= HUMAN GENETICS =

Aggression and Empathy as Genetic Differentiation Factors of Urban Population

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Abstract—Permanent residents of Kharkiv (637 men and 856 women at the age of 45-65 years) are tested on the level of aggression and empathy. The average aggression level (41.7 points) is higher in migrants (born outside Kharkiv) than in indigenous people (36.3 points); the average empathy level is lower in migrants (3.2 points) than in indigenous people (5.5 points). The average values of the aggression and empathy indices are not associated with ethnicity and degree of miscegenation. The correlation between spouses (*r*) by these personal features is within 0.20–0.31; the marriage conjugation index (*K*) is 0.13–0.18. Genotyping of the marriage assortativeness: the $C \times CC$ and $T \times TT$ pairs are developed more frequently than during panmixia; the $C \times TT$ and $T \times CC$ pairs, less frequently. The *T* allele is coupled with increased aggression level and decreased empathy level. The phenotypes of heterozygous women indicate the intermediate inheritance of these traits.

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INTRODUCTION

Urban population is a new type of populations, which arose relatively recently in human history [1]. Urban residents are exposed to the effect of new extreme factors that were not encountered in previous human history. High population density, chemical pollution of the environment, and increased pressure of physical and mental loads are among the factors to which the human organism can unfavorably respond [2]. Urban conditions are an additional stress for emigrants from small localities as compared with the indigenous population, which is more adapted to life in a megalopolis [3]. The increased stressful atmosphere in the city is a source of interindividual and intergroup conflicts, the severity of which depends on such personal characteristics of individuals as an aggression and empathy. Aggression makes it possible to survive under limited living resources [4]; however, it is a destructive property of a person in hypertrophied form [5]. Empathy is considered a quality opposite to aggression [6, 7]. Increased aggression and decreased empathy are peculiar to most criminals [8] and patients with some hereditarily caused psychopathological conditions [9]. A genetic component is present in the etiology of aggression and empathy [10, 11]. At present, the genes associated with the levels of aggression and empathy have been already revealed [12–20]. The world data provide an estimate of heritability of these personal features at the level 50% [21, 22]. Estimates of heritability of a number of behavioral traits

[27–29], including aggression and empathy, were obtained for the population of Ukraine studied with respect to genetic and demographic structure [23–26]. It was established that approximately 40% of phenotypic diversity in the levels of aggression and empathy is caused by a genetic component in Ukrainian populations [30].

The severity of quantitative traits with a genetic component (which include aggression and empathy) depend on the population structure [31]. At the same time, these traits themselves can be structure forming (through the influence on the choice of marriage partner) [32].

The specific weight of the urban population in Ukraine is 70%; the eastern part of the country is the most urbanized. All of the above governed the goal of the study: to detect what determines the level of aggression and empathy of the residents of a large city by example of the population of Kharkiv and whether personal features influence the population structure.

MATERIALS AND METHODS

Permanent residents of Kharkiv (637 men and 856 women) at the age from 45 to 65 participated in the study; all of them gave a voluntary informed consent for questioning and collection of biological material. The natives of Kharkiv are designated as indigenous residents; individuals born in other places are designated as migrants. The ethnicity of surveyed indi-

Trait	Statistics	Men ($n = 637$)	Women ($n = 856$)
	lim	31-47	27-49
Aggression	\overline{x} (s)	40.0 (3.1)	38.9 (3.3)
	CI	39.7-40.2	38.6-39.1
	lim	1-10	1-10
Empathy	\overline{x} (s)	5.4 (2.1)	4.8 (2.1)
	CI	5.2-5.5	4.6-4.8

Table 1. Statistical characteristics of distribution of aggression and empathy points in Kharkiv residents

n, number of observations; *lim*, minimum and maximum values; \overline{x} , arithmetic mean value of the trait; *s*, standard deviation; CI, 95% confidence interval.

viduals, their parents, and ancestors were recorded according to self-determination. The place of birth of parents was taken into account.

The aggression level was estimated according to Assinger's questionnaire; the empathy level, according to the Mehrabian and Epstein questionnaire [33]. The aggression and empathy were estimated in points that are whole positive numbers directly reflecting the degree of development of the trait.

