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ALTRUISTIC FACE: EXPERIMENTAL STUDY ON FACIAL MORPHOLOGY AND PROSOCIALITY IN BURYATS OF SOUTHERN SIBERIA

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The aim of the present experimental study was to investigate possible associations between individual cooperativeness and facial morphology. Participants of the study were Buryats of Southern Siberia (males: N=98; females: N=89; mean age 20 ± 2y.). Individual cooperativeness was assessed in experimental economic game "Public Goods Game", which was conducted "face-to-face", in groups of 4 same-sex individuals, who were strangers to each other. The game involved real monetary pay-offs. In the course of the experiment such individual behavioral features as propensity for unconditional/conditional cooperation, selfishness, or free-riding were revealed. Facial shapes of participants were explored through anthropological photographs using geometric morphometrics, and via assessing standard facial indexes. As a result the relationship between facial shape and unconditional cooperation was identified and visualized. This relationship appeared only among males. The analysis of sex-specific facial traits of Buryats revealed that faces of male unconditional cooperators combined both male-specific, and female-specific facial features. This is the first study to investigate association between full facial shape and human cooperativeness.

Keywords: altruism, facial morphology, Buryats, cooperation, geometric morphometrics.

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ЛИЦО АЛЬТРУИСТА: ЭКСПЕРИМЕНТАЛЬНОЕ ИССЛЕДОВАНИЕ ПРОСОЦИАЛЬНОГО ПОВЕДЕНИЯ И МОРФОЛОГИИ ЛИЦА БУРЯТ ЮЖНОЙ СИБИРИ

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Настоящее экспериментальное исследование посвящено выявлению и изучению возможной связи между индивидуальными особенностями кооперативного поведения и морфологическими чертами лица человека. В исследовании приняли участие жители г. Улан-Удэ (буряты, мужчины: N=98; женщины: N=89; ср. возраст — 20±2 г.). Индивидуальная кооперативность оценивалась в ходе экономической экспериментальной игры «Общественное благо», которая проводилась в условиях взаимодействия «лицом к лицу», в группах из четырех незнакомых друг с другом участников одного пола, и включала реальные денежные выплаты. В ходе эксперимента были выявлены индивидуальные особенности кооперативного поведения участников, такие как склонность к альтруизму, кооперации, эгоизму, обману. Форма лиц участников описывалась с использованием антропологических фотографий методом геометрической морфометрии, а также с помощью оценки стандартных морфометрических характеристик лица. Результаты исследования указывают на наличие взаимосвязи формы лица со склонностью проявлять альтруизм в условиях групповой кооперации, однако данная взаимосвязь характеризуется половой спецификой и обнаруживается только у испытуемых мужской части выборки. Анализ строения лиц представителей популяции бурят показал, что форма лица мужчин-альтруистов сочетает в себе как мужские, так и женские полоспецифические особенности. Проведенное исследование по своей проблематике носит новаторский характер и на настоящий момент не имеет аналогов в мировой науке.

Ключевые слова: альтруизм, морфология лица, буряты, кооперация, геометрическая морфометрия.

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Introduction

The aim of the present study was to investigate mechanisms of human cooperative and altruistic behaviour. Phenomena of cooperation and altruism, as a sacrifice of individual interests in favor of achieving common good or mutually beneficial outcomes, are fundamental to all social species on our planet [34]. Human beings have developed unprecedented ability to cooperate [13]. However, despite the fact that *Homo sapiens* is a hyper-cooperative species, it is known that humans demonstrate individual differences in propensity for cooperation, and that such differences are characterized by temporal and cross-contextual stability [3, 36, 43, 50, 54]. Studies show that human behaviour in the context of cooperative interaction can be explained by a number of more or less stable individual strategies, such as unconditional cooperation (altruism), selfish behaviour, conditional (or context-dependent) cooperation, and cheating [4, 16, 17, 29, 43]. Living in a social environment, individuals are selective in relation to potential partners for cooperation. This is a natural state of affairs that prosocial individuals do not want to be deceived, while selfish people and cheaters gravitate towards potential victims. Selectivity in choosing a partner for cooperation is based on numerous factors, including appearance. A number of studies show that humans may, to certain extent, be able to recognize cooperativeness of potential partners through neutral facial images. Such recognition was described even at cross-cultural level and was more common for men than for women [47, 49].

