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FACTOR STRUCTURE OF BEHAVIOR RATING INVENTORY OF EXECUTIVE FUNCTIONS IN CHILDREN WITH INTELLECTUAL DISABILITY

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SUMMARY

Background: Executive functions (EF) play a key role in child's cognitive, behavioral and emotional development. There are many instruments and tests created to measure different aspects of EF in children. One of the most widely used measures for assessing EF is the Behavior Rating Inventory of Executive Function (BRIEF). The goal of the present study was to assess the factor structure of the 8 domains of EF in children with intellectual disability.

Material/ Methods: Special education teachers of 90 children with intellectual disability aged 7-15 years (54 boys, 36 girls) filled the Bosnian translation of BRIEF- teacher version. BRIEF is valid and reliable instrument for the assessment of executive functions. It is composed of the 8 EF domains: Inhibit, Shift, Emotional Control, Initiate, Working Memory, Plan/Organize, Organization of Materials and Monitor.

Results: The results of this study confirmed the original two factor structure of the BRIEF for children with intellectual disability. Total percentage of explained variance for two factors was 83.6%. The data obtained in this study almost perfectly followed the original factor structure of the BRIEF.

Conclusions: BRIEF seems to have stable factor structure across the samples. Thus, it can be validly used in many clinical populations. Given the format of the BRIEF, it can be used in identifying weaknesses and creating programs for enhancing EF in children.

Key words: intellectual disability, cognitive functions, behavioral functions, emotions, Behavior Rating Inventory of Executive Function

INTRODUCTION

Executive functions (EF) have been a popular topic in psychology, neuropsychology and education research in the last 20 years. They are necessary for almost all of our daily activities (Snyder, Miyake, Hankin, 2015). EF play a key role in child's cognitive, behavioral and socio-emotional development (Isquith et al., 2005). Although present at birth, manifestation of EF starts between 3 to 5 years of age, along with a rapid growth of prefrontal cortex (Mahone & Hoffman, 2007). Developmental course of EF is parallel to the maturation of central nervous system, in particular to the maturation of frontal lobes. Although previously considered synonymous with frontal lobes, there is enough evidence now from neuroimaging studies to suggest that neuroanatomical correlates of EF are located across the Central Nervous System (Stuss, 2011).

Defining EF can present a difficult task to a due to many theoretical standpoints of the researchers. Detailed overview of these standpoints and different taxonomies of EF can be found in Jurado and Roselli (2007). EF can be conceptualized as a set of higher cognitive abilities responsible for many everyday activities such as planning, organizing, monitoring activities etc. One of the first neuropsychologists to tackle the issue of EF was Russian neuropsychologist A.R. Luria. He differentiated three functional brain blocks, Block 1 is responsible for maintaining arousal, Block 2 is responsible for coding, processing and storing information and Block 3 responsible for organizing, regulating and controlling actions and behavior (Luria, 1976). According to Luria, Block 3 has executive function that plans and organizes behavior. Some researchers argue that at younger age executive functions are unidimensional construct and that they differentiate into factors only later in adolescence (Wiebe et al., 2011). Most researchers nowadays have endorsed the view of multidimensionality of executive functions. One of the most influential theories on EF is the one formulated by Barkley (1997). His model regards EF as a complex function consisting of five domains: behavioral inhibition, working memory, self-regulation, speech internalization and reconstitution. Other researchers have also found evidence of the multi-component structure of executive function (Gioia et al., 2002) although the domains do not completely overlap with Barkley's model. In this study we will further examine the model of EF proposed by Gioia et al. (2000). According to this model, EF are a complex construct consisting of 8 different domains: 1. Behavioral inhibition; 2. Shifting attention; 3. Emotional control; 4. Initiations of activities; 5. Working memory; 6. Planning; 7. Organization of materials and 8. Monitoring. These 8 domains comprise two factors: 1. Behavior regulation index, consisting of domains one, two and three and 2. Metacognition index consisting of domains 4 through 8. What follows is the short description of these EF domains.

1. *Behavioral inhibition*. Behavioral inhibition refers to the ability of person to control his/her own behavior and actions, such as the ability not to act on an impulse. This function is impaired in certain neurodevelopmental disorders such as Attention Deficit Hyperactivity Disorder and traumatic brain injury. According

to Barkley (1997), there are three forms of behavioral inhibition: inhibition of a dominant response, inhibition of an ongoing response and inhibition of interference. The final goal of behavioral inhibition is improving the adaptive behavior in everyday life

2. *Shifting.* Shifting refers to the ability to switch between cognitive processes, such as shifting attention from one task to another task. The main aspects of shifting are an easy adjustment to changes, flexibility of ideas and an easy change of attention focus. Mild deficits in this area affect the ability to solve problems while more severe deficit are causing perseveration behavior

3. *Emotional control.* Emotional control is part of EF related to emotions and ability of person to modulate an emotional response. Weak emotional control can be manifested in two ways: as an emotional numbness or emotional overreaction. Children with weak emotional control have difficulties in behavioral control and have emotional outburst caused by trivial motives.

