Probing the Peoples Thought Complex

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GauharRaza[1], Surjit Singh[2], Rajesh Shukla[3]

[1]**Gauhar Raza**
Scientist
National Institute of Science Technology and Development Studies
Dr KS Krishnan Marg, New Delhi-110012
gauhar_raza@yahoo.com

[2]**Surjit Singh**
Scientist
National Institute of Science Technology and Development Studies
Dr KS Krishnan Marg, New Delhi-110012
ssdabas@yahoo.com

Rajesh Shukla
Senior Fellow (Chief Statistician)
National Council of Applied Economics and Research (NCAER)
New Delhi, India
rkshukla@ncaer.com

Abstract[1]

Public Understanding of Science is an area constituted by those scholars who essentially acquired expertise in various established academic disciplines and shifted their attention towards a few specific issues related to the science-society interface. The discipline though recognised as a legitimate area of research has not come out of all its teething problems associated with the formation of any new area.

The mainstay during the first phase of its development were the attitudinal surveys conducted in various countries. The objectives of these surveys were to measure the extent of scientific knowledge, probe public attitude towards science or scientists, and at times simply to explore the level of confidence or lack of confidence that a common citizen had in science. These surveys gradually turned into an important and regular activity in many countries.

The debate that followed the first phase resulted in refinement of methodology, tools and the models of assessment of Public Understanding of Science. The PAUS group at NISTADS, India,

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has since 1989 worked on methodology suitable for carrying out surveys in developing countries. Subsequently, a culturally sensitive model for analyzing the survey data was proposed by the group.

The present article in the first section gives details of the model designated here as the 'cultural model of Public Understanding of Science'. The following sections, in detail, deal with the application of the model on data sets collected by two different organizations in India. The conclusions drawn confirm that the method of measuring cultural distance could be successfully applied to various data sets to draw meaningful inferences.

Introduction

The debate on 'Public Understanding of Science' or 'Scientific Literacy' that started in the mid 1980s has progressively become more intense (Shen, 1975). During the initial phase, large-scale national surveys required development of methodology, probing tools and indicators for measuring 'Scientific Literacy' (Miller, 1998) among the masses (Bauer, Durant & Evans, 1991). The efforts were directed towards developing indicators of Scientific Attitude, Perception, Information and Knowledge prevalent among the public (NRF Report, 2004). On the basis of information and knowledge the public was divided in two broad categories, 'Scientifically Literate' and 'Scientifically Illiterate'. On the basis of attitudes and perceptions people were categorised as 'positive' and 'negative' (Einsiedel, 1994). Most groups that administered survey studies and data analysis engaged themselves in identifying the areas of 'deficit' scientific knowledge or attitude (Miller, 2001).

The outcome of these survey studies was three-fold. Firstly, the national level surveys that scanned citizens' level of scientific knowledge rang alarm bells. Surveys conducted in western countries showed low level of scientific literacy and, therefore, generated public debate. Secondly, the cross-national studies laid the foundation for comparison of the so-called 'scientific literacy levels' prevalent in various countries. However, policy makers and national leadership in the countries, where these surveys were carried out, did not take any serious note of the conclusions drawn from the data analysis. There is no evidence that in any of the countries a radical shift was brought about either in science teaching techniques, curriculum content, communication methods or an increase in expenditure on science and technology sector. Thirdly, the initial efforts led to establishment of a new legitimate area of research.

The second phase started during the first half of the 1990s. The warnings and cautionary notes implied in the conclusions drawn from the gathered data attracted attention of many experts working in various already established fields of investigations. Besides experts working in conventional scientific areas like physics, chemistry (Hewitt, 1995) and biology or modern areas of science (Murriello, 2006) such as environmental science (Morgan & Keith, 1995), bio-technology (Rabino, 1994), experts working in apparently unrelated fields such as law, linguistics, political science (McAllister, 1991), sociology (Pigliucci, 2006), cultural studies, philosophy, etc., started contributing to the debate. Each brought a fresh perspective and contributed to the academic enrichment process.

