies are conducted on immigrants trying to learn English. It fails to take into account the possibility that languages with simpler syntactic methods will be picked up at the same pace by children and adults. Due to the fact that most research is centered around western communities, there is no empirical evidence showing that the critical period hypothesis is universal. The sample is mostly people who have been immersed in that language for some time, so most studies move forward with the assumption that the individual trying to learn L2 will be surrounded by people speaking that; however, it makes the theory very rigid. Without a certain amount of flexibility, the theory will hold no utilitarian purpose and will be reduced to an axiom.

The participants usually have the freedom to explore and understand their L2 as they deem fit. The researchers mostly use questionnaires and personal interviews to test out their proficiency in a certain language. These are very rudimentary measures to check whether L2 acquisition is native-like or not. A study in which they used a panel of expert native speakers [7] concluded that the individuals who learned Hebrew after puberty had achieved native-like accuracy which was indistinguishable from the participants who learned at a younger age. Therefore a discrepancy in results is seen when the studies are conducted in a naturalistic setting as opposed to studies conducted strictly through self-report questionnaires. This implies that

Students' Section

there are methodological flaws that are affecting the research to a great extent and therefore affecting the credibility of the theory itself. This seems to indicate that it cannot be replicated under different conditions using both qualitative and quantitative methods.

The theory initially given by Lenneberg is very speculative. Though evidence has been generated afterwards, the base itself remains unchallenged. So the concept of a critical period remains controversial.

This theory has been received so positively because in most animals there is a positive learning curve with age which peaks during a very specific period during their lives. One example is imprinting on young ducklings which can only be done right after their hatching. Similarly, mating songs and spatial tuning of auditory locations in barn owls can only be acquired during a certain maturation period.

The similarities in our brain structures allow us to extend these observations to human beings and generalize them to a certain degree. Human language acquisition is a biologically constrained behavior. According to Lenneberg, after the cortical lateralization of function, the critical period ends. A stage that is reached in late puberty. This coincides with the age limitations he put. It also explains how language acquisition, which is essentially forming new neural pathways, is more difficult. As the level of lateralization increases, the plasticity of the brain decreases relatively. So it becomes harder to mold our understanding that way.

Moreover, according to Noam Chomsky's theory on language acquisition, children pick up phonetic elements from their environment and lose the ability to produce the speech sounds required for a foreign language. This further illustrates that after a certain age acquiring native-like fluency will be extremely difficult because of the

aforementioned biological barriers. The age at which a particular language is learned is represented differently in the brain. The left hemisphere gets activated for L1 whereas if L2 is learned after the first 7 years the patterns of activation are mostly non-overlapping.

Critical periods in other learning gradually taper down. It doesn't have a sudden decline. The same is observed in this case, however, language learning is most efficient during the early years. The ability to learn another language is permanent but the rate at which it is retained, fluency, and proficiency decrease with age.

Therefore, it stands to reason that in India we should advocate for a curriculum that introduces a second language as early as possible, but definitely before the age of 10. This would ensure an intrinsic understanding of the language in most children, native-like fluency, and pronunciation. Since the ability to learn L2 is inherently present in most children and it is subject to deterioration over time, we should take advantage of the range of age that allows for swift and effective learning. After all, language comprehension is as much a result of formal learning and exposure as it is a consequence of innate ability. The ability must be cultivated and enhanced in order for the child to fully grasp the intricacies of language. Languages are nuanced and have elements that can only be learned through constant use and practice, introduction to L2 at a younger age ensures that the child has plenty of potential and time to explore the language the way they want to; whether it be through visual media, reading or speaking; ideally a balance of all three as it stimulates different skills essential to language learning.

To take advantage of the propensity of children to pick up phonological elements, the formal curriculum should focus on

Students' Section

imparting language through primarily oral means at an early age (around 4-5 years old) and then move on to syntactic rules of the respective language when they are relatively older. This way of teaching might look like creating presentations as a form of a classroom assignment, group discussions and debates, and assessments done via interviews in L2. It enables them to form the neurological pathways and practice the phonetic elements unique to the L2 which in turn ensure native-like fluency and pronunciation. Understanding syntactic rules, however, are complicated for children that young and must be introduced starting from 10 years of age to promote comprehensive knowledge of how the language is structured. The continued oral practice of L2 throughout their early years will help them understand the complex grammatical rules much better. At this point, the combination of written and oral assessments will help the children develop an understanding of the pragmatic links between words, making it easier for them to understand L2 in a contextual sense. The history and etymology of certain words should be introduced in the curriculum later, as it provides important information about their place in the modern vocabulary and culture. Especially for immigrants, it

is important to understand the multicultural roots of most languages and their place in a world that is increasingly becoming aware of the importance of decolonization and cultural determinism. □

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Organizational News

India March for Science, 2021

The India March for Science was held this year throughout the country with a call to the scientific community to actively spread scientific temper among people. Every year the programme is held on 9 August. However, due to the pandemic situation, this year most programmes had to be held online, which were conducted over the period from August 7 to 14.