Numerous studies investigating cooperative behaviour are focused on the search of criteria for evaluation social reliability of interaction partners, including assessment of specific facial traits that can be viewed as signals of trustworthiness, attractiveness, or, conversely, inducing negative reactions [21, 25, 37, 52].

Human facial morphology is subjected to noticeable sexual dimorphism [26], which is explained by a number of evolutionary processes, including exposure to sex hormones [6, 20, 44]. Men of Caucasian origin usually have more robust shape of jaws, more wide mouths and noses, as well as more prominent brow ridges compared to women [8, 14, 15, 53]. These traits are commonly associated with masculinity in Western populations. One of the well-known facial traits related to perceiving male appearance as more attractive for cooperation, is facial width-to-height ration (fWHR). This parameter indicates the relation of the facial width, being measured as the distance between the most prominent lateral points of the zygomatic arches, to the height of the upper part of the face, measured from the line of the upper eyelid to the outer contour of the upper lip along the central axis of the face [45]. Studies show that men with lower fWHR are perceived by others as more trustworthy, reliable, and attractive for cooperation [25, 45], whereas high values of this index are perceived as a signal of aggressiveness, which was as well found in the context of communication between representatives of population of different origin [10, 18—20, 51]. The results of experimental studies confirm that men with high fWHR are actually appear to be more aggressive [10, 18, 19]. In African populations larger facial width is also associated with greater physical strength [9]. In a number of empirical studies on actual behavioural cooperativeness, it was demonstrated that Caucasian men with high fWHR are not prone to cooperate in same-sex dyadic interactions [23, 24, 45], however,

they were predisposed to cooperate in group interactions the context of intergroup competition context [46]. According to the numerous studies, same-sex cooperation plays special role particularly in male behaviour [5]; men are more predisposed to cooperate in groups, while females prefer to interact in pairs [12, 35, 43].

The degree of sexual dimorphism in fWHR varies across populations, and in some cases significant differences are not observed [20, 28, 31, 38, 39]. However, despite the facts that generally sex differences in fWHR are weak, in overwhelming number of populations men have slightly higher values of this facial parameter than women (meta-analytic study involving data on 32 populations [32]), which is especially pronounced in Asians[27]. From this perspective, Buryats are of a special research interest, since according to recent findings, they demonstrate inversed sexual dimorphism in fWHR [41, 42]. The study based on geometric morphometric analysis of the full facial shape of Buryats, as well as partial analysis based on 67 anthropometric facial indices, demonstrated that generally Buryats have sex-specific facial traits characteristic of other Asian populations (partly differing from those of Caucasian populations). However, Buryats were distinguished by significantly higher fWHR in women compared to men [42], which is currently an exceptional case.

The ***purpose*** of the present study was to investigate the interrelation between full facial shape of young male and female Buryats with individual cooperative behaviour in the context of same-sex group interactions. The ***objectives*** of the study were: 1) analysis of differences in facial shape between subjects applying different cooperative strategies; 2) assessment of the contribution of the sex-specific facial features, which are characteristic of Buryats, into observed differences in appearance associated with propensity for prosocial behaviour. The ***hypothesis of the study***: individuals who are prone to cooperate in group interactions have a set of specific facial features; such association between appearance and prosociality is more expressed in men than in women, and among men group cooperativeness is more characteristic of those having more masculine appearance.

This study is innovating in terms of combination of addressed research questions and applied methods, and, to our knowledge, yet has no analogues.

Research program

Participants of the study

Participants of the study were 208 Buryats: 104 young men (mean age — 20 ± 2 y.) and 104 young women (mean age — 20 ± 2 y.), residents of Ulan-Ude (Buryatia). All of them were students of different specialties (natural and humanitarian sciences, economics, art), represented in the sample in approximately equal proportions.

