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## THE RESULTS OF FACTOR ANALYSIS USE FOR ESTIMATION OF AGE DYNAMICS OF ACCOMMODATION-CONVERGENCE-FUSION SYSTEM

**Kochina M.L.**

doctor of biology, professor  
of the department of clinical informatics and information technologies  
in a management by a health care  
Kharkiv Medical Academy of Post Grade Education

**Yavorsky A.V.**

doctor of medicine, associate professor  
of the department of ophthalmology  
Kharkiv National Medical University

**Lad S.N.**

assistant of department of medical physics and informatics  
Kharkiv National Medical University

**Yevtushenko A.S.**

doctor-ophthalmologist

МІНП "KharkivMunicipal Clinical Hospital №14 named by Prof. L.L. Girshman"

### ABSTRACT

The research of functional organization characteristics of reception and primary processing of information in visual system of adolescents from different age groups was performed. The visual system's indexes that provide the visual perception on close distance was studied. There were 1272 persons in age between 6 and 17 years old had been researched.

The separation of focus and adjustment mechanisms provided by accomodation and convergence that occurs during child growing-up is confirmed by means of factor and cluster analysis. The primary analysis of visual information including fusion is performed in the central part of visual system.

Keywords: visual system, accommodation, convergation, fusion, mechanisms of visual perception.

Formulation of the problem. The visual system is a complex dynamic system, which contains a lot of information processing levels, its success of the work is defined by the peculiarities of structure, and also by the quality, quantity and conditions of visual information representation [1-3]. Normally, objects' perception by the visual system is carried out by the use of two eyes, on the retina of each the picture is formed. If a system has normal structural-functional organization, these pictures during their subsequent processing overlay one upon another and merge into single visual image, which is localized in definite point of space [4,5]. Important mechanisms ensuring visual information receiving and processing at short range are accommodation, convergence and fusion. Accommodation assures qualitative objects perception on different distances. Convergence allows in a definite way to place eyes for object perception on predetermined distance. Fusion is complex psychological mechanism, which ensures merging of two monocular pictures into single visual image. There are two components of fusion mechanism: motional (optomotor fusion reflex) and sensor (fusion) [4-7]. Fusion reserves are the indexes, which characterize visual system possibilities [4,8].

Analysis of latest publications. Depending on initial state and formation condition there can be several variants of visual system functioning. Those are monocular, synchronous, anormal binocular and binocular [4,8]. During monocular and synchronous perception fusion mechanisms are not involved. During anormal binocular vision they are working on shortened program. Binocular vision of a child appears later, then other visual functions and is the most perfect way of visual perception. This vision is being developed in the course of the two monocular subsystems for the creation of unified visual sensation. During binocular visual realization the activity of left and right halves of visual analyzer is connected in such way, that they are functioning as single organ. As a result of such merge of sensor and motor parts of visual analyzer visible objects are seen solitary and localized in the space in those places where they are. Binocular vision comparing with monocular provides man an ability to measure distance, increases perceptible brightness of the object (binocular summation), provides a perception of third space and gives a feeling of relief [4,5,8].

Highlight unsolved aspects of the problem. For binocular vision appearance the forming of the functional interconnection of all elements of visual realization is needed, that's supplied by

the connections between optical and motional eye apparatus. The most effective variant of binocular vision is stereoscopic vision. In the absence of conditions for the formation of the binocular vision system of children, which can depend on different anomalies of its structure and particularities of functioning, fusion mechanisms are not formed. If it is possible to create normal conditions of visual perception with the help of treatment: appropriate optical correction and training – the development of fusion of children is possible only until definite age. Elders cannot form these mechanisms [4,6,7].

The aim of this work – to find out the features of functional organization of system of receiving and initial processing of information by the children and teenagers of different age groups.

Basic material statement. The study of visual perception indexes on close distance was performed in 1272 of people at the age from 6 to 17 years. All test subjects were students of 1-11 grades of school. Only children and teenagers without any visual pathology have been to the study.

The positive accommodation reserve of right (AR OD) and left (AR OS) eyes [5,8,9], the position of the nearest convergence point (NCP)[9], convergent (FRC) and divergent (FRD) fusion reserves were measured for all probationers. Fusion reserves were measured with the help of GershelPrizm [4,8].

The descriptive statistics methods, correlation and factor analysis have been used for processing of the data [10,11].

