Lateral Functional Dominance in Behavioral Traits Observed in Five Populations of Inner Mongolia

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Abstract   A sample of 1768 participants was tested for seven different traits of lateral functional dominance (hand clasping, handedness, arm folding, leg folding, stride type, preferential foot, and preferential eye) in five populations (Oroqen, Ewenki, Daur, Mongol, and Han) from Inner Mongolia, China. The results are as follows. 1) Seven traits all show right dominance (RD) in Mongol. However, just arm folding of the seven traits shows left dominance (LD) in Oroqen and Ewenki. In addition, LD also present for hand clasping in Daur, and for hand clasping and stride type in Han. 2) Sexual characteristics are not obvious in the traits. 3) Significant ethnic characteristics are observed in stride type, preferential foot, and preferential eye. 4) Some relationships occur in the traits. Furthermore, leg folding has the mostly close correlation with other six traits, followed by between hand clasping and handedness, and, in the last place, preferential eye with other six traits. 5) From PCA and cluster analysis, it is shown that, compared with Oroqen that has relatively distinct distribution of RD and LD for most of the traits, Ewenki shows the most similar to Mongol, and the more to Daur and Han in the distributing pattern. On the whole, the result coincides with the known history data of ethnic origin of each population.

Keywords: lateral functional dominance, behavioral traits, Inner Mongolia

Lateral functional dominance traits are defined as some functional movements or habitual behaviors that indicate asymmetry between human body's two sides, i.e. right side and left side. For example, different individuals present different flexibility for his right hand and left hand during working in general manner. Thus, these individuals who are habitual to finish subtle works by their right hands are regarded as right-handed. Otherwise, the individuals are left- handed. Other traits such as hand clasping, arm folding, leg folding, stride type, preferential foot, and preferential eye are also laterally functionally dominant. Furthermore, the occurrence of these traits is possibly affected by genetic factors to some degree.

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Three Chinese minorities, Daur, Ewenki and Oroqen have only total population of one hundred thousand in all, according to the statistic yearbook of Inner Mongolia in 1999. They all live in Hulunber League, which lies in the northeast of Chinese Inner Mongolia, and borders upon Heilongjiang province of China, Siberia of Russia and the country of Monglia.

Ewenki and Daur, living mostly in Ewenki Banner in the southwest of Hulunber League, are the descendants of 1600 Ewenki soldiers and 730 Daur soldiers who were settled here to garrison the frontier from the drainage area of Nenjiang in the northeast of China in 1732. And Oroqen, living mostly in the Oroqen Banner in the northeast of Hulunber League, are the descendants of the people who were settled here from the drainage area of Jieya River in Russia and of Heilongjiang in China in the middle period of 17th century (Compiling Committee of Inner Mongolian Great Dictionary, 1991). However, Mongol, living in Zuo Banner of Alashan League in the northwest of China, is mainly originated from two Mongolian tribes (Khoshods and Dsungara) from the Tianshan area of Xinjiang in China. Later, the two tribes migrated to Alashan League by way of Qinghai Province. Khoshods Banner in Alashan League, in which the area of Zuo Banner of Alashan League is at present, was established accordingly. (Compiling Committee of chorography on Alashan League, 1998).
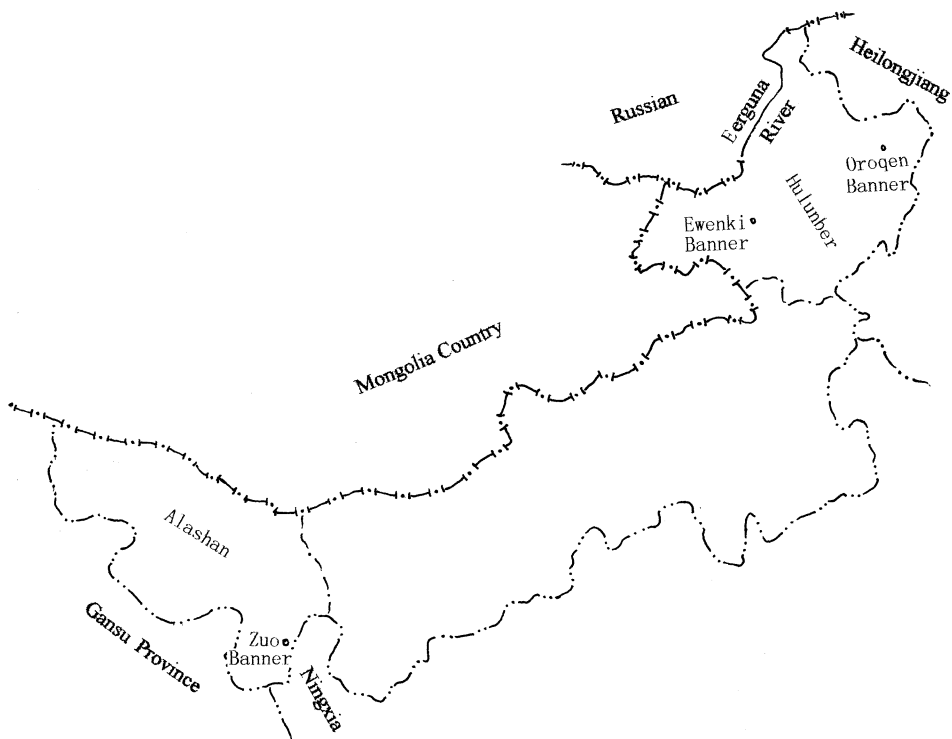

