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DERMATOGLIPHICS CAN BE AS METHOD OF BEHAVIOR GENETICS

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Abstract

Basing on investigations where the relationships between dermatogliographics and genetic diseases in medicine are determined, we conducted another kind of researches to investigate the relationships between dermatoglifics and personality traits. We provided two different researches at different times, with different respondents and methods, and many results were repeated in two surveys. The results showed lenear relation between boys' boldness and the end of the main palmar line D on the left hand. Thus, by giving this result of two researches, we showed that dermatoglyphics entirety can be used as a research method in the science of Behavior Genetics. The article describes the peculiarities of using dermatoglyphics in psychological research, a specific mathematical model for its application, and the "Heredity regulation of psychological properties of persons" notes that "The gradual trend of increasing or decreasing of frequency occurrence of dermatoglyphics patterns in groups, where the researching psychological property is expressed in ascending or descending order, proves that the studied psychological property has a genetic basis". Creation of this regularity suggest that dermatoglyphics can be considered as a scientific research method in psychological sciences. The use of dermatoglyphics in psychological research can contribute to the solution of theoretical and practical problems of the subject.

Keywords: *research method, heredity, dermatoglyphics, personality traits, boldness.*

INTRODUCTION

Behavior Genetics are remarkable with its attention toward the solution of the nature and nurture issue in psychology. The main goal of Behavior Genetics is to investigate the nature and origins of individual differences in behavior (McGue M. & Gottesman II., 2015). The study of the role of genetic factors in human abilities and personality traits can also identify the problem of personal development through education. It is inevitable that each individual psychological properties have been developing under the influence of varieties of genetic and social factors, so the definition of the proportion between these influences' levels is important both for the theoretical and practical aspects of psychology.

A wide variety of different methodological approaches are used in Behavior Genetic research (Vaughan V.M. & Vaughan A.T., 1999). Nowadays we can list following research methods of Behavior Genetics such as the use "primarily of family, twin, and adoption correlations to estimate the relative contributions of genetic and environmental influences in the etiology of individual differences; structural models and model-fitting, multivariate analysis, genetic change and continuity in development, shared and non-shared components of environmental variance, and genetic components of "environmental" variation" (Plomin, R. (1986).

"With the advent of a technology that allows us to examine human chromosomes, a renewed interest in the association of dermatoglyphics with disorders was created" (Mavalwala, 1978). Dermatoglyphics has a role in the study of genetic diseases. Most diseases, including daun sindrom (Iantovics B., Kountchev R., 2013), diabetes, schizophrenia (Markow, T.A. & Wandler, K., 1986), alcohol and drug addicts (Wilber, E. Newell-Morris, L. & Streissguth, A.P., 1993) and exc. specifically reflected in dermatoglyphic patterns. But notion as "dermatoglyphics" is not familiar to