A brief report of the online and offline programmes organized by the India March for Science (IMFS) Organizing Committees in different states is presented below.

Kerala

On August 14, a convention against the inclusion of astrology and other unscientific ideas in education was organized by IMFS Thiruvanthapuram Organising Committee. Prof. C P Aravindakshan, a well-known science popularizer, presided over the function. Prof. K Pappootty (former president of KSSP and science writer), Dr. Vaisakhan Thampi (Science popularizer and president AASTRO) and Prof P N Thankachan (Secretary, Breakthrough Science Society, Kerala Chapter) were the speakers. K S Harikumar conducted the program and Shaji Albert gave the vote of thanks. About 450 participants attended the program.

On the same day, a virtual march was organised from 5 PM to 6 PM. Pictures of science loving people holding posters and

placards highlighting different slogans were posted in different social media platforms in large numbers.

Karnataka

The Karnataka organising committee organized various programs from August 7 to 9 on the theme “Celebrate Science”. Quiz and Video making contests were conducted in which about 200 children participated from across the state. A webinar on “Joy of Astronomy” was held on August 7. Prof. Jayant Murthy (Senior Professor, Indian Institute of Astrophysics) was the main speaker. On August 8, a Panel discussion was held on “Role of Science & Scientists—Experiences from Indian Scientists’ Response to COVID-19 (ISRC)”. The panel comprised Prof R Ramanujam, Dr Reeteka Sud, Prof Pinaki Chaudhuri, and Ms Varuni Prabhakar (eminent scientists associated with ISRC), and Mr Mauryan (Convenor, IMFS Karnataka). The discussion was moderated by Mr Anil Jagalur (Senior IP Professional and Member, IMFS Karnataka)

Telangana

In support to the India March for Science, the Hyderabad chapter of Breakthrough Science Society held a demonstration program in front of Osmania University Arts block main building. Research scholars, teachers, students and science loving people actively participated in the demonstration.

Organizational News



The demonstration in front of the Osmania University, Hyderabad.

Dr Nathaniel, Professor, Department of Physics, Osmania University, addressed the gathering and expressed concern that even in this modern era people are sticking to old customs, beliefs and superstitions. He appealed to the people to come out of this mindset by integrating science in their day-to-day life.

Shri R Gangadhar, Convener, Breakthrough Science Society, said that education and scientific research have been affected very badly during the lockdown due to the government's apathy. PhD students have lost one-and-half years of research time, but the funding agencies have not yet extended the tenure of Fellowships.

The India March for Science Hyderabad organizing committee organized a webinar on August 9 at 6 PM in association with Jana Vignana Vedika (JVV), Breakthrough Science Society, and OYSTER (an NGO). The main speaker was Dr Ramachandraiah of NIT Warangal. Others who spoke were Dr Sathya (President, JVV), Mr Vara Prasad

(JVV Secretary) and Mr Devarshi Gangaji, BSS. Nearly 150 students, research scholars and others attended the program.

Andhra Pradesh

On Aug 8, the India March for Science, AP organizing committee held an online discussion on the topic 'Stand up for Science'. The speakers were Mr V P Nandakumar, All India vice president, BSS and Mr R Gangadhar, Asst Prof, Stanley Engineering College, Hyderabad. Mr D Suryanarayana Raju, Convener, IMFS AP and Mr Thabrez Khan, co-convener, IMFS AP moderated the discussions.

Chattisgarh

India March for Science organizing committee, Chattisgarh organized an online discussion on "Why India March for Science?" on 7 August 2021 at 4 pm. Dr. Radhakanta Koner (Secretariat member, Breakthrough Science Society, All India Committee), Dr

Organizational News



The demonstration in Ahmedabad, Gujarat.