Figure 1. Map of the Inner Mongolia Autonomous Region.

Other data show that the descendants of Khoshods Mongol, living in Alashan League at present, had settled to herd in the area of Hulunber League and Eerguna River. At the beginning of seventeenth century, they moved to the area of Xinjiang, Qinghai and Xizang Province, part of who settled Alanshan League. About after seventh century (from Tang), Ewenki, ancient Mongol and Daur, had been lived altogether in the drainage area of Eerguna River. That is Daur who may be the descendants of the ancient Mongol (Wuyundalai, 1998). It's the drainage of Yellow River, i.e. the area of Central Plains in China, that the origin of Han is. In the long history of China, Han, Whose core is the ancient Huaxia, mixed together with many other populations and developed gradually. Nowadays, as the largest nationality in China, the population of Han is above 94 percent in the total population (Liang et al, 1985). Han, living Alashan at present, mainly originated from Shanxi and Gansu Provinces because of business' floating mostly. Since Alashan is a remote area, there is less information on her populations, especially on Mongol in Alashan. Our latest research (unpublished) shows that the morphological traits of Mongol in this area are different from that of other Mongolian populations of Inner Mongolian area.

So far, the data on lateral functional dominance traits are mainly derived from foreign populations, and the reported traits are mostly human's hand-arm traits (Plato et al, 1984; 1985; Bryden, 1989; Datta et al, 1989; Mian et al, 1994). The studies regarding Chinese populations in this area are seldom reported (Zheng et al, 1993; 1998). Therefore, the present paper study seven lateral functional dominance traits in Chinese five populations, to reveal what distributing ways can be observed, and which populations have close relationship, and which traits are important, and how they may interact.

Materials and Methods

All participants are students living in Inner Mongolia. They all finish whole test for seven traits (hand clasping, handedness, arm folding, leg folding, stride type, preferential foot, and preferential eye). In Sept. 1997, we surveyed 322 participants (147 males, 175 females) from Ewenki, and 485 ones (238 males, 247 females) from Daur living in Ewenki Banner, and 100 ones (40 males, 60 females) from Oroqen living in Oroqen Banner, Hulunber League. In Oct. 1999, we surveyed 447 students (218 males, 229 females) from Mongol, and 414 ones (214 males, 200 females) from Han living in Zuo Banner of Alashan League. The students came from the classes randomly selected in whole school. All participants are normal students, from 13 to 18 years of age. Their parents belong to same one nationality.

Some common rules of classifying each of traits into RD and LD are applied in the present study. A detailed explanation is as follows.