Buryats are people of Southern Siberia of Mongolian origin, mostly residing in the Republic of Buryatia of Russia, in Ulan-Ude and rural surroundings (according to the National Census 2010). Buryats are traditionally nomadic pastoralists [1, 3]. Despite the fact that most of them have recently adopted an urban lifestyle, they are still strongly traditionally oriented. The official religion of Buryats is Buddhism.

Due to technical reasons, part of the subjects were excluded from the general sample (violation of the experimental rules, imperfect photographs). The final sample consisted of 187 individuals (98 men, 89 women).

All participants signed informed consents prior to the experiment.

Assessment of individual cooperativeness

To estimate individual propensity for cooperation we have conducted an experiment based on the cooperative interactions in the "Public Goods Game", adopted from game theory [11, 30]. Experimental interactions were held in groups of four individuals who were strangers to each other. Each group, consisting of the same-sex subjects, was placed in a separate room, all sitting at a common table. Any intentional communication between participants was prohibited during the whole run of the experiment. Prior to the start of the experiment, game rules were explained to the participants in detail. It was also announced that tokens, which they will earn during experimental interactions, will be exchanged into real money at the end of the game. Exact exchange rate was not announced till the end of the experiment, but participants were informed that pay-offs will widely vary according to individual performance. Interactions were implemented in 3 subsequent rounds. In each round participant was given initial 20 tokens, and had to decide how many of these tokens (from 0 to 20) he/she was willing to invest into a "common project". Decisions on the invested were kept confidential, so that other members of a group did not know amount of investments of their partners. Not invested tokens were kept by participant. After all members of a group have made their investment decisions, the sum of investments was doubled and equally distributed between all four group members [for details see: 43].

The "Public Goods Game" represents a social dilemma, where individual and group interests are confronted. During the whole experiment participants did not receive information about individual investments of their partners, but in the 2nd and 3rd rounds of the game they could judge the general level of cooperativeness in a group based on overall payoffs. The iterated "Public Goods Game" allows not only to get insight into individual cooperativeness of participants based on the amount of investments into the "common project", but also to assess individual cooperative strategies — as algorithms of behaviour across all three rounds [4, 16, 43].

Morphometric analysis

The analysis of subjects' facial morphology was based on the facial photographs. The full-face frontal portrait of each participant was made with neutral facial expression, in a sitting position with a straight back; head was positioned into the Frankfort horizontal plane. The camera was set at the eyes height. Distance to an object was 170 cm. Each photograph included a scale in centimeters.

The analysis of facial shape was implemented using geometric morphometrics [7, 55]. Facial configurations were based on 71 anthropometric landmarks, representing both cranio-facial approximations, and soft-tissue morphology [53].

Landmarks digitalization was held in tpsDig2 2.17 [40]. Thereafter, the facial configurations were standardized for the position, orientation and scale, using Generalized Procrustes superimposition in the tpsRelw 1.67 program [40]. The latter allowed distilling information that was related only to the facial shape. To reduce possible noise due to head positioning in the 2D projection the facial configurations were symmetrized [33] in the Mathematica 11.

To reveal possible associations between the facial shape and individual cooperativeness, facial coordinates were regressed upon each of independent factors using tpsRegr 1.45 [40]. The significance level was assessed with permutation test (10000 permutations) [22]. Visualization was realized with thin-plate deformation grids using tpsRegr 1.45 [40] and unwarping and averaging the images in tpsSuper 2.04 [40].

In addition to the assessment of the full facial shape, differences in partial morphological facial parameters were analyzed (Tab. 1) [2, 32, 45], which allowed localization of the differences according to specific facial areas.

Information about age, height and weight of the participants was also collected.