Renu Nayar (Professor, D P Vipra College, Bilaspur) and Mr Maifuz Ali (Asst. Prof IIIT Raipur) spoke on the various issues raised by IMFS. Many professors, teachers and students participated in the webinar.

IMFS Chhattisgarh also organized various demonstrative programs on 9th August in 6 districts—Raipur, Bilaspur, Dhamtari, Korea, Durg and Gariyaband.

Gujrat

A 'Science Chain' was organized in support of the India March for Science on 9th August, near Gujarat University, Ahmedabad.

Ahmedabad: The Principal, teachers and about 200 students of Shalin Vidyalaya celebrated Science Day in support of the India March for Science on 9th August. They decorated the classrooms with placards of science-related designs and slogans.

Rajkot: On 10th August the Universe Science Forum, in association with Purusharth Edu. Network school in Rajkot district, organized a talk cum interactive session for the 12th class students. The

talk was on "How scientific temper is necessary in every aspect of life". The program was conducted by USF members Kishan Malaviya, Devang Anadkat and Dhairya Vyas.

Gandhinagar: On the occasion of the birth anniversary of Dr. Vikram Sarabhai on 12th August and in support of the India March for Science, USF organised a programme on "Developing scientific temperament through science experiments" at M H Tirthdham High School of Kothi village, Gandhinagar district.

Tamilnadu

On 9 August, an Online March was organized by the IMFS Tamilnadu organizing committee by live streaming of offline events from different districts. The Committee consists of representatives from various science organisations in the state—Tamilnadu Science Forum, Breakthrough Science Society and Newton Science club. The program began at 11 AM with the inaugural address by Dr Uma Ramachan-

Organizational News



The March in Kolkata culminating in front of the statue of Ishwar Chandra Vidyasagar near the Calcutta University.

dran, convener IMFS Tamilnadu. Following this, Prof T R Govindarajan, Retired Professor, Institute of Mathematical Sciences, Chennai, Prof Ramu Manivannan, Dept of Politics and Public Administration, Madras University and Prof R Ramanujam, IMSc, Chennai addressed briefly.

Then the live streaming of offline events from different districts began. In some places participants held placards highlighting the demands of IMFS 2021 and one or two persons spoke about the issues raised by IMFS. In some other places like Thirupattur, Kanyakumari, etc., processions of students, teachers and general public took place. The IMFS offline events took place in Chennai, Kanchipuram, Villupuram, Vellore, Mayiladumthurai, Madurai, Theni, Thirupathur, Salem, Krishnagiri, Ramanathapuram and Kanyakumari covering most parts of the state. Around 500 people, mostly students, teachers and science activists participated.

The program came to an end with a con-

cluding speech by Mr G S Subramanian, Secretary, TNSF. The entire proceeding was coordinated by Prof Sethuraman of TNSF and Prof Yogarajan K of BSS.

West Bengal

The India March for Science programs were held with great fervor in different districts of West Bengal. Brief reports from different districts follow.

Kolkata

On August 9, the IMFS Kolkata Organizing Committee organized a March starting from the main gate of the Indian Institute of Cultivation of Sciences at South Kolkata. When the procession reached gate no.4 of Jadavpur University, Dr. Debabrata Bera (Professor, Jadavpur University) addressed the marchers. The March concluded near the statue of Acharya Prafulla Chandra Ray inside the university campus. Shri Debashis Roy, one of the Vice Presidents of

Organizational News



The demonstration by scholars in front of the Bose Institute in Kolkata.

BSS, laid a wreath at the statue of Acharya Prafulla Chandra Ray and addressed the gathering.

A demonstration was held at the main gate of the Presidency University in North Kolkata on August 9. Dr. Nilesh Maiti, Convener of the India March for Science, Kolkata Organizing Committee, spoke to the participants highlighting the issues raised by IMFS. The procession started and reached the Vidyasagar statue at College Square. Prof Soumitro Banerjee laid a wreath at the statue of Ishwar Chandra Vidyasagar, the pioneer of Indian renaissance and briefly addressed the gathering.

March for Science programs were organized following COVID protocols at Rajabazar Campus of Calcutta University, S N Bose National Center for Basic Sciences, Bose Institute and the Saha Institute of Nuclear Physics, where students and scholars stood with placards around the campus gates.

