Original Article

Indian Journal of Research in Anthropology
Volume 2 Number 1, January - June 2016

Variability of PTC and Colour-Blindness among Population Groups of Western India

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Abstract

Phenylthiocarbamideor PTC (or Phenylthiourea) is a chemical compound which has the ability to categorize people into two classes, tasters and non-tasters irrespective of age, sex and race (Fox, 1932). Blakeslee and Salmon (1935) concluded that the taste sensitivity (to PTC) is controlled by a single pair of autosomal gene 'T' and 't' with tasting 'T' gene being dominant over non-tasting 't' gene. Inability to clearly identify different colours of the spectrum is widely known as colour blindness. The difficulties can be mild to severe. Colour blindness exhibits a sex-linked inheritance.

A study of taste sensitivity to PTC and incidence of colorblindness was conducted among two population groups- Rajputs and Bhils- of Sirohi district, Rajasthan. A total of 230 individuals were studied among which Bhils constituted 128 individuals (59 males and 69 females) and Rajputs constituted 102 individuals (60 males and 42 females). The method of serial dilution as given by Harris and Kalmus (1949) was used for testing taste perception. Colour- blindness was examined with the help of Ishihara (1960) plates numbered 1 to 25 in a room with sufficient daylight. The frequency of non-taster't' gene was found to be higher in Rajputs (0.524) than in Bhils (0.405). The frequency of color blindness is low in the Bhil population(1.56%) in comparison to the Rajput population (1.96%). The results have been compared with the populations of North and West India. The incidence of colorblindness has also been studied in the respect to selection-relaxation hypothesis.

Keywords: Colorblindness; Phenylthiocarbamide; Polymorphic Systems; Population Groups and Variability.

Introduction

Taste perception to Phenylthiocarbamide(PTC) and incidence of colorblindness are two polymorphic systems which help to study genetic variability among human population groups.

Phenylthiocarbamide or PTC (or Phenylthiourea) is a chemical compound which tastes either very bitter or is virtually tasteless, depending on the presence of the gene. Blakeslee and Salmon (1935) concluded that the taste sensitivity to PTC is controlled by a single pair of autosomal gene 'T' and 't' with tasting 'T' gene being dominant over non-tasting 't' gene. The people who can taste it have dominant genetic trait and are called 'tasters' and those who cannot taste PTC are designated as 'non-tasters'. Das (1956) suggested that the dominance of taster 'T' gene is incomplete with the failure of its penetrance in the heterozygous to certain extent. Falconer (1947) observed that the female can detect the bitter taste of PTC at lower concentration as compared to the male. Seth (1962) found that smoking has significant effect on the taste threshold distribution. Taste perception phenomenon presents an excellent opportunity to population geneticists and anthropologists to study human variability.

Inability to clearly identify different colours of the spectrum is widely known as colour blindness. Colour blindness exhibits a sex-linked inheritance.

The most commonly found red-green color blindness is an X- linked defect. The inheritance of this defect shows a"criss-cross" pattern of inheritance.Colour vision is controlled by X – linked recessive genes and there seem certainly to be two (Siniscalco, Filippi and Latte, 1964) and possibly many more (Pickford, 1962) loci concerned.

Post (1962) formulated selection-relaxation theory. This theory has based on the fact that the frequency of color blindness is low among primitive hunting and gathering societies as compared to the more advanced or civilized, societies. Post believed that the civilized population had a settled lifestyle. So there is relaxation of natural selection against color blindness in civilized population. Hunter and gatherer depended heavily on their vision to obtain food and hence they are subjected to selection. Duta (1966) and Kapoor et al. (1983) utilized Post's hypothesis to study various Indian ethnic groups.

The present paper reports on PTC tasting ability and incidence of red-green colour blindness among the two population groups- the Rajputs and the Bhils of Mount Abu, Rajasthan and compares the result with various populations of North and West India.

Methods

To study the taste sensitivity and color blindness for the present report the data collection was done in District Sirohi, Mount Abu. This study was conducted among the Rajputs and the Bhils. A total of 230 individuals were studied among which Bhils constituted 128 individuals (59 males and 69 females) and Rajputs constituted 102 individuals (60 males and 42 females). The data was collected from various villages and schools.

The method of serial dilution as given by Harris and Kalmus (1949) was used for testing taste perception. Colour- blindness was examined with the help of Ishihara (1960) plates numbered 1 to 25 in a room with sufficient day light.

Statistical Tools

Gene Frequency Calculation

Non – tasters have homozygous genotype 'tt' while Tasters are either heterozygous 'Tt' or homozygous 'TT'. Thus frequency of non – taster 't' gene is computed as:

$$t = \sqrt{percentile\ frequency\ of\ non-tasters} = \sqrt{tt}$$

Percentile frequency = frequency percentage of non – taster ÷ 100

We know that in a population,

$(T+t)^2=1$

TT+ 2Tt + tt = 1

T + t =1

So, $T = 1 - t$

The frequency of heterozygous tasters can be calculated by substituting the values of 'T' and 't' in the expression 2Tt.

