
RELATIONSHIP BETWEEN GRAMMAR ABILITIES AND MENTAL OPERATIONS IN BULGARIAN CHILDREN WITH CEREBRAL PALSY

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Abstract: The relationships between cognitive and language abilities in typical developing children has always been an interesting research perspective. Those relationships are even more intriguing in children with complex neurodevelopmental disorders, where more than one area of functioning is affected. Cerebral palsy is a disorder that affects postural control, movement and coordination from the earliest stages of a child's development. It significantly limits sensory-motor experience of the child, their manipulative functions and the development of play. Cerebral palsy often manifests itself in comorbidity with various sensory impairments or sensory-processing disorders, and speech disorders. All these create preconditions for secondary impact on the development of language and cognitive processes. *The purpose* of this paper is to present the results from a study aiming to compare mental operations and grammar abilities in 5-7-years olds Bulgarian children with different type of cerebral palsy, as well as to find evidence of the direct links between the development of language ability and cognitive processes. *The methodology* comprises of comparison between two groups of children: the first one is an experimental group of 30 children with cerebral palsy, without any sensory or intellectual disabilities and without epileptic seizures, with developed verbal communication, but diagnosed with different extent of developmental dysarthria; the second one is a control group, consisting of 30 children with typical physical, cognitive, language and speech development at the same age. The area of grammatical competence tested is represented by morphological and syntax processes. In the processes at the level of morphology the inflection of words and the use of prepositions with spatial meaning are studied. Syntax probes are aimed at constructing sentences based on given words. The mental operations tested are those underlying logical thinking – generalization, serialization and classification, as in the qualitative evaluation of these samples underlying operations of analysis and synthesis are also envisaged. The evaluation procedures used are part of a more complex informal assessment of language abilities (including also phonological processes and lexical content) and cognitive abilities (including verbal memory and attention span). Processes from the language and cognitive areas are compared using several statistical methods: t-test, Chi-square, and Pearson correlation coefficient at $p < 0.01$, both for the experimental and the control groups. *The results* unequivocally show a direct relationship between the level of development of mental operations and grammatical ability, both in typical development and in cerebral palsy. In the children of the experimental group, a disharmonious connection was proved between the areas of language and cognitive functioning, which in typically developing children are relatively more homogeneous. The main *conclusions* suggest that the general motor impairment and the lack of sufficient manipulative experience in children with cerebral palsy are the basis of the inhomogeneous development of the linguistic and cognitive areas of functioning. Therefore, the main *recommendation* is to apply complex methods of therapy and habilitation, aimed at compensating for deficits in mental and language development.

Keywords: cerebral palsy, dysarthria, grammar abilities, mental operations

1. INTRODUCTION

Cerebral palsy (CP) is a term describing a group of non-progressive (permanent) motor disorders, which affects movement and posture (Patel, Neelakantan, Pandher, Merrick, 2020). It includes different and changing motor syndromes, which occur as a result of complex etiology and different combinations between underlying risk and causing factors: brain lesions or abnormalities, occurring in the early stages of its development, intrauterine infections, use of some medications during pregnancy, low gestational age, preterm birth, multiple gestation, brain injuries and many other (Chavdarov, Bozhinova, Ilieva 2019; Korzeniewski, Slaughter, Lenski, Haak, Paneth 2018). Cerebral palsy affects muscle strength and postural control, muscle tone, coordination and locomotion (Raychev, Raychev 2009), and it is categorized in four main forms: spasticity, dyskinesia, ataxia and mixed/other. The severity of their manifestation, as well as the combination of other developmental disorders that may be present suggest to some authors to define cerebral palsy as a spectrum. CP is accompanied by various combinations of secondary conditions and disorders: sensory, perceptual, cognitive, intellectual, language, speech, feeding, behavioral, by epilepsy, and by secondary musculoskeletal problems (Beckung, Hagberg 2002). Cerebral palsy is a socially significant condition with high incidence of 2 to 3 per 1000 live births (Patel et al. 2020; Vitrikas et al. 2020) and requires early (from birth) and prolonged (often for life) complex, multispecialty team (re-)habilitation. The issues that speech-language therapy has to address in order to achieve optimal involvement, participation and functioning

require knowledge of the links between language, speech, motor skills and cognition in typical and in impaired development.