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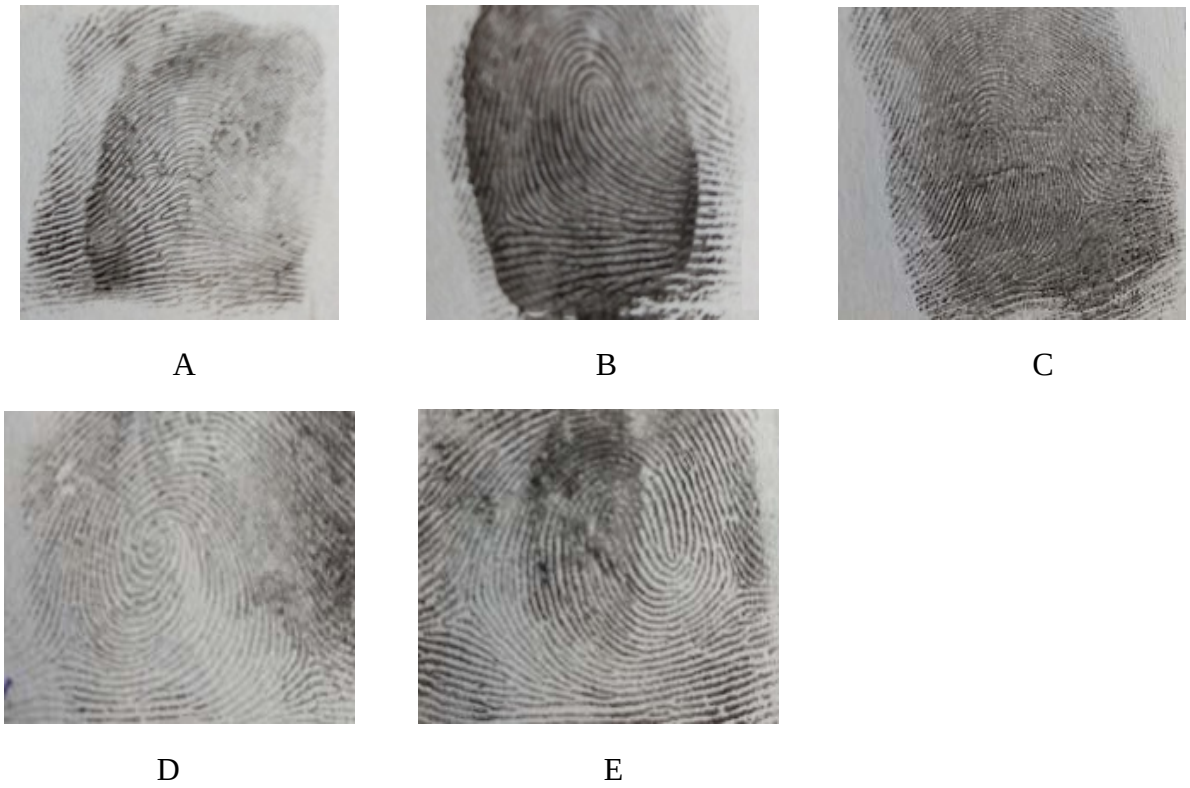
all scientists, especially in the field of Psychology. Further we will describe a notion of dermatoglyphics.

It is known that dermatoglyphics (from ancient Greek derma, "skin", and glyph, "carving") is the division of anatomy, to study the specific papillary lines in the hands and soles of the feet, and their properties. The first introduction of termin “dermatoglyphics” was given by Harold Cummins and Charles Midlo at the forty-second annual session of the American Association of Anatomists, April, 1926 (Cummins & Midlo, 1926).

Those who are unfamiliar with the dermatoglyphics may mislead it as a chiromancy and palmistry, but with N.Bogdanov's words, "There is a similar difference between Astronomy and Astrology, and between Dermatoglyphics and Chiromancy" (Bogdanov, 1998).

Dermatoglyphics expressed as phenotype. Dermatoglyphics are significant indicators of conditions existing several month prior to the birth of an individual (Iantovics & Kountchev, 2013). Dermatoglyphic patterns are fully formed during embryo period at the fifth and sixth month, and remain unchanged to the end of the life. Dermatoglyphic patterns will be restored without any changes even after injury. Patterns (drawings) were classified by different authors. For example, fingerprint patterns are mostly divided into three or four types: arch, ulnar or radial loop, whorl and double loop (Figure 1).

Figure 1. Finger patterns.



A-arch; B-ulnar loop (in right hand); C-radial loop (in right hand); D-whorl; E-double loop.

To date, differentiation of dermatoglyphics in different populations is studied. Dermatoglyphics is widely used as person’ identification in Criminology. Dermatoglyphics are used as alternative method to diagnose genetic diseases in the medical field. Dermatoglyphics are regarded as biological markers in the identification of sport abilities. So dermatoglyphics can be used to clarify issues related to heredity, but why it is not applied in the study of behavior, personality, and ability of the individuals? Can dermatoglyphic method be used as a method of research in the Behavior Genetics in solving these problems? In order to clarify this issue, we have

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tried to find out about the possibility of dermatoglyphics to clarify the problems of genetics during several years. At different times, we conducted two experimental studies (research № 1 and № 2) on relation between dermatoglyphics and human psychology, mainly the personal traits, using different psychological methods. Specific problems have been identified for recording the relationship between psychological features and dermatoglyphics. Creation of a new mathematical model on the use of dermatoglyphics in psychology, based on the analysis of the results of the study, has led to the elimination of this problem. The following is a summary of our researches and its results.

METHODOLOGY

RESEARCH № 1.

Participants

Psychological research was conducted in the Republic of Uzbekistan between 2000 and 2002. Participants consist of four hundred eighty nine male and five hundred and eight female pupils (M_{age}=16.5), who were studying in the secondary schools located in Tashkent city.