Table 1

Morphometric facial indices

№	Name	Definition
1	Relative forehead height	Relation of the forehead height (tr — n) to the upper facial height (n — lb)
2	Relative upper facial width (fWHR)	Relation of the zygomatic width (zy — zy) to the upper facial height (n — lb)
3	Relative facial height	Relation of the full facial height (n — gn) to the zygomatic width (zy — zy)
4	Relative cheekbones prominence	Relation of the zygomatic width (zy — zy) to the bigonial mandibular width (go — go)
5	Relative nasal width	Relation of the nasal width (al — al) to the zygomatic width (zy — zy)
6	Latitude nasal index	Relation of the nasal width (al — al) to the nasal height (n — sbn)
7	Relative mandibular height	Relation of the mandibular height (st — gn) to the bigonial mandibular width (go — go)

Notes. Anthropometric landmarks: tr (trichion) — the point on the border of the hair growth at the midline of the face; n (nasion) — the point at the intersection of the nasofrontal suture with the facial midline (placed along the line connecting upper edges of the upper eyelids) [45]; gn (gnathion) — lowest point of the chin in the medial-sagittal plane; zy (zygion) — the most protruding outward point of the zygomatic arch; lb (labrale superior) — the midpoint of the upper contour of the upper lip vermilion; go (gonion) — the most prominent point of the angle of the mandible; al (alare) — the most protruding lateral point of the nasal wing; sbn (subnasale) — the midpoint of the angle of the nasal septum, at which the lower edge of the nasal septum is connected to the upper lip; st (stomion) — the imaginary point of intersection of the vertical midline of the face and the horizontal line between the closed lips.

Results and Discussion

The analysis of the amounts of participants' individual investments over all three rounds of the experimental game allowed distinguishing four main behavioural strategies: 1) conditional cooperator — varied investments into the "common project" depending on situation; 2) unconditional cooperator ("altruist") — always invested ≥ 75% of own funds, even in cases of low general pay-offs in the previous rounds; 3) self-oriented — always invested < 50% of own funds into the "common project", regardless of the situation; 4) occasional free-rider — participants who invested > 50% of their funds in one or two rounds and crucially reduced investment (almost to zero) in at least one round. Strategies of participants whose decisions could not be classified according to this scheme were excluded from further analysis. Relative frequencies of occurrence of each type of strategies for men and women are presented in Figure 1.

The results of additional analysis revealed no any relations between participants' cooperative behaviour and their age, height, weight, and body mass index (BMI= m/h^2, where m — body mass (kg), h — height (m)).

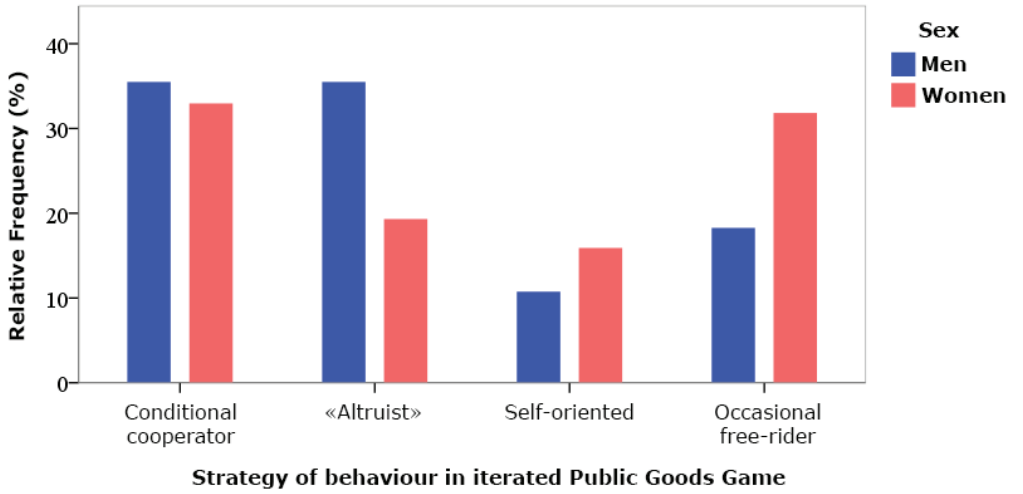

Fig. 1. Distribution of cooperative strategies in the iterated Public Goods Game for male and female participants. Sex differences is strategies' distributions are statistically significant according to a chi-square test of independence (X2= 8.602(3); p = 0.035)

In order to reveal possible associations between participants' facial shape and their cooperative behaviour, the facial coordinates were regressed upon cooperative strategies in the experimental game, separately for men and women. In female part of the sample (N=88) no significant associations were revealed. In the male part of the sample, for all kinds of strategies compared in a pairwise manner, only one considerable association was revealed — namely, the faces of young men applying strategy of unconditional cooperation (altruistic strategy) differed from the faces of conditional cooperators (permutation test with 10000 permutations: N = 66; R^2 = 0.03; p=0.062 — statistical trend). Obtained results are presented in Figure 2.