Handedness: Handedness is also called hand preference or hand dominance. Its study is to find out which one of two hands is more agile in action. In other word,

which hand is predominantly used to write, hammer, cut with scissors, use chop-sticks, pitch a ball, and so on. The individuals whose right hand is more flexible to use are considered as right-handed (R), otherwise as left- handed (L).

Hand clasping: Clasping the hands with the fingers interlocked, individuals who are constant, comfortable and leisure to put the right thumb on the top of the left one are classified as right hand clasping (R), otherwise as left hand clasping (L).

Arm folding: Some individuals who are constant, comfortable and leisure to put the right arm on the top of the left one are classified as right arm folding, otherwise as left arm clasping (L).

Leg folding: If an individual fells comfortable and leisure to overlap his right leg on the left one when sitting on a chair, he is considered as right leg folding (R), otherwise as left leg folding (L).

Stride type: When individuals are asked to stand, and then stride, they who form a habit of striding their right feet first are considered as right stride type (R), otherwise as left stride type (L).

Preferential foot: The individuals who habitually predominantly use their right feet to kick a ball are considered as right preferential foot (R), otherwise as left preferential foot (L).

Preferential eye: The individual is asked to star at one far point before, and than put his thumbs on the line of sight between his eye and the point. At this time, he cannot see the point. Following that, after closing his left eye, if he cannot still see the point, he is considered as right preferential eye (R). But, if he finds the thumb to remove, and he can see the point, he is considered as left preferential eye (L).

All of 1768 valid data are dealt with uniform computer procedure. We calculated the frequency of RD and LD for each trait of every population, and sexual and ethnic difference through chi-square test, and carried out correlation analysis (Wang, 1993), both principal component analysis and cluster analysis for the traits and the populations.

Results and Discussion

Table 1 lists percent frequencies of RD and LD for seven traits in five populations.

Hand-arm traits

Hand clasping: Oroqen, Ewenki, and Mongol all show RD for hand clasping, and very close distributing frequency with each other. However, Daur and Han show little LD, and their frequency is almost same as Huizu in Inner Mongolia (R-46.59%, L-53.41%; Zheng et al, 1998). Chi-square test discovers that hand clasping has no significant sexual difference in each population, which suggests this trait has not obvious relationship with sex. Such result agrees with Pentzos-Daponte and his colleagues (1986). The ethnic difference from frequencies of RD is significant ($P < 0.05$),

between Han and Mongol, Han and Ewenki, Ewenki and Daur. Moreover, the frequencies of RD in the five populations are all relatively lower than Negroes (62.05%; Freire-Maia et al, 1966), Russians (56.09%; Freire-Maia et al, 1960), but higher than Indian central federal Bisonhorns (34.00%) and Murias (38.65%; Datta et al, 1989).

Handedness: The majority of participants show RD for handedness. The frequencies of RD indicate in order as follows, i.e. Oroqen > Han > Mongol > Ewenki > Daur. Chi-square test discovers the frequencies of RD have no sexual and ethnic difference in each of the five populations. All the present five populations have higher frequencies of RD for handedness than Huizu (87.74%). But they except Oroqen have lower frequencies of RD than Indian Murias (95.75%), Bisonhorns (96.40%) and Sikkims (96.51%; Bhasin et al, 1987).

Arm folding: Arm folding shows LD in Oroqen, Ewenki, and Daur, but RD in Mongol and Han. Chi-square test discovers that, just Ewenki of the five populations indicated extremely significant sexual difference ($\chi^2 = 10.28$, $P < 0.005$) for this trait. Specifically, its frequency of RD is higher than that of LD in male (R-58.50%, L-41.50%), but a reverse performance pattern is observed in female (R-40.57%, L-59.43%). No obvious ethnic difference is found in the five populations. Moreover, Oroqen, Ewenki, and Daur have close frequencies of RD for this trait with Pakistan Rajputs (47.08%), Pathans (48.95%), Araeens (46.67%; Mian et al, 1994). And Mongol and Han have close frequency of RD with Pakistan Jats (50.17%) and Balochs (52.77%). However, all of the present five populations demonstrate relatively lower frequency of RD than Negroes (56.74%) and Russians (55.8%). It seems the trait has ethnic difference in world populations, to certain degree.

