EXECUTIVE FUNCTIONS IN CHILDREN WITH INTELLIGENCE DISABILITIES

Mirjana Japundža-Milisavljević and Dragana Maćešić-Petrović

Introduction

Executive functions are higher order functions on the top level in the cognitive hierarchy, which implies the presence of basic intellectual functions in respect to which they are superior. Executive functions thus play the role of controller and modulator of cognitive functions. It is believed that the position of executive functions, i.e. the frontal lobe, (Freeman, 2000) is responsible for the overall ability of representation of the outer world. Executive functions are responsible for acquisition of all knowledge. Complexity of identification of the aforementioned functions is reflected, inter alia, in the fact that one of the requirements for their operation is voluntary attention, which is also an executive function (Ranganath et al., 2003).

Impaired ability in self-control as well as emotional instability, carelessness in behaviour, impulsiveness, neglected hygiene, mental rigidity, difficulties in planning, commencing and implementation of activities and motivational deficit are all features characteristic of persons with disexecutive syndrome and persons with intellectual disabilities (Griffith et al., 1999).

Executive functions, frequently called the frontal functions, together with memory and attention as the basic cognitive functions that also belong to the frontal lobes, are recognized as particularly important for learning in children with mild intellectual disabilities. Dysfunction of the prefrontal lobes destabilizes the intention to memorize certain content, prevents active searching for means and modes of memorizing, disturbs the development of cognitive strategies and programmed behaviour, and also interrupts the voluntary attention functionality which, in turn, prevents or destabilizes the process of acquiring knowledge. This paper is based on results of previous studies suggesting the fact that deficit of frontal functions is present in children with intellectual disabilities. The difficulties are reflected in inadequate use of learning strategies, limited capacity of working memory and

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lack of adequate correlation of knowledge (Bray et al., 2003). Our objective was to evaluate the executive functions in school children with intellectual disabilities and identify factors that are directly related to the studied functions. Imbalanced development of executive functions in children with intellectual disabilities has been noted, but few papers suggest factors that may influence their development and the exact timing of the onset of executive function development in children with intellectual disabilities.

The facts listed above highlight the issues of this paper as reflected in the following questions: What is the quality of executive functions in children with intellectual disabilities? How can some of the factors directly related to the development of executive functions be identified in children with intellectual disabilities?

The main objective of this study relates to when the establishment of the quality of executive functions development is set. The following tasks have been derived from the research objective:

- Establishment of the quality of development of executive functions through logical thinking, keeping the conceptual direction and applying the problem solving strategies
- Identification of some of factors which are statistically significantly correlated with executive functions.

Method

Sample

Our study was conducted on a randomized sample including 124 school children of both gender distributions. The eligibility criteria for selection of participants included the following requirements: an Intelligence Quotient between 50 and 69, as evaluated on the Wechsler Intelligence Scale for Children (WISC) intellectual ability scale, a chronological age between 8 and 16 years, a school age covering the educational level from 2nd through 8th grade, absence of neurological, psychiatric, sensory or combined disturbances. The sample does not include people with autistic spectrum conditions and other developmental disabilities.

The study was conducted in all elementary schools for children with intellectual disabilities in the Belgrade metropolitan area.

This was a descriptive study so a control group is lacking and it is thus not possible to compare the data with a standardised sample. The shortcomings of the design of this study can be found in the discussion section.

As TABLE I illustrates, the gender distribution of the sample was fairly balanced with 63 male and 61 female participants.

The differences in achievement at the implemented test of executive functions between children of different chronological age are statistically significant, as shown in TABLE II.

Instrument

The instrument used to evaluate executive functions was the Twenty Questions Test, proposed by Klouda and Cooper (1990). This test is a sensitive indicator of maturation of executive functions. The questioning technique is based on the well known game of guessing an object the other player is thinking of and it is used to evaluate development of strategies and their implementation.
in problem solving. The participant is expected to correctly identify the hidden object by asking simple questions to which he/she may receive only yes or no answers. The test is finished when the subject successfully identifies the object or after twenty questions based on which he/she failed to identify the hidden object. This evaluation technique makes it possible to analyze the process of hypothesis development and testing, discrimination of relevant from irrelevant information, logical thinking, maintenance of conceptual direction and short-term memory. The test also investigates the ability to apply and use acquired knowledge. Ability to assess organization and devise problem solving strategy, as well as quality, informativeness and innovativeness of questions asked make this test appropriate for executive functions studies.