4. *Initiate.* Initiate, as the name suggests, is related to the ability of person to initiate activities, to provide independent answers, ideas or strategies for solving the problem. Activities in this sense are the ones related to school and home activities. Deficits in this area are manifested in problems of the person to start some activity. These people (mostly children) are necessary to permanently motivate to perform certain activities such as homework or chores

5. *Working memory.* Working memory is one of the mostly researched areas of EF. IT was popularized by Alan Baddeley and the concept of working memory is present in cognitive psychology for over 40 years. First definitions of working memory have conceptualized it as an active memory system responsible for temporary storing and simultaneous processing of information. Current definitions stress the active component in working memory that is temporary storage of information while performing more complex cognitive tasks.

6. *Planning*. Planning refers to the child's ability to conduct current and upcoming tasks and actions. This includes anticipating events, setting goals and conducting necessary steps to execute the tasks for achieving the goal. Planning involves imagining or creating the final goal and finding the most efficacious method to reach that goal. This includes sequencing the tasks and dividing it into a few achievable steps.

7. *Organization of materials.* Organization of materials refers to tidiness in work, organization and keeping play toys in one place. It is reflected in the ability to find things easily and putting them back where they belong. Children with this deficit have many problems at school, have difficulties in finding things, often forget their homework etc. Their school packs are untidy and not organized well. It is important to note that this ability is not inherent in children but can be trained. Teachers and parents can help children who have deficit in this area to prioritize and organize things.

8. *Monitoring.* Monitoring can be defined as a habit to occasionally or permanently check your own work/performance. This ability is of particular importance for academic achievement at school, as the children who check their work more

frequently tend to make fewer errors at school. Children with this kind of deficit are hasty and rarely check the accuracy of their work. This sub-domain can be further divided into self-monitoring and task monitoring. In this study we regarded domain Monitor as a single domain.

After this short overview of the domains let us say a few words about measuring the EF. The instruments for assessing EF can generally be divided into two categories: 1. Performance-based measures and 2. Rating scales (self rated and proxy rated). There are numerous tests purported to measure different domains of EF and a number of neurocognitive tests have been developed for measuring the concept (Carlson, 2005). For example, Wisconsin Card Sorting Test is related to Shifting, Tower of Hanoi measures inhibition, Random Number Generation measures Inhibition and Updating (Miyake et al., 2000). There are tasks specifically designed for use with children such as Shape school test (Espy, 1997) because assessment of EF is very complex in young children taking into account child's limited capacity for symbolized processing and task performance (Jacques & Markovitch, 2010). The second group of EF assessment measures are rating scales. One of them, that has proven to be psychometrically sound and ecologically valid instrument is the Behavioral Rating Inventory of Executive Functions (BRIEF) (Gioia et al. 2000). BRIEF has been used extensively in many studies with clinical populations such as children with ADHD, Tourette syndrome (Mahone et al., 2002) but not so much with children with intellectual disability. One of the advantages of the BRIEF is that it can validly be used even with the preschool children (Skogan et al., 2015). In this study Bosnian version of the BRIEF – teacher version was used to assess the factor structure of BRIEF in a diverse sample of children with intellectual disability.

The goal of this study was to assess the factor structure of BRIEF in children with intellectual disability and to expand our knowledge on executive functions in children with intellectual disability. The hypothesis for this study was that the BRIEF will have the same factor structure in children with ID as it had for the typically developing children.

METHOD

Participants

Special education teachers of 90 children with intellectual disability aged 7-15 years (54 boys, 36 girls) filled the Bosnian translation of BRIEF – teacher version. Each teacher was familiar with the child and had known the child for at least 6 months. Children were classified into three etiological categories, 30 children with Down syndrome, 30 children with unknown etiology of intellectual disability and 30 children with other genetic cause/brain injury etiology of intellectual disability. There were 42 children in the category of mild intellectual disability and 48 children in the category of moderate intellectual disability. Mean age of children in the sample was 11.3 years (SD-2.75). The mean age of chil-

dren did not differ significantly among the three etiological categories. There were no significant differences in proportion of boys and girls in three etiological groups. All children were attending two special education school in Canton Sarajevo, Bosnia and Herzegovina. The same sample of participants was used in a study by Memisevic and Sinanovic (2013) to assess EF in children with intellectual disability.

Procedure

BRIEF was translated into Bosnian language. A person who was unaware of the English version translated the Bosnian version back to English. The translation was sent to the publisher of the BRIEF and after some ambiguities were corrected, the Bosnian version was approved by the publisher. We asked special education teachers of selected children to fill the BRIEF questionnaire. Children were selected based on etiology, in order to have as diverse sample as possible. Authors were at disposal to special education teachers to provide additional explanations.