Leg-foot traits

Leg folding: In all participants, above two-thirds students demonstrate RD for leg folding. Among the five populations, the frequencies of RD range from 82.00% (in Oroqen) to 70.72% (in Daur). Chi-square test discovers that Daur has extremely significant sexual difference for the frequency of this trait ($\chi^2 = 8.17$, $P < 0.005$). Specifically, the frequency of LD in male (35.29%) is one and half times as high as in female (23.48%), which is similar that Plato and his colleagues reported that the frequency of LD for this trait in American male was twice as high as in American females (Plato et al., 1985). The other four populations all fail to present similar behavioral pattern. Moreover, the frequencies of the trait indicate significant ethnic difference ($P < 0.05$) between Daur and Oroqen, Daur and Mongol. Furthermore, the frequencies of RD of the present populations are obviously higher than that of Indian central federal population (50.35%-56.53%), but comparatively close to Indian Sikkims (70.5–81.6%).

Preferential foot: The majority of the five populations show RD for preferential foot. Leg folding and handedness show similar distributing order in frequency of RD

Table 1. Number and percent frequencies of LD and RD for seven traits in five populations

Population	Sex	Number	Clasping hand R	Clasping hand L	Handedness R	Handedness L	Folding arm R	Folding arm L	Folding leg R	Folding leg L	Preferential foot R	Preferential foot L	Stride type R	Stride type L	Preferential eye R	Preferential eye L
Oroqen	Male	40	23 57.50	17 42.50	38 95.00	2 5.00	16 40.00	24 60.00	31 77.50	9 22.50	40 100.00	0 0.00	22 55.00	18 45.00	29 72.50	11 27.50
	Female	60	31 51.67	29 48.33	58 96.67	2 3.33	29 48.33	31 51.67	51 85.00	9 15.00	58 96.67	2 3.33	36 60.00	24 40.00	47 78.33	13 21.67
	Total	100	54 54.00	46 46.00	96 96.00	4 4.00	45 45.00	55 55.00	82 82.00	18 18.00	98 98.00	2 2.00	58 58.00	42 42.00	76 76.00	24 24.00
Ewenki	Male	147	84 57.14	63 42.86	139 94.56	8 5.44	86 58.50	61 41.50	114 77.55	33 22.45	137 93.20	10 6.80	81 55.10	66 44.90	95 64.63	52 35.37
	Female	175	89 50.86	86 49.14	159 90.86	16 9.14	71 40.57	104 59.43	129 73.71	46 26.29	161 92.00	14 8.00	115 65.71	60 34.29	112 64.00	63 36.00
	Total	322	173 53.73	149 46.27	298 92.55	24 7.45	157 48.76	165 51.24	243 75.47	79 24.53	298 92.55	24 7.45	196 60.87	126 39.13	207 64.29	115 35.71
Daur	Male	238	111 46.64	127 53.36	214 89.92	24 10.08	114 47.90	124 52.10	154 64.71	84 35.29	213 89.50	25 10.50	121 50.84	117 49.16	172 72.27	66 27.73
	Female	247	115 46.56	132 53.44	224 90.69	23 9.31	126 51.01	121 48.99	189 76.52	58 23.48	224 90.69	23 9.31	144 58.30	103 41.70	178 72.06	69 27.94
	Total	485	226 46.60	259 53.40	438 90.31	47 9.69	240 49.48	245 50.52	343 70.72	142 29.28	437 90.10	48 9.90	265 54.64	220 45.36	350 72.16	135 27.84
Mongol	Male	218	105 48.17	113 51.83	200 91.74	18 8.26	117 53.67	101 46.33	162 74.31	56 25.69	205 94.04	13 5.96	101 46.33	117 53.67	132 60.55	86 39.45
	Female	229	129 56.33	100 43.67	215 93.89	14 6.11	118 51.53	111 48.47	183 79.91	46 20.09	219 95.63	10 4.37	129 56.33	100 43.67	144 62.88	85 37.12
	Total	447	234 52.35	213 47.65	415 92.84	32 7.16	235 52.57	212 47.43	345 77.18	102 22.82	424 94.85	23 5.15	230 51.45	217 48.55	276 61.74	171 38.26
Han	Male	214	102 47.66	112 52.34	202 94.39	12 5.61	112 52.34	102 47.66	164 76.64	50 23.36	204 95.33	10 4.67	67 31.31	147 68.69	143 66.82	71 33.18

