1.2 Features of the development of speech prerequisites in children with perinatal lesions of the central nervous system

The ability to achieve early diagnosis and provide speech therapy assistance for children with developmental disabilities is one of the most important issues in the field of special pedagogy in the modern world. Particular attention is paid to this issue because there is a tendency for an increase in the incidence of perinatal pathology (PP) of the central nervous system (CNS) among infants (up to 70%). Importantly, early-life brain damage pathogenetically affects the development and social adaptation of children at later age periods. Therefore, to achieve timely correction of these disorders, it is necessary to consider the large compensatory capabilities due to the increased plasticity of the brain at an early age [13, 14].

According to the Republican Centre for Health Development of the Republic of Kazakhstan, 50,960 cases of diseases of the nervous system were registered in children under the age of one year in 2018, which is about 141.6/1000 children under the age of one year. The absolute number of children in whom isolated cases occurring in the perinatal period were identified was 67,169, which corresponds to 186.7/1000 children under one year of age [15]. Notably, approximately 70% of all lesions in the CNS are associated with hypoxia. According to the World Health Organization (WHO), the incidence of severe asphyxia in newborns during childbirth ranges from 2–9/1000 newborns.

Importantly, a system for the early detection and correction of developmental disorders should include a screening examination and differential diagnosis as well as special psychological, medical, and pedagogical assistance [16, 17].

In 2001, the WHO proposed the International Classification of Functioning, Disability and Health (ICF) as an international standard for describing and measuring the degree of health disorders. To consider the peculiarities of assessing those at 18 years of age, WHO experts developed and adopted the ICF version for children and youth (ICF-CY) in 2007 [18].

Correction from an early age is effective both from the medical, psychological, and pedagogical rehabilitation point of view as well as from a socioeconomic and ethical point of view. In fact, it is known that children with developmental disorders are more likely to have concomitant pathology in various organs and systems [19]. Early detection of developmental disorders in children and the provision of assistance at an early age in the Republic of Kazakhstan is provided by several regulatory documents, including:

(1) Approval of the rules for the organization of screening. Order of the Minister of Health of the Republic of Kazakhstan dated September 9, 2010, No. 704. Registered with the Ministry of Justice of the Republic of Kazakhstan on September 15, 2010, No. 6490 [20].

(2) Approval of the roadmap for improving the provision of comprehensive assistance to children with disabilities in the Republic of Kazakhstan for 2021–2023. Order of the Prime Minister of the Republic of Kazakhstan dated August 17, 2020, No. 2020 [21].

The speech sphere is an important aspect of development in infancy. During the pre-speech period, the prerequisites of verbal communication are critical, which help to ensure the full-fledged formation of speech activity in ontogenesis. Previous studies have successfully identified the most important indicators of speech development and found that they can be used to indicate a deficiency in this area at an early stage. One of these indicators is the understanding of speech at the stage of sensorimotor development, as evidenced by experimental observation of infants with perinatal CNS pathology. The ICF-CY also has a voice and speech function domain, and professionals have found it useful for documenting the functions and activities of a child’s body [22].

Importantly, speech perception depends on the features of ontogenesis and dysontogenesis [23, 24]. The problems of diagnostics and correction of the receptive side of speech in children in their first year of life are considered to be much greater in those with perinatal disorders of the CNS.

For example, a previous study investigated the development of receptive and expressive language in young children at risk for PP of the CNS, and using special methods, conducted a survey of parents and checked congenital oral reflexes [25].

Another study used the method of diagnosing the mental development of children in the first year of life proposed by Bazhenova for the early diagnosis of deficiencies in the preverbal development of children with perinatal lesions of the CNS [26]. Using this approach, signs of impairment of the speech base were revealed in children in the first year of life with organic lesions of the CNS [27].

Many diagnostic methods for studying the state of the components and functions of speech are complex, since they cover not only the child's speech sphere, but also the motor, social, visual, auditory, and play spheres. Therefore, it is difficult to single out methods aimed at the isolated study of exclusively speech function, especially at the pre-verbal stage of ontogenesis.

