Confirmatory factor analysis of Bosnian version of Behavior Rating Inventory of executive functions in children with intellectual disability

(scientific paper)

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Abstract: *The purpose of the study was to assess factor structure of Bosnian version of Behaviour Rating Inventory of Executive Function (BRIEF). This instrument is a rating scale used for assessment of executive functions in children and adults of different ages and sample category. Executive functions are crucial for early development of cognitive and social capacities, which are very important for children with intellectual disabilities and very often serve as a basis of their future integration into society. However, benefits of well-developed executive functions, its relationships and effects to different aspects of life in this population, have started to be investigated relatively recently. Therefore, beside increasing knowledge about executive functions in children with intellectual disability, the study aimed to test feasibility and stability of BRIEF in this population with future goal of its application in schools for development of educational plans for children of this population.*

The sample consisted of 104 children with intellectual disability (62 boys and 42 girls) from 7 to 18 years of age. There were 49 children with mild and 55 with moderate intellectual disability. The BRIEF – teacher version was completed by 15 special education teachers of children participating in the study. The goal was to examine factor structure of 8 BRIEF scales: inhibit, shift, emotional control, initiate, working memory, organization of materials, plan/organize and monitor. Teachers were not considered to be participants, but only supporters of its implementation.

The study confirmed original two factor structure of the BRIEF with 80.6 % of total variance explained. It has shown that BRIEF is feasible and reliable in application with this population and it can be used for school assessment as a basis for educational planning and development of executive functions.

Keywords: *intellectual disability, executive functions, behaviour rating inventory of executive functions, factor analysis*

1 Introduction

Executive functions have become a very popular topic among the scientists, and studies on executive functions (EF) in children have grown significantly over the past few decades.

Executive functions are often connected with school readiness and school achievement (Morrison, Ponitz, & McClelland, 2010), successful work (Bailey, 2007), social functioning (Diamond, 2012) and the quality of life (Brown & Landgraf, 2010). They begin to emerge in infancy (Diamond, 1988), with improvements across toddlerhood and the preschool period (Hughes, Ensor, Wilson & Graham, 2010). Improvement continues during school-age years (Huizinga, Dolan & van der Molen, 2006), and some aspects of EF continue to develop throughout adolescence (Luciana, Conklin, Cooper & Yarger, 2005) with decline in later life after 50's (Best & Miller, 2010).

There is a lot of different definitions and classifications of EF due to many theoretical backgrounds, but many authors agree that the core EF are working memory, inhibition and cognitive flexibility/shifting (Diamond, 2012). The model that was chosen for this study explains EF as a collection of processes that are responsible for guiding, directing and managing cognitive, emotional, and behavioural functions, especially during new, problem-solving situations (Gioia, Isquith, Guy, & Kenworthy, 2000). In this study we will further investigate model of EF developed by Gioia et al. (2000).

Although the concept of EF was first defined in the 1970s, the concept of a control mechanism was discussed as far back as the 1840s when a railroad construction foreman, Phineas Gage was pierced with a large iron rod through his frontal lobe (Ratiu & Talos, 2004). This accident destroyed a majority of his left frontal lobe, but he survived and after a period of recovery, changes in Phineas' behaviour and personality became apparent. Phineas was described as "disinhibited" or "hyperactive," which suggested a lack of inhibition often found in those with damage to the prefrontal cortex (Pribram, 1973). This case and others prompted researches to start investigating concept of EF which led to development of different theories and models of EF. For more information on this, see review of Chan, Shum, Toulopoulou, and Chen (2008).

One of those theories that have shown in theoretical and empirical literature is distinction between hot and cool EF. Cool EF are defined as the goal-directed, future-oriented skills that tend not to involve much emotional arousal and are relatively "mechanistic" or "logically" based (Burgess, Veitch, de lacy Costello, & Shallice, 2000). Examples of cool EF are planning, the ability to sustain attention, working memory, inhibitory control, mental or cognitive flexibility and monitoring of actions (Chan et al., 2008). On the other hand, those EF involving more "emotional", "belief" or "desires" such as the experience of reward and punishment, regulation of

one's own social behaviour, and decision-making involving emotional and personal interpretation, are regarded as "hot" components (Chan et al., 2008;).

An important debate in the evolution of the EF construct concerned whether a unitary or multifactorial view on this domain was a more accurate representation. Some researchers have found that at younger age EF are unitary construct and that they differentiate into factors only later in adolescence (Wiebe, Sheffield, Nelson, Clark, Chevalier & Espy, 2011). One of the most influential structural models of EF, developed from an adult sample, demonstrated both the unity and diversity (three factors of working memory, shifting, and inhibition) of EF (Miyake, Friedman, Emerson, Witzki, Howerter, & Wager, 2000). Many scientists today have accepted multifactorial concept of EF including the authors of model chosen for this study (Gioia et al., 2000).

