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ARTICLE

Cultural Distance Between Science and Society: Empirical Evidence of Past Thirty years[1]

[1]GAUHAR RAZA & [2]SURJIT SINGH

Former Chief Scientist, CSIR-NISCAIR, New Delhi
Superannuated from CSIR-NISCAIR, New Delhi

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ABSTRACT

Scholars have argued that science communication, like any other form of communication, is a socio-cultural process and should be considered as an interaction of two cultures. The thought structure of individual citizens, and thereby collectives, is shaped through socio-cultural processes (Raza, 2014). As scientific information, laws and theories generated in a far-removed scientific culture percolate and some of the ideas assimilate within the thought complex of the public fast, while others take longer time to get absorbed. This process is a complex function of factors, both extrinsic and intrinsic to the scientific information (Zhu X, 2017). In this article we present the shift in 'relative cultural distance' based on the analysis of data collected during Kumbh-1989, Ardh-kumbh-1995, Kumbh-2001, Ardh-Kumbh-2007, Kumbh-2013 and Ardh-kumbh-2019 at Allahabad over a period of thirty years. The present analysis has been conducted on five issues related to astronomy and cosmology section of the larger survey study, containing questions related to four areas of scientific knowledge, taking socialisation through education as the proxy-scale for cultural distance. It has been observed that there is a noticeable shift in the cultural distance between science and public. The mean cultural distance of astronomy and cosmology has progressively reduced in India.

KEYWORDS: Public understanding, Scientific literacy, Shift, Cultural distance, Kumbh Mela

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Introduction

The multiplicity of the research in the area of Public Understanding of Science (PUS) and its magnitude, both have a direct bearing on tools, methodology, conceptual models and statistical analysis to produce some convincing results. Of late Chinese scholars have contributed to the area significantly (Wu, S. *et al.*, 2018). A cursory scanning of literature shows that the area of PUS is still undergoing a change. Certainly, there is divergence in the research, in the sense that more and more scholars working in traditional areas of scientific investigation, philosophy, sociology, mathematics and education have directed their gaze on the questions which concern the propagation of science to public. However, the conceptual models suggested in the 1980s and in the later three decades have also been scrutinised keenly. The lively discourse has led to convergence and agreement among the scholars. For example, the deficit model has been rejected (Miller, 1998), contextual model has been further developed and of late there has been an intense debate suggesting that science society relationship may be looked at from the perspective of culture of science (Marec, 2018).

In the past thirty years the researchers conducted surveys and started measuring and mapping the level of 'scientific literacy', 'public attitude to science' (Zhongliang, 1991), 'public understanding of science' (Durant, 1992: Bauer *et al.*, 2007), or 'public engagement of science' (Metcalfe and Reidlinger, 2009), and 'scientific temper'. The frequent change of nomenclature on the one hand suggests that the research area still remains surrounded by haziness, and on the other hand, indicates that new conceptual inputs are enriching the debate continually. As the debate on what constitutes PUS progressed, indicators, methodology, conceptual models and even conclusions were put under the scanner (Gregory J 2003).

Indian Contributions

In India, the research on science communication started in the mid 1980s, however, the first survey study was carried out during the Kumbh Mela at Allahabad in 1989 (Raza *et al.*, 1991). Subsequently, survey teams of CSIR, in collaboration with NCSTC (DST), collected data during the Kumbh and Ardh-kumbh

gatherings held over 30 years. The databases constructed in 1989 (Raza *et al.*, 1991), 1995 (Raza *et al*., 1996), 2001 (Raza *et al*., 2001), 2007 (Raza and Singh, 2007), Raza and Singh in 2013 and more recently in 2019, helped us observe the shifts in public understanding of science in India.

