URSZULA MIRECKA
Maria Curie-Skłodowska University, Lublin
Department of Logopedics and Applied Linguistics

The Assessment of Phonological Hearing in Dysarthric Children in the ICP Syndrome. Experimental Studies *

SUMMARY

The article discusses the problem of the assessment of phonological hearing in children aged 6-15, diagnosed with dysarthria in the infantile cerebral palsy syndrome. The experimental group consisting of 36 children was divided into two equinumerous subgroups: 1) intellectually normal children, and 2) mentally retarded children. Diagnostic tests, devised by the author and used in the experiments, were described. These were experimental tests for phonological hearing: phonemic and prosodic. The presented experiments concern one of the problems examined as part of the project "Segmental and Suprasegmental Specificity of the Phonic Sequence and the Intelligibility of Utterances in Dysarthria Cases in Infantile Cerebral Palsy."

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Key words: dysarthria, infantile cerebral palsy, phonological hearing, phonemic hearing, prosodic hearing.

INTRODUCTION

In infantile cerebral palsy (ICP), an etiologically and clinically diversified set of disease symptoms, along with the dominant motor disorders, the so-called co-existing disorders, are also reported: usually intellectual dysfunctions (30–75%), speech disorders (50–75%), sight impairments (ca. 50%) and hearing impairments (ca. 25%) as well as epilepsy (ca. 35%) (Kułak, Sobaniec 2006; Michałowicz 2001). "Symptoms indicating the impairments of the central motor neuron (limb pareses), subcortical nuclei (involuntary movements), and the cerebellum (motor coordination and balance disorders)" are regarded as the dominant conditions in the clinical picture (Kułak, Sobaniec 2006: 442). According to one of the recent definitions developed by the international team of experts, the term ICP "describes

a set of permanent motor and posture disorders, causing activity limitation, which are attributed to non-progressive disturbances occurring in the development of the brain of the fetus or infant. Motor disorders in infantile cerebral palsy are often accompanied by disturbances of sensation, perception, cognition, communication ability and behavior, epilepsy, and secondary muscular and skeletal problems" (Gajewska 2009: 68).

Disturbances in language communication, understood as problems in communicating by means of one's ethnic language in its primary version (spoken language) and secondary version (written language) affect most patients with infantile cerebral palsy. The percentage of persons with ICP, reported in literature, in whom all kinds of speech disorders are diagnosed such as dysarthria, oligophasia, alalia, the hypoacousia- or deafness-induced limitation of speech development, dyslalia, stuttering, dysglossia, and delayed speech disorder, ranges between 50 to 80% (Mierzejewska, Przybysz-Piwkowa 1997; Mirecka, Gustaw 2005; Otapowicz et al. 2002).

On account of movement dysfunctions dominant in the clinical picture of infantile cerebral palsy, dysarthria[1], as a motor disorder, can be regarded as a speech defect specific to ICP. Diagnosing dysarthria in ICP requires special thoroughness: diagnostic problems may result from the fact of co-occurrence of all kinds of dysfunctions in patients, which, consequently, produces a complex picture of symptoms related both to the sphere of competences (cultural, communicative, and linguistic) and realization abilities. Of significance is also the age of subjects: A. Obrębowski and B. Woźnica (1997) point out that the symptomatology of dysarthric disorders in children is less typical, less pronounced than in adults.

THE OBJECT OF STUDY

The investigations described in the present article embrace one of the problems studied by the author as part of her postdoctoral-degree research project "Segmental and Suprasegmental Specificity of the Phonic Sequence and the Intelligibility of Utterances in Dysarthria Cases in Infantile Cerebral Palsy."

[1] As I propose – as part of standardizing of logopedic management (Mirecka 2008) – to adopt one term - dysarthria (without distinguishing anarthria) I define it as follows: dysarthria is a disorder at the executive level of the motor speech mechanism induced by structural and functional changes in the nervous system (the pyramidal and extrapyramidal systems, cerebellum and cerebellar tracts, and peripheral nerves supplying the speech apparatus muscles) and manifested in dysfunctions within the respiratory, phonatory, and articulatory apparatus, which result in distortions of the phonic substance of utterances at the segmental and suprasegmental levels; disorders in the realization of phonemes and in the prosodic organization of the phonic sequence have different ranges and intensity: in extreme cases they consist in the inability to produce speech sounds. .