Paschim Medinipur

The March for Science was held in front of the Medinipur College following the Covid protocols. Numerous science-loving people including professors, teachers, researchers and students participated. At the conclusion of the March, a brief discussion-meeting was held near the Vidyasagar statue. Prof Suresh Chandra Das, former Professor, Dept of Physics, Medinipur College, Prof Prosenjit Acharya, Dept of Geography, Vidyasagar University, Prof Debashish Aich, Dept of Physics, Kharagpur College and Mr Tapan Das, teacher, spoke. Teachers of Pingla College, Narajol Raj College and Medinipur College and teachers of several schools in the city participated in the discussions. Researcher Kaushik Das spoke about how research is being affected very badly during the lockdown due to the government's apathy.

March for Science was held in Belda, West Midnapore district, in which several people including professors, teachers and students participated. Prof Basudev Dhara, Mr Pratap Panda and Mr Anindya Sundar Pal addressed the gathering.

March for Science was held in Sabang town of West Midnapore district. The March was inaugurated by Mr Sharanan Panda. About 30 people including students and teachers of the area participated in the program.

IIT Kharagpur: Researchers organized a demonstrative program holding placards inside the IIT campus.

Purba Midnapur

A procession was taken out in the town of Kanthi from the statue of Birendra Nath Shasmal to the Central Bus Stand. Prof Rumpa Sau inaugurated the March. At the conclusion of the March in Central bus stand, Mr. Asit Baran Pramanik, President

Organizational News



The demonstration in Medinipur town in West Bengal.

of Kontai Science Centre, Mr Tridib Kar and Mr Ranjit Jana addressed the gathering.

A March was held from the Maniktala junction in Tamluk to the Hospital junction. Prof Manas Kumar Maiti inaugurated the march. Teachers Guruprasad Jana, Sumanta Shee and Subrata Giri spoke to the gathering of students, teachers and members of various science clubs.

Howrah

March for Science was organized in front of the Indian Institute of Engineering Science and Technology at Shibpur.

South 24 Parganas

March for Science program was held at Joynagar in South 24 Parganas district. Retired teacher and veteran scientist Shri Sadhan Kundu, teacher Kingshuk and Mr Sauvik Chakraborty spoke.

A protest demonstration in support of the India March for Science was held in front of the Baruipur SDO office. Retired headmaster Kanailal Das, teacher Animesh Halder and Mr Kingshuk Halder spoke in support of the various demands of the March for Science.

Jalpaiguri

March for Science was held in in Jalpaiguri on August 9. The march was inaugurated by Dr. Sougata Karjee, (Associate Professor, Dept. of Mathematics, Sukanta Mahavidyalaya, Dhupguri). The march proceeded from Kadamtala More to Samaj Para More. Science activists, science loving people, teachers and students participated in the program. Science organisations and their representatives who took active part in organizing the program included Light of Science (BSS affiliated), Mr Subhomoy Khan Karmakar of Jalpaiguri Science and Nature Club, Mr. Tulsi Dhar of Jalpaiguri Welfare Organization and Mr. Surjo Kamal Banik of Society for Nature Education and Health Awareness.

Coochbehar

Students in Haldibari and Coochbehar towns participated in a poster demonstration in support of the March for Science.

Uttar Dinajpur

Students in Raiganj University participated in a poster demonstration in support of the March for Science.

Organizational News

Nadia

Students took part in a protest demonstration in support of the March for Science in Krishnanagar.

Purulia

March for Science programs were organized in Purulia town, Bandoyan and Raghunathpur in Purulia district. Many science-loving people including teachers and students participated in these programs.

Darjeeling

Procession and meetings were organized in the Siliguri town by the India March for Science Siliguri Organizing Committee. The procession started from the main gate of Baghajatin Park and ended at the Court Junction area after going through different parts of the town.

Delhi

The India March For Science, Delhi Organising Committee organised a demonstrative program at Jantar Mantar, New Delhi on 10 August, 2021. The program highlighted the problems facing science today in India. Dr. Amitabh Basu, (Retd. Senior scientist, NPL, New Delhi), Prof. Narendra Sharma (Retd. Professor, Zakir Hussain Delhi College, DU), Dr. Vinay Kumar (Associate professor, Zakir Hussain Delhi College, DU and Coordinator IMFS, Delhi organising committee) and several others joined the program. They also addressed the gathering and demanded the people to build up mighty movements against the government's anti-science agenda.