A hundred of married couples were genotyped for the *rs2235186* single nucleotide polymorphism (SNP) in the monoaminooxidase A (*MAO-A*) gene by the PCR-RFLP method [34]. DNA was isolated from the buccal epithelium cells by means of *ChelexR100* ion exchange resin. The restriction was carried out by *Bsp*TI endonuclease. Electrophoretic separation of the products of amplification and DNA fragment restriction was conducted in 2% agarose gel with visualization in ultraviolet light.

The database was developed in the Microsoft Excel program. The statistical estimation and comparison were conducted by methods of one-dimensional statistics. The distribution of the aggression and empathy points for the correspondence to Gauss's law was checked by the Kolmogorov–Smirnov method. The comparison of mean group values was conducted using an unpaired two-sample Student *t* test with Bonferroni correction. The χ^2 criterion was used for the comparison of portions, as well as actual theoretical series. The Pearson correlation coefficient (*r*) and marriage conjugation index (*K*) were calculated. The check of the null hypotheses was carried out at the significance level 0.05. Calculations were conducted in the Statistica program.

RESULTS AND DISCUSSION

The distribution of the aggression and empathy points are given in Table 1. A direct weak correlation exists between the aggression and empathy levels; it is described by a correlation coefficient r = 0.08 (p < 0.05) in men and r = 0.12 (p < 0.001) in women. This fact

apparently means that, although aggression and empathy are perceived by their manifestations as opposite personal features, they are not complementary; an individual with high scores according to the aggression scale is not automatically a holder of weakly expressed empathy. Apparently, there is some common property which determines the degree of development of each trait.

According to the number of points, the surveyed individuals were divided into the groups with low (I), average (II), and high (III) aggression and empathy levels. It turned out that 48% of men and 62% of women were in the group with a combination of average values of traits (II/II) (p < 0.001). Accordingly, boundary combinations of these traits (I/III and III/I) are more frequently found in men than in women.

The prominence of aggression and empathy does not depend on the ethnicity and degree of miscegenation of the surveyed individuals (as indicated by the confidence intervals of arithmetic mean values) (Table 2).

The average aggression level was higher in those born outside Kharkiv (41.7 points) than in indigenous residents (36.7 points, p < 0.05) (Table 3). The empathy level in migrants (3.8 points) was decreased as compared with the natives of Kharkiv (5.9 points, p < 0.05). Aggression is expressed to the least degree in neighbor migrants (natives of Kharkiv oblast) and to the greatest degree in distant migrants (natives of near and distant foreign countries). The natives of other oblasts of Ukraine (the group "averages") are intermediate with respect to the studied indices (Table 4).

In order to explain the results obtained, it is possible to assume that more energetic (consequently, more aggressive) individuals are prone to a change of place of residence. It is possible to assume that the group of migrants living in Kharkiv is a biased sample from a more purposeful part of the population from where they came. In this consideration, higher aggression of the migrants is understood as innate (genetically caused). If we assume that the migrants living in Kharkiv are a random sample from the donor population, their increased aggression should be explained by

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Proband sex	Group	n (%)	Aggression			Empathy		
	Gloup	n (70)	\overline{x}	S	CI	\overline{x}	S	CI
	1	32 (25.8)	39.1	4.3	37.5-40.7	5.2	1.6	4.3-6.1
Male	2	55 (44.3)	40.3	4.0	39.3-41.3	5.0	1.9	4.1-5.9
	3	10 (8.1)	39.2	4.9	36.0-39.4	5.4	2.8	3.6-7.2
	4	27 (21.8)	40.3	3.6	38.9-41.7	5.5	2.1	4.7-6.3
	1	111 (27.2)	38.4	3.1	37.8-39.0	5.0	2.3	4.6-5.4
Female	2	200 (49.0)	38.4	3.6	37.8-39.0	5.0	2.2	4.6-5.5
	3	33 (8.1)	39.2	4.0	37.8-40.6	5.0	2.1	4.2-5.8
	4	64 (15.7)	38.5	3.3	37.7-39.3	5.0	2.2	4.6-5.8