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Dysarthria, along with oligophasia, is one of the most often reported speech disorders in ICP. In the studies presented by A. Obrębowski and B. Woźnica (1997) dysarthria was found in ca. 30% of cases. In the 90-person population studied by U. Mirecka and K. Gustaw (2005) dysarthric disorders were diagnosed in 26 cases (29% of the investigated group), and oligophasia in 49 cases (54%); the co-occurrence of oligophasia and dysarthria was reported in 17 subjects (19%). On account of frequent coexistence of dysarthria and oligophasia in patients, this question was taken into account in the author's own studies - the control group was divided into two subgroups: 1) children with dysarthria, and 2) children with dysarthria and oligophasia.

One of the project's research tasks was to verify the effect of possible phonological hearing disorders in the diagnosed patients on the realization of the phonic aspect of utterances at the segmental and suprasegmental levels. The present article presents the first part of these studies covering the assessment of phonemic hearing and phonological prosodic hearing.

The experimental phonological hearing tests used in the presented investigations are based in their assumptions on the concept of phonemic hearing, presented in a series of articles devoted to the problems of auditory reception of speech (Domagała, Mirecka 2001, 2002, 2007). The reception of speech is a complex cognitive process, in which hearing functions are closely linked with other sensory-motor functions as well as with intellectual functions participating in the process of processing language information. In the adopted concept, phonemic hearing is broadly understood, it relates to the reception of speech sounds in all the aspects that, when reflecting the multiaspectuality of phenomena in the phonic sequence, emerge in the process of language acquisition and in the process of linguistic communication as a source of varied information to the listener. The categorization of phenomena situated within phonemic hearing enables distinction of:

1) abilities determining the acquisition of the language system:
   – in the segmental aspect
   – in the suprasegmental aspect
2) abilities determining the reception of extra-systemic information
   – at the phonetic level
   – at the suprasegmental level of the phonic sequence

Consequently, we can respectively distinguish:

– phonemic hearing related to the phonological subsystem of language in its segmental aspect,

– phonological prosodic hearing related to the conventional features of the structure of suprasegmental units characteristic of a language, and thereby belonging to the language code

– segmental phonetic (or sound) hearing related to the sound characteristics in its different aspects: on the basis of phonetic contrasts as the foundation of formation of phonemic features and as the ability to discern differences between sounds that are realizations of the same phoneme.

– phonetic prosodic hearing related to the characteristics of the suprasegmental level of the phonic sequence in its aspect which goes beyond the systemic prosodic information and applies to individual differences, including variable ones, e.g. depending on emotions, or one's psychophysical condition.

Phonemic hearing and phonological prosodic hearing are two different hearing abilities but performing the same function: they serve the development of the phonological system in the mind and then its functioning in the process of linguistic communication, they determine the reception of phonologically relevant elements – they relate to the phonological system in its segmental and suprasegmental aspects.

When comparing the proposed treatment of phonological hearing i.e. phonemic and prosodic, with the dichotomy in S. Grabias's concept (2001): competence/skills, the phonological hearing should be regarded as a biological-mental skill (ability) within the systemic skill, or more precisely, in its aspect which is associated with the reception of utterances. Phonological hearing would serve to develop the phonological system of language in the mind (i.e. at the level of competence); it would enable reception of speech as well as development of systemic skills of different types.

With linguistic competence broadly understood (without opposing competence to skills and conscious knowledge), phonological competence comprises knowledge and the ability to use it as well as epilinguistic and metalinguistic phenomena, i.e. that which is biologically determined and acquired and constantly developed in social contact. Phonological hearing as a component of phonological competence refers therefore to abilities serving to develop the phonological system in the mind in the segmental and suprasegmental aspects (the phonemic inventory, conventional prosodic units and structures as well as phonological rules), to develop phonological skills and metaphonological functions.