After carrying out research of indexes which supply visual perception on close distances, their average value for each group has been calculated (Table 1). Analysing the indexes we can point out, that during the person's growth the changes are taking place, though there are no trustworthy differences between different age groups have been found. It can be explained by a great scattering of the indexes, the huge mistakes of average indexes are evidences of it. The indexes provided in the Table 1, both accommodation reserves and fusion reserves are quite low. This point about not high functional abilities of children's and teenagers' visual system [8,12]. We can point out, that with the age growth the AR increase somehow and in the second age group the highest values of the FRC and FRD are found. They are decreasing later. This tendency of unequal change of fusion reserves with the age increase was pointed out by other researchers as well [3,6,7,11].

Table 1

Average indexes of probationers' visual system

Group №	Age group, years	Indexes				
		AROD (D)	AR OS (D)	NCP (Sm)	FRC (av.D)	FRD (av.D)
1	6-9 (n=245)	3,9±2,4	3,8±2,2	4,5±1,6	9,2±4,7	3,2±2,2
2	10-11 (n=377)	5,6±3,2	5,6±3,3	4,5±1,5	12±5,3	4,6±3,2
3	12-13(n=256)	4,8±3,0	4,5±2,8	5,1±1,9	11,2±5,3	1,5±1,0
4	14-15(n=244)	5,0±3,1	4,8±3,1	5,7±2,4	11,1±5,8	1,7±1,2
5	16-17(n=150)	6,0±3,0	5,9±3,0	5,4±2,1	11,9±4,8	1,3±0,9

Note: n – age group size.

From our point of view more valuable information can be received by analysis of correlation tightness in the researched

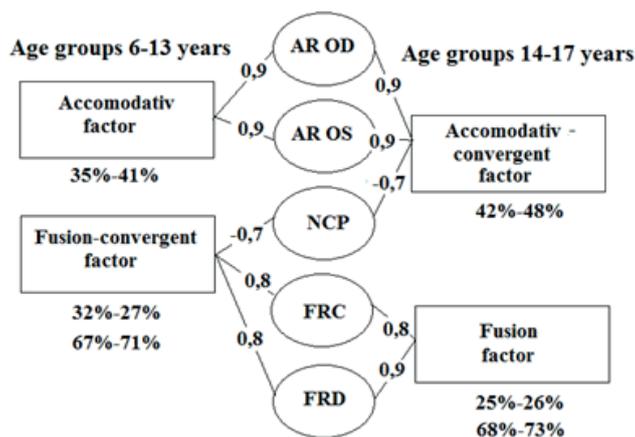
system of indexes. During carrying out of correlation analysis with calculation of Pirson correlation coefficient we have

found a meaningful connection between indexes of researched system, and the number of these connections. Moreover they have changed with the age growth. In the first age group there were 7 meaningful connections, in the second – 9, in the third – 5 and in the fifth – 4. A great number of connections in the first and especially in the second group, represents a significant determinativeness of researched system. It can be explained by the process of active formation of the visual system under the influence of rising visual load. The decrease of number of meaningful connections with the age growth represents stabilization of researched system and formation of adoption mechanisms. Connections structure between researched indexes changes in the first three groups and substantially different in two older groups. We can point out that the coefficient of correlation between AR of left and right eyes is significant in all age groups and increases with the age from 0,67 in the first group to 0,88 in the fifth.

The correlation between AR and NCP is presented in all groups, it is meaningful and negative. That presents the increase of convergence and fusion abilities, since NCP is getting closer to the eyes with the growth of accommodation reserves. NCP in the first two groups is connected to FRC and FRD by negative meaningful connections, so the decrease of fusion reserves, and an evidence of fusion weakness will lead to NCP moving away from the eyes. In the third and fourth groups NCP is connected not only to FRC by negative meaningful connection, and in the fifth the connection is absent. In the fifth group NCP is connected to AR of right and left eyes, and FRC is only connected to FRD. The researched system has stabilized and formed solid configuration of indexes connections, which provides the visual perception at the close distances as a result of this. The use of correlation analysis and construction of correlation matrix allowed to point out several significant stages of formation of binocular system of visual

perception. If in the youngest age group NCP has formed meaningful connections with AR of right and left eyes and with fusion reserves, but with the age growth situation has changed. NCP has formed complex only with AR. In the same way, first FRC and FRD, and then only FRC has been connected with AR and NCP, and in the fifth age group only connection between FRC and FRD has left. In the researched system till the end of the formation has been explicitly emphasized two autonomous mechanisms of visual perception: mechanism of setting and focusing and mechanism of union (fusion) of received pictures. These two mechanisms have significant independence from each other. This is evidenced by the absence of meaningful correlation between indexes, which characterize them.