The analysis led the research team to propose a conceptual framework called cultural-distance model and further led to the 'Cultural Distance Model' of mapping understanding of science. It was proposed that there exists a cultural distance between the science and the public. An empirical method to determine comparative cultural distance was also suggested. The proposed empirical method suggested acculturation in modern education as proxy for the cultural distance. The sixteen-point normal education scale was extended from minus infinity to plus infinity (Raza *et al*., 2002).

Broad Properties of the Data Sets Used

The data under scrutiny was collected in the years 1989, 1995, 2001, 2007, 2013 and 2019, through face-to-face interviews using a pre-designed interview schedule. The same set of questions without altering language and methodology of posing a question during the interview were used for data collection. The sample – 1989 (N=3404), 1995 (N=2713), 2001 (N=3484), 2007 (N=3686), 2013 (N=4789) and 2019 (N=4808) – was skewed in favour of northern states of the country such as Uttar Pradesh, Madhya Pradesh, Bihar, Haryana. It should be mentioned that all the three data sets collected, though in much less number represented almost all the states of India.

It could also be argued that people who visited Allahabad during the Kumbh Mela were favourably predisposed towards religious and cultural structures of configuring the natural phenomena. The questions used for the present analysis have been tabulated in Table 1. The analysis of cultural distance is not available for 1989.

Preparing Data for Comparative Analysis

The open-ended questions in the form of simple statements (shown in Figure 4) were posed to every respondent. Each question was read out without changing the language and the

responses were recorded in four categories; 'scientifically correct', 'scientifically incorrect', 'extra-scientific' and 'don't know' by the enumerators. Enumerators were extensively trained in categorising a response. However, they were instructed to record a response verbatim in case of any ambiguity. Such responses were later categorised by the research team.

In order to perform statistical tests presented here a bi-variate response variable was constructed. Scientifically valid responses were assigned a value of 'one' and all other responses were grouped and assigned a value 'Zero'. For analysis purpose, out of all independent variables, only age and education level recorded for each respondent could be used as continuous variables. Therefore, these two were candidates for the proxy for cultural distance. It was observed – and has been reported in the past – that education has strong association with all the other independent variables and influence of other demographic factors reflected socialisation in modern schooling. The response versus education and response versus age graphs plotted repeatedly confirmed this hypothesis. Thus, education level was selected as a better choice for proxy.

As reported earlier, using continuous education scale and bi-variate response variable curves were plotted to compute cultural distance of each of the five scientific phenomena. Quadratic Curve estimation facility available in SPSS was used for plotting curves and obtaining values of quadratic constants at 50 percent. Since the response variable was bi-variate, it always intersected at Y=50, therefore it was easy to compute value of X using quadratic equation solver. Value of X so computed for a scientific idea was its cultural distance from the quotidian life of the Indian populace. These values were later used as reference values.

Once the values of cultural distance for each scientific notion was computed these were arranged in ascending order. Other statistical parameters for the two datasets have also been given in Table 2.

Comparative Shift in Cultural Distance

We now move on to discuss shift in cultural distance observed over a period of thirty years. For this we have used the samples

gathered at three different points on time scale, i.e. in 1989 (Kumbh), 1995 (Ardh-kumbh), 2001 (Kumbh), 2007 (Ardh-kumbh), 2013 (Kumbh) and 2019 (Ardh-kumbh), at Allahabad in Northern part of the country.

In order to compute the shift in cultural distance the following 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.

Analysis and Discussion

The values of cultural distances thus computed clearly showed that the notion 'rotundity of earth' could be placed closest to the quotidian life of all the cultural groups. These values (X_{Ci1}=) were 1.0 in 1995 and -2.4 in 2019. It can be observed that being in fourth quadrant the values suggest a substantial decrease in cultural distance. The polarity shows that the perception of 'a round earth' has moved slightly closer to the cultural cognitive structure of the sampled populace (see Table 4). The shift is quite significant and shows that the round earth idea has become part of the thought complex of majority of the Indian population. Here a word of caution is necessary, the next stage of analysis demands normalisation of collected data on demographic parameter so that level of confidence in preliminary result could be improved.