However, during this period the discourse was mainly centred around analytical models. The implicit and explicit objectives of survey studies, the methodologies, the research tools, the indicators and the conclusions drawn were intensely debated. Each component of the research being undertaken in the area of Public Understanding of Science came under the scanner. The issues and concerns raised during this period are still far from settled. Even the taxonomy is a contested arena. Attitudinal Research, Scientific Literacy, Public Understanding of Science (PUS), PCST, PUSET, and Public Engagement of Science are but a few names that were suggested for this area of investigation.

The above example was chosen not to trivialise the debate but to show that every notion, including the nomenclature, that constituted the discourse, was contested and debated. The underlying parameters and hazy boundaries associated with notions such as science, scientific method, public understanding, attitude, information, knowledge, culture, models of analysis, engagement, are still being pondered upon.

Cultural Distance

The present article is placed in the context of this debate and focuses on cultural distance between science and the peoples' structure of thought. As early as 1991, we proposed that there is a natural cultural distance between science and the people's cultural thought complex. A common citizen's worldview is positioned in her/his cultural locale (Raza, Singh & Dutt, 2002). This distance is a compound function of a set of socio-cultural and economic factors. The authors argued that it is erroneous to pigeonhole a subset of citizens as scientifically illiterate, instead, on the basis of empirical data we have also shown that when a natural phenomenon placed at a large cultural distance is encountered, in the absence of broad scientific knowledge base a non-expert is likely to resort to an extra-scientific explanation (Raza, Singh & Dutt, 2000).

Later, it was shown that these factors could be divided into two broad categories. Social, economic, educational and cultural positioning of an individual constitutes the first category. These factors are extraneous to science and yet they have a bearing on the cultural distance that a common citizen or a cultural group would have from a given scientific notion. The other set of factors, such as life cycle of a phenomenon, its level of complexity, the control that an individual or a collective can exercise over its life cycle and its impact on the life of people play an important role in determining the cultural distance. These factors are intrinsic to the nature of science and determine the cultural distance of scientific phenomenon, episode, issue or a piece of scientific information.

It has been observed that any representative group sampled at the international, national or for that matter regional level is composed of various cultural sub-groups. Though the boundaries of these cultural sub-groups cut across each other and form intersection sets, they are defined by hazy permeable membranes, which offer varied resistance to the propagation of a scientific idea. Their permeability is a function of economic and socio-cultural factors.

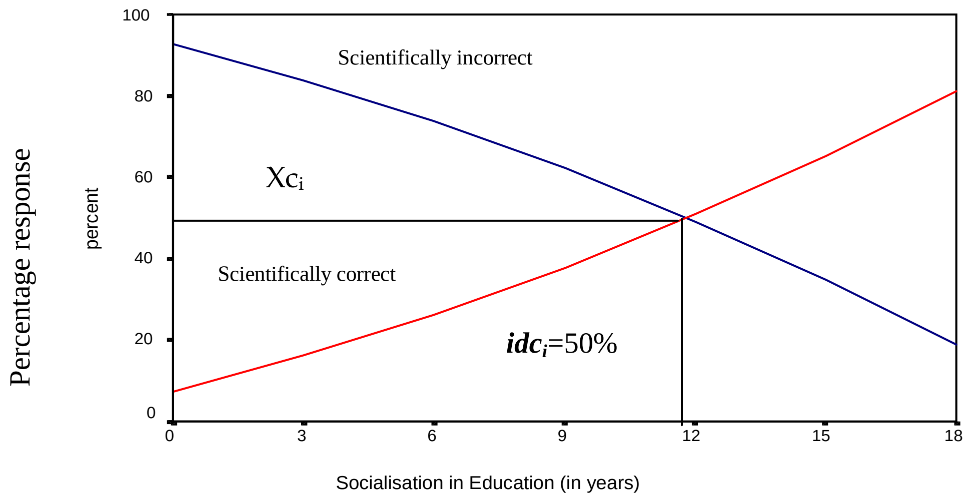
An effort was made to develop a method of empirically determining the cultural distance of a scientific explanation from the quotidian life of common citizens. In this context, cultural distance was defined as the distance that a worldview, attitude, perception, or an idea, generated within one cultural context, travels on a time scale for its democratization within the thought structure of the other cultural sub-group(s). Having proposed a working definition of cultural distance an attempt was made to test the hypothesis that various ideas generated within the scientific realm of thought could be placed at diverse cultural distances from the quotidian life of a set of common citizens.

