UDC 376.356
BBC Ч452.091
GSNTI 14.29.27
Code VAK 13.00.03

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PSYCHOMOTOR DEVELOPMENT OF CHILDREN WITH HEARING DEPRIVATION

Abstract. Helping children with sensory deprivation is a complex, multifaceted and multidisciplinary problem. The analyzers' defects lead to a delay in the formation of functions caused by the deficiency of the sensory flow provided by this analyzer. In particular, the role of the partial hearing loss in the formation of attention deficit hyperactivity disorder in children is well known to specialists. Hearing impairment in childhood is a serious medical and social problem encumbering life activity, especially in the field of education: acquisition of the program of mass preschool and school institutions; the need for inclusion of children in the world of hearing people. *The purpose* of this study is to determine the spectrum of developmental disorders and to identify the patterns of their development in children with hearing deprivation. All children participating in the experiment were tested using at least two of the three scales presented: the Griffiths Mental Developmental Scale (GMDS), the Alberta Infant Motor Scale (AIMS) and the Denver Developmental Screening Test (DDST). The results were processed using the Statistica for Windows 10.0 software package using nonparametric statistics methods (Spearman rank correlations, and χ^2 criteria). The next stage of the study was the search for individual variants of the development of children with partial hearing loss with the help of the above mentioned standard methods of assessing psychomotor development. From these tests, DDST was chosen as the basic one, including a smaller number of scales (4), which reasonably limits the versatility of variants of individual development trajectories. As a result, 22 profiles of individual development were identified.
Keywords: psycho-motor development; psycho-motor activity; surdopedagogy; children with hearing impairments; hearing impairments; partial hearing loss; early age; hearing deprivation.
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Support for children with senso- ry deprivation is a complex, multifaceted and multidisciplinary task.

Its urgency is substantiated by a number of not only salient but also covert causes. Salient causes consist in high frequency of early lesions of the nervous system and analyzers mostly taking place during the perinatal period. Analyzer defects lead to a delay in the formation of functions caused by the deficiency of the sensory flow provided by this analyzer. At the same time, permanent analyzer defects bring about lesser impairments of integrative processes of the nervous system and psychopathological dysfunctions. In particular, the role of partial hearing loss in the formation of attention deficit hyperactivity disorder in children is well known to specialists [8]. A number of researches, including ours, illustrate the impact of inadequate sensory flow (and not only the analyzer one) upon the development of neuroticism of a person [5].

Hearing impairment occupies a significant place in the structure of analyzer defects.

It is estimated that more than 440 million children in the world have the hearing threshold of 85 dB; their number grows up to 800 million when the hearing threshold is lowered to 50 dB [2].

Epidemiological research shows that the incidence of partial hearing loss from moderate to severe degree in children including sensory-neurological and conductive impairments is about 6 per 1000; and about 10% of the children suffer from severe hearing loss (1, 3, 4). Hearing impairment in childhood is a serious medical and social problem encumbering life activity, especially in the field of education: acquisition of the program of mass preschool and school institutions; and the need for inclusion of children in the world of hearing people.

A bilateral permanent impairment of the hearing analyzer in children with moderate to absolute hearing loss radically damages the formation of all components of oral speech [11; 13; 14; 15] and, consequently, affects all skills connected with the capability to speak and hear, such as reading and writing [10; 17].

A number of earlier works showed that the correspondence between biological, medical and social factors and the peculiarities of development of children with hearing loss, as well as the structure of resulting impairment is often obscure and controversial [9].

The purpose of this study is to determine the spectrum of developmental disorders and to identify the patterns of their development in children with hearing deprivation.

Materials and methods

Observation was conducted on the base of the City Outpatient Center for Rehabilitation Treatment of children with speech and hearing pathology # 1.

100 children (62 boys and 38 girls) aged from 1 to 35 months took part in the experiment. In addition to a routine somatic-neurological observation, the children were examined by a surdologist.

A high-tech operation of cochlear implantation was performed on 13 patients out of those examined; three of them were operated on binaurally. The hearing correction of 34 children was done with the help of hearing aids depending on the degree of hearing loss and accompanying pathology. Other children had no experience of using hearing aids or operative intervention (operation of cochlear implantation) as they were too young at the time of observation or had no medical condition for such intervention.

All children participating in the experiment were tested using at least two of the three scales presented: the Griffiths Mental Developmental Scale (GMDS), the Alberta Infant Motor Scale (AIMS) and the Denver Developmental Screening Test (DDST) [16; 18; 19; 20]. In accordance with the children's age they were offered tasks from the observation charts of these scales completed independently without help of the parents or the tutors. The length of the test session was determined by the level of attention and the emotional state of the child. If it was necessary, testing was repeated not later than a week after the first test and not more frequently than once in a half year.