Measured from the point of origin X_{Ci2}, i.e., rotation of earth, on the scale occupied second position, its cultural distance from the sampled populations was 8.9 (1995) and 7.4 (2019). The polarity and the magnitude for ΔXci_2, show a substantial

shift (-1.5 years) towards origin, which indicates further democratisation of this scientific idea.

Revolution of earth for the populations was found to be at a very large cultural distance (CD). Values of X_{Ci3} were 10.6 (1995), 10.8 (2007) but decreased to 8.8 (2019). The plot shows that this idea has also remained in the first quadrant and is placed comparatively farther, vis-à-vis rotation of earth. However, shift shows that during the last 25 years there has been a reduction in cultural distance of the concept 'revolution of earth around sun'.

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_{Ci4} for 1995, 2007 and 2019 were 14.1, 12.4 and 10.7, respectively. The value of $\Delta X ci_4$ shows a big shift towards origin. It could be noted with satisfaction that the efforts of science communicators, which they have made during the past 30 years, have yielded positive results. The scientific explanation of eclipse has become part of the cognitive structure of a large population. In other words, a significantly large population has shifted from the realm of myths and superstitions, associated with eclipse, to scientific explanation, during the past twelve years.

As is the case with other concepts the relative position of theory of evolution, i.e. explanation of 'how did humans evolve' has changed to some extent. It remains at fifth position in this set of indicators. The absolute values of these distances ($X_{\mathbf{Ci5}}$) for the sampled population sets were 22.1 (1995), 21.2 (1995), 19.5 (2007), 20.5 (2013) and 18.2 (2019) (see Table 3). It once again confirms our hypothesis that intrinsic factors, complexity of the phenomenon, its likely impact on existence, control that an individual or collective could exercise and life cycle of the phenomenon influences the cultural distance. It is disturbing to note that the computed value of $\Delta X ci_5$ was positive one year from 1995 to 2013 and decreased by more than three years from 1995 to 2019. The concept during the past thirty years has moved away and then closer from origin in the first quadrant which shows an increase and decrease in cultural distance,

It is quite evident from the data analysis that using the suggested method and conceptual model the values of cultural distances can be computed. However, dissimilar dataset should to be carefully operated upon for a meaningful comparative analysis.

The polarity of shift in cultural distance across the chosen scientific concepts shows that $C_{i1,}$ $C_{i2,}$ $C_{i3,}$ C_{i4} and C_{i5} though to a varying degree, all have moved closer to the peoples' cultural thought structure. The average cultural distance (**$\Delta X ci_{mean} = -2.8$**) in the area of astronomy and cosmology has reduced over a period of thirty years by a factor of 2.8 years.

It is remarkable that on the one hand after privatisation of the media channels, the onslaught of myths, superstitions and religiosity has increased many folds in India. The cutting-edge satellite technology is being used for propagating the most backward anti-science and reactionary ideas in the society. On the other hand, efforts of science communicators, science societies and science NGOs are making a substantial impact. Though gradually, the scientific information is reaching the masses and getting integrated in their cognitive structure of thought (Raza, *et al.*, 2009).

If we analyse the shifts in cultural distance in the country, we can conclude that over thirty years, the scientific area 'astronomy and cosmology' has come closer to the publics' cultural worldview. However, it should be noted that within the area movement of scientific concepts on cultural distance scale is not unidirectional. Some of the scientific concepts, during the period of observation, have moved towards the people's complex of thought and some have moved away during the period. The values of shifts (ΔX) in cultural distance shows that to arrive at effective communication strategies both micro as well as macro level analysis are equally valuable.

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 ($\mathbf{\Delta X c_{mean}} = -2.8$ for the country), absolute value and the polarity of each ΔXc_i also needs to be scrutinised.