Method

Psychological Methods: A modified and adopted version of Eysenck's Personality Inventory (57 items) for the evaluation of extraversion-introversion and neurotism in adolescents (Matmuratova, 1998); a "Map of the Person" (Dyachuk, 1997), designed for self evaluation the psychological features of adolescents (92 items); The Expert Evaluation Questionnaire (EEQ), consisting of 86 questions specially developed for our research to evaluate participant's personality traits by several experts. We have been talked about its features in our previous articles (see Akbarova, Tadjiev, & Islamov, 2016). We will describe it more on Material and Procedure section.

The dermatoglyphic signs were taken and analyzed by the method of T.D.Gladkova (Gladkova, 1966).

The first process of mathematical analysis was provided by using a method of artificial intellect (data mining) – neuron networks (Ignatyev, 2003). This method will help us to find hidden regularities that can not be found in other ways (including statistical methods). Also we used ordinary statistic method for biological and medical researches including Student criterion.

Materials and procedure

Dermatoglyphic experimental data for boys and girls have been analyzed separately because of gender differences. We analyzed finger pattern types (arches, ulnar and radial loops, whorls and double loops), termination of main palmar lines DCBA, palmar triradius, patterns on thenar and hypothenar, patterns on interdigital areas.

The process of analyzing the relationship between psychological experimental data and dermatoglyphics was carried out in two different mathematical models. The first model was called as "Certain pattern and others model". A group of respondents who have the same dermatoglyphic patterns were compared with the rest of the respondents. For example, a group of respondents with ulnar loops (Lu) on all fingers or a group of respondents who have main DCBA line like 11.9.7.3 on the right and left hands. The psychological empirical data of these groups were compared with the other respondents group using mathematical methods of neural networks.

We called our second mathematical model as "four-dimensional psychological trait' groups". Expert Evaluation Questionnaire, where three experts (the parent, a teacher and friend of the respondent) will assess the level of manifestation of personality traits in participant. For example, in order to evaluate personality trait as boldness of person (that is exists in H factor of Cattell' 16 PF Questionnaire too), experts rate it by choosing one of the four variants below:

His boldness

A) expressed at a high level;

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B) expressed at an average level;
C) slightly reflected;
D) does not exist.

We accumulated four groups, where the first group consists of participatnts who assessed by all experts similar as “his boldness expressed at a high level” (by variant “A”). Participants who assessed by variant “B” consist of second group. So we also created third and fourth groups, where participants were with little boldness and no boldness accordingly. The frequencies of the dermatoglyphic patterns in these 4 groups were analyzed separately.

Valence and arousal ratings

The following mathematical amount of neural network method was used for the "Certain pattern and others " model:

1. W – the weight of pattern. This indicates the diagnostic significance of the investigated dermatoglyphic pattern for the characteristic of the groups. Its value varies from 0 to 1.
2. I – the informativity of patters. It indicates the degree of difference of pattern between the groups. In this case the interactions and participation of all other patterns will be taken into account, that is, the distinctive ability of the certain pattern will be considered within a set of all patterns. Its value varies from 1 to 1.
3. S - group intrinsic similarity. The common similarity (homogeneity) level, based on the distribution of a certain pattern within the group. Its value varies from 0 to 1. For example, if we assess boldness as a sign, for the first group, created and mentioned above, S = 1, because all respondents in this group were assessed by the experts as well as by variant “A”.
4. R - difference between the two groups. The difference by means of distribution of pattern’ options in the groups. Its value varies from 0 to 1.

The weight of the pattern is equivalent to the multiplication of group similarity and differences:

$$W=S\cdot R$$ (Ignatyev, 2003).

Amount that can reflect mathematical determinant of the psychodiagnostic significance (Ws) of studied pattern between two group can be set as follows:

$$W_s = W_2 + \left(\frac{W_1 - W_2}{2}\right),$$

where, W_1 and W_2 – the weight of pattern in compared first and second groups accordingly. These limit values are recorded differently in different cases, in other words, not always constant value for all investigations.