IMFS-Delhi Organising Committee also organized a webinar on 'Introduction of Astrology courses in the Indian Knowledge System' on 14 August 2021. The speakers were Dr. Soumitro Banerjee (IISER-Kolkata), Dr Hamid Dabholkar (Indepen-

dent Medical Practice Professional and son of martyr Narendra Dabholkar) and Dr. Soma Marla (Principal Scientist, Bioinformatics, ICAR, NBPGR, New Delhi). The program was moderated by Dr. Vinay Kumar (Assistant Professor, Zakir Hussain Delhi College, DU, and Coordinator, IMFS-Delhi Organising Committee)

Assam

At the call of the India March for Science, members of a few science organizations in Assam organized various programs in online and offline mode. In Silchar, a demonstrative program was organized in front of the statue of Shahid Khudiram. Members of the science organisations Breakthrough Science Society, People's Science Society, and APJ Abul Kalam Memorial Development Forum joined the program.

The BSS, Jorhat chapter, Sonitpur chapter and Dhubri chapter also observed the day displaying the demands of India March for Science and spread the message among the people.

IMFS – Abroad

Indian students and scholars studying or working abroad have formed an 'India March for Science – Abroad Chapter'. On behalf of the IMFS-Abroad, an online panel discussion on 'The state of research and research scholars' was held on August 8. The panelists were Prof Ramakrishna Ramaswamy (Dept of Chemistry, IIT Delhi and former President, Indian Academy of Sciences, Bangalore), Dr Anindita Bhadra (Associate Professor, Dept of Biological Sciences, IISER, Kolkata), Dr Arghya Das (Post-Doctoral Research fellow, Theoretical Physics, TIFR, Mumbai) and Ms Anita Banerjee (Research Scholar, Biological Sciences, IISER, Tirupati). Another online panel discussion on the topic 'Environmen-

Organizational News

tal Crisis in India' was held on August 14. The panelists were Prof. Dhrubajyoti Mukhopadhyay (Former Professor, Department of Geology, Calcutta University and President, BSS), Dr. Mainak Mandal (Research Scientist, New York University, Abu Dhabi campus).

Haryana

The India March for Science Haryana organizing committee organized a demonstrative program in Rohtak on August 9. An online meeting was also held on the same day evening, highlighting the issues raised by IMFS. The speakers were Mr Chanchal Ghosh, Mr Hemant Shekavath and Mr Harish Kumar.

Sikkim

The IMFS Sikkim organizing committee organized a webinar on 'Women in science' on August 8. The speaker was Ms Dipti B (IT professional, Bangalore).

Tripura

The IMFS Tripura organizing committee organized demonstrative programs in front of the Tripura University, and Bardowali High School, Agartala on 9 August.

Other programmes organized by Breakthrough Science Society

Convention against the introduction of astrology

All India Online Convention against the introduction of astrology and other unscientific ideas in curricula was held on July 24, 2021. Dr Dhrubajyoti Mukhopadhyay,

former professor of Geology, Calcutta University and President, Breakthrough Science Society presided. The speakers were Dr Partha P Majumder, former Director, National Institute of Biomedical Genomics and President, India Academy of Sciences; Dr Sunil Mukhi, former professor, TIFR and Dr Aniket Sule, Homi Bhabha Centre for Science Education, TIFR. These write-ups of the talks are presented in this issue of Breakthrough.

Kerala

Online Science camps for school students have been conducted by the BSS district chapters of Ernakulam, Idukki, Alappuzha and Thiruvananthapuram, Pathanamthitta, Kottayam and Kozhikode during the months of May and June. Nearly 500 students took part in all. School teachers, professors and scientists participated as faculty for conducting the camps.

June 5: World Environment Day was observed with various programs like seminars, quiz programs, essay and photography competitions etc. in different districts – Trivandrum, Pathanamthitta, Kottayam, Idukki, Alappuzha and Ernakulam.

Marie Curie Remembrance on 4th July: Various programs, both online and offline, were conducted by the BSS district chapters of Trivandrum, Pathanamthitta, Kottayam, Idukki, Alappuzha and Ernakulam. The programs included seminars, presentations by students, quiz etc.

BSS Ernakulam chapter has been conducting regular weekly online sessions for students on various topics every Sunday as a follow-up of the science camp. The Astronomy club in Ernakulam is also conducting regular sessions on every Saturday.

Aug 6-9: Hiroshima-Nagasaki days were observed through different programs in Trivandrum, Pathanamthitta, Kottayam,

Organizational News

Idukki, Alappuzha, Ernakulam and Trichur districts.