An Empirical Model for Measuring the Cultural Distance

In 2001, the first two authors of this article presented a simple method for measuring the relative cultural distance of a set of scientific episode, notion, tenet or a piece of information, from the quotidian life of a given cultural group. In the following section some of the salient features are reiterated.

Let us consider a scientific concept *Ci,* which was included for probing the cognitive structure of common citizens during a survey study. A question was formulated and responses were sought from the given set of populace. The varied responses were recorded and a database was constructed. Let us consider that a dichotomous response variable was created, where the first category was constituted by valid scientific answers and all scientifically invalid responses were grouped together to form the second category (see Figure 1). This percentage response variable is plotted on a scale constituted by the years of formal schooling that a respondent has received. For convenience sake, let us call it the *education variable* and plot it on the x-axis. The y-axis characterizes the dichotomous percentage response variable and is represented by two curves, that is, scientifically valid and scientifically invalid responses offered by the populace that was interviewed. Since the response variable is dichotomous, the two curves would always intersect each other at a point where 50 per cent of those who were interviewed offered valid scientific explanations or vice versa.

Figure 1: Cultural distance for an idea C_i



The perpendicular line drawn from this point on the x-axis would show the education level required for the concept or idea or information to become part of the cognitive structure of 50 per cent of the population under discussion. In the region beyond the point where the two curves cross-sect more than 50 per cent of the populace subscribe to the scientific explanation. Let us call this point *Index of Democratization* (***id***) of a concept. An incremental increase in the level of education would mean that more than 50 per cent of the population subscribes to a valid scientific explanation. Conversely, we could say that a piece of scientific information or concept has to travel on the education scale for x number of years to achieve the threshold level ***id*** at a given point of economic and socio-cultural development of the given cultural group (Miller, Pardo, and Niwa 1997).

The idea here is not to establish that socialization in modern education is the only determinant that influences the worldview of a common citizen and that a change in the educational level will bring about an identical change in the worldview irrespective of other factors. It has been established repeatedly that a whole host of factors, external to the nature of scientific information such as gender, occupation, access to non-formal channels of information, economic status, predisposition to cultural and religious activities, and age have a bearing on the worldview of cultural formations and subgroups (Raza, Singh, & Dutt, 1995).

We here propose to develop a scale on which the comparative cultural distance of various scientific concepts and information from the quotidian life of people could be mapped. This helps us measure the distance of the ***id*** on the x-axis from the origin. In most survey studies, the years of schooling that the respondents have attained is recorded as one of the control variables, followed by questions related to indicators of public attitudes toward, and understanding of, science (National Science Foundation, 1998b). Through curve-fitting techniques, any empirical data set collected from the field can be used to determine id_{ci} and the distance χ_{c_i} for each of the questions *ci* posed to the populace. The curve plotted on a two-dimensional graph, that is, response variable versus education, can now be reduced to a one-dimensional plot without loss of information. We could, on an education scale, plot ***id*** for each concept at a corresponding cultural distance *x* and also measure its comparative distance from the quotidian life of the populace that has been interviewed. The larger the distance χ_i for a given natural phenomenon or episode in the first quadrant, the farther would be the phenomenon from the quotidian life of the population segment under scrutiny. Once the actual distances for a set of questions posed to the populace are determined, they could be plotted as bars arranged in ascending or descending order representing the absolute and comparative cultural distance of each concept from the thought complex of the sampled population.

Broad Properties of the Data Sets Used

In the present article we make an attempt to further validate the efficacy of the suggested method. For this purpose the authors have used three data sets. The first and the second data sets were gathered during two surveys conducted at Allahabad, a town in Northern parts of India where a large section of the Indian population had gathered to participate in a religio-cultural event. These samples were collected in the years 2001 and 2007[2]. The third data set was generated as part of a national survey carried out in 2004[3].