In the mathematical model named "four-dimensional psychological trait’ group" we analyzed the Student criterion (t) to check reliability of the results. We paid attention to the cases where studied dermatoglyphic pattern’s frequency has the upward trend or downward trend in created four groups. Only in cases, where such trends were detected, the Student criterion was calculated for pattern’ frequency difference between the first and fourth groups by following formula:

$$t = \frac{P_1 - P_4}{\sqrt{\frac{N_1P_1+N_4P_4}{N_1+N_4}\left(100-\frac{N_1P_1+N_4P_4}{N_1+N_4}\right)\frac{N_1+N_4}{N_1*N_4}}}$$, where

P-percentage occurrence of dermatoglyphic sign (P_1 – in the first group; P_4- in the fourth group); N-number of respondents in the study group (N_1 – in the first group; N_4- in the fourth group); t – Student criterion (test) (Urbah, 1963).

RESULTS

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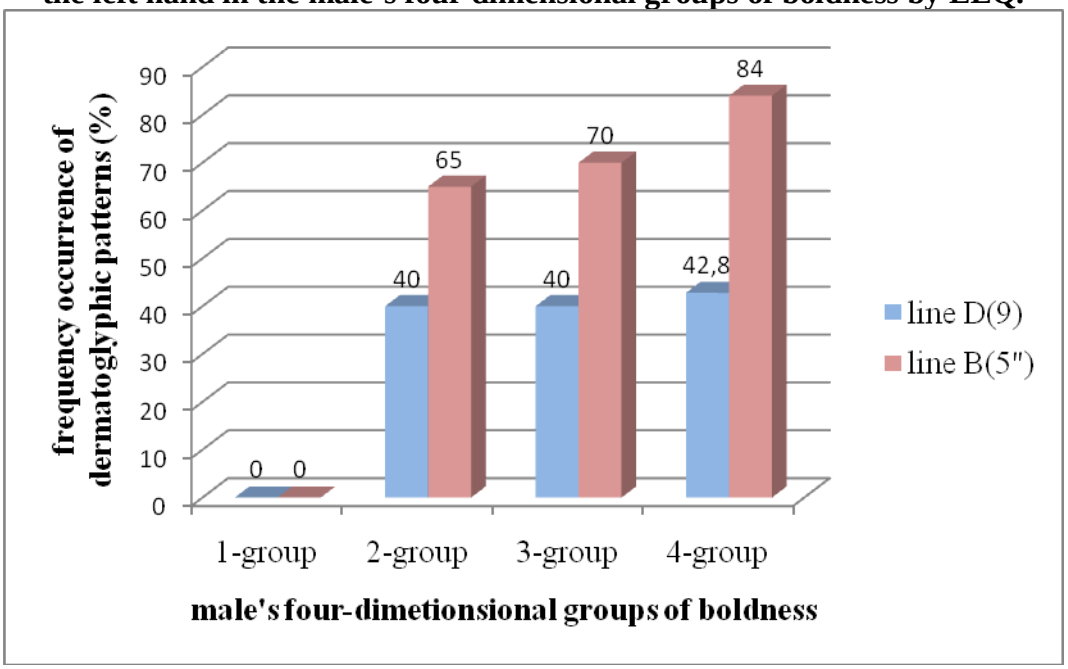
There was no association between the "Map of the Person" (self-assessment) test' results and the dermatoglyphics.

When analyzing the results of the Eysenck test using the "Certain pattern and others" model, we detected relation between the termination of main DCB lines on the right hand like 11.10.8.* and introversion (at W = 0,758) in boys.

No significant results have been achieved in the EEQ results using the "Certain pattern and others" model.

Applying model of "four-dimensional psychological trait' groups" resulted in detecting different relations between a lot of personality traits and dermatoglyphics (Akbarova, Tadjiev & Islamov, 2016; Akbarova & Nurkhodjaev, 2015). Among obtained results, the highest coefficient of Student criterion (P<0,01) was found concerning to boldness. There were 16 males in the first group, 76 males in 2-group, 10 boys in 3-group and 14 in fourth group, created according reflection of boldness' level. Males' boldness were linked with patterns on thumbs (right hand), on index finger (left hand) and left palmar triradius at P<0,5; and with termination of the main D and B lines (left hand) at P<0,01(Figure 2). Discussion of some of these results will be followed by the results of the second research.

Figure 2. Frequency occurrence of termination of main palmar lines D(9) and B(5") in the left hand in the male's four dimensional groups of boldness by EEQ.



RESEARCH № 2

Participants

In the second stage the research was provided in the first course students (208 males and 239 females, M_{age}=20.8, age range: 18-25 years) of Tashkent Pediatric Medical institute in 2015. These participants were also Uzbek nationality.