The other information needed for our study relating to the level of intellectual functioning (IQ), chronological and school age, gender distribution and socio-economic status of the subject’s family were obtained by conventional analysis of pedagogical records. The overall school achievement was defined and measured through the categories taken from standard clinical and school documentation process analysis.

### Procedure

The different tests were carried out by the team of multidisciplinary oriented professionals in the area of special education and rehabilitation. All participants were subjected to the same test and the investigation was managed over the period of one school year.

The study was conducted in all Belgrade elementary schools for children with mild intellectual disabilities. Selection of participants was based on the research criteria listed below, trying to make the sample as representative as it was possible. All obtained data were scored, entered into the data matrices and statistically processed.
Data analysis

The obtained results are presented in the tables. Analysis of the obtained data was conducted by various models of parametric and non-parametric statistics. The obtained data were entered into a database using SPSS software for processing frequencies, percentages, arithmetic mean, standard deviation, variability measure calculation, Analysis of variance (ANOVA), T test and its significance.

The following dependent and independent variables were processed in statistical analysis procedures:

- The age of subjects was classified as follows: 8-9 years of age (scored in group 1), 10-11 years of age (scored in group 2), 12-13 years of age (scored in group 3), 14-16 years of age (scored in group 4)
- Gender – M (male, scored in group 1) and F (female, scored in group 2)
- Intelligence quotient measured by WISC for assessing intellectual abilities. The intelligence quotient of the participants ranges within the category of mild mental retardation, which was divided, for the purposes of this study, into a higher functioning level (61-69, scored in group 1) and a lower functioning level (50-60, scored in group 2).
- Socio-economic conditions of the child’s family. The criterion for better socio-economic conditions, scored as group 1, is a flat with modern conveniences, including electricity and water. If the child lives in a flat without a bathroom or if several families use one bathroom, then we are talking about lower socio-economic conditions of living, scored in group 2.
- Categories of school achievement of the subjects were classified by numbers 1, 2, 3, 4 and 5. For the purposes of statistical analysis, school achievement is classified as more (2) and less (1) successful.

Results

The results of the 20 questions test item analysis are presented in TABLE III.

The executive functions were registered only from the age of 12 in children with intellectual disabilities. Out of our participants in the 12-13 age group only 12.9% of the sample were successful at the applied test. In the oldest group the part of tested sample that managed to be successful at the executive functions test was 19.35%.

In the group of children aged 12-13 (chronological age) most participants showed the presence of strategy for

| TABLE III |
| Results of item analysis pf 20 Question Test |

<table>
<thead>
<tr>
<th>Items</th>
<th>Age</th>
<th>8-9</th>
<th>10-11</th>
<th>12-13</th>
<th>14-16</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>%</td>
</tr>
<tr>
<td>Successful guess</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Has a strategy, but unsuccessful</td>
<td>19</td>
<td>61.3</td>
<td>17</td>
<td>54.8</td>
<td>20</td>
</tr>
<tr>
<td>No strategy</td>
<td>12</td>
<td>38.7</td>
<td>14</td>
<td>45.2</td>
<td>9</td>
</tr>
</tbody>
</table>
problem solving. The strategy was, however, unsuccessful and it mainly included asking the questions, but lacked the cognitive processing and therefore was not adequate so that they were not able to successfully solve the problem. We have also noted that many children are prone to simple guessing, instead of asking questions that will lead to the solution of the applied test. Thus, more than half of the participants in the 12-13 age group were unable to apply an adequate strategy to reach the solution to the posed problem. Somewhat poorer results were achieved by the youngest children, while the remaining two groups in the studied sample showed the same success rate.

Absence of strategy to resolve the test was noted in more than 30% of the participants in the youngest age group. In the subsequent age group, the rate was somewhat higher, reaching 45%, which is a reason for concern, since at an older age better use of strategy and development of executive functions are expected. The oldest two groups showed similar achievement: absence of strategy leading to solution of the problem was noted in around 30% of participants, respectively.

The results of statistical analysis point to the statistically significant relationship between the chronological age of the subjects and executive functions, except for the two youngest and oldest age categories of children at the level of tested variables (TABLE IV).

Presence of correlation between executive functions and other variables, i.e. gender distribution, intelligence quotient, overall school achievement and socioeconomic status of families of the studied children could not be established (TABLE V).