The first two data sets collected in 2001 and 2007 predominantly represent North-Central Part of India. Though in the data sets almost all the states were represented, the sample was skewed in favour of three states, Uttar Pradesh, Madhya Pradesh and Bihar. Put together they constituted about 85 and 94 per cent of the sampled population in 2001 and 2007, respectively (See Table 1 & 2). These are the states that score quite low on economic development, education level and health indicator scales. National Census reports have repeatedly shown that in these states majority of people live in abysmal poverty, they are afflicted with low literacy levels and access to health facilities is appalling (Census of India, 2001). It should be pointed out here that these provinces are geographically quite large and are also densely populated, representing about 29 per cent of the total population of India. It could also be argued that people who visited Allahabad during the Kumbh Mela[4] were favourably predisposed towards religious and cultural structures of configuring the natural phenomena.

The third data[5] (CG_2) set represents the national population. Sample respondents, individuals over 10 years of age, were selected by adopting a multistage stratified random sampling design from a wide cross-section of people (age, education, and sex) in the country by covering both rural and urban areas. In view of India's diversity in terms of languages and locations, the sample size and selection procedure were designed to provide state level estimates. A total of about 347,000 individuals (115,000 rural and 232,000 urban) were listed, covering 553 villages in 152 districts as rural and 1128 urban blocks in 213 towns as urban. Over 30,000 individuals were selected from

[2] The two survey studies, conducted in 2001 and 2007 were administered by Gauhar Raza and Surjit Singh, National Institute of Science Technology and Development Studies, India. Partial funds for both the studies were provided by National Council for Science & Technology Communications, Department of Science & Technology, India.

[3] This study was carried out by the National Council of Applied Economic Research, India.

[4] Kumbh Mela is a religio-cultural conglomeration of people at the confluence of two holy rivers of the country at Allahabad (Prayag), held after every twelve years and half Kumbh in between after six years of Kumbh.

[5] The detailed survey methodology, refer Appendix III of India Science Report (Rajesh Shukla, 2005), is available at *www.insaindia.org/India%20Science%20report-Main.pdf*

the listed individuals to collect detailed information using a questionnaire involving face-to-face interviews.

For convenience, the data sets have been placed here chronologically. CG_2 covers 23 states of the country. In order to perform statistical operations representative weighted data was used. Therefore, it could be safely concluded that this data set represents the economic, social and cultural diversities and imbalances that exist across the Indian provinces.

Efficacy of Cultural Model of Public Understanding of Science

At the outset it should be stated that out of all the questions posed to the respondents, 37 figured in the schedules used for administering the three survey studies. Out of these, five questions were chosen for testing the efficacy of the suggested method (see Table 1). These questions were related to the area of physics and cosmology.

Table 1. Questions posed to the respondents

Idea	Question	Concept
C_1	What is the shape of Earth?	Rotundity of earth
C_2	How do day and night form?	Rotation of earth
C_3	What causes eclipse?	Revolution of earth
C_4	What is Akaash Ganga?	Formation of Galaxy
C_5	How did humans come to being?	Theory of evolution

The first objective was to confirm the hypothesis put forward earlier, that for a given cultural group the parameters intrinsic to science influence the cultural distance at which various scientific ideas, notions and explanations could be placed. In order to fulfil this objective, for each data set the values of cultural distance were computed.

All three data sets have shown a fair degree of statistical consistency (Cronbach's alpha values for all three years is more than 0.72). The estimates of skewness, kurtosis and their standard errors are presented in Table 2. These estimates clearly show that the distribution of the characteristics in the population is asymmetric. For instance, the skewness as well as its standard error of the distribution for the three subsequent years 2001, 2004 and 2007 is (-1.09, 0.042); (-0.82, 0.039) and (0.75, 0.040), respectively. This shows that the distribution of the data represented by 2001 and 2007 indicates a huge departure from symmetry. Also a positive value indicates the possibility of a positively skewed distribution (that is, with scores bunched up on the low end of the scale). In 2004, since two times the standard error of the skewness is 0.080 (0.040 x 2=0.080) which is lower than the absolute value of the skewness statistic i.e. -0.82, this implies that the distribution is significantly skewed. Also the ratio of skewness to SE for the three years is 26.02, -20.64 and 18.84. These values further reinforce the above inference. Having examined the statistical characteristics of the data set, the dichotomous curves were plotted for each of the five scientific concepts (see appendix 1, 2 & 3).

