# SIGNIFICANCE OF GENETIC FACTORS FOR THE DEVELOPMENT OF SPEECH IN EARLY AGE CHILDREN

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Summary. Based on performed analysis of works of foreign and national scientists, features of development of early age children speech were highlighted as a process based on a genetically determined program. Achievements of genetics help to clarify the mechanism of hereditary pathology when genetically determined forms of pathologies of development and speech are caused by disorders in the brain systems. Interdependency of neurological and psychological mechanisms of speech disorders contributed to the emergence of neuro-logopedics as a new trend in speech therapy. Genetic disorders are studied during genetic counselling, in prenatal centres, where correction of developmental and speech disorders is carried out professionally with the help of speech therapists, developmental paediatricians, psychologists, neurologists and that involves a combination of speech therapy, psychotherapy and drug treatment in accordance with individual developmental pace and terms of each child in a comprehensive set for treatment and rehabilitation.
Key words: child, early age, speech, pathology, speech therapy, genetics.

## INTRODUCTION

Early childhood is the period from birth to three years, this is a period of life when rapid mental and physical development takes place and foundations for further formation of personality are laid. As for child's mental development, speech plays a leading role and determines child's development, so the period up to 3 years of age is sensitive [3, 8]. Therefore, underdeveloped speech affects child's physical and mental health at an early age, that makes it necessary to use a multidisciplinary approach and to study and explore speech development, especially on the basis of psychological and pedagogical achievements, life sciences and genetics.

Genetics, the science of heredity, explores passing of different characteristics from parents to children with special material called genes and chromosomes and individual changes over time as a result of complex interaction of genetic material and environmental conditions [4]. Genetic disorders are any physical or mental pathology that can be inherited from parents. Some genetic diseases cannot be detected at birth, their signs and symptoms develop later and pathology can sometimes remain undetected until adulthood. Genes are basic units of heredity. The term «genetic» refers to a pathology arising from defects in the structure of one or more genes or a chromosome; all races, ages, genders can suffer from it and it is a universal problem.

Speech therapy, as well as modern special pedagogy and psychology, uses a wide range of genetic knowledge to analyze different types of speech disorders. The human body is the result of complex interaction between genetic programs inherited from parents and the environment. From this point of view speech development in early age children can be examined as a complex dialectical process based on a genetic program. Such a genetic program arranges certain typical biological characteristics of a person and inheritance of his/her parents' traits which was confirmed by researches of N. Zhuchenko, I. Barylyak, S. Kozlova [2, 4, 5].

Therefore, the aim of our research was to study the influence of genetic factors on the development of primary speech pathology in early age children and prevention of secondary speech disorders and social maladjustment in their future life.

## ANALYSIS OF THE PROBLEM

The problems of speech development were studied by foreign and national scholars (G. Piaget, A. Luria, L. Vygotsky, S. Rubinstein et al.) who researched into the mechanisms of speech, main factors and stages of its development, disorder causes, etc. [6, 8]. The review of publications and research results (O. Ushakova, V. Tarasun, M. Sheremet et al.) shows that a number of children with speech disorders is growing each year and speech disorders gain more complex forms [6]. Speech disorders are often associated with deterioration of physical and neuropsychological health caused by complications of pregnancy (prenatal); features of childbirth (peripheral, natal); postnatal (post-delivery) factors up to three years of age; surrounding influences (psychological traumas, bilingual families, social negligence, poor upbringing), hereditary factors (mental illness, speech disorders of parents, etc.), and they contribute to emotional and volitional disturbances, deviations in children's mental and physical development.

Thus, development of speech of early age children is affected by a large number of positive and negative genetic and social factors. Adverse factors are divided into endogenous (genetic or internal influences) and exogenous (external or social) influences. Taken together they become leading determinants of development of child's speech and the child as a whole.