Table 2 represents mean values and the results of comparative analysis of morphometric facial indices (see Tab. 1) for male participants who were distinguished by their cooperative strategies (altruist/conditional cooperator) (see Fig. 2), as well as the overall data for representatives of each sex. Since values of the facial indices were normally (or approximately symmetrically) distributed, for estimating differences between categories of consideration the Student's T-test was used. The significance threshold was set to 5%.

Among all analyzed morphometric facial indices significant association with altruistic behaviour was revealed only for two parameters: 1) higher relative forehead height was characteristic of male altruists (this morphological trait was generally more typical for female part of the sample); 2) higher relative height of the mandible was also characteristic of altruistic men (this morphological trait was generally more typical for male part of the sample). Obtained result shows that altruistic men did not demonstrate more pronounced male-specific facial traits compared to other male participants of our study. Of the eight sex-specific facial indices [see also 41] altruists differed from others only in two of these indices, moreover, combined traits characteristic of both male and female sexes. This result is consistent with other findings obtained earlier in a similar study involving Buryats and Russians. In that study, altruists were characterized by mean values of the digit ratio, which is viewed as a marker of prenatal exposure to testosterone/estrogens [4]. Respectively, it can be suggested that men-altruists express neither extremely masculinized, nor

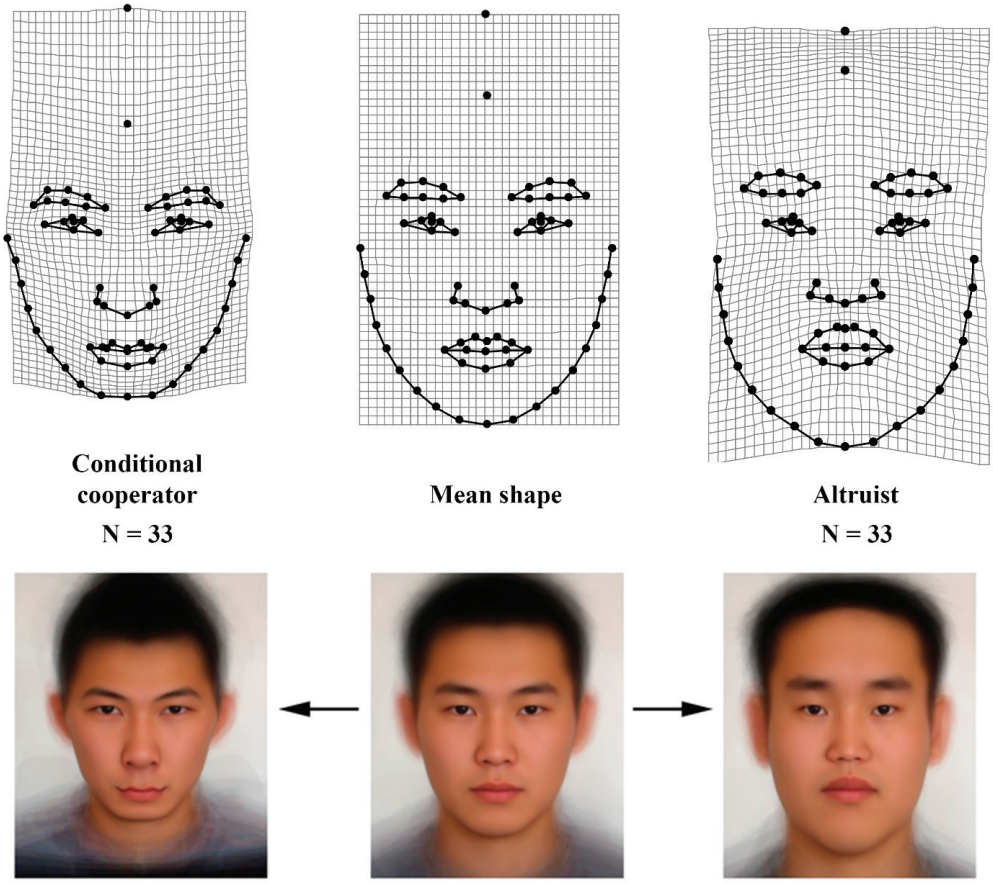

Fig. 2. Visualization of facial shape differences between altruists and conditional cooperators. To enhance the details actual differences were 10-fold exaggerated.
Regression analysis: N=66; R2=0.03; p = 0.062

feminized morphology. This may be related to heterozygosity or a mosaic set of key genes responsible for sex-specific morphogenesis. However, this is only a hypothesis that needs testing.

The results of the current study do not allow concluding that Buryat men with lower fWHR (male-specific Buryat trait) demonstrated increased level of cooperativeness in groups. It may be due to the specific features of the experimental design, which involved group interactions, but did not imply the inter-group competition [46]. Therefore, there is a need for additional studies to assess the sensitivity of male behavior to the pressure of inter-group competition and its relation to the morphological masculine complex.