In order to determine the precise values of cultural distance X_{C_i}, a dummy variable was created. The aggregate values of $\mathbf{X}_{c\ mean}$ were also computed, through SPSS package, using this dummy variable**.** In 2002, after plotting the dichotomous response graphs, the values of X_{C_i} were computed manually and thus were approximate. This explains the difference between the present values and the earlier reported values X_{C_i} for 2001 data.

The values of cultural distance thus computed clearly showed that the notion 'rotundity of earth' could be placed closest to the quotidian life of all the three cultural groups. These values were -1.0, -1.4 and -2.0 for 2001, 2004 and 2007 (Table 2). The data analysis also revealed that theory of evolution occupies the farthest end of cultural distance scale. The values of cultural distance (X_c) for C_5 were 18.8(2001), 16.5(2004) and 18.0(2007), for the three data sets. The other four concepts occupy places between these two extremes. Measured from the point of origin X_{c3}, i.e. revolution of earth, on the scale occupied third position, its cultural distance from the three sampled populations was 9.1(CG_1), 8.5(CG_2) and 9.1(CG_3). In India, formation of eclipse (C_4) is a phenomenon that is deeply associated with myths, superstitions and religious practices. Therefore, as expected the comparative cultural distance of C_4 from the quotidian life of three sampled sets is large when compared to the previous concepts. The computed values of X_{c4} for CG_1, CG_2 and CG_3 were 12.0, 11.5 and 11.5 respectively.

Table 2. Statistical properties and cultural distance

Estimate	Years		
	2001 (CG_1)	2004(CG_2)	2007(CG_3)
X_{c1} shape	-1.0	-1.4	-2.0
X_{c2} rotation	8.5	5.2	7.1
X_{c3} revolution	9.1	8.5	9.1
X_{c4} galaxy	12.0	11.5	11.5
X_{c5} evolution	18.8	16.5	18.0
$X_{c\ mean}$	9.5	8	9.2
Cronbach's alpha	0.721	0.805	0.749
Standard deviation	5.47	5.47	5.15
Skewness	-1.094	-0.816	0.755
Kurtosis	2.188	1.746	2.10
Standard error (Mean)	0.094	0.032	0.084
Standard error (Skewness)	0.042	0.040	0.040
Standard error (Kurtosis)	0.084	0.079	0.080
Coefficient of variation	0.58	0.68	0.56

The $X_{c\ mean}$ reported in the table are not the simple average of cultural distances but is computed from individual response values recorded in the database.

The assumption that as the phenomena under scrutiny becomes mathematically more complex and far removed from the experiential reach of a common citizen, the cultural distance progressively increases, is further confirmed. And we also conclude that in order to overcome the threshold of index of democratisation, various scientific explanations will have to travel varying degrees of cultural distance. Conversely, in order to travel through the permeable membranes that define boundaries of a cultural grouping or a cultural sub-group, various ideas face varying degrees of resistance (Raza & Singh, 2004). Empirically, this resistance could be measured in terms of cultural distance.

On the basis of the analysis, an assertion can be made that policy makers, educators and communicators of science, keeping in mind the nature of parameters intrinsic to these scientific phenomena, will have to devise and implement effectual strategies so that these explanations become integral components of the cognitive structure of a specific cultural group.

It was apparent that for all three data sets the values of cultural distance consistently increased in the same order. All the five chosen scientific concepts occupied the same relative positions on the cultural distance scale plotted for the three data sets. Thus, it could be concluded that all these concepts could be placed at varying, yet relatively similar, cultural distances from the quotidian life of the populace sampled in all the three data sets. Evidently, in order to democratise, or reduce the cultural distance of the given scientific concepts, similar strategies are likely to prove efficacious for all three sets of Indian populace.

At this stage a word of caution must be introduced. Since all the data sets were collected in India and represent a large segment of the population, the relative position of concepts C_1, C_2, C_3, C_4, and C_5 remains the same. However, it should be pointed out that for a culturally diverse group even the relative position of these five scientific concepts may significantly change. In other words if for a different cultural group (e.g. sampled in a different continent) cultural distances of these very concepts from quotidian life of citizens are computed, C_1 may occupy a diverse relative position vis-à-vis C_2.