According to W. Stern, both factors (hereditary and social) are equally important for child's mental development and determine two lines of development: one line is maturation of hereditary traits and abilities and the other is their development influenced by child's social environment. These lines approach each other, intersect and cause convergence [1]. The concept of relationship between biological and social factors was accepted by national psychologists. It is based on the ideas of L. Vygotsky who emphasized the unity but pointed to their different proportions at different age stages [8]. Modern psychology understands relations between biological (genetic) and cultural (social) factors as indissoluble chain of mental development. The unity of genetic and social factors during person's mental development is studied by a new branch of psychology, i.e. psychological genetics [2, 4]. The achievements of psychological genetics help clarify mechanisms of hereditary diseases. The science uses the data about new hereditary forms of mental retardation, deafness, blindness, disorders of emotional and volitional behaviour, children's autism and speech problems. However, the basic functions (starting with sensations and perceptions) are determined rather by heredity factors. This is also true for speech development; but the more complex a particular function is, the longer its path of ontogenetic development and the lesser impact of heredity. Child's speech develops under direct influence of his/her social environment, therefore it is necessary to examine specific combination of biological and social aspects and to study its dynamics. Achievements in clinical, molecular, biochemical genetics and cytogenetics allowed scientists to clarify mechanisms of hereditary diseases. Therefore, a relatively new health specialty - clinical genetics – is able to apply the principles of genetics to health care of children and adults. Geneticists diagnose many genetic diseases and provide genetic counselling. Genetic disorders are divided into three main types: single gene defect, chromosomal defect and complex, multi-factor disorders [1, 2, 4, 5].

One gene defects occur in 1% of neonates with autosomal dominant, autosomal recessive, X-linked (sometimes called sex-linked) inheritance.

An autosomal dominant genetic defect is transferred from one affected parent. There are about 1,000 diseases transmitted this way. If one parent has a defective gene, there is a 50 percent risk of passing it to his/her children. Under adverse conditions, when both parents have the same defective gene, the risk rises to 75%.

An autosomal recessive gene defect can be transmitted from a parent suffering from the disease or from a parent – carrier of the defect. If both parents are carriers, their children have 25% probability to become affected and 50% probability to become a carrier of the disease (like each of the parents). There are about 1,000 recessive genetic disorders.

An X-linked genetic defect takes its name because the pathology is transmitted with an X chromosome, one of the sex chromosomes. If a man has a defective gene in his X-chromosome, he has a genetic basis to develop a disease. Each

boy born by a female-carrier has 50 percent risk of recessive manifestations. There are more than 150 sex-linked genetic defects.

Chromosomal defects exist because of changes in the number or structure of chromosomes. Chromosomal defects arise mostly spontaneously as a genetic „disaster" resulting in the formation of a chromosome set that is not similar to the parental sets. Chromosomal defects are generally formed during the formation of reproductive (eggs and sperm) cells. If such cells merge and an embryo is implanted, the foetus will have an altered number or structure of chromosomes.

Complex or multi-factor disorders emerge as a result of interaction of a gene (or genes) and environmental factors. As yet, the exact number of multi-factor diseases has not been precisely defined, but there are over 2,000 of such diseases, and 3% of children are affected. In the latter case, a developmental pathology is usually a result of complex relations between genetic and external factors.

Depending on the time these factors occur, there are antenatal or prenatal pathologies. Perinatal, natal (damage during delivery) and postnatal (after birth adverse effects) pathologies are of interest to prenatal psychology and prenatal pedagogy, not just embryology, therefore speech mechanisms should be studied beginning in these periods. Perinatal factors are more traumatic than postnatal ones since they influence lesser formed brain cells. According to medical histories of children with speech disorders, the influence of various biological factors on the body in ante-, peri- and early postnatal periods is observed in 77-85% of cases (A. Kornev, 1997).

Prenatal period is the period of individual development from the conception to birth, during which inherited potential is being deployed, it lasts about 266 days (40 weeks) and consists of three phases.

The first phase lasts 2-3 months of foetal development. By this time, the anatomical and physiological differentiation of tissues and organs has taken place, the central and peripheral nervous systems are formed as well as the cerebral cortex and Broca's speech centres – a kinaesthetic analyzer that is responsible for speech praxis, and located in a posterior part of the inferior frontal gyrus of the leading hemisphere and Wernicke area – an acoustic analyzer that is responsible for speech gnosis, recognition of different sounds and sound sequences and is located in the posterior part of the superior frontal gyrus of the leading hemisphere;

The second phase includes the next 2-3 months of foetal development when the brain sulcus and gyrus are formed. The brain cortex obtains a six-layer structure that is characteristic of adult brain. It is a critical period for the occurrence of alalia (I. Samoilova, A. Lindenbaum, V. Tyschenko), possible nonclosure of the upper lip and palate at the 7-8th week (C. Konoplyasta).