Observed specific features of the altruists' facial shape is not restricted to a set of standard anthropometric indices. Part of the differences are obviously related to soft-tissue morphology, the analysis of which is beyond the scope of this paper.

The lack of significant association between female facial shape and propensity for same-sex group cooperation once again points to the different directions of the selective pressure, functioning among men and women, with regard to group cooperative behavior, and supports the suggestion of a special role of such behaviour particularly among men.

Table 2

Descriptive statistics and comparison of morphometric facial indices

№	Index	Group	N	Mean	SD	t	p
1	Relative forehead height	Altruists	33	1.03	0.10	2.03	0.046*
		Conditional cooperators	33	0.98	0.10		
		Men	98	1.00	0.10	-5.62	<0.0001*
		Women	89	1.08	0.11		
2	Relative upper facial width (fWHR)	Altruists	33	2.09	0.12	1.53	0.130
		Conditional cooperators	33	2.04	0.11		
		Men	98	2.07	0.11	-3.94	<0.0001*
		Women	89	2.13	0.10		
3	Relative facial height	Altruists	33	0.92	0.05	1.36	0.178
		Conditional cooperators	33	0.90	0.05		
		Men	98	0.91	0.05	4.359	<0.0001*
		Women	89	0.88	0.05		
4	Relative cheekbones prominence	Altruists	33	1.25	0.04	-1.02	0.311
		Conditional cooperators	33	1.26	0.04		
		Men	98	1.26	0.04	5.79	<0.0001*
		Women	89	1.22	0.04		
5	Relative nasal width	Altruists	33	0.27	0.02	0.64	0.527
		Conditional cooperators	33	0.26	0.02		
		Men	98	0.26	0.02	7.88	<0.0001*
		Women	89	0.24	0.01		
6	Latitude nasal index	Altruists	33	0.71	0.05	1.70	0.090
		Conditional cooperators	33	0.69	0.05		
		Men	98	0.69	0.05	4.67	<0.0001*
		Women	89	0.66	0.05		
7	Relative mandibular height	Altruists	33	0.37	0.04	2.24	0.029*
		Conditional cooperators	33	0.35	0.04		
		Men	98	0.36	0.04	7.10	<0.0001*
		Women	89	0.32	0.03		

Note: N — number of cases; SD — standard deviation; t — statistics of the Student's T-test; p — statistical significance ("*" — $p < 0.005$).

Conclusions

The results of our study revealed:

1) that association between facial morphology and within-sex cooperativeness occurs only among men;

2) men, who are predisposed to cooperative behaviour, have a set of specific facial traits, however these traits cannot be considered as unambiguously corresponding to strongly pronounced male sex-specific facial features; apparently, altruistic behavior is more characteristic of men with a mosaic distribution of sex-specific morphological features of the face.

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