The results were processed using the *Statistica* for Windows 10.0 software package based on nonparametric statistics methods (Spearman rank correlations, and χ^2 criteria).

Results

Our study of the anamnesis via the principle of optimality [6; 7] showed that the majority of children (44%) with hearing impairments were born by mothers aged 29-35. 35 mothers had partial hearing loss. A considerable number of babies were born by first time mothers (35%), and by second and third time mothers – 30% and 16% respectively. Pregnancy had complications in 87% of the mothers; in 16% of cases the pregnancy was accompanied either by an infectious condition (cytomegalovirus, rubella, toxoplasmosis or herpes simplex), or the mother suffered from chronic hepatitis C virus (4 cases). Natural delivery was registered in 73 cases; 76 babies were born in due time; 84 babies weighed more than 1500 gr. Assisted pulmonary ventilation was necessary for 17 newborns.

Neonatal hypoxic-ischemic encephalopathy (HIE) was diagnosed in 36 newborns (first degree HIE – in 18 babies, and second degree HIE – in 18 babies); permanent hyperbilirubinemia was found in 20 newborns. 22 babies had neurosonogram deviations; 11 newborns had *ventricular dilation, and 12 and*

6 newborns had the symptoms of intraventricular hemorrhage (IVH) and periventricular leukomalacia (PVL) respectively (a detailed description of the anamnesis and clinics was presented in our previous research).

Medical, pedagogical and psychological assistance to the children according to standard scales was registered in observation charts described earlier [9].

Evaluation of the psycho-motor development of the children according to standard scales is presented in the table.

Table

Psychomotor development indices for children
with partial hearing loss according to different tests and scales

Indices				
Test / scale	n	Under-development	Normal development	Ahead-of-time development
DDST	99			
Speech scale		48	47	4
Individual-social scale		9	82	8
Fine motor skills		18	70	11
Gross motor skills		21	66	12
AIMS	78	18	54	6
GMDS	70			
Locomotion scale		7	46	17
Individual-social scale		12	37	21
Speech scale		52	16	2
Eye movement coordination		15	42	13
Experience		30	35	5
General development age		25	35	10

Note : n — the number of children tested

As shown in the table, speech development of children is the first to be affected both according to DDST and GMDS (48.5-74.2% of cases). According to the data of different tests and scales, fairly widespread delay in various forms of motor development is less evident (10.0-23.1 %). Anyhow, normal basic indices of psychomotor development tempo dominate in all 5 scales (with the exception of the speech scale) of the tests (50.0-82.8 %).

Correlation analysis showed negative correspondence between the level of the child’s motor development according to AIMS and the degree of HIE (r = –0.24, p = 0.02), loop of cord (r = –0.21, p = 0.04), presence of IVH (r = –0.22, p = 0.04), neonatal hyperbilirubinemia (r = –0.24, p = 0.03), and stimulating therapy (r = = –0.23, p = 0.03).

According to the GMDS data it was found that the level of motor development is negatively related to the diagnosis of cytomegalovirus – CMV – in the pregnant woman (r = –0.27, p < 0.01), loop of cord (r = –0.32, p < 0.001), prescription of stimulating therapy (r = –0.24, p < 0.02), specialist training (r = –0.22, p < 0.03); and is positively related to multiple pregnancy (r = 0.28, p < 0.006) and premature birth (r = 0.25, p < < 0.02). Social development is correlated with the presence of cochlear implant in the right ear (r = = –0.24, p < 0.02), diagnosis of CMV during pregnancy (r = –0.32, p < 0.001), diagnosis of hepatitis C virus (r = –0.21, p < 0.03), loop of cord (r = –0.29, p < 0.004), prescription of stimulating therapy (r = –0.22, p < 0.03), and specialist training (r = –0.28, p < 0.005). The child's speech development is related to the degree of hearing loss in the right ear (r = –0.44, p < 0.000006) and the left ear (r = –0.47, p < 0.000002), parents' hearing loss (r = –0.26, p < 0.01), diagnosis of CMV during pregnancy (r = –0.25, p < 0.01), and loop of cord (r = –0.24, p < 0.02). Eye movement coordination depends on diagnosis of CMV during pregnancy (r = –0.23, p < 0.03), loop of cord (r = –0.23, p < 0.02), prescription of stimulating therapy (r = –0.22, p < 0.03), and specialist training (r = –0.31, p < < 0.002). The level of the child's development in the subscale "Experience" correlates with the child's age (r = = 0.66, p < 0.05). The general level of the child's development is connected with loop of cord (r = –0.30, p < 0.003), the degree of hearing loss in the right ear (r = –0.23, p < 0.03) and in the left ear (r = –0.22, p < 0.03), diagnosis of CMV during pregnancy with the degree of hearing loss in the right ear (r = –0.23, p < 0.05) and in the left ear (r = –0.31, p < 0.03).