		Clasping hand		Handedness		Folding arm		Folding leg		Preferential foot		Stride type	
Female	200	82	118	188	12	96	104	150	50	191	9	67	133	138	62
		41.00	59.00	94.00	6.00	48.00	52.00	75.00	25.00	95.50	4.50	33.50	66.50	69.00	31.00
Total	414	184	230	390	24	208	206	314	100	395	19	134	280	281	133
		44.44	55.56	94.20	5.80	50.24	49.76	75.85	24.15	95.41	4.59	32.37	67.63	67.87	32.13

Table 2. Combinative percent frequency of LD and RD types between seven traits in five populations ($N = 1768$)

		Clasping hand		Handedness		Folding arm		Folding leg		Preferential foot		Stride type	
		R	L	R	L	R	L	R	L	R	L	R	L
Handedness	R	46.49	46.1										
	L	2.77	4.64										
		7.96***											
Folding arm	R	26.02	24.04	47.23	2.83								
	L	23.25	26.69	45.36	4.58								
		5.22*		7.99***									
Folding leg	R	39.25	35.81	71.44	3.62	39.65	35.41						
	L	10.01	14.93	21.15	3.79	10.41	14.53						
		19.59***		51.88***		16.32***							
Preferential foot	R	47.06	46.38	89.31	4.13	47.51	45.93	72.12	21.32				
	L	2.21	4.35	3.28	3.28	2.54	4.02	2.94	3.62				
		12.16***		328.25***		6.30*		60.59***					
Stride type	R	26.08	23.87	47.96	1.98	26.13	23.81	40.27	9.67	47.79	2.15		
	L	23.19	26.86	44.63	5.43	23.93	26.13	34.79	15.27	45.65	4.41		
		6.12*		30.53***				29.31***		14.67***			
Preferential eye	R	33.99	33.32	62.78	4.53	33.94	33.37	51.87	15.44	63.41	3.9	34.89	32.41
	L	15.27	17.42	29.81	2.88	16.12	16.57	23.19	9.5	30.03	2.66	15.05	17.65
								7.79**				5.29*	

"N" represent the total number of participants; the number below the percentages in each group is Chi-square value; *$P < 0.05$, **$P < 0.01$, ***$P < 0.005$.

for the populations. It seems that some relationship possibly occurs between the two traits. Plato and his colleagues reported that the frequency of LD for preferential foot in male (8.9%) was twice as high as in females (4.1%). However, the present five populations fail to demonstrate such difference. Among the five populations, significant ethnic difference is observed between Ewenki and Oroqen, Daur and Oroqen, Daur and Mongol, Daur and Han. In addition, Daur shows the highest frequency of LD (9.90%) and the frequency is almost twice as high as Mongol (5.14%) and Han (4.59%), and above four times as high as Oroqen (2.00%). Furthermore, the frequency of LD (7.45%) in Ewenki is above three times as high as in Oroqen.

Stride type: It is not a common model that all people firstly stride right/left foot to begin to walk habitually. The present study discovers that most of Han (67.63%) are habitual to stride left foot to walk, whereas the remaining four populations show a reversed behavioral pattern. Thus, Han shows highly significant difference with others. Highly significant difference also is observed between Mongol and Ewenki ($\chi^2 = 6.72$, $P < 0.01$). Of the five populations, just Mongol indicates that the frequency of LD for stride type has significant sexual difference, which is higher in male (53.6%) than in female (43.67%) ($\chi^2 = 4.47$, $P < 0.05$).