Table 2. Level of aggression and empathy in Kharkiv residents taking into account ethnicity of their ancestors

1, Ukrainians are the ancestors; 2, Ukrainians and other Slavs are the ancestors; 3, Ukrainians and not Slavs are the ancestors; 4, Ukrainians are not the ancestors; *n*, number of probands; \bar{x} , arithmetic mean value of the trait; *s*, standard deviation; CI, 95% confidence interval

 Table 3. Level of aggression and empathy in indigenous Kharkiv residents and migrants

		М	en	Women		
Trait	Statistics		indigenous $(n = 273)$	migrants $(n = 203)$	indigenous $(n = 394)$	
Aggression	\overline{x} (s)	42.1 (2.0)	37.2 (2.1)	41.2 (2.4)	36.1 (2.2)	
	CI	41.7-42.5	36.4-37.9	40.6-41.8	35.6-36.5	
Empathy	\overline{x} (s)	4.2 (2.7)	6.8 (2.1)	3.4 (2.5)	5.0 (2.5)	
	CI	3.3-5.0	6.3-7.2	3.0-3.7	4.3-5.6	

n, number of observations; \overline{x} , arithmetic mean value of the trait; *s*, standard deviation; CI, 95% confidence interval.

Table 4. Aggression and empathy (points) depending on migration distance

Migrapts	Statistics	Aggre	ession	Empathy		
wigiants	Statistics	men ($n = 171$)	women ($n = 203$)	men $(n = 171)$	women $(n = 203)$	
Near	\overline{x} (s)	40.4 (2.1)	37.8 (2.2)	5.3 (2.5)	5.0 (1.9)	
	CI	40.0-40.8	37.0-38.6	4.9-5.7	4.6-5.4	
Mean	\overline{x} (s)	40.8 (2.0)	37.8 (1.8)	5.1 (2.1)	5.0 (2.0)	
	CI	40.2-41.5	37.0-38.6	4.7-5.5	4.2-5.8	
Distant	\overline{x} (s)	42.2 (2.0)	39.3 (2.0)	5.0 (2.1)	4.4 (2.0)	
	CI	41.6-42.8	38.8-39.8	4.3-5.7	4.0-4.8	

 \overline{x} , arithmetic mean value of the trait; s, standard deviation; CI, 95% confidence interval.

the effect of a new environment (it is clear that the migrants in general are under less favorable conditions as compared with indigenous residents). In order to check this assumption, the natives of Kharkiv were distributed in the groups depending on the place of birth of the parents (Table 5). The aggression level was minimal, while the empathy level was maximal in those whose parents were also natives of Kharkiv. The natives of Kharkiv both parents of which were from

another town demonstrated the highest aggression and the lowest empathy. The prominence of both traits was intermediate in the group in which only one of the parents was a native of Kharkiv. The proband migrants were distributed in the subgroups by the same principle. The same ratio of mean points depending on the place of birth of the parents was registered in the surveyed migrants (with higher overall aggression level and decreased empathy level). Those whose both par-