Methods

Personality traits were studied by Cattell's 16 PF Questionnaire (C variant) adapted for Uzbek population (Shoyimova, 2009).

Dermatoglyphic patterns were taken with scanning technique (Epson Perfection scanner).

Valence and arousal ratings

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In this study the most effective mathematical model concerning dermatoglyphics, i.e. the "four-dimensional psychological trait' group" model was used, and the Student criterion was calculated using the formula described above.

Based on the Cattell test's results, general participants were divided into four groups where scoring points, (ranging from 0 to 10 balls) were different as following:

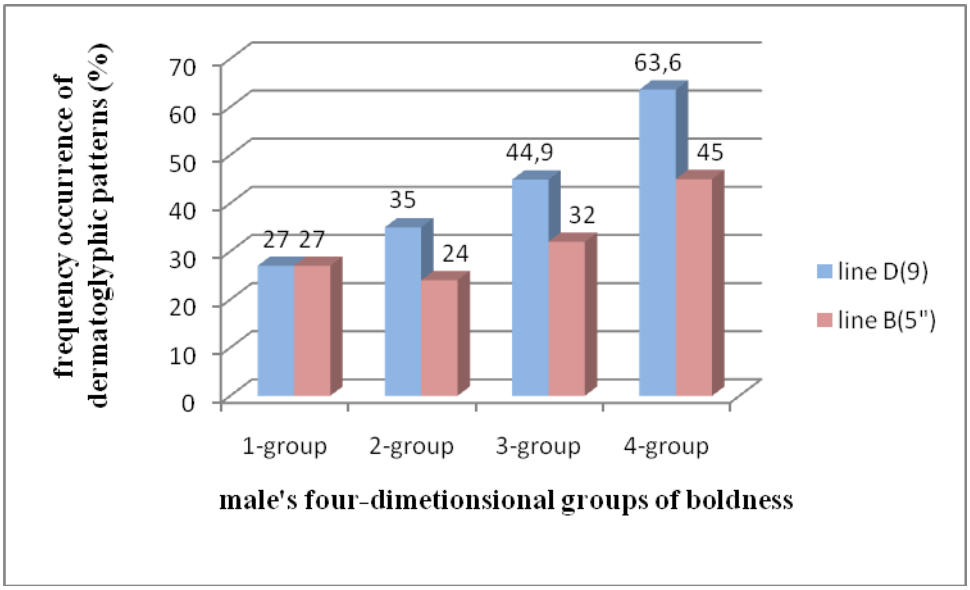
1-group: respondents with 8– 10 balls;
2- group: respondents with 6– 7 balls;
3- group: respondents with 4– 5 balls;
4- group: respondents with 0 – 3 balls.

RESULTS

Since the main purpose of our article is to show that dermatoglyphics can help determine the heredity base of human behavior, we will describe only some limited results of this study.

The most interesting thing for us among the findings was the re-examination of the link between certain dermatoglyphic patterns and personality trait mentioned in our first study. Relation between boldness and dermatoglyphics in this research can be checked by comparing results concerning to the factor "N", i.e. "Socially Boldness" described in Cattell's 16 PF Quessionnaire. We observed again a link between male' boldness and termination of main palmar D(9) line (P <0,1) on the left hand (Fig. 3).

Figure 3. Frequency occurrence of termination of main palmar lines D(9) and B(5") in the left hand in the male's four dimensional groups of H factor of Cattell's 16 PF Quessionnaire.



DISCUSSION

In the above two studies, there was a high degree of relation between the boldness and the dermatoglyphic pattern, such as the completion of the main palmar line D to the 9-th area on the left hand. It can be seen that this result, obtained in the first research, was not accidental; it was repeated in the second research too. These results prove that the boldness has a strong heredity basis. In order to justify this, we will hereby cite many facts concerning to this statement.

First of all, the genetic inherentity of the boldness was also identified in animal studies. In particular, the heritability of boldness in the zebrafish named as *Danio rerio* (a kind of fish) were estimated by 0.90. (Ariyomo, T. O., Carter, M., & Watt, P. J., 2013). In Avian, such as *Parus major* (a kind of bird) dominant genetic effects were important determinants of phenotypic

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variation in boldness (Van Oers, K., et al., 2004). Studying the behavior of dogs, L.B. Krushinsky and his colleagues quoted that timidity (that is, opposide to boldness) has genetic inheritance (Krushinsky, 1993).