Discussion and Conclusions

Notwithstanding the apprehensions we have about the phrase '*scientific awareness level*', it could be concluded that during the past thirty years, the scientific awareness level of the population has increased in India in the area of astronomy and cosmology.

We report with satisfaction that the 'cultural distance model' of analysis has been successfully applied on the datasets. The hypothesis that as the level of complexity increases the relative cultural distance of the scientific phenomenon, tenet or information, from the quotidian life of populace also increases, is confirmed by the analysis carried out on the datasets.

It is also concluded that the language and the expression of a scientific question or statement has a serious bearing on the cultural distance. Therefore, while conducting a survey, constructing instruments of data collection–schedules for interviews or questionnaires–requires careful selection of words.

Authors reiterate the assertion that spaces available to communicate science are sparse and narrow (Cees, Mark, & Ivar 2006). Therefore, the efficacy of communication needs to be increased. The method presented here is a step towards that direction. Using this method the magnitude of cultural distance of scientific ideas from quotidian life of people could be computed. Such mapping of the cultural distances will facilitate formulation of effectual strategies of communication of science to the public.

Table 1: Questions posed to the respondents

Concept	Question	Scientifically Valid Responses	Scientifically Invalid Responses
Ci_1 = Rotundity of earth	What is the shape of Earth?	Earth is Round/spherical	Flat, Long, Beautiful
Ci_2= Rotation of earth	How do day and night form?	Earth Rotates on its axis	Revolution of Sun, Sun goes behind mountains at night, God's will

Ci_3= Revolution of earth	What causes eclipse?	Shadow of earth or moon/earth / moon come between Sun and moon/earth	Shadow of stars, Rahu-Ketu, God's will
Ci_4= Evolution of Galaxy	What is Akaash Ganga (milky way)?	Collection of stars	Mist, heavenly River, Bhagwati Ganga, path for ghosts, path for heavenly Gods
Ci_5= Evolution of Humans	How did humans come to being?	Humans evolved from other life forms	Monkeys, Baba Adam and Eve, Brahma, the creator

Table 2: Statistical properties of Indian datasets

Constant	**1995 (**N=2713**)**	**2001 (**N=3484**)**	**2007** (N=3863)	**2013** (4789)	**2019** (4808)
Standard deviation	5.53	5.511	5.15	5.27	7.106
Skewness	-0.160	-0.227	0.755	-0.587	4.472
Kurtosis	-1.260	-1.045	2.10	-0.711	1.131
Standard error (Mean)	0.106	0.093	0.084	0.077	0.102
Standard error (Skewness)	0.047	0.041	0.040	0.036	0.035
Standard error (Kurtosis)	0.094	0.083	0.080	0.071	0.071

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

Table 3: Shift in Cultural Distance computed for Indian populace (1995 to 2019)

Concept	**1995 (AK)**	**2001 (K)**	**2007 (AK)**	**2013 (K)**	**2019 (AK)**
X_{Ci1}	1.0	-1.0	-0.5	-0.07	-2.4

X_{Ci2}	8.9	8.4	8.8	8.1	7.4
X_{Ci3}	10.6	9.2	10.8	9.8	8.8
X_{Ci4}	14.1	12.2	12.4	10.2	10.7
X_{Ci5}	22.1	21.2	19.5	20.5	18.2
Average	**11.3**	**10.0**	**10.2**	**9.7**	**8.5**

C_{i1} Shape of the Earth
C_{i2} Occurrence of day and night
C_{i3} Eclipse Occurrence
C_{i4} Galaxy
C_{i5} Theory of Evolution

Table 4: Magnitude and polarity of shift in cultural distance (1995 to 2019)

India	
Concepts	**Shift (ΔX_{ci})**
$\Delta X_{ci\ mean}$	**-2.8**
What is the shape of Earth?	-3.4
How do day and night form?	-1.5
What causes eclipse?	-1.8
What is Akaash Ganga (milky way)?	-3.4
How did humans come to being?	-3.9

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