A webinar on 'Foundational Insights: The Life and Work of Steven Weinberg' was organized on August 22. The speaker was Dr. Sunil Mukhi, Professor, Department of Physics, IISER, Pune.

Assam

June 19 – Webinar on "Tremors of time: How do earthquakes occur?". Speaker: Pritom Sarma, Research Scholar, The Freddy and Nadine Hermann Institute of Earth Sciences, Hebrew University, Jerusalem.

Webinar on "SARS-CoV2 and COVID-19: Where from and whither to" was held on August 21. Speaker: Dr Parimal Misra, Chief Scientist, Dr Reddy's Institute of Life Sciences, Hyderabad.

Haryana

Webinar on 'Origin of life' was held on June 13, 2021. Speaker was Shiva Agarwal, Research scholar, Western Michigan University, USA

Jharkhand

June 6 – Webinar on 'Environment and Natural Calamities'. Speaker: Dr Aaley Ali, Dept of Geography, Karim City College, Jamshedpur.

June 27 – Webinar on 'Evolution of Humans'. Speaker: Prof Abhijit Dutta, Dept of Zoology, Ranchi University.

July 4, Madam Curie memorial: Talk on 'Radioactivity and the life struggle of Madam Curie'. Speaker Prof Satish Chandra Gupta, Retd Director, Institute of Management Studies, Ranchi University.

Webinar on 'Life Struggle of Acharya Prafulla Chandra Ray and Bengal Chemicals' on August 1. Speaker : Shri Debasish Roy, BSS All India Vice President.

Karnataka

J R Lakshman Rao centenary observation: Talk by Dr Soumitro Banerjee on "Science in ancient India – The true achievements" on 22 July.

Maharashtra

The Nagpur unit of BSS organized a webinar on July 4 on 'Astronomy Vs. Astrology' (in Marathi). Speaker: Mitali Damle, Research scholar, University Potsdam, Germany, and member of BSS-Abroad.

Sikkim

Webinar on 'COVID-19 : Facts and misconceptions'. Speaker: Dr Manmath Narwane, Post-doctoral fellow, Dept of Biomedical engineering, National Tsing Hua University, Taiwan and member BSS-Abroad.

Telangana

Webinar on 'Discoveries of Marie Curie and Radiocarbon Dating' on July 6. Speaker: Dr R.Venkatesan, Head, Radiological and Environmental Division, IGCAR, Kalpakkam.

Tamilnadu

The BSS Tamilnadu chapter has been conducting regular weekly sessions on 'Art of learning Science' for the last few months. The sessions included interactive discussions of experts and students so as to develop methods of learning and teaching science in a conceptual manner and with hands on experience. The topics taken were those covered in the school syllabi. This activity is aimed at initiating the BSS science learning centre in due course. So far 23 sessions have been conducted.

West Bengal

Two-day webinar on Indian Knowledge Systems:

A two day Online Seminar was organised on 13-14 February, 2021 on 'Indian Knowledge System'. Total six topics were discussed in four sessions. In the first session Prof. Soumitro Banerjee (General Secretary, BSS and Professor, IISER-K) spoke on 'Science in Ancient India – Reality vs. Myth' and it was presided by Prof. Amitava Datta (President, BSS WB Chapter and retired Professor of IISER-K, JU & CU). The second session was presided by Dr. Debabrata Bera (JU) where Prof. Nabakumar Mondal, an eminent particle physicist and retired professor of TIFR-Mumbai spoke on "Astronomy in Ancient India", and the eminent science writer and retired professor of SINP, Prof. Palash Baran Pal spoke on "New Education Policy and language learning".

In the third session, Mr. Subrata Gauri (Vice President, BSS) discussed the various schools of ancient Indian philosophy. Dr. Parimal Mishra (Dr. Reddy Institute of Life Science) discussed on the topic "Medical Science in Ancient India". The session was chaired by Dr. Nilesch Maity (Working President, BSS WB Chapter). The final session was chaired by Prof. Ayan Banerjee (IISER-K) and Prof. Dhrubajyoti Mukhopadhyay (retired prof. of Geology, CU and President, BSS) spoke on "Ancient Indian Thought in the New Education Policy 2020". Nearly three thousand people attended the sessions.

National Science Day: A well decorated cycle rally was organised in Kolkata from Hazra to Jadavpur 8B Bus Stand to observe the National Science Day (28th February). Nearly 70 students from different science clubs participated in the cycle rally which was inaugurated by Dr. Nilesch Maity, Working President, BSS WB Chapter.

