A Longitudinal Study of Children with Developmental Dysphasia

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Abstract: This study reports longitudinal follow-up of 300 children with developmental dysphasia. Their expressive disturbances are a manifestation of their auditory decoding impairment. These children were investigated on battery of tests of spoken language, of phonological processing and of different audiometric procedures, in order to register all the information necessary to be able judge the speech-language development. The tests focused on diagnosis of central auditory disorder, confirmed the difficulties in association area in children with developmental dysphasia. In speech perception, the temporal processing is one of the functions necessary for the discrimination of phonemes, and of similar words. Our results confirmed long-term problems of children with developmental dysphasia with central auditory perception disorder.

Introduction

The literature on auditory-phonological processing presents the heterogenety of SLI (specific language impairment). In our language we usually use the term developmental dysphasia. Some studies have focused on children with severe comprehension problems, asking to what extent their difficulties are auditory or linguistic. Others have concentrated on searching for a link between defective speech production and abnormal speech perception. Identification of speech sounds appears to be a problem in all groups. Several reviewers have documented a number and variety of cognitive tasks that are difficult in children with SLI [1]. Developmental dysphasia denotes inability to acquire normal expression and comprehension of language in the absence of peripheral hearing impairment, neurological disorder and mental retardation. The use of the term of developmental dysphasia implies that the child's perceptual abilities for auditory speech events underlie his impairment for the acquisition of auditory symbols. At the heart of developmental dysphasia, there is disorder of auditory perception. Central auditory deficit may result in or coexist with difficulties in other CNS-based skills, such as speech-language impairment, attention deficit, learning and developmental disabilities.

Concerning developmental dysphasia, the typical clinical picture is delayed speech-language development, with specific disorders within all structures; disorder of the distinctive features of phonemes, disorders in the sequential arrangement of syllables (transpositions and reductions), problems with grammar (with word categories and with syntax), and problems with semantic and association language functions. These children experience typical speech comprehension problem, varying in intensity; they also have typical auditory decoding deficits, integration deficit, associative deficit and out-put organisation deficit of speech. Many of these children are unable to recognize acoustic contours and to identify keywords from a spoken message. These children often behave as if peripheral hearing loss was present, despite normal hearing. In some children, problems with perception are so conspicuous that the children appear as having a hearing disorder as they do not understand common conversation and elicit impression of the disorientation.

The neurological examination confirm diffuse lesion of CNS: more often slight hypotonic syndrome with a delay in maturation of cerebellar function, in some cases slight dyskinetic syndrome or signs of spasticity-pyramidal irritation (lower extremities). Generally, the children have problems mostly with muscle coordination, especially with graphomotor functions. The CNS imaging techniques (CT and NMR of the brain) neither enable further subdivision of the dysphasia nor bring any other explanation concerning the ethiopathogenesis (as opposed to CT and NMR results in patients with aphasia, enabling further differentiation according to localization of the organic lesion).

During the impaired EEG records, the children are also affected either by impairment or by a stagnation of the speech-language development. EEG abnormalities within developmental dysphasia are less severe, but fully correspond to changes within Landau-Kleffner syndrome: the acquired epileptic aphasia of children [2, 3].

Disorders of speech comprehension are typical of all patients with central auditory processing disorders (CAPD). In speech perception, temporal processing is one of the functions necessary for the discrimination of phonemes, and of similar words. The existence of cognitive functions disorders is much more important than difficulties directly involved in speech production. Impairments have been reported both within receptive and expressive language and, more specifically, in morphosyntax and naming [4].

Central auditory processing disorder is an auditory processing deficit caused by deficiency in those skills that are subserved by the central auditory mechanism in the brainstem and brain. Many children will suffer from only one subtype of CAPD, others may suffer from combined subtype profiles. Concerning primary subtypes; based upon presumed anatomical site of dysfunction, include auditory decoding deficit, integration deficit and prosodic deficit. Secondary subtypes include auditory association deficit and out-put organization deficit [5].

Central auditory tests go beyond standard tests of hearing to examine how well the auditory system uses or interprets the information that the ear sends it. The term "auditory processing" refers to "what we do with what we hear" [6]. Concerning dichotic speech tests, dichotic listening involves the presentation of stimuli to both ears simultaneously, with information presented to one ear being different from that presented to the other. Depending on the test itself, the listener may be required to repeat everything that is heard (binaural integration). The information presented to each ear is composed of a portion of the entire message, necessitating integration of the information order for the listener to be able to perceive the whole message [7].