Discussion

The obtained results of the conducted study suggest the fact that school age children with intellectual disabilities show marked problems with tasks in which they are required to develop strategies

| Particular aspects of executive function/chronological age using independent samples test |
|-----------------------------------------------|-----------------|----------|
| Particular aspects of executive function/chronological age (group 1 and 2) | t = 0.507 | df = 62 | Sig.0.614 |
| Particular aspects of executive function/chronological age (group 1 and 3) | t = 2.108 | df = 62 | Sig. 0.039 |
| Particular aspects of executive function/chronological age (group 1 and 4) | t = 2.683 | df = 62 | Sig. 0.009 |
| Particular aspects of executive function/chronological age (group 2 and 3) | t = 2.108 | df = 62 | Sig. 0.039 |
| Particular aspects of executive function/chronological age (group 2 and 4) | t = 2.683 | df = 62 | Sig. 0.009 |
| Particular aspects of executive function/chronological age (group 3 and 4) | t = 0.682 | df = 62 | Sig. 0.498 |
for problem solving and adjust these to new requirements. Our results suggest that development of this highly complex function in children with intellectual disabilities takes place at the age of about 12, reaching the peak at the age of 15. Physiological findings have shown that myelination of nerve fibres and maturation of structures in these areas take place in the course of childhood and adolescence (Anderson et al., 2001), although Yakovlev and Lecours suggest that this process continues, even in the third decade of life (Yakovlev and Lecours, 1967). In the few similar papers dealing with evaluation of particular aspects of executive function in children with intellectual disabilities markedly low scores have also been reported (Van der Molen et al., 2007).

The applied test is used primarily for evaluation of the initial formation and subsequent development of problem solving strategy. Since the test differentiates only between the successful and unsuccessful ones, we wanted to identify whether children with intellectual disabilities use any strategy. We have, therefore, used the item analysis dividing the responses into three groups. The “successful” group includes the participants who managed to be successful in the test. Only very few from the two oldest age groups fell into this group. Another category includes participants who have shown a certain strategy for problem solving, but still failed to identify the hidden object. A total of 58% participants belong to this group who asked logical and correlated questions, but could not differentiate between relevant and irrelevant information, use logical reasoning or maintain the conceptual direction and short-term memory, thus failing, to identify the hidden object. Children with intellectual disabilities are not able to guide their own problem solving properly by asking the questions that will eliminate a larger number of alternatives. This is the “in-between category”, since the last category comprised children who were unable to understand the task. It may be concluded that about 40% of our participants did not show any (i.e. not even the minimum level of particular aspects of) executive function development.

### TABLE V

Values of related variables between particular aspects of executive function and gender distribution, IQ, overall school age (OSA) and socio-economic status of subject’s family using independent samples test and chronological age - nonsignificant parameters

<table>
<thead>
<tr>
<th>Particular aspects of executive function/gender distribution</th>
<th>t = 1.196</th>
<th>df = 124</th>
<th>Sig.0.245</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particular aspects of executive function/(IQ)</td>
<td>t = 1.091</td>
<td>df = 124</td>
<td>Sig. 0.278</td>
</tr>
<tr>
<td>Particular aspects of executive function/(OSA)</td>
<td>t = 1.861</td>
<td>df = 124</td>
<td>Sig. 0.065</td>
</tr>
<tr>
<td>Particular aspects of executive function/</td>
<td>t = 0.550</td>
<td>df = 124</td>
<td>Sig. 0.584</td>
</tr>
<tr>
<td>socioeconomic function</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Particular aspects of executive function/</td>
<td>t = 0.507</td>
<td>df = 62</td>
<td>Sig. 0.614</td>
</tr>
<tr>
<td>chronological age (group 1 and 2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Particular aspects of executive function/</td>
<td>t = 0.682</td>
<td>df = 62</td>
<td>Sig. 0.498</td>
</tr>
<tr>
<td>chronological age (group 3 and 4)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Successful solution of the test requires formulation of a planned sequence of questions, suggesting the need to involve several cognitive processes. Therefore, the markedly poor achievement in the applied test may be interpreted from the point of view of imbalanced development of working memory since it is the bridge of the central executive system (Cabeza and Nyberg, 2003), and it plays the crucial role in solving this test because of the need to store the questions and answers to reach the correct solution. Children with intellectual disabilities rely more on the visual working memory and visual strategies. Since this test did not require any of these, the results, although markedly poor, are hardly unexpected. Children in our sample show limitation of metacognitive skills so that the obtained results may be interpreted from that point of view, as well (Bull et al., 2004).