Mean

M = Mean threshold value $=\Sigma fx/N$

Where,

f= frequency of the given distribution

x=individual value in the given distribution

N=sample size

Σ= Indicates summation of all observations

Standard Deviation(S.D.)

It is defined as the square root of the mean squared deviation. Subtraction of the individual value from mean provides deviation. The summation of product of frequency (f) and square of deviations (d^2) is divided by sample size (N). The square root of the result provides standard deviation. It represented as:

S.D. = $\sqrt{\Sigma fd^2 \div N}$

Standard Error of Mean ($S.E._m$)

Standard error of mean is the ratio of standard deviation of the sample divided by the square root of the total number of observations.

$(S.E._m)$ = S.D. $\div \sqrt{N}$

Standard Error of Standard Deviation (S.E.σ)

S.E.σ = S.D. $\div \sqrt{2N}$

Chi – Square (χ^1)Test

The general formula applied is:

$\chi^2 = \Sigma (O-E^2) \div E$

Where,

O= observed frequency in a class

E= expected frequency in a class

In contingency table data is cross-classified in a manner that there are certain levels. In 2x2contingency table there are two rows and two columns.

Presentation of Data in 2x2 contingency Table: *Observed Values*

Population	Tasters	Non – tasters	Total
Population A	a	b	a + b
Population B	c	d	c + d
Total	a + c	b + d	a + b + c + d

The degree of freedom (d.f.) is calculated as

df = (no. of rows – 1)×(no. of columns – 1)

Here, both rows and columns are 2,

So, df= (2-1) x (2-1) =1

Calculation of Expected Values

Population	Tasters	Non - Tasters
Population A	((a+c)x(a+b))/T	((b+d)x(a+b))/T
Population B	((a+c)x(c+d))/T	((b+d)x(c+d))/T

The probability for chi square value at degree of freedom 1 is read from chi – square distribution table and level of significance (α) is regarded as 0.05.

Percentage of Misclassification

In the present report, two categories like taster and non – taster are reduced to single scale of threshold values. This aids in finding individual value misclassified at a given point of time.

The quantitative effect of gene can be generated by comparing the difference between the two mean threshold values, where $D= M_1-M_2$ in the two groups being genetically different. Mean standard deviation is calculated as: $\bar{S}= (S_1+S_2)\div 2$

Penrose (1951-52) suggested that the proportion of each group misclassified is equal to the one tail area under the normal distribution curve when $X= D/2\bar{S}$. The value of D/S index is dependent upon the accuracy of measurement. It involves an accurate determination of the taste threshold solution number and the position of anti-mode in the distribution.

D/S index has a useful application in field of human genetics study where it amounts to more than 3. When the value of index declines below 2, the effect is not large enough to indicate bimodality in the distribution (Harris and Smith, 1949).

The percentage of misclassification has been calculated from the Normal Probability Integral Table (Fisher and Yates, 1968). The 'Z' values irrespective of the sign were read from the table, multiplied by 2 and expressed as percent.

'C' is computed as:

$C= (M_1S_2+M_2S_1)\div(S_1+S_2)$

And 'Z' is calculated as:

$Z = (C–M_1)\div S_1$

Results

PTC Taste Sensitivity

The taste sensitivity to PTC was studied among Rajputs and Bhils. Among Bhil population studied, majority of individuals (modal value) perceived taste at threshold solution number 9. Anti- modal value lied at solution number 5. In total 102 Rajputs tested, majority of individuals perceived taste at threshold solution number 9. Therefore, mode value lied at solution number 9. The anti-mode value lied at threshold solution number 3.

Table I shows percentage and gene frequency of tasters and non-tasters among two population groups. In total Bhil population studied, tasters constituted a greater percentage i.e. 83.59% than non-tasters. The frequency of taster 'T' gene (0.595) was higher than the frequency of non – taster 't' gene (0.405). Among Rajputs tested, 72.55% were tasters and 27.45% were non-tasters. The 't' gene (0.524) had higher frequency than 'T'gene (0.476).

Table IIshows mean S.D. and D/S value for two population groups. Mean threshold value for tasters and non – tasters among total Bhil population was 9.762±0.209 and 1.259±0.260 respectively. The mean threshold values for taster and non – taster among total Rajput population were 8.554±0.229 and 0.857±0.173 respectively. The D/S Index of Penrose indicates bimodality of distribution. The values of D/S index for Bhil and Raj put population were 4.934 and 5.341 respectively. This clearly indicated that distribution of tasters and non – tasters among two population groups was statistically bimodal.

On comparing two populations it was found that the frequency of non-taster 't'gene was higher in Rajputs (0.524) than in Bhils (0.405). Bhil population exhibited a significantly higher mean threshold value for tasters (9.762±0.209) in comparison to Rajput population (8.554±0.229). To check arbitrary allocation of subjects to taster and non-taster classes, percentage of misclassification has been calculated (mentioned in Table 3). The values were 0.76 and 1.38 for Rajputs and Bhils respectively.

Incidence of Colour-Blindness

Table 4 shows incidence of color blindness among Rajput and Bhil population groups.