THE PROFILE OF THE STUDIED GROUP

The studied population was composed of children aged 6-15 with a medical diagnosis of infantile cerebral palsy. The experimental group, consisting of 36 children, was divided into two equinumerous subgroups: 1) children with dysarthria, 2) children with dysarthria with coexisting oligophasia (in these investigations these subgroups are identical with the groups: 1) intellectually normal children, and 2) mentally retarded children). Between October 2011 and April

2011 the children were tested by the project author in the rehabilitation/therapy centers and in educational institutions situated in towns in the Lublin province, with the consent of heads of these institutions and parents. Dysarthria identified in the diagnosed children had different clinical forms and different degrees of intensity. The most frequent type of dysarthria was spastic dysarthria (17 cases), then mixed spastic-dyskinetic dysarthria (11 cases), dyskinetic dysarthria (5 cases), ataxic dysarthria (2 cases), and mixed ataxic-dyskinetic dysarthria (1 case). The following degrees of dysarthria were reported: mild dysarthria – 19 cases, moderate dysarthria – 8 cases, severe dysarthria – 8 cases, and 1 case of severe dysarthria.

The subjects came form the rural background or from town milieus, some of them living outside of the localities where rehabilitation classes or lessons took place (they were brought in there). The most essential information in the context of the problems dealt with in the article come from medical, rehabilitation, psychological, and teaching information made available (for inspection) to the project author by the managers of the institutions.

Group structure by age of the subjects

– whole group: mean age ca. 10.5 years; the youngest child aged 6, the oldest – aged 15;

– the group of intellectually normal children: mean age 10 years; the youngest child aged 6, the oldest aged 14;

– the group of mentally retarded children: mean age 11 years; the youngest child aged 6, the oldest at the age of 15.

Group structure by gender of the subjects

– whole group: 19 girls (ca. 53%) and 17 boys (ca. 47%);

– the group of intellectually normal children: 10 girls (ca. 56%) and 8 boys (ca. 44%);

– the group of mentally retarded children: 9 girls (50%) and 9 boys (50%).

Group structure by the intellectual development level of the subjects

– whole group: from moderate mental retardation to average intelligence;

– the group of intellectually normal children: 11 children (ca. 61%) with below-average intelligence, 7 children (ca. 39%) with average intelligence;

– the group of mentally retarded children: 9 children (50%) with light mental retardation, 9 moderately retarded children (50%).

Group structure by education of the subjects

The studied children have a diverse level of education: from the stage of preschool education to the first grade of *gimnazjum* [junior high school]; 5 intellectually normal children and 8 mentally retarded were one year late in the fulfillment of the school duty. The forms of education were also diversified: public institutions (schools with and without integrated classes), special schools (individual

and non-individual instruction), preschool classes and school grades organized in rehabilitation/therapy centers (instruction according to the mass school curriculum and special school curriculum);

Group structure by clinical forms of infantile cerebral palsy diagnosed in the subjects (neurological diagnosis)

– whole group: dominant ICP forms – spastic (24 cases– ca. 67%), then mixed forms (7 cases of the spastic-athetoid form – ca. 19% and 1 spastic-ataxic-athetoid form – ca. 3%), ataxic forms (2 cases – ca. 6%), and dyskinetic forms (2 cases – ca. 6%);

– the group of intellectually normal children: 10 children (ca. 56%) with a spastic ICP form, 2 children (ca. 11%) with an ataxic form, 5 children (ca. 28%) with a spastic-dyskinetic form, and 1 child (ca. 6%) with a spastic-ataxic-athetoid form;

– the group of mentally retarded children: 14 children (ca. 78%) with a spastic ICP form, 2 children (ca. 11%) with a dyskinetic form, 2 children (ca. 11%) with a spastic-dyskinetic form.

Group structure by the co-existing disorders

– whole group: vision defect (15 cases– ca. 42%), epilepsy (1 case – ca. 3%);

– the group of intellectually normal children: vision defect (7 cases – ca. 39%);

– the group of mentally retarded children: vision defect (8 cases – ca. 44%), epilepsy (1 case – ca. 6%).

It should be emphasized at this point that only disorders that were regarded as typical co-existing disorders in ICP (hearing and sight impairments, and epilepsy) were recorded.

METHODS OF INVESTIGATION

The investigations used experimental tests assessing phonological hearing: a phonemic hearing test and a phonological prosodic hearing test.