Adults and older children have a greater ability for implementation of strategy that corresponds to the needs and situations. If they are given a task that rules out the use of strategy, the age differences disappear. Interestingly enough, younger children find it hard to learn new strategies, and even when they manage to learn them, they are unable to use them flexibly, suggesting the problem of cognitive operational maturity as the critical learning prerequisite (Brown, 1975).

Correlation analysis of the conducted study suggests the fact that development of particular aspects of executive function depends on the chronological age of participants and that other variables are not statistically significantly correlated with quality development of these functions. The obtained results suggest the possibility that the deficits in particular aspects of executive function are independent of the gender distribution, intelligence quotient, achievement at school and socio-economic status of family, but they are directly related to the chronological age.

Studies dealing with the skill of target setting where application of adequate strategy is needed for reaching of the target suggest that rapid development of this ability is expected at the age of about 12 (Anderson et al., 2001), but that the adult level is not reached at that age (Korkman et al., 2001). Our results fully agree with this finding suggesting the fact that the development of particular aspects of executive function are directly correlated with age, and unrelated to gender distribution, school age, academic achievement, socioeconomic status and intelligence where failure in particular aspects of executive function test is fairly common in spite of relatively preserved intellectual ability (Bishop et al., 2001).

Descriptive comparison of our results with the results of similar studies based on the sampling of children from a typical population indicates that the latter show a development trend. The results correspond to ours since these findings suggest that the maturation of executive skills, although rapid during early and middle childhood, slows considerably during late childhood and adolescence. Differences between the two groups of children were found when assessing the effect of gender on executive functions. Sex differences, although uncommon, provide some suggestion of a crossover effect occurring around ages 12 or 13, when girls become more effective than boys on a range of tasks (Anderson et al., 2001; Klingberg et al., 1999).

The practical implications of this study point to the need for further defining educational processes of children with intellectual disabilities. Bearing in mind that the applied test assesses
the implementation of a strategy with a view to solving a problem, the results suggest that there is a reduced ability of implementing and using acquired knowledge. The question arises as to the purpose of acquired school knowledge if it cannot be applied adequately. The answer to this question must be sought in altering teaching methods to enable pupils to use the knowledge they have acquired in real life situations. It is very important to apply active learning methods in the teaching process, as well as to enable pupils to master different learning techniques, i.e. to create cognitive maps within which facts would be classified in a particularly organised way according to the hierarchy of notions. Maps would be drawn on larger pieces of paper, blackboards or computer programmes, in order to significantly reduce disorganisation in gathering and processing data in the course of learning. One of the important practical implications of the study is the need to develop and practice work strategies and techniques based on interesting and meaningful tasks. Finally, the pattern of results achieved in this study supports the multidimensional nature of executive skills, which points out the significance of multimodal oriented treatment of this population of children. This focuses on the role of the special educator in defining the new methods of rehabilitation such as computer techniques, the Montessori method (Montessori, 1948) or the method of drama workshops and re-education of psychomotor activity.

Summary

The purpose of the study designed in this way is related to establishment of the quality of development of particular aspects of executive function evaluated by the logical thinking, maintenance of conceptual direction and use of problem solving strategies, as well as identification of factors statistically significantly correlated to the particular aspects of executive function in children with mild intellectual disabilities. The main purpose of the study is related to the fact that it was necessary to identify factors directly linked to the higher cognitive processes in children with mild intellectual disabilities, as well as determination of the exact onset of the beginning of their development. One hundred twenty-four participants with intellectual disabilities, aged 8-16 were subjected to the Twenty Questions Test for the evaluation of particular aspects of executive function. Our study has shown a very high percentage of participants who were unsuccessful in this test designed to evaluate higher cognitive functions. The correlation analysis of the particular aspects of executive function shows statistically significance with chronological age of the children only: no significant differences are identified in respect to their school age, gender distribution, overall school achievement and socioeconomic status, suggesting that executive function deficits are independent of these variables and that the deficits are related to chronological age only. The onset of development of higher cognitive functions in children with intellectual disabilities could be expected only at the age of 12.

References