Developmental dysarthria, also referred in the Bulgarian terminology in the area of speech-language pathology as childhood mixed dysarthria, is a motor speech disorder that affects all the levels of speech mechanism (respiration, phonation, articulation, prosody), as well as the coordination in-between the processes during speech. Childhood dysarthria is a secondary to cerebral palsy and as a motor speech disorder it is expected to occur more often than a language disorder. Usually, if there is no presence of mental retardation and sensory/perceptual deficits children with cerebral palsy demonstrate good levels of impressive and expressive language skills. The same statement could be expressed to their cognitive abilities. It is considered, that the main barrier to the development of concepts in both language and cognitive areas is the restriction to the manipulative activity and to the free access to the environment in the early stages of child development. Thank to early intervention programs, most children with CP succeed in developing cognitive abilities and language competence at a satisfactory level (Reid, Meehan, Arnup, Reddihough 2018; Stadskleiv 2020).

The levels of linguistic and cognitive functioning in cerebral palsy have been a subject of long-standing interest, but the interaction between them has not been well studied yet. There are a large number of studies of one or a group of cognitive processes within the different forms of manifestation of CP (Chilosi, Cipriani, Bertuccelli, Pfanner, Cioni 2001; Gupta, Bhatia, Rajak 2017; Petrov 1990; Petrov, Marinov 1994; Ramenskaiya 2011), as well as descriptions of the language disturbances accompanying the dysarthria (Boyadzhieva-Deleva, 2021; Mastiyukova, 1983; Soriano, Hustad 2021; Wiecha, Zajac 2020). The cognitive and communicative functioning in children with cerebral palsy and intellectual disabilities and with hearing and or visual impairments are well described, but currently there is no study revealing the links between the two areas in children with CP and no intellectual or sensory outcomes.

2. MATERIALS AND METHODS

The aim of the study is to compare some basic mental operations to some basic grammar abilities in 5-7-years olds Bulgarian children with different type of cerebral palsy, as well as to find evidence of the direct links between the development of their language ability and cognitive processes. The main hypothesis of the study is that the correlation between language and cognitive abilities that exists in a harmonious way in children with typical development is a considerably disrupted and inhomogeneous in the population of children with cerebral palsy. The main reason for this suggestion is that the motor disorder sets a number of limitations to the development of manipulation, play activities and the access to the environment, which are the main barriers to the formation of cognitive and linguistic concepts concerning orientation, space and direction of movements that usually are expressed through the use of prepositions and prefixes.

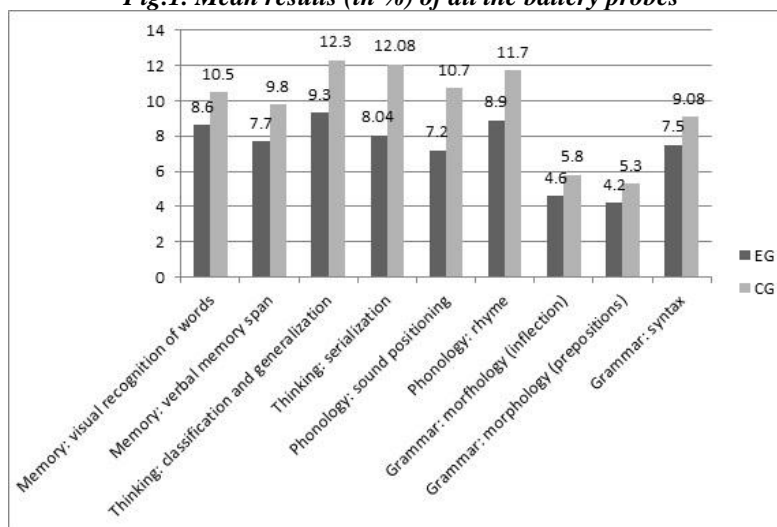
The methods of the experiment are specially structured in a battery of informal probes used in speech and language pathology for testing cognitive and language skills. The probes include: attention tasks; verbal memory tasks (for visual and auditory recognition stimuli and for capacity of auditory memory); logical thinking tasks (for classification, generalization and serialization), phonology tasks (sound positioning and rhyming); grammar tasks for morphology (word changing through inflection and use of prepositions for space); grammar tasks for syntax (structuring sentences by given words). This article presents only the results and analysis of mental and grammatical operations.