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	Men		Women				
Status	Place of birth of parents	Aggression \overline{x} (s) CI	Empathy \overline{x} (s) CI	Status	Place of birth of parents	Aggression \overline{x} (s) CI	Empathy \overline{x} (s) CI
Indigenous $N = 273$	Both indigenous, n = 91	40.0 (2.0) 39.6–40.4	5.6 (2.7) 5.1–6.1	Indigenous $N = 394$	Both indigenous, n = 149	37.4 (2.2) 36.9–37.8	5.2 (2.5) 4.7–5.7
	Both nonresident, $n = 42$	41.8 (2.0) 41.4–42.2	5.0 (2.4) 4.5–5.5		Both nonresident, $n = 56$	39.4 (2.3) 38.9–39.9	4.9 (2.9) 4.4–5.4
	Father nonresident, $n = 68$	41.0 (2.1) 40.6–41.4	5.2 (2.6) 4.8–5.6		Father nonresident, $n = 81$	38.3 (2.2) 37.7–38.7	4.9 (2.7) 4.4–5.4
	Mother nonresident, $n = 72$	40.4 (2.5) 39.9–40.9	5.2 (2.5) 4.8–5.6		Mother nonresident, $n = 108$	38.5 (2.4) 38.0–39.0	5.1 (2.7) 4.6–5.6
Migrant $N = 171$	Both indigenous, n = 62	41.1 (2.1) 40.6–41.6	5.0 (2.2) 4.5–5.5	$\begin{array}{c} \text{Migrant} \\ N = 203 \end{array}$	Both indigenous, $n = 71$	38.4 (2.1) 37.9–38.9	4.8 (2.4) 4.3–5.3
	Both nonresident, $n = 27$	42.2 (2.1) 41.7–42.7	4.7 (2.0) 4.2–5.2		Both nonresident, $n = 37$	39.7 (2.1) 39.2–40.2	4.4 (2.5) 4.0–4.8
	Father nonresident, $n = 38$	40.2 (2.9) 39.7–40.7	5.5 (2.7) 5.0–6.0		Father nonresident, $n = 44$	38.2 (2.4) 37.7–38.7	5.0 (2.6) 4.5–5.5
	Mother nonresident, $n = 44$	40.6 (2.6) 40.2–41.0	5.4 (2.5) 5.0–5.8		Mother nonresident, $n = 51$	38.1 (2.1) 37.6–38.6	4.9 (2.7) 4.4–5.4

Table 5. Level of aggression and empathy (in points) of Kharkiv residents depending on place of birth of parents

N, number of probands; *n*, number of parental couples; upper line in the cell: \overline{x} , arithmetic mean value of the trait; *s*, standard deviation; lower line in the cell: CI, 95% confidence interval.

ents were natives of Kharkiv showed minimal (for its cohort) mean aggression (39.8 points) and maximal empathy (4.9 points). These probands were born outside Kharkiv (in places of temporal residence of parents owing to study or work), but inherited the genes in the ratios typical of the Kharkiv population gene pool (and therefore can be considered as "conditionally indigenous"). It is interesting to compare the subgroup of "truly indigenous" with the subgroup of "conditionally indigenous." It is logical to assume that the gene pools of these groups are largely alike, since the parents of both of them are members of the Kharkiv population. If the level of aggression and empathy were determined only genetically, the groups would not differ in these indices. However, geographical movement played a certain role (the aggression level increased, while the empathy level decreased). With the same direction in men and women, it has the following quantitative expression: the increase in the mean aggression owing to geographical movement is

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2.7–2.8%; the mean empathy level decreases by 10.7% in men as a result of migration; in women, it decreases by 7.7%. Under such consideration, the difference between the groups of "truly indigenous" and "conditionally indigenous" can be attributed to the environmental component.

A dependence exists between husbands and wives according to the studied behavioral traits: for aggression, it is described by the correlation coefficient r = 0.28 (p < 0.01); for empathy, r = 0.31 (p < 0.001). The cross-correlation coefficients are within 0.20-0.23 (p < 0.05). Marriage conjugation is most strongly expressed by the empathy level (K = 0.18); for other combinations, the conjugation index is at the level 0.13-0.14 (Table 6).

The conducted phenotypic analysis demonstrated that aggression and empathy have a structure-forming effect on the population (through the influence on the marriage partner selection); this should create a particular degree of its subdivision with known genetic effects [2] that are possible if the traits according to

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Table 6	Marriage	coniligation	hy aggre	ssion and	emnathy
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Trait husband (wife	Statistics					
Hait, husband/ wite	r	ϕ^2	K	χ^2	р	
Aggression/aggression	0.28	0.08	0.14	8.0	< 0.05	
Empathy/empathy	0.31	0.13	0.18	13.4	< 0.001	
Aggression/empathy	0.23	0.06	0.13	6.3	< 0.05	
Empathy/aggression	0.20	0.07	0.13	6.9	< 0.05	

r, Pearson's correlation coefficient; ϕ^2 , contingency coefficient; *K*, polychoric association index; χ^2 , Pearson's conjugation index; *p*, significance level.

which the partner selection is conducted have a genetic component [31]. In order to clarify whether the marriage assortativeness by aggression and empathy can have genetic consequences, single nucleotide polymorphism (SNP) C/T in the position *rs2235186* of the X-linked *MAO-A* gene (which is the first candidate "aggression gene") was studied [35]. The *MAO-A* gene controls the enzyme monoaminooxidase cleaving serotonin, which is the main mediator controlling aggressive behavior [36–39].