Like all auditory evoked potentials, the long latency auditory evoked potentials (LAEP), and wave P3 are non-specific for disease, but provide information about auditory system function. LAEPs were studied in children with speech-language disorders. The author [8] explains the P3 (300) positive peak as a first phase of the language processing and they also consider the manifestation of the hemisphere dominance. The electrophysiological changes recorded correspond with the character of the respective speech disorders: it is apparent that the long latency auditory evoked potentials can be used to study the disorders of speech comprehension and their pathology is related to the role of the temporal processing of the auditory stimuli.

Material and Methods

It is not correct to make a diagnosis of developmental dysphasia according to our opinion using one type of examination. We must combine the electrophysiological examination with behavioural auditory tests. The group of 300 children (212 boys and 88 girls – Figure 1), of age 4–8 years was being monitored. Initial neurological investigation and waking standard EEG were performed in all cases and serious disorders of central nervous system were excluded. The relationship of handedness: 247 right-handed and 53 left-handed (Figure 2). The mean age of children suffering from SLI (dysphasia) was 6 years 2 months, follow-up period 1–5 years. Children within this age (6 to 7 years) were being best diagnosed in view of the fact of possibility to accomplish the widest possible spectrum of examinational methods. All the children underwent detailed phoniatric examination. Majority of dysphasic children were repeatedly evaluated during speech-language education by means of special auditory tests (of phonological awareness, of auditory evoked potentials and dichotic central tests). The phonological awareness was tried by pairs of words that are similar or differ on one phonem. While being tested, the child makes a selection from the presented

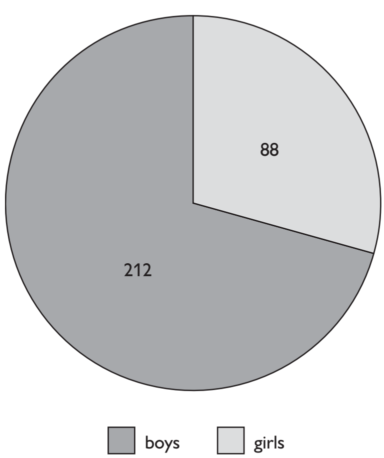

Figure 1 – Children with developmental dysphasia (DD).

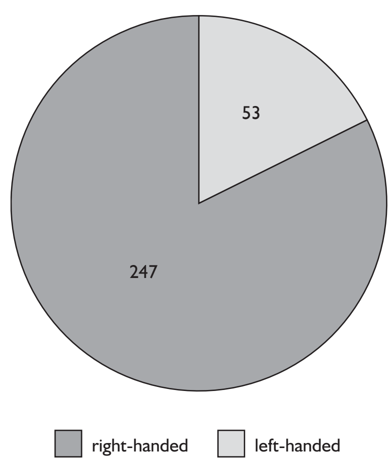

Figure 2 – The relationship of handedness.

pair of pictures in time limit given. We used original dichotic binaural tests in Czech language modified for younger children. Tests are based on behavioral audiometry using dichotic listening (different auditory stimuli that presented to each ear simultaneously). The experimental tasks consisted of 3 auditory measures (test 1–3); dichotic listening of two-syllable words presented like binaural interaction tests; to create simple sentence from two words that are heard separately but simultaneously (the children had to repeat all together).

Results

Family history: positive family history was confirmed in 185 children. Sex of risk relatives – overbalancing representation of male relatives, as it is with majority of speech-language disorders. Perinatal history: Positive perinatal risks were found in 145 children (risk pregnancy in 59, immaturity in 26 children, pathological delivery – in 19, respiratory distress syndrome in 41 cases (Figure 3). Disorders of phonemic discrimination and of verbal comprehension were found in majority of cases. Auditory decoding deficits, phonological, lexical and syntactic deficits and associative deficit were diagnosed. Pure tone audiometry was normal in all cases. Developmental dysphasia (DD) is occasionally complicated by other diagnoses. In a group of 300 children were mentioned these complications: stuttering (balbuties) and dysarthria (Figure 4).

The special test of phonological awareness for pre-school children (presenting phoneme pairs different in one distinctive feature; the words were chosen according to distinctive features of sounds of Czech language) was used for

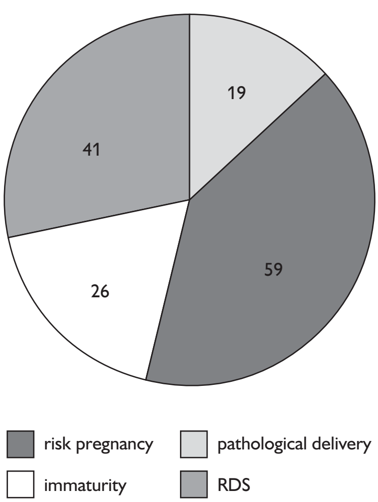

Figure 3 – Perinatal history – positive risks in group of DD children.