The third phase takes place during the last months (7-9 months) of foetal life and is associated with the development of functions and systems that will allow a child to survive after birth. The frontal areas are critical for the occurrence of immaturity in successive analysis and synthesis (E. Sobotovich, V. Tarasun). All neurons of the brain are being formed, eyes become sensitive to light and response to sound appears. The foetus is able to perform grasping movements, make wrinkles, move eyes, make grimaces. The organs of hearing and smell develop [6].

Perinatal period begins from the 22$^{nd}$ full week of pregnancy and ends after 7 full days of life of a newborn baby, which marks the achievement by the foetus of such maturity that allows him/her to be extrauterine. Here, there are three periods distinguished: antenatal (prenatal) - from the 22$^{nd}$ week of full pregnancy to the first stage of labour; intranatal - from the beginning of the first stage of labour until baby's birth (during the first and second stages of labour); postnatal (early neonatal) - from birth to the end of the 168$^{th}$ hour of life. As child's speech functions are implemented through integrative activities of the whole brain, a primary disorder (according to L. Vygotsky) is a direct result of a biological state of child's central nervous system. If a child had difficult perinatal period, speech disorders should be expected. Genetic disorders can be diagnosed through a variety of tests before delivery. Many diseases can be diagnosed immediately after birth, before symptoms and signs of the disease have developed (e.g. phenyl ketonuria). However, other diseases appear only after weeks, months, years even decades have passed. Due to a large variety of inherited diseases of the CNS that cause abnormal development their differential diagnosis is much complicated. Early correct diagnosis of the disease is of primary importance for timely treatment and corrective measures, right prognosis for development and prevention from giving birth to another child with developmental disabilities in the same family.

Thus, the main feature of pre- and perinatal periods is anatomical and physiological initiation

and rapid development of natural mechanisms of speech and awareness of the impact of genetic and hereditary factors is essential for the prevention of disorders of mental and physical development and speech as well.

Child's postnatal period is characterized by rapid development of speech activity along with general psychophysical development. Baby's first cry and later reflex activity of the larynx (cooing) is the only evidence of a newborn's potential of phonation. The next developmental transition from phonation to babbling constitutes onomatopoeic speech activity and normally appears after three months of life.

A. Leontiev in his "speech ontogeny" concept divides the formation of speech activity into the following periods: the 1st period is preparatory (from birth to 1 year); the 2nd one is before preschool (from one to three years), the 3rd one is preschool (3 to 7 years) and the 4th period is school (7 to 17 years) [8, 9].

Speech development in children's under 3 years of age is, in turn, divided into three main stages: the stage before speech appearance (the 1st year of life), initial stage of speech development (before grammar appearance) in the second year of life and the stage of grammar mastering (the third year of life). A. Leontiev indicates that the timing of these stages is extremely variable, in addition, the acceleration is observed in children's speech development, age characteristics as being shifted to earlier stages of ontogeny [6, 7, 8]. Based on the findings by A. Leontiev, three phases of speech development in early age children are distinguished for the postnatal period, too [9].

In the 1st year of life, the stage before speech appearance in a healthy child is divided into several phases. The first phase covers the first 2 months of life and is characterized by cry that, at the end of that phase takes intonation expressions. The second phase of the stage before speech appearance (2.5-3 months) is characterized by the appearance of cooing and the first laughter with a combination of throat sounds and vowels in cooing; thus voice, breathing and articulation are "trained". The third phase of the stage before speech appearance is the phase of "real" cooing. This period ends at the age of 3.5-4 months. The first conditional relationships between auditory and articulation are formed along with self-repeating. The fourth phase of the stage before speech appearance is the period of babbling. At the age of 5-7 months a child utters sounds forming chains of vowels and consonants, cooing transforms gradually into babbling, adults' sounds are imitated. Development of sensoro-motor functions and preverbal communication during the first year of life is the basis for speech and thinking formation.

In the 2nd year of life, child's active speech is formed. At the age from one to three years, speech begins to take central place in child's mental development. Child repeats many words happily and says words himself/herself. But he/she confuses sounds and rearranges their places, distorts, passes them. Up to 1 year 6 months of age, a child can say about 30 simple-sound words, and by the end of the 2nd year, he/she can say 200-300 words. Two-word sentences appear between 1 year 6 months and 1 year 10 months, three-word sentences do 2-4 months later. At 1 year of age, interrogative and exclamation sentences with clear intonation are present. Boys usually have slower rate of speech development.