In fact, one previous study noted that scientists from different fields have described speech disorders in children and adolescents with CNS damage using a variety of descriptors and taxonomies. Importantly, hypoplasia and microstructural abnormalities of white matter fibres, including the corpus callosum, have been observed [28].

Another study drew attention to the fact that when speaking about young children, especially about the period of infancy, we are talking about a gradual transition from non-verbal communication to mastering the means of verbal communication, or speech [29].

Kurbanova (2011) found that impaired formation of active speech, motor activity, difficulties in social communication, a lack of cognitive activity, positive emotions, and fear are associated with some indicators of bioelectrical activity of the brain in children with CNS damage [30].

For the development of speech in children in the pre-verbal period, a special type of speech is often used, known as infant speech (Infant-Directed Speech, IDS). IDS benefits language acquisition through amplified low-frequency amplitude modulations. It has been reported that this amplification increases electrophysiological

tracking of IDS compared to adult-directed speech (ADS). It is still unknown which particular frequency band triggers this effect. Has been founded significantly higher speech-brain coherence for IDS compared to ADS in the prosodic stress rate but not the syllabic rate. This indicates that the IDS benefit arises primarily from enhanced prosodic stress. Thus, neural tracking is sensitive to parents' speech adaptations during natural interactions, possibly facilitating higher-level inferential processes such as word segmentation from continuous speech [31]. The mother's voice is of particular importance in stimulating early vocalization in infants [32]. In addition, previous studies have been conducted assessing the effect of breastfeeding on the development and processing of language stimuli during the first six months of life [33]. Prelexical phonetic capacities have widely been described to be a precursor for later speech and language development. However, studies so far varied greatly in the measurements used for the detection of canonical babbling onset (CBO) or the description of infants' phonetic capacities at one or more set time points. The comparability of results is, therefore, questionable. It was found that the different applied prelexical measures equally well serve as valid estimators for the detection of CBO or of infants' phonetic capacities. Further, age of CBO and phonetic capacities at 9 months were significantly associated even though the age of CBO did not reliably predict phonetic capacities. Prelexical measures and word onset were not related. Reasons for no indication of a significant association are discussed. Importantly, the age of onset of canonical babbling and phonetic ability at nine months was found to be significantly related, even though the age of onset of canonical babbling did not reliably predict phonetic ability [34].

Therefore, a review of the scientific literary sources indicates that early diagnosis of speech impairment in children remains a relevant problem.

This study was carried out over the course of 3 months. In total, 15 children were examined. At the beginning of the study, the children were 6 months old, and by the end of the study, they were 9 months old.

When conducting the experiment, the following methods were used:

- Analysis of anamnestic and clinical data;

- Research on preschool development of the children:

(1) Speech therapy examination with the derivation of the coefficient of development of pre-verbal speech

(2) The ratio of the rates of development of the prerequisites for receptive and expressive language

(3) Screening diagnostics of oral praxis

(4) Checking the condition of the articulatory apparatus

Based on the anamnesis, the diagnosis of children in the first month of life was performed according to the International Classification of Diseases of the 10th revision (ICD-10), section XVI: “Certain cases arising in the perinatal period”. As such, 3 children were diagnosed with “Cerebral ischemia” (P91.0), 6 children were diagnosed with “Foetus and newborns affected by maternal tobacco use” (P04.2), and 6 children were diagnosed with “Foetus and newborn affected by unspecified maternal effects” (P04.9). According to the etiopathogenetic classification, the main role of the CNS in the acute period of PP is to produce pathological effects such as hypoxia and toxic effects on the nervous system. The children in the risk group for PP in the CNS were under the dispensary supervision of a neuropathologist.