Phonemic hearing test

In the present approach, in the application aspect, the range of phenomena being part of phonemic hearing is determined by the following three factors:

1. Features of a phoneme
2. The number of phonemes in the word structure
3. The order of phonemes in the word structure (the sequential arrangement)

The system of investigation reflecting the interrelationship between the hearing ability in question and the phonemic structure of words, taking into account the features of segments constructing this structure, the number of segments and their orderings, was proposed by the author in the method of studying the pho-

nemic hearing in 5-6 year-old children (Mirecka 1982). The experimental studies conducted at that time, concerning the differentiation of paronyms, words differing in the number of phones and in their ordering, showed that the use of the devised method for diagnostic purposes was right: the investigations enabled a multi-aspectual description of difficulties in the studied children. The pattern of examination presented above is based on the arrangement adopted in this method. In the later period, experimental tests to study phonemic hearing were used in diagnosing children with difficulties in verbal and written communication (Mirecka 2010, 2011), paying special attention to relationships between written communication and phonemic hearing disorders (Mirecka 2009). The exact diagnosis of these phenomena is required not only in cases of speech disorders but also in children with developmental dyslexia (Domagała, Mirecka 2008).

The experimental phonemic hearing test used in the studies conducted under the present project comprised 40 word pairs arranged in the following groups[2]:

1) words differing with one phoneme (with elementary phonological oppositions and differentiated by a greater number of features) – 28 word pairs, e.g.

/pačka/ : /tačka/ /p/ : /t/
/žebra/ : /zebra/ /ž/ : /z/
/bućik/ : /buʒik/ /ć/ : /ʒ/
/kaśa/ : /kasa/ /ś/ : /s/
/noc/ : /nos/ /c/ : /s/
/but/ : /bat/ /u/ : /a/
/pi̯esek/ : /pi̯asek/ /e/ : /a/

2) words with a diverse number of phonemes (words differing with one segment) – 7 word pairs, e.g.

/osa/ : /kosa/ /k/
/list/ : /lis/ /t/
/pasek/ : /pi̯asek/ /i̯/

3) words with the changed order of phonemes (words with the changed order of two neighboring phonemes, and words with the changed order of a greater number of phonemes occupying more remote positions from one another in the word structure) – 5 word pairs, e.g.

/palma/ : /plama/
/smou̯a/ : /su̯oma/
/mata/ : /tama/

[2] This study adopted the phonological system as interpreted by B. Rocławski (Rocławski 2001, Milewski 2005), consisting of 36 phonemes: 8 vowel phonemes: /i/, /y/, /e/, /a, /o/, /u/, /ę/, /ǫ/ and 28 consonant phonemes:0 /i̯/, /u̯/, /r/, /l/, /m/, /n/, /ń/, /f/, /v/, /s/, /z/, /š/, /ž/, /ś/, /ź/, /x/, /c/, /ʒ/, /ć/, /ʒ́/, /č/, /ǯ/, /p/, /b/, /t/, /d/, /k/, /g/. Phonological notation is given in slashes, using the characters of the Slavic alphabet.

The selection of words for a test largely depended on the possibility of presenting their referents in a graphic form. The referents of the words given below were represented in colored drawings and placed on separate sheets in pairs, in a horizontal arrangement, in the order of drawings in pairs being in accordance with the above notation of words.

The instruction given to the children at the beginning of this test was formulated in the following way: *We are going to look at pictures. I am going to name two pictures and then I will give the name of one of them and you will show me this picture.* Then the tester said the words, pointing to appropriate pictures, and then said the word whose referent was presented in the picture, while the child was supposed to show it.

During that test, the children looked at the pictures rather than at the face of the tester, therefore there was no need to cover the mouth to prevent observation of the speech organs (lip-reading). The test lasted ca. 5 minutes, during which the tester marked correct (+) or incorrect (-) answers on the form.

Test of phonological prosodic hearing

Units that form the phonological system in the suprasegmental aspect are understood in terms of discrete phonological models (as units made up of smaller units) or as units with an analogue continuous structure which constitutes characteristic prosodic arrangements (Sawicka 1995). Suprasegmental phonic features regarded as the most essential for the prosodic structure of language: differences in volume, pitch and length occurring between the segments of the phonic sequence and perceived through hearing by the receiver of an utterance, relate to such variable acoustic processes as intensity (volume level), frequency and duration respectively (Dukiewicz 1995). They are constituents of complex prosodic features: intonation and stress, which, together with pause, play a significant role in verbal communication. The prosodic phenomena in question are part of the area of interest of suprasegmental phonetics and phonology[3].

In the experimental test of phonological prosodic hearing devised for the purposes of this research project, two suprasegmental phenomena relating to utterance were selected: stress and intonation.