The methodology comprises of comparison of the results between two groups of children: the first one is an experimental group (EG) of 30 children with different forms of cerebral palsy, without any sensory or intellectual disabilities and without epileptic seizures, with developed verbal communication, but diagnosed with different extent of developmental dysarthria; the second one is a control group (CG), consisting of 30 children with typical physical, cognitive, language and speech development at the same age (5;0 to 7;6, as years;months). In EG gender ratio is 2:1 in favor of boys, and in CG the gender ratio is 1:1. The children of the EG have different forms of CP, differentiated according to International Classification of Diseases, ICD-10: G80.0 Spastic quadriplegic CP, n=5; G80.1 Spastic diplegic CP, n=9; G80.2 Spastic hemiplegic CP, n=11; G80.4 Ataxic CP, n=1; G80.8 Other/mixed CP, n=1; G80.9 CP unspecified, n=3. Cerebral palsy in all of the forms is demonstrated at different extent (severity) of the motor disorder (mild, n=22; moderate, n=7; and severe, n=1). 27 of the children are able to move independently, and 3 use aids. According to anamnestic data and information from medical records took prior to the experiment all children in EG have normal intelligence (although low to borderline IQ coefficient) and have no accompanying sensory and/or perceptual disorders. Children in EG are very carefully selected so that they do not have any epileptic symptoms due to data on its effect on cognitive functioning and the proven relationship between cognitive retardation and registered epileptiform discharges (Chilosi, et al., 2001; Jasseja, 2007). All children in EG have developmental dysarthria but no language impairment.

3. RESULTS

The individual and group results from the samples are transformed from point scores into percentages and are related to a five-leveled scale of cognitive and language functioning: 0–19% – very low, impaired or retained level of cognitive / language functioning; 20–39% – low level; 40–59% – middle level; 60–79% – good level; 80–100% – normal to high level. The average percentages for each battery samples are presented in Figure 1.

Fig.1. Mean results (in %) of all the battery probes



The analysis of descriptive statistics confirms the preliminary expectations for cognitive and language functioning around and above the average level of children from EG (mean value of the total score for the whole battery 15.89 points (p.) or 66.2%) and level of functioning at high levels of CG (mean value of the total score for the whole battery 21 p., resp. 87.5%).

Compared by individual battery performance, EG children scored higher on cognitive probes (67.5%) than on language probes (64.9%). The same trend is demonstrated in CG (89.6% for cognitive processes and 85.25% for language system). In the individual parameters of the cognitive processes in both groups the higher results are noted in the parameter thinking (69.3% for EG and 97.6% for CG), compared to the parameter memory (65.5% for EG and 81.6% for CG). In the internal indicators for thinking, the better results are for the classification and generalization (74.3% for EG and 98.6% for CG) compared to the serialization (64.3% for EG and 96.6% for CG).

In the analysis of the individual parameters of the language system in EG, better results were obtained on the samples for grammar compared to those for phonology (65.16% for grammar and 64.3% for phonology, respectively). CG receives 81% for grammar level. In the internal analysis of the grammar samples, the higher results fall on the morphology, and the lower ones – on the syntax (for EG – 70% for morphology and 60.3% for syntax, for CG – 89.3% and 72.6% respectively). The low results of CG in themselves of the syntactic representation make an impression here. In the analysis of the mean values in the breakdown of the morphology parameter, better results are obtained in the samples for word change (73.3% for EG and 93.3% for CG), compared to the samples for use of prepositions – 67.2% for EG and 85.3% for CG.