When conducting speech therapy examinations of children, we used a previously described methodology [35]. Due to the peculiarities of the emotional and communicative sphere of a young child, speech therapy tests were carried out in a playful way, arousing interest in the children. The examination was carried out next to the mother. The mother usually sat the child on her lap; otherwise, anxiety inherent in children of this age may have led to speech negativism. To fully cover the possible compliance with the standards of child development, we took the age range of 4–10 months. Notably, most often, children are behind rather than ahead of age norms.

To objectify the results obtained, the coefficient of development of pre-verbal speech was calculated as follows [25]:

(development coefficient = developmental age/chronological age × 100.)

Developmental age refers to the level of functional maturity of a child, while chronological age refers to their actual age. Moreover, if the development coefficient

is less than 75, the child lags in pre-verbal development compared to a normally developing child of the same age. Indicators of the coefficient of development in the range of 75–100 are considered variants from the norm.

When assessing the ratio of the rates of development of the prerequisites for receptive and expressive language, modern normative data in the field of neuroontogenesis were considered. Therefore, in children aged 6–9 months, the indicators of the prerequisites of speech were characterized by the "outstripping" of expressive language.

The method of screening for oral praxis was borrowed from a previous study [25]. The study of the state of oral praxis included the following types of examinations:

- Diagnostics of reflexes of "oral automatism"
- Samples with "food reinforcement"
- Identification of the state of imitation activity

The study of oral praxis was carried out using only two unconditioned reflexes, since other types of reflexes died out in all examined children under 6 months of age (Table 1).

Table 1.

Oral automatism reflexes

Reflex name	Examination technique	Child's reaction
Sucking	Slight irritation of the lips, tip of the tongue with a nipple or spatula (3–4 cm deep into the mouth).	Tongue rhythmically moves back and forth. After eating, the reflex fades away and reappears after 1–1.5 h.
Swallowing	Slight irritation of the root of the tongue, back of the throat, hard palate.	Swallowing, sometimes gagging, coughing

To perform a test with "food reinforcement" (rosehip syrup), a spatula with a small amount of syrup was brought to the tongue, stimulating the protrusion of the tongue forward, left, right, and up. The result was marked as "+" if the child coped

with the task, "±" if the child performed an incomplete execution of the movement, and "-" if they did not cope with the task.

Imitative activity consists of two components that make up the proto-language system:

(1) Non-verbal (gestures, facial expressions, kinesis)

(2) Verbal (spontaneous vocalizations)

The following rules were observed in the simulation games:

- Repetition of spoken texts two to three or more times
- Encouragement of any communication of the child and their self-imitations
- Keeping the child's attention during such games (tactile, intonation, mimicry)

The following were revealed: 1) the type of imitation activity, and 2) the ability to imitate speech and speech movements. At the very beginning of the test, emotional contact with the baby was established, and non-verbal material was used. If the child did not cope with the task, they were helped using "passive" tactics (joint performance of movements in a play situation). They then switched to speech and paralinguistic imitations (repetition of sounds, movements of lips, and tongue). Their speech was accompanied by movements that "prompt" the child to repeat several times. The repertoire of movements was suggested by the child's social environment:

- "Flapping" lips
- "Clicking" the tongue
- Repetition of sounds, syllables, spontaneous vocalizations during repeated reading of nursery rhymes, children's poems, etc.

The state of the articulatory apparatus was examined according to the following parameters:

- Lips (normal, hypotension, hypertension, dystonia)
- Language:

(1) Position in the oral cavity (along the midline, deviation to the right, deviation to the left, pulled up to the root, flattened in the oral cavity, during crying in the form of a “cup” rises to the hard palate).

(2) The tip of the tongue (formed, not formed).

(3) Tone (hypotonia, hypertonicity, dystonia, norm).

(4) The state of the hard palate (palatine vault: large, small, compressed, proportional, “gothic” palate; the presence of oral synkinesis; the presence of pseudobulbar disorders).