Sentence stress (logical, syntactic), which consists in emphasizing a selected word in the sentence by means of prosodic factors, is treated as only one of the exponents of the thematic-rhematic structure of utterance, which can perform distinctive functions[4].

[3] Suprasegmental (prosodic) phonology is defined as "a branch of phonology investigating phonological phenomena whose scope goes beyond single segments such as stress, rhythm, intonation, duration, and tone, as well as the properties of prosodic units such as mora, syllable, foot, phonological word, phonological phrase, and utterance" (Szpyra-Kozłowska 2002: 239).

[4] "Stress sentence functions as an indicator of the sentence rheme, indicating in the sentence the word most heavily laden with new information" (from the dictionary entry authored by

Intonation, based on changes in the sentence tone height, is regarded as its obligatory component that can perform various functions: distinctive function (as an indicator of semantic differences between utterances: declarative, exclamatory, and imperative sentences are characterized by cadence, i.e. the lowering of the tone of the last post-stress syllable, while interrogative and declarative sentences requiring completion are marked by anticadence or the raising of the tone in the last post-stress syllable), delimitative function[5], as well as non-linguistic functions, e.g. emotional, social, or individual (Sawicka 1995).

The experimental test of phonological prosodic hearing consisted of 10 pairs of utterances, of which five pairs relating to intonation differentiation and five to the differentiation of sentence stress:

1) intonation differentiation

Mama pisze.	Mama pisze.
Mother is writing.	Mother is writing.
Będziemy rysować.	Będziemy rysować?
We are going to draw.	We are going to draw?
Dasz mi ołówek?	Dasz mi ołówek!
You will give me a pencil?	You will give a pencil!
Kotek pije mleko.	Kotek pije mleko.
The cat is drinking milk.	The cat is drinking milk.
Drzwi się zamyka!	Drzwi się zamyka.
The door should be closed!	The door should be closed.

2) differentiation of sentence stress

Kolega poszedł **do domu**.	Kolega poszedł **do domu**.
My friend went **home**.	My friend went **home**.
Jacek ma rower?	Jacek ma **rower**?
Jacek has got a bicycle?	Jacek has got a **bicycle**?
Kupuję **owoce**.	**Kupuję** owoce.
I buy **fruit**.	I **buy** fruit.
Tata **myje** samochód.	**Tata** myje samochód.
Father is **washing** the car.	**Father** is washing the car.

R. Laskowski) (Polański 1999: 23); "Syntactic stress, also called logical stress, can be used as an exponent of the thematic-rhematic structure of utterance. It can perform this function on its own, then it is a distinctive element, or together with the word order, then it is an element accompanying the order" (from the dictionary entry authored by S. Karolak) (Polański 1999: 469).

[5] "Intonation. Melodic characteristics of an utterance (sentence) consisting in variations of tone when speaking it (the utterance). Differences in speech melody (intonation contour) are indicators of semantic differences between utterances" (from the dictionary entry authored by R. Laskowski) (Polański, 1999: 261); "It performs a distinctive function when it is the only exponent of difference between two sentences /…/ by performing a delimitative function, intonation inter alia enables distinction between a set of many sentences and a simple or complex sentence" (from the dictionary entry authored by S. Karolak) (Polański 1999: 468).

Pojedziemy **na wieś**. Pojedziemy **na wieś**.
We are going **to the country**. We are going **to the country**.

These sentence pairs read out by the author were recorded on a CD, there being a two-second pause between the sentences in a pair. After listening to the sentence pairs played from the CD, the child's task was to say whether the sentences sounded the same or different. Instructions given to the children at the beginning of the test were as follows: *You are now going to listen to recorded sentences. Each time you are going hear two sentences and you will tell me if they sound the same or different. Listen attentively*.

The test lasted ca. two minutes; during the test the tester marked correct (+) or incorrect (-) answers on the test form.

RESULTS

The assessment of phonemic hearing

In the phonemic hearing tests consisting in auditory differentiation of 40 word pairs, the intellectually normal children coped very well – single errors (1–2) occurred only in several children. In the group of mentally retarded children, two children did more poorly as compared with the rest of the group: one of them made 5 mistakes and the other as many as 17 (almost half of possible errors) – in those subjects, apart from problems with phonemic hearing, there may be deficits of auditory attention. Furthermore, several children in the group made single mistakes (1–2). In the test for auditory differentiation of words, the majority of children in the two investigated groups coped very well (zero errors). It was not possible to carry out experimental diagnostic tests for phonemic hearing with a moderately retarded girl with serious difficulties in concentration of attention.