Online workshops on mental health in COVID times:

On 19th June, 2021, an on-line workshop was organised on the growing issues of mental health during the covid situation. Speakers were Dr. Prasanta Kr. Roy (Clinical Psychologist, Institute of Psychiatry, Kolkata), Prof. Partha Pratim Pan (Head, Dept. of Physical Medicine & Rehabilitation, North Bengal Medical College & Hospital) and Mr. Pratap Kumar Nandi (Senior Physiotherapist, North Bengal Medical College & Hospital).

On 27th May, a webinar was organised by the IIT Kharagpur chapter of BSS on "Covid Pandemic and Mental Health Care". Dr. Prasanta Kr. Roy, Clinical Psychologist, was the speaker and the webinar was conducted by Prof. Damodar Maity.

Online COVID Helpdesks organized: An online Covid help desk along with free medical counselling was organised in many districts of West Bengal. A Tele-Clinic was opened in West Midnapore from 17th May onwards and it is still continuing. Masks, sanitizers and detergents were distributed in several places. Similar endeavours were taken in the districts of East Midnapore, Kolkata, Darjeeling, Burdwan, Murshidabad, Nadia, Birbhum, North Dinajpur.

Cyclone relief: Several relief camps were organised in the areas ravaged by super-cycle 'Yaas'. Relief camps were organised at Bhubaneswari Block (7th & 13th June, 3rd & 7th July), Patharpratima Block (11th June, 19th June, 13th July), Kultali Block (21st June), and Gosaba Block (2nd July) of South 24 Parganas. In East Midnapore district, camps were organised at Chandipur Block (2nd June), Tamluk (5th June), Haladia 21 no. Ward (6th June), and Deshapran Block (25th June, 29th June). Volunteers and medical teams were sent to several places. Books and educational materials were also distributed to the needy students in Deshapran Block of East Midnapore.

Science for Society

Science for Man

Science in Thinking

BREAKTHROUGH SCIENCE SOCIETY

A Voluntary Organization Committed to the Cause of Science, Culture and Scientific Outlook

The science organization BREAKTHROUGH SCIENCE SOCIETY (BSS) was started in West Bengal in the year 1995 as a platform to create a new science movement in the country. Since then it has been functioning as a non-profit social welfare organization registered under the West Bengal Societies Registration Act, 1961 with the Registration No. S/86180 of 1996-97. It has now taken the form of an all-India organization, through the All India Science Conference held in Bangalore, 17-19 October 2014.

AIMS AND OBJECTIVES

1. To cultivate and promote scientific outlook and logical faculty of mind to establish a scientific culture in the society; 2. To explain, disseminate and popularize different discoveries and advancements of science; 3. To foster consciousness against unscientific notions, superstitions, fanaticism, communalism, untouchability, casteism and such other orthodoxy; 4. To cultivate the study of history and philosophy of science; 5. To inculcate ethical values and social responsibility in all fields of scientific endeavour; 6. To work towards a scientific education system through devising and introducing correct method of teaching and learning; 7. To fight against the application of science that would cause harm to the society and destruction of humanity. 8. To conduct campaign and movement for a secular, scientific and democratic education policy; 9. To mobilize opinion and to move for the introduction of correct and pro-people government policies in regard to research, development and application of science and technology; 10. To build up movements for the preservation and socialization of natural resources and for protection of environment; and 11. To stand by the people and to provide relief at the time of natural calamities.

ACTIVITIES

We function through Science Clubs, Societies, and Chapters of BSS created in different localities and educational institutions. They take up a variety of activities to pursue the above objectives. Some of these are: (1) Popularization of astronomy and counterposing it against beliefs in astrology (we organized large-scale programmes on the occasion of the Total Solar Eclipse of 1995, 1999, and 2009, the arrival of the Comet Hale-Bopp 1997, Leonid Meteor Shower 1998, Transit of Venus 2004, 2012, etc.); (2) Comprehensive science education through experiments at the school level; (3) Anti-superstition campaigns; (4) Cultivation of the life and struggle of great scientists; (5) Relief works for people affected by natural calamities like flood, earthquake, super-cyclone, tsunami etc.; (6) Scientific agriculture; etc.

Our central office is open every Monday, Wednesday and Saturday from 5 p.m. to 8 p.m. at

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