The incidence of color-blindness among the Bhil males is 3.39% whereas it is 3.33% among Rajput males. No female subject was found to be color-blind due to X – linked nature of the trait.

Table 1: Table showing percentage and gene frequency of tasters and non-tasters among two population groups

S.no.	Population	Sample	Taster	Non-taster	Percentage Taster	Gene frequency Non-taster	Taster	Non-taster
1	**Rajputs**	102	74	28	72.55	27.45	0.476	0.524
2	**Bhils**	128	107	21	83.59	16.41	0.595	0.405

Table 2: Table showing mean, S.D. and D/S value

S.No.	Population	Mean±Se		Sd±Se		D	S	D/S
		Taster	Non-Taster	Taster	Non-Taster			
1	**Rajputs**	8.554±0.229	0.857±0.173	1.967±0.162	0.915±0.122	7.697	1.441	5.341
2	**Bhils**	9.762±0.209	1.259±0.260	2.097±0.148	1.350±0.184	8.503	1.724	4.934

Table 3: Table showing percentage of misclassification

S.No.	Population	C-value	Z-value	Percentage of Misclassification
1	Rajputs	3.3	-2.67	0.76
2	Bhils	4.59	-2.47	1.38

Table 4: Table showing incidence of color blindness

S. no.	Population	Total no. of individual tested	Colour blind	Type		Percentage (%)
				Protan	Deutan	
1	Rajputs	102	2	2		1.96
2	Bhils	128	2	1	1	1.56

Discussion

On comparing two populations it was found that the frequency of non-taster 't' gene was higher in Rajputs (0.524) than in Bhils (0.405). Bhil population exhibited a significantly higher mean threshold value for tasters (9.762±0.209) in comparison to Rajput population (8.554±0.229). In the present study the values of D/S Index for Bhils and Rajputs were 4.934 and 5.341 respectively. This clearly indicated bimodality in the distribution of tasters and non – taster in the two populations.

The t-allele frequency of Bhil population (0.672) of Gujarat (Vyas et al., 1962) and Bhil population (0.562) of Bombay (Mukerjee et al., 1977) was higher in comparison to presently studied Bhil population (0.405) in Sirohi district. The presently studied Rajput population showed close resemblance to the Kolis of Panchamahal district, Gujarat in terms of t-allele (0.527)(Kshatriya and Bhasin,1979) frequency. The t-gene frequency of Rajputs in the present report show close resemblance to Marathas (0.531) of Maharashtra (Mukherjee et al., 1977) and Ved Nagar Brahmins (0.516) of Bombay (Sanghavi and Khankolkar, 1949).

The chi-square test has been devised to compare Bhil and Rajput population of Sirohi District with various populations of West India to see whether statistical differences exist among them for the frequency of 't' gene in the populations. It had been found that Bhil population of Sirohi District under study show significant difference with Rajput population of Sirohi district in the present study (4.130, df=1 and 0.05>p>0.025).

The Bhil population in the present study showed significant difference with Bhils of Panchamarhi, Bhils of Bombay, Minas of Udaipur, Muslims of Narender Nagar, Rajputs of Kumaon and Kolis of Surat. Rajput population of Sirohi district (in present study) show significant difference with Rajputs of Uttar Pradesh, Rajputs of Lucknow, Bhils of Panchamarhi, Dublas of Surat, Gujars of Udaipur, Minas of Udaipur and Gujars of Delhi.

It has been found that the frequency of color blindness is quite variable in India. The frequency of color blindness ranges from 0.00 among Raigars of Rajasthan (Ghosh, 1970-71) and Angami Nagas of Nagaland (Seth & Seth, 1973) to a high frequency (0.104) among Apatanis of Arunachal Pradesh (Jaiswal,1975). In general, the frequency of color blind males in Indian populations is 0.036.

The frequency of color blindness was low in the Bhil population (1.56%) in comparison to the Rajput population (1.96%) which might be due their ethnicity and occupations. Bhils primarily rely upon agriculture or forest – based economy and they frequently visit to nearby forest area to collect fuel wood and color blindness could act as a disadvantage

to their livelihood. Selection pressure increases and tends to remove color blind individuals, resulting in a low value of red – green color blindness among them. This study provided support to Post's hypothesis of relaxation of selection as the main idea of the hypothesis revolved around the fact that there is greater incidence of color blindness among higher caste groups such as Brahmins and Rajputs as they are further removed from primitive lifestyle in comparison to lower occupation groups.

Conclusion

When the two (the Rajput and the Bhil) populations were compared, it was found that the frequency of non-taster 't' gene was higher in Rajputs (0.524) than in Bhils(0.405). Bhil population exhibited a significantly higher mean threshold value for tasters (9.762±0.209) in comparison to Rajput population (8.554±0.229). It had been found that Bhil population of Sirohi District under study show significant difference with Rajput population of Sirohi district in the present study (4.130,df=1 and 0.05>p>0.025).

Taste perception to PTC and incidence of colour-blindness interlinks and provides an insight into various fields such as genetics, ecology, evolution and nutrition. These traits also help us to understand the origins of genetic variation in humans.

Acknowledgements

We are thankful to all subjects for their cooperation in the field.

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