Cultural Distance of various Groups from Scientific Concepts

We had also proposed earlier that for a given scientific concept, notion, piece of information or a tenet various cultural groups could be placed at different cultural distances. The data analysis amply reveals that for each of the five scientific concepts the three sample groups could be placed at different cultural distances. From C_1 (rotundity of earth), the cultural distance of data sets CG_1 was at 1.2, CG_2 i.e., national representative was placed at a distance of -1.4 and for CG_3 sample the computed value was -2.0 (see table). Similarly, for C_6 (theory of evolution) these values, respectively, were 18.8, 16.5 and 18.0.

It should be pointed out here that though the national sample was collected four years after CG_1 and three years before CG_3, barring X_{c1}, the cultural distances of CG_2 from all scientific concepts were consistently lower than the other two sets. The reason could be attributed to the change in the nature of the sampled population. When the data was collected at Allahabad during the Kumbh Mela, respondents from many southern, eastern and western sates were either altogether absent or were represented in very low percentages. It has been pointed out earlier that CG_1 and CG_3 predominantly represented the three north Indian states of Bihar, Uttar Pradesh and Madhya Pradesh. Compared to Bihar, Uttar Pradesh and Madhya Pradesh the provinces east, west and south of India are, economically, educationally and culturally far more developed. Some of these provinces have 100 per cent literacy level. Thus, the national data set CG_2 represents a universe that is different from CG_1 and CG_3. In fact, the former two are subsets of CG_2. Several scholars designate the three states that constitute about 90% of the first two cultural groups, as backward states of India. They were sampled on time scale at two different points, 2001 and 2007. The analysis also confirms the hypothesis that the cultural distance of a scientific phenomenon is also determined by a gamut of extrinsic factors such as socio economic conditions, literacy levels, access to media channels, geographical location and caste compositions of the sampled population.

The mean cultural distance computed for all three data sets X_{CG} varied in magnitude. The value of mean cultural distance X_{CG1} was 9.5, X_{CG3} was 9.2 and it was the lowest for CG_2 i.e. 8.0. It clearly suggests that among the three, the national sample (CG_2) is at the lowest cultural distance from the set of five chosen scientific concepts. The sample collected in 2007 at Kumbh Mela scores the second position and the population interviewed at the same site in 2001 occupies the farthest end on the cultural distance scale.

The method also suggests that none of the groups could be categorised as scientifically literate or illiterate, instead they could be placed at varying degrees of cultural distance from a scientific idea or a set of ideas that we may decide to probe during a survey study.

Cultural Distance of Various Provinces

Using the national representative data collected in 2004, values of $X_{ci=1 \text{ to } 5}$ were computed for all the twenty three Indian states. For the present discussion two states from each broad geographic region were selected. Kerala and Andhra Pradesh represent southern parts of the country, Uttar Pradesh and Bihar are located in the North of India, West Bengal and Assam are the eastern states, Delhi and Haryana are situated in the centre and Rajasthan and Maharashtra represent the eastern geographical region. Values of mean Xc_i , for each of these states were also computed (see table 3). Subsequently, all the ten provinces were ranked on the basis of their cultural distance from each of the five selected scientific concepts. They were also ranked in ascending order according to the mean value of Xc_i . Value 1 was assigned for the lowest mean cultural distance and 10 occupied the outermost end. In the following paragraphs an effort has been made to present the salient features of the rank distribution.

The relative position of cultural distance for all the concepts remained the same across each state (Table 3). For all the ten provinces C_1 could be placed at the shortest cultural distance and C_5 could be placed at the farthest end. In between, the value of cultural distance for each concept i.e. C_2, C_3 and C_4, increased progressively. For example, Kerala ranked the first, with a mean value of Xc_i=4.5, the computed values of Xc_1, Xc_2, Xc_3, Xc_4, and Xc_5, for Kerala, were -.0.5, 3.0, 6.2, 6.6 and 7.4, respectively, and for West Bengal which scored 10th position, the respective values were 1.2, 6.3, 8.9, 15.5 and 17.1. This, quite clearly, shows that parameters intrinsic to a scientific notion play a predominantly significant role in determining not only the absolute value but also ascertain its relative position on cultural distance scale.