The level of the child's speech development according to **DDST** is related to HIE (r = –0.17, p < 0.05), the degree of hearing loss in the right ear (r = –0.37, p < 0.00002) and in the left ear (r = –0.35, p < 0.00006), diagnosis of CMV (r = –0.22, p < 0.01) and hepatitis C virus during pregnancy (r = = –0.21, p < 0.02), loop of cord (r = = –0.19, p < 0.04), and specialist training (r = –0.18, p < 0.05). The level of the child's social development according to DDST is connected with HIE (r = –0.23, p < 0.01), diagnosis of CMV (r = –0.17, p < 0.05) and hepatitis C virus during pregnancy (r = –0.23, p < < 0.01), loop of cord (r = = –0.27, p < 0.002), and ventriculomegaly (r = –0.19, p < 0.04). The development of fine motor skills according to DDST is affected by diagnosis of CMV (r = –0.26, p < 0.003) and hepatitis C virus during pregnancy (r = = –0.29, p < 0.001), presence of multiple pregnancy (r = –0.23, p < 0.01), loop of cord (r = = –0.22, p < 0.01), prescription of stimulating therapy (r = –0.18, p < 0.04), and specialist training (r = –0.18, p < 0.04). Gross motor skills are connected, according to DDST, with diagnosis of CMV (r = –0.20, p < 0.02) and hepatitis C virus during pregnancy (r = –0,18, p < 0.04), presence of multiple pregnancy (r = –0.25, p < 0.005), and loop of cord (r = –0.18; p < 0.04).