Second of all, the manifestation of humanbeing's boldness in the highest possible level, even in this case are signed as pathology, there is genetic base of this behavior trait. This disease is called Urbach-Wiethe's disease, where patients are unaware of the fear and feel no life threatening. Urbach–Wiethe disease (also known as lipoid proteinosis and hyalinosis cutis et mucosae) is a rare recessive genetic disorder (Urbach & Wiethe, 1929). Relation between this disease and genes described as following: "The disease is caused by loss-of-function mutations to chromosome 1 at 1q21, the extracellular matrix protein 1 (ECM1) gene" (Hamada et al., 2002).

Finally, our last argument is the existing of genetic base of the dermatoglyphic sign, which linked to boldness mentioned above. As research works shows, "main palmar line's inheritance was assigned by correlation 0,72+0.05, that suggests a polygenic mode inheritance" (Pons, 1959).

All these facts help to understand and accept the statement that boldness have strong heredity base, and dermatoglyphics was shown as great scientific method that can help to prove it.

Moreover, as a result of our research on the connection of dermatoglyphics with personality traits, we have created a specific law. We have named it "Heredity regularity of psychological properties of person" (Akbarova, 2007), according to it:

> **"The gradual trend of increasing or decreasing of frequency occurrence of dermatoglyphics patterns in groups, where the researching psychological property is expressed in ascending or descending order, proves that the studied psychological property has a genetic basis".**

We would also like to recall the law of Genetic Behavior described by Turkhemer, in which "All human behavioral traits are heritable" (Turkhemer, 2000). This claim is called as a law by Turkhemer. As it is known, the scientific law means a verbal or mathematical expressive statement having evidence, that describes the relationship between various scientific concepts, proposed as an explanation of the facts and recognized by the scientists at this stage, as Newton's laws are. We named our statement about detection of hereditary base of psychological traits by dermatoglyphics as "regulation" rather than "law" now. This is because this statement must be examined and evaluated by other researchers too, and we consider this phenomena must be studied more deeper and more comprehensively. In addition we should find the answer to the following questions: Does any genetic based personality (behavioral) traits have a relationship with dermatoglyphics? Could it be inherited psychological traits that are not linked to dermatoglyphics?

Another important aspect of dermatogyphics is its ability to evaluate the degree of genetic influence to the psychological phenomena. In order to determine this value, we recommend to pay attention to the difference of the dermatoglyphic pattern's frequency between the first and fourth groups of "four-dimensional psychological trait' groups". The greater the difference, the greater the depth of the influence. We propose to reflect that figure as mathematical expression conditionally by "Dh" (Depth of heredity).

Secondly, it is possible to assess width of the heredity influences (which can also be conditionally defined as Wh), which influence to studied phenomena. We should look at how many dermotoglyphic signs have been linked to the psychological phenomena is being studied. When a large number of dermatoglyphic signs are observed, the psychological phenomena is so influenced by many genes that it can be assumed that the genetic wideness is large. So far, we only guess, because we do not know which genes are closely linked to each dermatoglyphic patterns. At the same time, the role of the external environment can be determined in the formation and manifestation of the psychological traits studied on the basis of these results. Looking at each psychological trait abstractly it is possible to examine the ratio between the effects of genetic and social factors on the formation of psychological traits according to each person individually. No

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personality traits in our research reflected 100% contact with dermatoglyphic patterns, ranging from 0 to 100% in the 1st and 4th group. This result indicates that social factors also impact on the formation of all psychological traits. Other researchers also mentioned that all researched psychological traits are influenced by both genes and environment, to varying degrees (Polderman J.C., et al., 2015; Turkheimer E., 2000). In order to determine the role of genetic factors in the formation of certain psychological (behavioral) traits, it is sufficient to see how many of all dermatoglyphic patterns (definitively all the dermatoglyphic patterns that correlate with the study phenomena) are present in that person. Understanding personal differences in behavior can be based on that. «One major result of genetic association studies is the general finding that psychological traits and psychopathology, as well as complex medical diseases, are highly polygenic, where a large number (on the order of hundreds to thousands) of genetic variants, each of small effect, contribute to individual differences in the behavioral trait or propensity to the disorder» (Visscher et al., 2012; Lee SH et al., 2012; Sullivan PF, Daly MJ & O'Donovan M., 2012; De Moor, M.H., et al., 2015). Based on this, it will be possible to create targeted and effective educational programs individually. Thus, dermatoglyphics is an adjustment, means and method to study of the nature and nurture problem of Behavior Genetic. It is easier and more accurate to study the heredity side of the person by means of dermatoglyphics, since the gene and dermatoglyphics appear as a constant indicator of human being. This situation allows scholars to examine the personality, the nature of all psychological phenomena, to learn about the structure of personality, interactions between all psychological phenomena, interactions (including interference, to strengthen or weaken each other) and other issues. For this purpose, connections between dermatoglyphic and gene should also be sufficiently studied. Galton (1892) and Wilder (1902, 1904) studied the hereditary basis of dermal patterns, which has been confirmed by numerous genetic studies (Schauman, B., & Alter, M., 2012). Inheritance of dermatoglyphic patterns were found by many investigation (Bali & Chaube, 1978). But these studies are not enough. It is important to determine which genes are closely linked to each dermatoglyphic patterns.