The analyses of intergroup comparisons (using the Mann-Whitney U test) showed a statistically significant difference ($p<0,05$) in phonemic hearing between the mentally retarded children and intellectually normal children.

The assessment of phonological prosodic hearing

More problems were caused in both groups by the phonological prosodic hearing test based on auditory differentiation of intonation and sentence stress in 10 sentence pairs. The difficulty of this test in the case of intellectually normal children is proved by the fact that only 5 children compared the sentences correctly, most of them having made errors: several of them single errors (1-2), and two made errors in half or more than half tasks (5-6). In the group of mentally retarded children, no one managed to differentiate all sentences correctly by ear: all of them made 2 or more errors (even 6-7). The poor results in this test, apart from deficits in auditory differentiation of prosodic phenomena, can be the effect

of problems in auditory attention, focusing on words in the sentence rather than on the whole sentence and the information carried at their prosodic level. Experimental diagnostic tests for phonological prosodic hearing could not be carried out with three moderately retarded children: the girl who was unable to take part in the prior phonemic hearing test and two boys – the reason was attention deficits and problems with understanding the instruction.

The analyses of intergroup comparisons (using the Mann-Whitney U test) showed a statistically significant difference ($p<0,001$) in prosodic hearing between the mentally retarded children and intellectually normal children.

DISCUSSION

The acquisition of language, both in its primary version (verbal language) and secondary one (written language), is usually made difficult in the case of deficits in auditory perception: this is pointed out by the authors of logopedic, psychological and pedagogical studies. In Polish literature on the cognitive functioning of patients with infantile cerebral palsy, the problems of auditory perception have been treated less thoroughly. The first extensive publication in this area is a monograph by S. Mihilewicz (2003) devoted to the problems of auditory processing of non-verbal signals (differentiation of sounds by volume, duration, rhythm, pitch, tone color, and direction) and verbal ones (recognition and processing of words in sentences); the analyses showed a lowered level of auditory processing in the investigated group of children with ICP aged 7–10; the author emphasizes the need for earlier diagnosis to determine the degree of disorders in processing verbal and non-verbal signals, which would be the basis for creating therapy programs oriented towards stimulation of various aspects of hearing functions.

The problem of the development of phonological hearing in patients with ICP, so far omitted in studies, was taken into account in the present project as one of the elements of diagnosing dysarthric children in cerebral palsy. The experimental phonological (phonemic and prosodic) hearing tests used in the experimental studies enabled the assessment of abilities important for acquisition of the language system at all levels of its organization, in particular its phonological subsystem. In both phonological hearing tests, the mentally retarded children did more poorly than the intellectually normal children did, especially in the prosodic hearing test, which proved to be more difficult for the two groups than the phonemic hearing test. The worse results in the children with global intellectual dysfunction may result not only from the weaker abilities to auditorily differentiate verbal signals but also from difficulties in functioning in the testing situation, from attention deficits. The phonological prosodic hearing test, which caused considerable problems to children in both groups, used longer units than

the phonemic hearing test (sentences rather than words), while the correct answer required decoding and comparing linguistic prosody in a pair of heard sentences; the results may also have been influenced by problems with auditory attention and difficulties with understanding the instruction properly. Consequently, it is obviously necessary to standardize and normalize the proposed diagnostic tests used to assess the phonemic and prosodic aspects of phonological perception.

Problems in logopedic diagnosis in cases of infantile cerebral palsy are usually connected with the complex picture of symptoms stemming from intellectual, motor, hearing and other dysfunctions which have an adverse impact on the development of competences and realization abilities. Despite the fact that dysarthria, as a motor disorder, has been recognized as a speech disorder specific to ICP because of frequent coexistence of various dysfunctions in this syndrome, it is important to diagnose the level of the development of particular cognitive functions. In order to identify the specificity of communication disorders in the patient with ICP, it is necessary to assess the level of his/her acquisition of the language system, the way of realizing utterances (verbal or written), the ability to use language in social situations, as well as the possibility of using forms of non-verbal communication.

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