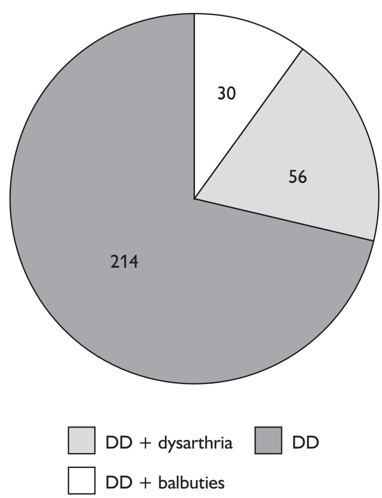

Figure 4 – Combination of diagnoses.

multiple examinations of 300 children with developmental dysphasia. These children exerted problems in the tests requiring understanding of phonological constants (Figure 5). In comparison with results of children of appropriate age, dysphasic children have disturbed ability to differentiate phonemes. Children with physiologic speech-language development accomplish this test as early as at the age of 5 years. Although the results in children with developmental dysphasia approach the norm for 6-7 years, mainly in voiced-voiceless consonant distinctive feature, the approaching of 100% is slower at a later age (8–9 years), in terms of the total result (with other distinctive features), compared with a control group.

Long latency auditory evoked potentials (LAEPs) were observed in a considerable part of children with developmental dysphasia. The responses to verbal stimuli were not recorded or were found with decreased amplitudes and with prolonged latency (wave P3), almost in the left dominant hemisphere. When testing the hypotheses on differences between the values of the P3 latencies in children with dysphasia (the P3 was chosen for testing as the most important response with respect to the stimulation by verbal stimuli), the following relationships were found:

a) tonal stimulation – no significant difference was found between the P3 latencies on the right versus left side,

b) verbal stimulation – statistically significant differences were confirm in the records of the P3 latencies from the left and right sides between the studied group and the match-control group (at 1% significance level). The record from the left hemisphere was statistically the most significant (p – 0.001),

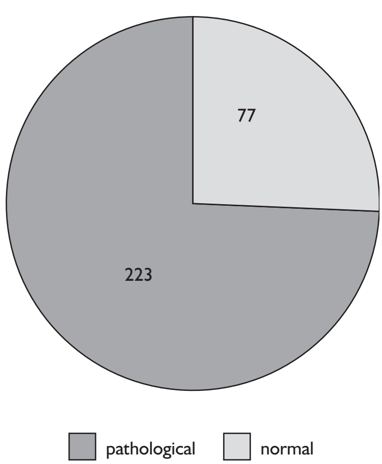

Figure 5 – Phonological awareness in children with DD.

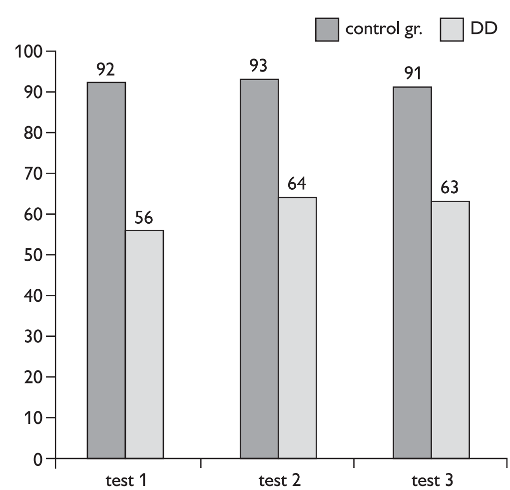

Figure 6 – Results (in %) of central dichotic tests – comparison of children with DD versus control group

c) when comparing the results after tonal and verbal stimulation – no significant difference was found in the P3 latency values on the right side. However, at the left side the statistically significant difference (1%) was confirmed; after the verbal stimulation the P3 latencies are longer on the left side compared to tonal stimuli (Table 1).

Results of the dichotic speech test in 90 children with developmental dysphasia (DD), of age 6–7 years. Average rate of success of these children was 56% in test 1, 64% in test 2, and 63% in test 3. Rate of success of the control group was 92%, 93%, and 92%. Highly significant differences ($p<0.001$) were confirmed by statistical evaluation using the pair t-test. The average number of correct responses was significantly lower in children with DD than in children from control group (of chronological age and normally developed – Figure 6). Dysphasic children obtained lower scores at all targets than controls. Results in our group of pre-school children confirmed their disability to synthesize 2 two-syllabic words during dichotic listening. DD children are unable to create simple sentences from different two words presented simultaneously to both ears. Results of the tests in mentioned children confirmed integration deficit, and problems with temporal processing and with quality of short-term memory.