In this article, we demonstrated how to learn connection between dermatoglyphic sign and psychological phenomena and to draw relevant conclusions by using an example boldness of males. Two researches above showed the same result. The connections, found in the 1-research, are obtained in the 2-research too concerning not only to boldness, but also other psychological phenomena, such as responsibility (Akbarova, 2016), intelligence and others. These facts suggest that dermatoglyphics can be used in the research of Behavioral Genetics. We suggest to apply following mathematical models and we will describe some of the peculiarities that must be considered in the use of dermatoglyphics in psychological research.

Mathematical model for usage dermatoglyphics in psychologic studies.

The mathematical model of the "four-dimensional psychological trait' group" is considered to be the most reliable model for determining the link between human behavior and heredity. Because in this model linear growth or decline of expression of studied psychologic trait in several groups is considered as fixed (constant) indicator. As a variable indicator, we consider the frequency of dermatoglyphics in these groups. Therefore, the mathematical model of the "four-dimensional psychological trait' groups" is more reliable than the model used in the field of medicine to study hereditary diseases, where dermatoglyphics comparison provided only between disease group and control group. In the mathematical model "four-dimensional psychological trait' groups" overall respondents can be divided into 5 or more groups. The most important thing is to have more than three comparable groups in order to detect more clarily tendency of increasing or decreasing variables relatively to fixed indicator. The degree of expression of any studied psychological traits in these four groups must be changed from maximum to minimum or in vise versa.

When using dermatoglyphics in psychological research, it is also crucial for all researchers to select the same classification method. Until now, different classification were described by various authors concerning dermatoglyphics. In addition, some rare patterns of fingerprint appear in different population differently. So far, in the use of dermatoglyphics in medicine and other fields

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"one of the major problems in dermatoglyphic studies has been the adoption different system of classification" (Bali & Chaube, 1994). Therefore, in subsequent studies, the combination of dermatoglyphic markers' name and their sign must be described equally.

In the study of personality behavior and dermatoglyphics, it is important to take into account biological statements. Studied respondents in research should be resident in a single geographical area and belong to the same ethnicity as the dermatoglyphic character of the population is different.

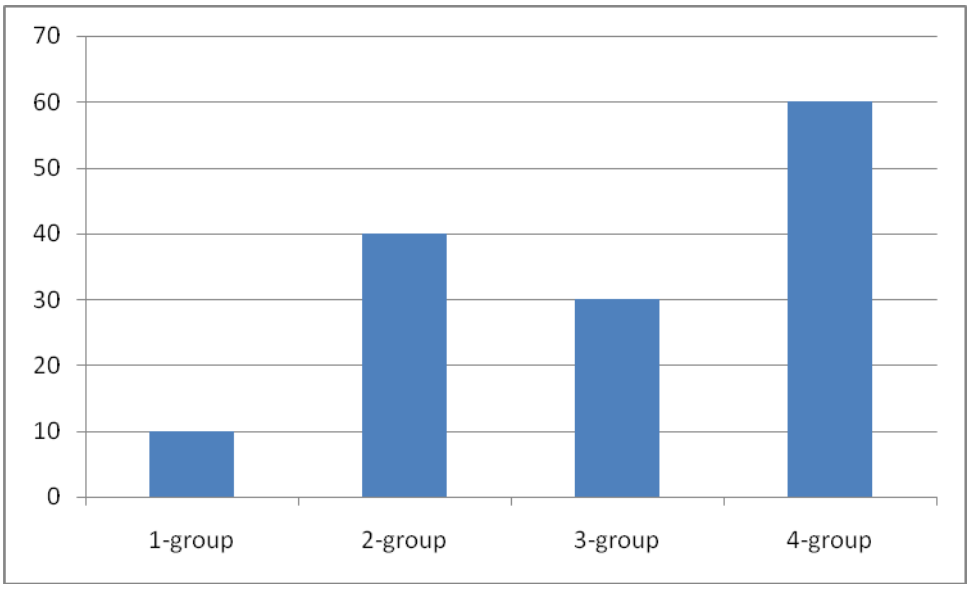
The gender differences in genetic data that leads to dermatoglyphical differences also must be taken into account during data analyzing. In this article we described the results concerning only to male participants.