In the 3-year of life, child's vocabulary has accumulated significantly, there are up to 1,200-1,500 words, almost all parts of speech are present. There is intensive development of the grammatical structure of speech, there are elements of coordination and subordination of words in a sentence; by the end of the 3rd year of life, forms of child's speech become close to adult's speech. By the age of 3 years, children should have formed all basic grammatical categories. At this stage, speech understanding is better than articulation ability. Broad speech activity is noted, a child comments with speech his/her game acts, begins to ask questions. Speech development at this age rebuilds child's all mental processes. Namely, speech becomes a leading tool for the development of communication and thinking. At the age of 3 years, a child communicates with others by developed phrases, starts talking about himself/herself in the first person. The sense of "I" is formed, so a child distinguishes himself/herself from the outside world.

Thus, normally the feature of the postnatal period is not only enhanced rate of speech development in the 1st, 2nd and 3rd year of life, which are characterized by its manifestations, but also possible speech disorders.

Development of speech is associated with normal functioning of the central nervous system, mainly of the brain, and is understood as a complex medical, genetic, psychological and pedagogical problem, therefore, identification of speech disorders has integrated nature. For diagnosing,

data of clinical medicine (neuropsychiatry, medical genetics, and paediatrics), speech therapy, and psychology are taken into consideration, but genetic factors are especially important for speech development in early age children. To study genetic determinants and social impact on speech development, observations of the same families over several generations are performed, twin method is often used [1, 5]. Genetic factors are one of the main reasons for the specificity of speech development in early age children. If an early age child has delay in speech development, has skin defects and neurological problems, careful examination is required, because pigmentation may be one of the first signs of various hereditary diseases of the nervous system, indicating congenital or acquired forms of speech disorders and necessity to provide adequate medical treatments, rehabilitation and educational activities [1, 7, 8].

Abnormalities in the peripheral or central departments of the speech analyzer (muscle atony, brain haemorrhages, inflammations, intoxication, degenerative changes in brain tissues and phonation organs) are direct root causes of its disorders and are considered as primary causes. However, there is a large number of genetic and chromosomal syndromes, when speech disorders are one of the symptoms of secondary disorders (indirect disorders) from the systems and organs of analyzers of vision, hearing, locomotor system, intellectual, mental and physical health and educational neglect. Therefore, it is important that, during speech therapy examination, an attention was drawn to the features of child's phenotype. Genetically caused anatomical features in the structure of the peripheral speech apparatus, so called minor malformations within the oral region, incorrect development of the jaws slow down and distort development of sound pronunciation. Vowels are pronounced correctly, but phonemes which should have normally developed by that time, i.e. 3rd year of age [b, d, n, p, t] are distorted. There are cases when three generations of one family have individuals with identical incorrect pronunciation of [r] sound indicating hereditary dyslalia.

Recently, a gene responsible for a rare syndrome of non-closure of the upper lip and palate has been identified. Moreover, a number of other genes likely to increase susceptibility to non-closure, including excess level of retinoid were found. These defects are normally present in the early stages of foetal development and the lip is usually closed within 5-6 weeks after conception, and the palate does by 10 weeks, but non-closure occurs in one newborn for every 1,000 children and is more common in girls than boys. Non-closure occurs in anomalies of 50% chromosomes (91, 3, 4, 5, 7, 10, 11, 13, 14, 18, 21 and X) and manifests itself by rhinolalia with unclear and incorrect pronunciation of sounds [10].

According to M. Zeeman hereditary speech development delay, i.e. absence of normal speech in a 3- year old child is observed in 20.6% of cases of late speech development, particularly in three generations, often in the father's line. The cause of delayed speech development is delayed process of myelination of motor and associative nerve fibres in the nervous system. As a result, a 1.5-year old child is unable to repeat simple words and sounds, uses non-verbal signs for desire expression, cannot use simple words and two-word phrases till three years of age [6].

Thus, structural features of the vocal apparatus can be inherited, e.g. the number of teeth, bite form, susceptibility to non-closure of the upper lip and palate and features of development of the brain speech areas.