Preferential eye

Most participants of the five populations indicate RD for preferential eye. The frequency of RD for this trait is in order as follows, i.e. Oroqen > Daur > Han > Ewenki > Mongol. Chi-square tests reveal that the difference of the frequencies between the sexes is not significant in each population. However, highly significant ethnic difference is observed between Mongol and Oroqen ($\chi^2 = 7.24$), Mongol and Daur ($\chi^2 = 11.45\%$), and comparatively significant difference between Ewenki and Oroqen ($\chi^2 = 4.74$), Ewenki and Daur ($\chi^2 = 5.62$). In addition, the present five populations have a relatively lower frequencies of RD for this trait than that of Chaoxian (78.2%) in Inner Mongolia (Zheng et al., 1993). However, Oroqen and Daur show higher frequencies of RD than Huizu (69.7%) in Huhhot, and American Caucasians (69.5%).

Relation between seven traits

We adopt Φ-correlation analysis based on Chi-square test as the method of correlation analysis. Correlation analysis is performed for the seven traits in all participants observed by the present study, regardless of populations. Table 2 lists, among RD or LD of each of traits, the frequencies of RD and LD of other traits. Taken hand clasping-handedness combination as example, all of 1768 participants show 46.49% of RD of hand clasping with RD of handedness (RR), 2.77% of RD of hand clasping with LD of handedness (RL), 46.10% of LD of hand clasping with RD of handedness (LR), and 4.64% of LD of hand clasping with LD of handedness (LL). Correla-

tion analysis discovers that hand clasping has close relationship with other six traits except preferential eye. The frequencies of LD handedness and LD preferential foot in the individuals with LD hand clasping show two times as high as the frequencies of LD handedness and LD preferential foot in the individuals with RD hand clasping, respectively. Furthermore, the frequencies of LD of arm folding, leg folding and stride type in the individuals with LD hand clasping are also obviously high. Generally speaking, handedness has a high correlation with other traits. RD type of leg folding and preferential foot in the individuals with RD handedness show obvious dominance. And functional dominance also presents in LD type of arm folding and stride type in the individuals with LD handedness. Moreover, more or less correlation can also be found between the seven traits except preferential eye. As far as the combination types from a pairs of traits, RR or LL generally show a relatively high occurrence, which seemly suggests some interaction in the gene level may occur among these traits.

In the present study, preferential eye has relation with two (leg folding and stride type) of other traits. The comparatively high frequency of combination show in the participants of RD of preferential eye with RD of leg folding, and LD of preferential eye with LD stride type. It may reveal that preferential eye is a relatively distinct trait in the traits. At present, genetic pattern of the traits has no explicit conclusion. Therefore, the relationships presented among the traits will need to further explore in nature.

The principal component analysis and the cluster analysis

The RD values of the seven traits are used as the indexes in the principal component analysis and the cluster analysis. The analysis results are shown in Figs. 2–4.

The principal component analysis reveals as follows. The percents of trace of the first three principal components are 52.5%, 25.7% and 20.3%, respectively, and their accumulated percent reach to 98.5%. In PC I, the traits with the relatively most loading capacity are leg folding (0.496), handedness (0.475) and preferential foot (0.456), which mainly reflects hand-foot characteristics. And in PC II, the traits with those are stride type (0.722) and hand clasping (0.476), which also mainly reflects hand-foot characteristics. In PC III, however, the traits with those are preferential eye (0.722), arm folding (-0.465) and hand clasping (0.417), which reflects the eye and hand-arm characteristics.