The best results in general for both groups are in terms of thinking – classification and generalization (9.3% for EG and 12.3% for CG), and the lowest – in terms of use of prepositions defining space relationships and destination, as above, under, behind, in-between etc. (4.2% for EG and 5.3% for CG). The results from the probes of serialization immediately follow those of classification and generalization, which puts thinking at the highest level of functioning compared to the other parameters studied – both for cognitive and linguistic areas. For serialization EG receive 8.04% and CG 12.08%. The level of morphology is generally the lowest for both groups. Higher internal results are at the probes of word change (4.6% for EG and 5.8% for CG), compared to the use of prepositions with spatial meaning (4.2% for EG and 5.3% for CG).

Qualitative analysis of thinking tasks also confirms expected results. In EG, the most characteristic difficulty is to derive the generalizing concept and to name the category that unites the three pictures from the test for the fourth redundant one. Argumentation of the choice is very difficult, even with a correct answer of the task. A common mistake in EG is to combine three subjects on an insignificant basis.

The statistical processing of the results obtained was done through the SPSS package. The hypothesis is verified by Pearson's correlation coefficient with $p < 0.01$. Results (as shown in table 1) prove that there is a statistically significant correlation between levels of grammar abilities and mental operations concerning thinking.

Table 1. Results from Pearson Correlation test

Experimental Group (EG)		Mental operations	Grammar - Morphology	Grammar - Syntax
	N	30	30	30
Mental operations	Pearson Correlation	1	,423*	,363*
	Sig. (2-tailed)		,020	,048
	N	30	30	30
Grammar - Morphology	Pearson Correlation	,423*	1	,619**
	Sig. (2-tailed)	,020		,000
	N	30	30	30
Grammar - Syntax	Pearson Correlation	,363*	,619**	1
	Sig. (2-tailed)	,048	,000	
	N	30	30	30

The relationship between the degree of cerebral palsy and the level of linguistic and cognitive functioning is also checked by t-test and ANOVA. The results show that in cases of more severe motor disorder the levels of cognitive and language operations are lower. The obtained results also prove the existence of a relationship between the level of development of mental operations and grammatical ability, both in typical development and in cerebral palsy. In the children of the experimental group, a disharmonious connection was proved between the areas of language and cognitive functioning, which in typically developing children was to be relatively more homogeneous.

4. DISCUSSIONS

Children with cerebral palsy who are outside the adverse effects of other disorders, except the motor ones, do not show deviations below the average levels in their language and cognitive functioning compared to typically developing children. Normal intelligence and sensory perception and the absence of other severe secondary disorders allow language and cognition to develop not too far from the typical stages. Evidence of this are the obtained average results, falling within the lower borderline of the fourth of five possible conditional levels of cognitive and language functioning, related to both the whole battery and the two parts separately.

The inhomogeneity in the language-cognition interaction in children from EG is confirmed. The significance of a specific cognitive process for the development of a certain language level can also be confirmed – the reflection of mental processes in grammatical operations is proved. The degree of cerebral palsy directly affects the level of cognitive functioning. Statistical indicators also define this proportional relationship as relatively strong. This and the above conclusion confirm the importance of general motor impairment as one of the leading negative factors for language and cognitive development in children in the study group. They suggest that despite the lack of intellectual and sensory deficits, the limitations of the subject-manipulative activity and the later onset of its manifestation, as well as the narrow contacts with the environment in the early stages of the child's development do not remain without visible consequences in later age periods.

5. CONCLUSIONS

The general motor impairment and the limited and insufficient manipulative experience in children with cerebral palsy are the basis of the inhomogeneous development of the linguistic abilities and cognitive processes. Therefore, the main recommendation is to apply early intervention and prevention services, based on provision of complex methods of therapy and habilitation.

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