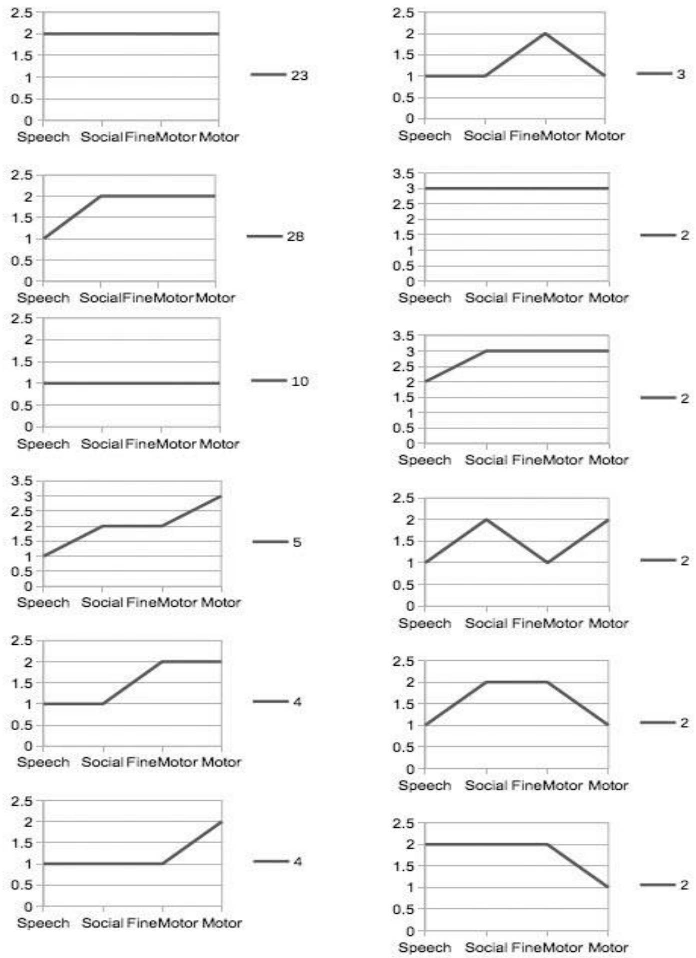

Fig. 1—12. Individual development profiles

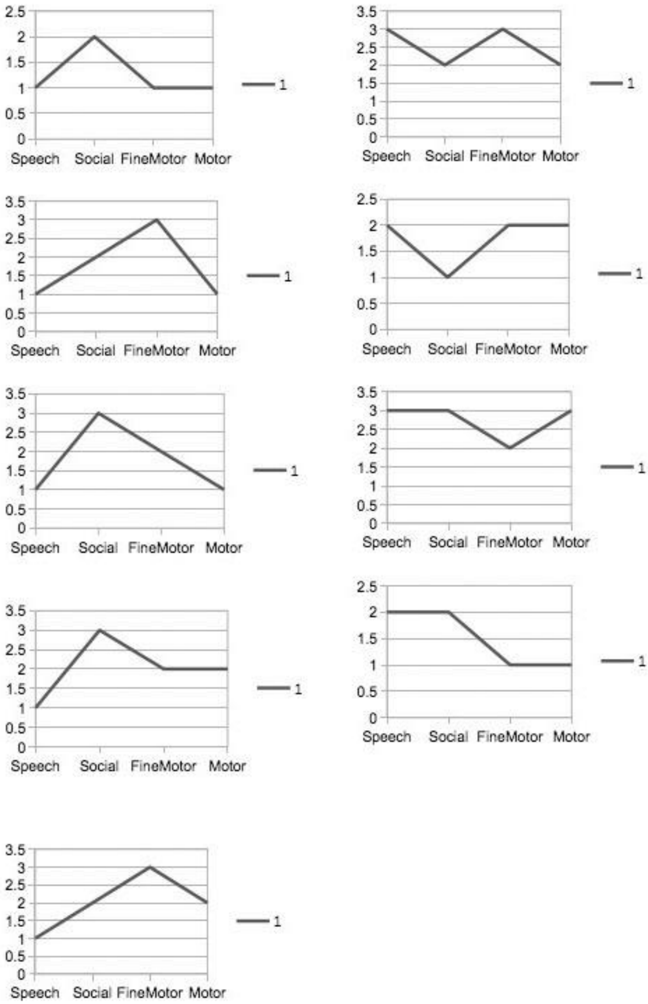

Fig. 13—21. Individual development profiles

The next stage of the study consisted in the search for individual variants of the development of children with partial hearing loss with the help of the above mentioned standard methods of assessing psychomotor development. From these tests, DDST was chosen as the basic one, as it included a smaller number of scales (4), which reasonably limited the versatility of variants of individual development trajectories. Indices of each DDST scale (speech, individual-social, gross and fine motor skills) for each child were ranked as normal, running ahead of time and lagging behind (delay). In this way, an individual development profile was determined for each child under observation. As a result, 21 profiles of individual development shown in the corresponding figures were identified.

The illustrations show that 3 main types of development of children with hearing deprivation were revealed covering almost two thirds (64%) of all development variants:

1) normal or accelerated harmonious development (25 babies, type I);

2) speech underdevelopment with safe social development and motor skills (29 babies, type II);

3) total uniform underdevelopment (10 babies, type III).

The comparison of clinical results in children developing in accordance with the 3 main types shows the following:

1) the children with type II development had significantly more often higher degrees of hypoxic-ischemic encephalopathy (χ^2 = 23.79; $p < 0.0001$) and sensory-nerval hearing loss (χ^2 = = 3,96; p = 0,047) than the children with type I development;

2) children with total underdevelopment (III) had significantly more often neonatal hypoxic-ischemic encephalopathy than the children with normal and accelerated development (I) (χ^2 = 7.02; p == 0.008);

3) children of group II demonstrated more evident presence of the connexin gene than the children with total underdevelopment (III).

Thus, the following conclusions can be made on the basis of the given research.

1. Children with hearing deprivation have deviations of various parameters of psychomotor development (motor skills, individual-social development, experience, eye movement coordination), but the speech function is affected in significantly more cases.

2. Multiple pregnancy, exposition to cytomegalovirus and hepatitis C virus during pregnancy, loop of cord during delivery, neonatal hypoxic-ischemic encephalopathy, parents' hearing loss, and the child's partial hearing loss in the right ear are the leading factors affecting the development tempo of children with hearing deprivation.

3. 21 types of individual development of children with hearing deprivation were singled out with the help of DDST; three types are the leading ones (64% of cases): normal or accelerated harmonious development; speech underdevelopment with safe social development and motor skills; speech and individual-social

underdevelopment with normal motor development and total uniform underdevelopment.

4. It has been shown that there are evident differences in the formation of the main types of development of children with loss of hearing; but according to the basic clinical-anamnestic indices children with isolated speech underdevelopment and speech and individual-social underdevelopment, as well as babies with speech and individual-social underdevelopment and total uniform underdevelopment do not differ.

5. Determination of the main types of development of children with loss of hearing makes it possible to organize more purposive and personalized rehabilitation of the diagnosed disorders.

The results obtained testify to a wide range of possible routs of development of children with hearing deprivation. This may be caused by the variety of sources of loss of hearing (genetic, hypotoxic brain lesions, neonatal hyperbilirubinemia, and intra-amniotic infections), which was corroborated in the given research, and the character and volume of assistance to the children with loss of hearing. Evident and easily explained speech underdevelopment are quite often (in almost quarter of the children) accompanied by motor underdevelopment, which may be attributed to the primary damage of the brain matter causing both motor disorders and loss of hearing proper, and also to the secondary problems in motor training of children with sensory deprivation. A significant role in individual trajectories of development of children with hearing deprivation is played by neuroplasticity mechanisms which are markedly reduced in cases of early hearing loss, but are considerably modulated by early implantation [12]. Timely diagnostics and complex rehabilitation using early implantation facilitate favorable types of development of children's loss of hearing, which is testified by the data obtained in our research (25% of children had normal or accelerated harmonious development).

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