Instrument

Behavioral Rating Inventory of Executive Function- BRIEF (Gioia, 2000) is valid and reliable instrument for the assessment of executive function. It has 86 items on which teachers provide answers (never, sometimes, often). Inventory is composed of 8 clinical scales that measure the extent to which the respondent reports problems with different types of behavior. The scales are: Inhibit, Shift, Emotional Control, Initiate, Working Memory, Plan/Organize, Organization of Materials and Monitor. Based on original factor analysis, the clinical scales form two indexes: Behavioral Regulation and Metacognition.

Statistical analysis

We performed principal component analysis of the 8 scales (not individual items). An orthogonal rotation (Varimax method) was used in order to increase the interpretability of factors. According to the statistical conventions, to perform principal component analysis, it is necessary to have at least 10 participants per scale. Factor loadings higher than .5 were considered as significant. Data were analyzed with computer program SPSS v.13 for Windows.

RESULTS

We examined a factor structure of the 8 clinical scales on BRIEF by using principal component analysis. Sampling adequacy according to KMO measure was excellent, KMO= .90 and Bartlett's test of sphericity was highly significant, $p<.001$. There were two factors extracted with eigenvalues higher than 1. Factor loadings are shown in Table 1.

The results show two factor structure of the BRIEF on sample of children with intellectual disability. Total percentage of explained variance for two factors was

Table 1. Results of Subject PP's concurrent responses of temperature and sounds with numbers and operations

Scale	Factor loading		Communality
	1	2	
Inhibit	**.66**	**.61**	.80
Shift	.34	**.79**	.74
Emotional Control	.15	**.92**	.86
Initiate	**.89**	.29	.88
Working Memory	**.92**	.23	.90
Plan/organize	**.77**	.44	.79
Organization of material	**.89**	.14	.80
Monitor	**.85**	.42	.89

Note. Boldface indicate significant loading. Total % of variance 83.6

83.6%. The factor structure of BRIEF follows the original structure with only one exception and that is the scale- Inhibit, which is loading highly on both factors, .66 and .61 on first and second factor respectively. Emotional control scale loaded the most on the second factor, 0.92. The first factor was loaded the most by the Working memory scale, 0.92.

DISCUSSION

The goal of this study was to assess the factor structure of Bosnian translation of the BRIEF in a sample of children with intellectual disability. The results presented in this study confirmed the original two factor structure of the BRIEF for children with intellectual disability thus confirming the main hypothesis of the study. The results of this study showed that the clinical scales that contributed significantly to the second factor, Behavioral Inhibition, were Inhibit, Shift and Emotional Control. Scales that significantly contributed to the first factor, Metacognition, were Inhibit, Initiate, Working Memory, Plan/organize, Organization of material and Monitoring. The only difference from the original structure was that the scale Inhibit loaded highly on both factors. Although, its loading on Metacognition was lowest of all other scales, its influence should not be neglected. One of the possible explanations for this might be that results on Behavioral Inhibition depend on some other EF measure such as working memory. This explanation needs further validation and verification. Next steps in elucidating the role of Inhibition in EF would be to examine the very factor structure of that domain. In this study we could not perform factor analysis for all BRIEF items due to the small sample size.

This is the first study, to the author's best knowledge, to examine the factor structure of BRIEF in a sample of children with intellectual disability. There were, however, other studies examining BRIEF factor structure in other clinical populations. Thus, for example, in a study by Gioia et al. (2002) examining BRIEF factor structure in children with Attention Deficit Hyperactivity Disorder, learning disabilities, autism spectrum disorders, affective disorders and epilepsy, the authors found three factor solution to best fit their data. Their model included Be-

havior Regulation, Emotional Regulation and Metacognition, but in that study domain Monitoring was divided into two components: self-monitoring and task monitoring.

This study further supports the multidimensional model of EF and the ability of the BRIEF to capture that multidimensionality. Of course not every sample will provide such a good fit to two-factor model but it is obvious that the EF model postulated by Gioia et al. (2000) seems to be stable across different samples.

The BRIEF is an instrument that can validly be used with typical population as well as populations with medical conditions (Gioia et al. 2002; Mahone et al., 2002; Ciszewski et al., 2014). Also, the good thing about BRIEF is that it can validly be used across the life-span. There are a couple of limitations of this study that need to be noted. First the sample size was not sufficiently large to allow factor analysis of all the BRIEF items (instead of domains). Secondly, the sample was randomly selected which can cause some issue in the generalizability of the results.

As a conclusion, the results of this study further validate the model of EF postulated by Gioia et al. (2000). It was demonstrated that BRIEF can be validly used with children with intellectual disability and that their development of EF follows the same trajectory as that of their typically developing peers. BRIEF has been created in such a way that its results can indicate the weak points of the students. This, in turn, can serve as a basis for making individualized educational-rehabilitation programs for children with intellectual disability (Chrapusta & Pachalska 2014). Having that in mind we propose that BRIEF should become an integral part of the psycho-educational assessment of all children at risk, including children with intellectual disability.

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