Fig. 2 shows Daur, Ewenki and Oroqen in Hulunber League are situated above, and Mongol and Han in Alashan League are situated below the PC I axis, which reveals obvious regional difference. Oroqen located on the right of PC II axis is comparatively far from other four populations located on the left of PC II axis. Furthermore, relatively close distance can been found between Ewenki and Mongol, Mongol and Han, Daur and Ewenki, Daur and Mongol. In addition, consider the
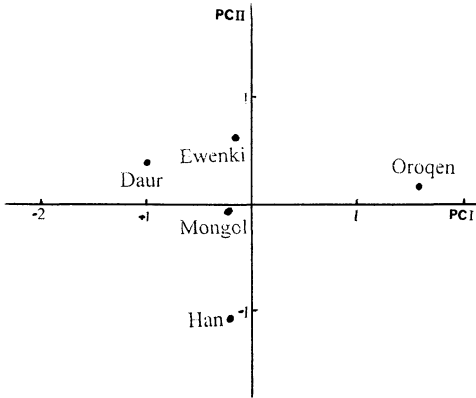
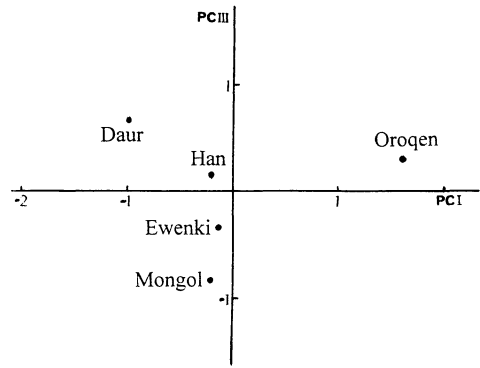**Figure 2.** Scattergram of five populations based on 1st and 2nd factor scores.

Figure 3. Scattergram of five populations based on 1st and 3rd factor scores.
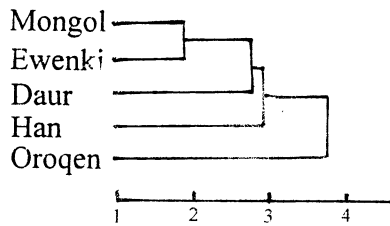
Figure 4. Dendrogram of cluster analysis in five populations.

traits with the relatively most loading capacity in PC I and PC II, we can find that LD and RD of hand clasping, handedness and preferential foot have similar occurrence between Ewenki and Mongol. Furthermore, LD and RD of handedness, leg folding and preferential foot also have similar occurrence between Mongol and Han. In addition, LD and RD of handedness, leg folding, preferential foot and stride type have somewhat similar occurrence with Ewenki and Mongol (see Table 1).

In general, the distribution of five populations in Fig. 3 is similar to that of the populations in Fig. 2. Ewenki, Mongol and Han relatively cluster together. In addition, consider the traits with the relatively most loading capacity in PC I and PC III, we can find that the three populations show similar LD and RD distribution of the traits. Ewenki shows similar LD and RD distribution of some traits to Mongol, Daur and Han. However, compared with other four populations, Oroqen with relatively distinct distribution characteristics has the most high frequency of RD of seven traits except arm folding, and the most low frequency of RD of arm folding.

The result of the cluster analysis (see Fig. 4) reveals that Ewenki is close to Mongol, is middle to Daur and Han, and is far from Oroqen, which coincides with the pattern of the principal component analysis. On the whole, the results are consistent

with the above-mentioned history data about populations' relationship in the Introduction part of this article. Consequently, there had been close affined relationship among Ewenki, Mongol and Daur in history, which may be the important reason that most of the three populations' behavioral traits are similar. Although the ethic origins of Mongol and Han in Alashan League are different, in some degree, however, because of a long-term cohabit in the same area, there is some resemblance in certain traits, such as handedness, preferential foot, arm folding and so on. China's history recorded many large-scale national migrations, what lead to the common phenomena that multi-populations live in same place. If things go on like this, there must be the trend of gene exchanging, mixing and establishing affinity among different populations. Accordingly, in some degree, there will be resemblance in certain anthropological traits, including morophological or behavioral traits. In our investigation, the phenomenon is also reflected by the seven behavioral traits.

Summary

In the present study, Mongol shows RD for all of the seven traits, and Oroqen and Ewenki show RD for the seven traits with the exception of arm folding. However, Daur show LD for arm folding and hand clasping, and Han show LD for hand clasping and stride type. Sexual difference is observed in few of traits among five populations, which suggests that lateral functional dominance traits are less related to sex. Stride type, preferential foot, and preferential eye have relatively obviously ethnic character. Correlation occurs between the seven traits, to some degree. In the five populations, Ewenki shows similar LD and RD distribution of some traits to Mongol, Daur and Han. However, Oroqen shows relatively distinct distribution characteristics.

Acknowledgements

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