Table 3. Relative cultural distance of selected Indian states

State	Xc_1	Xc_2	Xc_3	Xc_4	Xc_5	Xc_{mean}
	Shape of Earth	Rotation of Earth	Revolution of earth	Formation of Galaxy	Evolution of mankind	
Kerala	-0.5	3.0	6.2	6.6	7.4	3.5
Rajasthan	0.0	5.0	6.0	7.2	11.0	5.8
Delhi	-2.0	5.2	8.2	9.8	14.2	7.2
Bihar	2.4	5.7	6.8	9.1	16.1	7.2
Haryana	0.5	5.0	6.2	8.5	21.0	6.8
Andhra Pradesh	-0.5	6.8	9.3	10.0	16.9	8.0
Uttar Pradesh	-0.9	4.8	8.0	12.0	19.0	8.4
Maharashtra	2.8	6.2	9.9	12.5	15.9	9.0
Assam	1.8	8.5	11.3	13.5	13.8	9.8
West Bengal	1.2	6.3	8.9	15.5	17.1	9.8

However, it should be noted that the absolute value of cultural distance, for various physical concepts, varies a great deal across provinces. Delhi scored the lowest on cultural distance scale for the concept C_1, i.e. shape of earth, the value of Xc_1 was -2.0, and Maharashtra scored 2.8 for the same scientific notion. Haryana was placed at the largest cultural distance for the theory of evolution, the value of Xc_5, was 21.0, where as, for Kerala the value of Xc_5 was quite low, i.e. 7.4. It is evident that using this empirical model if a cultural sub-group is taken as the reference point, the cultural distance of each phenomenon could be mapped and strategies to bridge the cultural distance for each of the scientific concepts could be devised. It is also evident that scientific notions placed at large cultural distances are not expected to become a part of the peoples' cultural thought through short-term solutions.

It has been pointed out that each state was ranked according to the mean cultural distance and arranged in ascending order (Table 4). Kerala scored the lowest followed by Rajasthan, Delhi, Bihar, Haryana, Andhra Pradesh, Uttar Pradesh, Maharashtra, Assam and West Bengal. However, individual ranking according to different concepts portrayed a detailed picture of the reality.

Table 4. Ranking of states based on cultural distance

State	R_{c1} Shape of Earth	R_{c2} Rotation of Earth	R_{c3} Revolution of earth	R_{c4} Formation of Galaxy	R_{c5} Evolution of mankind	$\boldsymbol{R_{c\ mean}}$
Kerala	4	1	4	1	1	1
Rajasthan	5	4	1	2	2	2
Delhi	1	5	6	5	4	4
Bihar	9	6	3	4	6	5
Haryana	6	3	2	3	10	3
Andhra Pradesh	3	9	8	6	7	6
Uttar Pradesh	2	2	5	7	9	7
Maharashtra	10	7	9	8	5	8
Assam	8	10	10	9	3	9
West Bengal	7	8	7	10	8	10

Kerala, which scored the first position on the mean cultural distance distribution scale, occupied fourth position when it was ranked according to its cultural distance from C_1 and C_4. Conversely, if we take a scientific concept as the reference point, then various states, taken here as cultural subgroups, could be placed at varying degrees of cultural distance. For example, in order to democratise the notion of revolution of earth (C_3), cultural subgroup represented here as Kerala (R_{c3} =4) will have to travel a longer cultural distance compared to the population of Rajasthan (R_{c3} =1), Haryana (R_{c3} =2) and Bihar (R_{c3} =3).

If we take C_5 i.e. theory of evolution as the reference point, the relative positions of various states change significantly. Kerala occupies the first rank, a position that represents shortest cultural distance, followed by Rajasthan ($\boldsymbol{R_{c\ mean}}$ *=2*). Haryana and Bihar, moved to the 10^{th} and 6^{th} positions respectively. Thus, we conclude that the strategy to communicate ‘revolution of earth’ or ‘theory of evolution’ to the people of Kerala may not work in Haryana or Bihar. In other words, if a scientific notion is to be democratised among a cultural subgroup, specificities of their cultural-cognitive-structure will have to be taken into account.

1.

Comparative Shift in Cultural Distance

Having, pointed out that the national scientific awareness level is higher than the scientific awareness level of the north Indian population, we now move on to discuss shift in cultural distance observed over a period of six years. For this we have used the samples gathered at two different points on time scale, i.e. in 2001 and 2007, at Kumbh Mela.