We consider that the EEQ provides more reliable outcome in determining the extent of expression of person's psychological traits. Because through many results obtained by this method we highlight and use for subsequent mathematic analyze only those respondents (group of respondents) who were assessed by the same answer by three experts (those, who know participant very well for many years). In the cases where respodents were assessed differently, for instance a mother of participant evaluated by "his boldness expressed at a high level", but a teacher and friend of participant chose another variant as "his boldness expressed at an average level", such cases were not included in mathematical analysis. The number of respondents in each of the four groups for analysis should be no less than 10. That is why, number of research sample in case of using EEQ will be more than usage methods like Cattell's 16 Pf Quessionnaire.

Non-linearities (see Figure 4) at diminishing or decreasing of dermatoglyphics' frequency in the four groups also can be under scientific interest. Because of the formation, development and manifestation of psychological phenomena and process of assessment by experts is influenced by many (sometimes difficult to take into account) factors. However, the frequency of the dermatoglyphics in groups 2 and 3 should be under following equation:

$$P_1 < P_2 \text{ (and } P_3) < P_4 \quad \text{or} \quad P_1 > P_2 \text{ (and } P_3) > P_4.$$

Figure 4. Non-linear connection between psychological phenomena and dermatoglyphic patterns.



But this statement is not so strong to assess heredity side of studied phenomena, all cases where at list three groups' indexes have tendency of increasing or decreasing must be considered toward heredity. Unfortunately, assessing of any psychological phenomena has not international etalon like gram or kilogram and equal equipment. That's why, accuracy of level of any personality traits expressing in created four groups depend on methods that assess the personality differently.

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Further according to "Heredity regularity of psychological properties of person", we are able to count the level of confidence in mathematical data by using the Student criterion (using the formula above).

Depth of heredity (Dh) can be count by next formula:

$$Dh=F_1-F_4,$$

where, F_1 – frequency occurrence of dermatoglyphic pattern in the first group; F_2 - frequency occurrence of dermatoglyphic pattern in the fourth group. If $F_1<F_4$, so we count by $Dh=F_4-F_1$.

For example, in our first research boldness' heredity depth concerning main palmar D line termination can be assessed as Dh=42.8 (see Figure 2), because frequency occurrence of it differs from 0 to 42.8 in comparing groups. In the second research it is Dh=64-27=37 (Figure 3).

As width of heredity means number of dermatoglyphic patterns connected to studied trait, we can count it for male' boldness in first research as Wh=7, because seven kind of dermatoglyphic patterns were determined as connected with boldness (from P<0,05 and more).

CONCLUSION

Until now, dermatoglyphics has not been used in the study of the genetic aspects of behavior, we think the reason for this is that a reliable mathematical model was not created for it. In this article, we sufficiently clarified the potential of dermatoglyphics in determining the role of genetic factors in the formation and manifestation of the human behavior by means of personality traits. We presented the most effective mathematical model created during our researches.

Creation of "Heredity regularity of psychological properties of person" suggest that dermatoglyphics can be considered as a scientific research method in psychological sciences. The use of dermatoglyphics in psychological research can contribute to the solution of theoretical and practical problems of the subject. At the same time, researches by using method of dermatoglyphics is easier than the other traditional methods used in Behavior Genetics. Therefore, we assume that there are a lot of substantial reasons to use the dermatoglyphics as a research method of Behavior Genetics.

Compliance with Ethical Standards:

Author, Akbarova S.N., declares that she has no conflict of interest.

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

This article does not contain any studies with animals performed by the author.

Informed consent: Informed consent was obtained from all individual participants included in the study.

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