The EEG records obtained during monitoring of children with developmental dysphasia contain an important portion of abnormalities (223 children in our group) and especially epileptiform abnormalities (66 children from mentioned group) localized in the region of speech and auditory centres which correspond with the respective characters of the individual speech-language disorders. From the group of children with specific EEG changes, 6 of them manifested clinical seizures (absences occurred in 5 children, in 1 child tonic-clonic seizures were present).

Discussion and conclusion

A longitudinal study was conducted to document and compare evolution of children with developmental speech-language impairment. Our results indicate the relationship between developmental dysphasia and central auditory processing disorder (CAPD): our dysphasic children have auditory processing deficit: not only integration, but also associative deficit. Deficiency concerned the ability to

Table 1 – LAEP – latency of wave P3 (ms)

Group	Latency – dx	n	Latency – sin	n
		verbal stimuli		
Control	321±22	10	311±28	10
Dysphasia	410±68	27	440±62	31
		tonal stimuli		
Control	332±30	16	335±25	16
Dysphasia	380±60	17	382±78	17

perform tasks that require interhemispheric communication and the inefficient intrahemispheric cooperation.

Speech-language comprehension disorders are typical in all patients with central auditory processing disorder. It is important to realize the matter of perception of the acoustic signal in connection with time. The temporal processing is a decisive factor for the myriad of auditory perceptions, including speech and music perception.

Temporal processing in speech perception is one of functions, which are necessary to distinguish between the fine stimuli, such as voicing, and other. In other words, it is necessary to distinguish between the distinctive features of the phonemes or to distinguish between similar words.

The results of phonological awareness remain close to the lower limit of the norm for a long time. The hypothesis of the worst results in voiced-voiceless consonants and compactness-diffusivity distinctive features, seen generally in children with developmental dysphasia, was confirmed. However, the results are always proportional to the intensity and the duration of rehabilitation care and to the individual characteristics of a child (e.g. concentration ability during the test). The examination of older dysphasic children suggests that the deficiency in voice versus voiceless consonant distinctive characteristic results in the risk of development of congenital learning disorders dyslexia and dysorthography (regarding central auditory processing disorder). The difficulties within final realisation of sounds in dysphasic children persist despite improvement of their auditory differentiation – later on, the children have difficulties predominantly in the semantic domain (not being able to follow the story line and reproduce even a short story).

The judgement of temporal order does not occur at ear, it rather represents a central auditory function. Using a variety of acoustic stimuli, an interstimulus interval of only 2 msec is required for the normal listener to perceive two sounds instead of only one. However, this interval must be 17 msec long to identify correctly which sound appeared as the first one. If the listener needs more than 15 to 20 msec to realize the sequence of two consecutive stimuli, the examiner should check the central auditory system for pathologic changes. The first 100 to 250 msec of an auditory stimulus presentation is the most critical consequence for stimulus recognition. As a result of our study, we suppose that the very important matter in speech perception in children with developmental dysphasia is a disorder in temporal processing of acoustic signals. This presumption has also been confirmed by the results of examinations of the long latency auditory evoked potentials presented in this paper.

The potentials records display prolongation of the P3 latencies (as cognitive potentials) especially after stimulation with verbal stimuli. Great variability in the responses, probably related to a variation in the bioelectrical activity, which can be seen also in abnormal native EEG records; this can be found in the results. Children with developmental dysphasia have most difficulties in processing of the speech signal. The abnormalities or epileptic seizures in the region of speech and hearing centres probably explain the cause of the central speech and auditory disorders. The mechanisms of the speech comprehension disorder in developmental dysphasia and in Landau-Kleffner syndrome are quite similar and it is evident that these EEG changes cause disorders in comprehension and verbal expression abilities. Ethiopathogenesis is unclear, however a disorder of integration auditory and speech connections due to the defect in myelinisation, delayed maturation of the unknown origin, or due to the relationships of pre- and postsynaptic elements is expected [9].

Genetic factors could make a significant contribution to developmental disorders of speech and language; the analysis of compiled background variables indicates that speech-language problems are genetically influenced (gender and family aggregation; in our study of group of 300 children – positive family history was in 185 cases).

We suppose that this initiate evaluation corresponds with approach to developmental dysphasia at our workplace. With an auditory training producing improved speech-language abilities in everyday context, this would be the strongest support yet for the view that linguistic difficulties in these children are secondary to more fundamental auditory limitations. Special hearing and speech-language treatment can be improved auditory and auditory-related skills to create long-term benefit for children with developmental dysphasia. In comparison and evaluation of results of special tests during our therapy were confirmed good successes in word recognition, in phonological analysis and in central auditory function. With auditory training, common language skills of these children can be improved. The level of pragmatic language, i.e. the comprehension of spoken language in real communication, is being developed, too.

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