For more detailed connections structure research in accommodation-convergent-fusion (ACF) system the factor analysis has been used. In first three age groups (pic. 1) configuration of factor structure is the same. The first factor is “acomodative”, since it has influence only on accommodation reserves and invokes their growth. The contribution of this factor into overall dispersion with the children’s age increase, slightly rises (from 35 % to 41%). The second factor can be called “fusion-convergent”, its influence leads to the growth of fusion reserves and the nearest point of convergence approximation to the eyes. Received configuration of connections in the researched system points out on influence of accommodation and fusion mechanisms. The NCP index is connected to accommodation and convergence, but can be characterized by the fusion abilities. The value of NCP is fixed, when probationer notes the double vision of tested objects, in other words fusion doesn’t occur. Therefore, this index must be connected to fusion abilities of the visual system, which characterised by fusion reserves. In the researched age groups this index is connected to fusion reserves and is not connected to accommodation reserves.



Pic.1. Structure of connections in accommodation-convergent-fusion system of children and teenagers.

For the construction of factor structures the data received from a sufficiently great number of probationers has been used (table 1). Only elder age group consisted of 150 people, the number of probationers in other groups was more than 200 people. Received connections in factor structures quite differ from the connections received with the use of correlation analysis. However, here we can also notice the initial merge of NCP with fusion reserves, with savings of accordance of

+/- signs of factor loads and correlation coefficients. In factor structures AR are combined with each other, and they have a significant factor load in the first factor and correlation analysis, it is a meaningful positive correlation coefficient.

In the group of teenagers (14-17 years) configuration of connections in the researched system transforms (pic.1). If during the process of active formation of the visual information perception system, NCP has merged into one factor with fusion

reserves, then in elder groups this index has turned into the first factor and merged with AR. The signs of the correlation coefficient and factor loads received in factor structures are the same.

Thus, the results of correlation and factor analysis indicate that during child growth connections transformation in the system of receiving and processing of visual information by the means of mechanisms of setting and focusing the separation of primary information analysis occurs. In normal visual system the fusion is a mechanism which points on qualitative and low quality functioning of alignment and focusing system. If fusion is carried out, everything is normal, if merging doesn't occur the signals about the inabilities of qualitative visual perception to the control block are received. At the same time the person with normally formed binocular visual system starts to perceive both pictures, which are not combined into a single visual image, that provoke a feeling of doubling, leading to significant discomfort. The task of controlling block in this case is trimming of visual system due to mechanisms of accommodation and convergence. If this trimming is possible, the doubling will disappear and the normal visual information perception will appear. If due to some kind of reason this won't be possible the person would need mechanically exclude one of the pictures from the perception. For example, by closing eyes, since doubling leads to a considerable discomfort and giddiness. In child age this situation existing for a long time leads to appearance of strabismus, as a result of disbinocular amblyopia [4].

Based on the obtained results we can make the following conclusions:

1. Visual system indexes values, which supply visual information perception on close distances in different age groups of children and teenagers are not different for sure, there is only a tendency for certain increases with the age growth.

2. There is a great number of meaningful connections between indexes which supply visual information perception on close distances. In the first and second age groups (6-11 years) this evidence about the active formation of the visual system under increasing visual load, caused by the beginning of studying at school. The decrease of number of meaningful connections with the age growth can denote to stabilization of researched system and formation of adaptation to visual load mechanisms.

3. In the first three age groups (6-13 years) the position of nearest point which characterizes the abilities of united perception of object on minimal distance from the eyes depends on fusion reserves and it is drawing near to the eyes during age growth. In older age groups (14-17 years) the position of nearest point is defined by accommodation reserves, and their

increase lead to its bringing closer to the eyes. This is evident on what in the process of a child's growth in the visual system the division of setting and focusing mechanisms appears. These mechanisms are supplied by the accommodation and convergence, as well as initial analysis of information, which is carried out in central parts of the visual system which includes fusion that can be verified by the results of cluster and factor analysis.

The prospective study presents the approaches to prevention and correction of visual disorders, which appear among children and teenagers during growing up and studying at school.

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