Table 7.	Distribution	of married	couples
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Genotypes of married couples	Number of married couples expected during panmixia	Actual number of married couples			
$X^{C}Y \times X^{C}X^{C}$	18.3	27↑			
$\mathbf{X}^{C}\mathbf{Y} \times \mathbf{X}^{C}\mathbf{X}^{T}$	31.1	30			
$\mathbf{X}^{C}\mathbf{Y} \times \mathbf{X}^{T}\mathbf{X}^{T}$	11.6	5↓			
$\mathbf{X}^T \mathbf{Y} \times \mathbf{X}^C \mathbf{X}^C$	11.7	3↓			
$\mathbf{X}^T \mathbf{Y} \times \mathbf{X}^C \mathbf{X}^T$	19.9	21			
$\mathbf{X}^T \mathbf{Y} \times \mathbf{X}^T \mathbf{X}^T$	7.4	14↑			
Total	100	100			
Statistics	$\chi^2 = 20.4; p < 0.05$				

X and Y are sex chromosomes; C and T are alleles; (\uparrow) increased and (\downarrow) decreased as compared with the number during panmixia.

The distribution of genotypes in men (*C*, 61; *T*, 39) and women (*CC*, 30; *CT*, 51; *TT*, 19) was used for calculation of the allele frequencies. The *C* allele was major in the Kharkiv population ($p_C = 0.58$). The distribution of married couples indicates a deviation from the panmixia (Table 7). The pairs with similar genotypes ($C \times CC$ and $T \times TT$) are developed more frequently than with random selection; the pairs between the holders of different genotypes ($C \times TT$ and $T \times CC$) are found less frequently.

Potential spouses select a marriage partner according to the phenotype. It is logical to assume that the assortativeness for the *MAO-A* rs2235186 SNP genotype is secondary, caused by the association between this polymorphism and studied behavioral characteristics. As we can see (Table 8), the *T* allele in hemizygous men is associated with higher mean aggression level (39.9) and decreased empathy (4.3); at the same time, aggression (36.5) is lower (p < 0.05), while the empathy (5.5) is higher (p < 0.05) in the *C* allele carriers. The same association between the genotype and phenotype was registered in homozygous women. The level of aggression and empathy in heterozygous women demonstrates the effect of intermediate inheritance of these traits.

The conducted study demonstrated that the prominence of aggression and empathy in the residents of the Ukrainian megalopolis is not associated with ethnicity and does not depend on the degree of miscegenation. The demographic status is a factor which modifies these traits; migrants are characterized by increased aggression and decreased empathy. Aggression is in direct dependence, while empathy is in inverse dependence on the distance of migration. Marriage conjugation with respect to aggression and empathy indicates that these personal features influence the population structure. The association of these traits with the *MAO-A* gene indicates possible genetic

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Trait	Statistics	Genotypes of men Genoty			enotypes of wome	otypes of women	
Han	Statistics	<i>C</i> , <i>n</i> = 61	<i>T</i> , <i>n</i> = 39	CC, n = 30	CT, n = 51	<i>TT</i> , <i>n</i> = 19	
Aggression	\overline{x} (s)	36.5 (2.9)	39.9 (1.9)	34.8 (2.5)	36.7 (2.5)	38.8 (2.6)	
	CI	Ç5.8–37.2	39.3-40.5	33.9-35.7	36.0-37.4	37.6-40.0	
Empathy	\overline{x} (s)	6.0 (1.9)	4.3 (1.5)	6.4 (1.6)	5.3 (1.6)	5.6 (1.8)	
	CI	5.5-6.5	3.8-4.8	5.8-7.0	4.8-5.8	4.8-6.4	

Table 8. Aggression and empathy points at different MAO-A gene rs2235186 SNP genotypes

n, number of observations; \overline{x} , arithmetic mean value of the trait; *s*, standard deviation; CI, 95% confidence interval.

consequences of the positive marriage assortativeness by the aggression and empathy indices.

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