Based on the analysis of the anamnesis data, the following risk factors of negative development of speech activity in children of this group were identified:

(1) Pathology of pregnancy and childbirth was observed in all 15 cases (100%) (aggravated obstetric and gynaecological history, presence of infection in the mother, presence of extragenital diseases in the mother, and stimulation of labour).

(2) Nine (60%) children had minor anomalies in the development of the articulatory apparatus, particularly stigma of dysembryogenesis (shortening of the frenum of the tongue; “gothic” palate).

(3) A lag in the formation of a “social” smile (one of the stages of emotional development) occurred in three (20%) children.

According to the analysis of the clinical data (based on the developmental charts of children), no suspicious factors in the auditory and visual sphere were revealed in any children. There were also no significant changes in muscle tone, and their unconditioned reflexes were normal. In three children, in the first months of life, screams during crying were weak and sucking was not active enough, after which everything recovered. Voice activity (humming sounds) was evoked through emotional-speech communication with an adult through visual and tactile stimulation with toys and their hands. Oral automatism reflexes were observed in all the children from birth. These reflexes disappeared in 9 children within the normal expected period, and a delay of 1–2 months was observed in 6 children, but this did not exceed one epicrisis period.

According to the results of the speech therapy examination of the children, the coefficient of development of pre-verbal speech was within the normal range in 9 children (60%) and below the norm in 6 children (40%), with an average of 80.

In children aged 6–9 months, in accordance with normative heterochronism, receptive and expressive language developed in 9 children (60%). Dissociation was observed in the remaining 6 children: an advance in receptive language was observed in 3 children, and a uniform development of these functions was also revealed in 3 children.

Analysis of automatic oral reflexes showed that only 3 (20%) children had a slight weakening of the sucking reflex, 2 (13%) occasionally coughed when swallowing, and the rest had normal indicators.

All 15 children demonstrated the ability to push their tongue forward (100%), 12 demonstrated the ability to push to the left side (80%), and 12 demonstrated the ability to push to the right side and to raise the tongue up (80%). Six (40%) children coped with the task of tongue elevation, and incomplete tongue elevation was noted in nine (60%) children. These children demonstrated asymmetrical motor skills (uneven lifting of the left/right side of the tongue, explained by the presence of dystonia). All children completed the task. Samples with “food reinforcement” showed that several children had latent muscular dystonia in the lingual muscles. The results from all children that coped with the task of imitation are shown in Table 2.

Table 2.

Performing imitation movements with children

Types of imitation	Compliance
Imitation of “sign” material	12 (80%)
Imitation of “speech” material	3 (20%)
Repetition of the movement of lips, tongue	6 (40%)
Spontaneous vocalization	6 (40%)

Articulator examination of the 15 children revealed disordered lip tone in 3 (20%) children with slight hypotension.

The state of the language was as follows. Position in the oral cavity: the tongue was located at midline in 12 children (80%) and deviation of the tongue to the left was noted in 3 children (20%). The tip of the tongue was not formed in 3 children (20%) but was in 12 children (80%). State of tone: tongue dystonia was noted in 3 children (20%), hypertonicity was noted in 1 child (7%), and 11 children had normal tongues (73%). State of the hard palate: 3 children (20%) demonstrated a “gothic” palate. The remaining children had well-proportioned palates.

Based on the results of the observations, it can be concluded that there is a predominance of the non-verbal type of imitative activity, as well as a scarcity of skills and abilities associated with possible oral praxis in infants from the risk group for perinatal CNS damage. Our results generally agree with other studies found in the literature. For example, in a small sample of children with PP of the CNS, we noted the development of speech prerequisites. The proposed methods of speech examination can be successfully used in practice by specialists in the early diagnosis of paediatric speech disorders. Taken together, it can be concluded that an assessment of the pre-verbal development of children at risk in infancy is necessary for the early detection of deficits, and the use of a select diagnostic complex to determine pre-verbal development and the formation of prerequisites for the development of speech in children at risk will contribute to the optimal construction of correctional and developmental therapy.