In order to compute the shift in cultural distance the following simple equation was used.

$$\Delta Xc_i = \sum Xc_{it2} - \sum Xc_{it1}$$

Where,

ΔXc_i: denotes the shift in cultural distance

t_2: is the latest point of observation on time scale

t_1: is the earliest point of observation on time scale

It should be noted that both polarity and magnitude of ΔXc_i are significantly important. The magnitude denotes degree or extent of shift that has taken place over a time period Δt and the polarity signifies the direction of this change.

The data analysis reveals that in six years values of cultural distance for all the scientific concepts under scrutiny have reduced. Rotundity of earth, which was at a cultural distance of -1.0, in six years, has moved closer to cultural-cognitive-structure of north-central Indian populace, the value of Xc_i computed for CG_3 was -2.0. The magnitude of ΔX_{c1} was -1.0 and it was a significant change. The negative polarity shows that the perception of ‘a round earth’ has moved closer to the cultural cognitive structure of the sampled populace (see Table 5). The computed values of ΔXc_2, ΔXc_3, ΔXc_4 and ΔXc_5 were -1.4, -0.0, -0.5 and -0.8 respectively (Table 5). The negative polarity of shift in cultural distance across the chosen scientific concepts shows that all these notions, though to a varying degree, have moved closer to the peoples' cultural thought structure.

Table 5. Magnitude and polarity of shift in cultural distance

Concepts	Shift
$\mathbf{\Delta X}c_{\mathbf{mean}}$	-0.3
ΔXc_1 shape	-1.0
ΔXc_2 rotation	-1.4
ΔXc_3 revolution	0.0
ΔXc_4 galaxy	-0.5
ΔXc_5 evolution	-0.8

Here we would like to introduce a word of caution: if the observed value of ΔXc_i, is negative, predisposition to draw a conclusion that the scientific awareness level of populace has gone up could be erroneous. While arriving at a conclusion based on aggregate or mean value of the shift in cultural distance ($\mathbf{\Delta X}c_{\mathbf{mean}}$=-0.3), absolute value and the polarity of each ΔXc_i also needs to be scrutinised.

The above analysis shows that though for all the scientific concepts being examined in this article the absolute value of ΔXc_i varies significantly, the polarity of shift in cultural distance consistently remains negative across C_1-C_5. In other words, notwithstanding the apprehensions we have about the phrase '*scientific awareness level*', it could be concluded that during the past six years, in the area of physics and cosmology, the scientific awareness level of the north Indian population has increased. It should be noted that survey studies administered in most countries, including the developed countries, have repeatedly reported 'no significant change' in scientific awareness level. We report with a high degree of confidence that in India, over the past six years, a definite reduction in cultural distance has been observed.

2. Conclusions

It has been repeatedly shown that spaces available to communicate science are sparse and narrow. A recent study shows that television is the most effective medium to communicate science and that too is watched by the target groups only during the leisure time (Cees, Mark, & Ivar, 2006). Therefore, the efficacy of communication needs to be increased. The method presented here is a step towards that direction. It clearly marks the magnitude of cultural distance of scientific ideas from quotidian life of people. Mapping the cultural distances could be used to formulate effectual strategies of communication of science.

On the basis of the analysis conducted, it could be argued that the cultural model of public understanding of science suggested in this article is well grounded in the conceptual frame work that rejects categorisation of the ‘Publics’ into ‘scientifically literate’ and ‘scientifically illiterate’.

The method lends itself to meaningful statistical tests and can be used for determining the relative distance between ‘scientific structures of configuring the reality’ and ‘peoples’ cultural world views’.

The analysis carried out on different cultural data sets leads us to the observation that the cultural model suggested in this article can be effectively used for computing the cultural distance of each of these groups from a given set of scientific notions.

In case time series data is available for a given cultural group, the method can also be used to observe shifts in cultural distance over a period of time. If the public has been observed for a sufficiently long duration, the observations may also lead to prediction of future trends.

Reduction in cultural distance across all five scientific concepts indicates that during the past six years there has been a noticeable increase in the public understanding of science in India.

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Apendix 1 (Graphs for CD)

Apendix 2

Apendix 3