Development of speech in early age children is closely related to the nervous system and brain, dysontogenetic and encephalopathy disorders, developmental disorders, and injuries of various brain structures. Children with speech disorders often have neurological and pedagogical problems that reinforce each other. A chain, linking health and speech problems in a child with speech disorders, is a part of neuro-logopedics - a new direction of speech therapy [11]. Neuro-logopedics is a science on the verge of neurology, neuropsychology, speech therapy and linguistics. It studies the formation of brain organization of mental functions during children's personal development. The central place in the neuro-logopedic approach is taken by knowledge of which brain areas work when a person speaks, writes, reads, etc. Neuro-logopedic techniques eliminate neurological causes of speech disorders with pedagogical methods. Neuro-logopedic correction is aimed at stimulation of speech development and formation of coherent, coordinated activities of different brain structures and correction of psychological and physiological foundations of speech activity and formation of child's personality. On the basis of the first signal system and congenital unconditioned reflexes in the cerebral cortex, conditional relationships are created between different parts of the brain and vocal apparatus. Nerve impulses from the

speech-motor analyzer set the organs of speech in motion through cranial nerves. Feedback from the periphery to the centre is performed on kinaesthetic and auditory ways. Based on this feedback system, the second signal system is formed that is supported by functions of the first signal system (especially by functions of the auditory and visual analyzers). Under these conditions, from the first months of life an infant communicates emotionally with an adult, repeats different voice sounds that contribute to speech apparatus development, shows auditory concentration and fine auditory differentiation of sounds of human voice, speech hearing and tonal side of speech, can perceive and distinguish sounds they hear.

Since pre-, peri- and postnatal periods together constitute a continuous process, speech disorders include: delay of speech development, general underdevelopment of speech due to impaired maturation of brain systems of phonetic and phonemic structures and lexical and grammatical structures of speech, alalia, characterized by absence or inherited underdevelopment of the speech-motor analyzer (Broca's area) - motor alalia, speech-hearing analyzer (Wernicke's area) - sensorial alalia; delayed speech development as secondary underdevelopment of speech caused by primary defects of the analyzers (hearing, vision) or total underdevelopment of mind (mental retardation). Neuro-logopedics first resolves neurological problem, and only afterwards speech skills can be developed using different teaching methods. To resolve the neurological problem of the diseases, a comprehensive program is used (E. Yatsenko) that includes drug and non-drug treatment aimed at restoring brain functions, e.g. hypoxic therapy, micro-polarization and developing computer techniques «Tomatis», «Fast ForWord», «Interactive Metronome» developed by leading US specialists [7, 11].

In some cases, defect carriers can be determined and certain circumstances can be understood under which children with disorders can be born. Therefore, a relatively new trend in speech therapy, i.e. neuro-logopedics uses a genetic approach to establish preventative measures for children's mental and physical health and prevention of speech disorders. Genetic disorders are examined in genetic consultation centres that are closely related to prenatal care centres, where correction of developmental and speech disorders is carried out professionally with the aid of speech therapists, developmental paediatricians, psychologists, neurologists and involves a combination of speech therapy, psychotherapy and drug treatment in accordance with individual developmental pace and terms of each child in a comprehensive set for treatment and rehabilitation [5, 7].

## CONCLUSIONS

Speech development in early age children, healthy or with some disorders primary or secondary ones is associated to a large extent with the laws of brain maturation determined by relationships between genetic factors and surroundings in pre-, peri- and postnatal periods. This fact has led to a new speech therapy approach, i.e. neuro-logopedics that allows diagnosing various forms of developmental deviations (development of delayed speech, general underdevelopment of speech, developmental abnormalities in various hereditary diseases of the nervous system, etc.) and identifying medical and psychological mechanisms of disorders to clarify and correct recognized theoretical and practical problems of speech origin and development.

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## ЗНАЧЕНИЕ ГЕНЕТИЧЕСКОГО ФАКТОРА В РОЗВИТИИ РЕЧИ ДЕТЕЙ РАННЕГО ВОЗРАСТА

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Аннотация**.** Анализ исследований зарубежных и отечественных ученых свидетельствует об особенностях развития речи детей раннего возраста, как процесса в основе которого лежит генетически детерминированная программа. Достижения современной генетики разрешают уточнить механизм наследственной патологии, когда генетически детерминированные формы патологии развития и речи предопределены нарушениями мозговых систем. Взаимообусловленность неврологических и логопсихологических механизмов нарушения речи способствовали возникновению нейрологопедии, как нового научного направления логопедии. Генетические нарушения изучаются в условиях генетических консультаций, пренатальных центрах, в которых, также, профессионально осуществляется коррекция нарушений развития и речи с участием логопеда, дефектолога, психолога, невролога и предусматриваетв в комплексе лечебно-реабилитационных мероприятий сочетание логопедической работы, психотерапии и медикаментозного лечения с учетом индивидуального темпа развития каждого ребенка .
Ключевые слова: ребенок, ранний возраст, речь, патология, логопедия, генетика.

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