This model for assessment of EF is called Behaviour Rating Inventory of Executive Functions (BRIEF) and according to this approach, EF are composed of 8 subdomains as follows:

- inhibit (control impulses, self-control, resisting temptations);
- shift (cognitive flexibility, flexibly adapt to new situation or activity depending on circumstances; problem-solve flexibly, switch or alternate attention);
- emotional control (modulate emotional responses appropriately);
- initiate (begin task or activity, generate ideas independently, responses, or problem-solving strategies);
- working memory (hold information in mind for purpose of completing a task),
- plan/organize (anticipate future actions, set goals);
- organization of materials (keep workplace, play areas and materials in order) and
- monitor (check work, assess performance during and after task). Monitor includes two functions, a self-monitoring and a task monitoring function, but for the purpose of this study it will be regarded as single subdomain.

The BRIEF (Gioia et al. 2000) has been developed as a response to great challenges in assessment of EF. Given the importance EF have for children's development, the issue of their assessment has been recognized a long time ago (Denckla, 1994). Barkley (2012) argued that the main problem in assessment of EF is the absence of clear operational definition of this domain. In the time of developing of BRIEF, most of assessment methods of EF relied on traditional performance measures that potentially can lead to incomplete measures (Gioia & Isquith, 2004). Rabin, Barr, and Burton (2005) surveyed 747 neuropsychologists about their test usage patterns regarding executive functioning. Many respondents appeared to be using the Wisconsin Card

Sorting Test (75.5%), Rey–Osterrieth complex figure test (41%) and Halstead Category Test (40%). All these tests fall into category of so-called performance-based tests. It has been discussed that performance-based tests capture individual components of the executive function system over a short period of time and not the multidimensional, decision making that is often demanded in real-world situations (Goldberg & Podell, 2000).

For this reason, and in order to systematically compare clinical observations with real-world observations, the BRIEF authors recognized the potential efficacy of gathering structured observations of children's everyday self-regulatory functioning from parents and teachers.

It was one of the first attempts to measure EF via self-reports, and today, proven to be psychometrically sound and standardized rating scale used by parents or teachers to assess EF of children in everyday, real world setting (Roth, Erdodi, McCulloch, & Isquith, 2015).

With regards to clinical population it has been mostly used in children with ADHD, Tourette syndrome (Mahone, Cirino, Cutting et al., 2002), and traumatic brain injury (Anderson, Anderson, Northam, Jacobs, & Mikiewicz, 2002), but not so much in children with intellectual disability (ID). From the studies that have been done with population of children with ID, most of them have been focused on disorders related to ID such as Williams syndrome (John & Mervis, 2010), Prader-Willy syndrome (Jauregi, Arias, Vegas, et al., 2007), Down syndrome (Lee, Pennington & Keenan 2010) or Autism Spectrum Disorder (Chan et al. 2008). Moreover, most of these studies have typically used a narrow range of tests, targeted specific aspects of EF, rather than a comprehensive test battery. One of the first studies with this population using BRIEF (Pratt & Chapman, 2000) has shown that children with ID are having significant deficits in working memory, while the remaining BRIEF scales were rated similarly to controls. However, the authors of this study used parent version of the BRIEF and they often may not have fully objective view of their children condition. Relatively recent study with children with ID using BRIEF have shown that they demonstrate impairments in all BRIEF scales when comparing results with BRIEF normative sample (Memisevic & Sinanovic, 2014). The same study also showed great feasibility and reliability in administration of BRIEF in children with ID.

The objective of this study is to perform factor analysis of BRIEF in children with ID from Bosnia and Herzegovina (B&H) and to expand body of knowledge on EF with this population.

2 Material and Methods

2.1 Procedure

After obtaining the written approvals for data collection from Ministries of Education at different government levels of B&H and from all the schools where data collection took place, the meetings with schools' staff and parents/caregivers of children with ID about research project, goals and expectations have been organized. Parents/caregivers who agreed for their children to participate signed the informed consent at the same meeting. BRIEF scales about children's EF have been completed by 15 teachers and altogether there were 126 BRIEF scales done. After analysis of data 22 BRIEF scales were removed from research because of improper completion or data missing. Therefore, 1 teacher was completing BRIEF for more than one child. Twelve teachers were special education teachers, whereas 3 of them were physical education teachers.

2.2 Participants

One hundred and four children took part in this study (62 boys and 42 girls with ID) from seven special schools and two special classes on primary and secondary school level in six larger cities in Bosnia and Herzegovina. There were 49 children with mild ID (IQ range from 50–69; 29 boys and 20 girls) and 55 children with moderate ID (IQ range from 35–49; 33 boys and 22 girls). Information about children's IQ were based on World Health Organization (1992) and it was taken directly from the school's records. The children were included in case they were not diagnosed with Attention Deficit Hyperactivity Disorder, Autism Spectrum Disorders, Down syndrome or other comorbid disorder. The age range of the children was from 7 to 18 with mean age of 14.0 (SD 3.3) years. Teachers were not treated as participants in the study but rather as assessors of the children. The idea of BRIEF is to be completed by someone who knows the subject very well, like teachers in our case. Therefore, there were 15 teachers altogether that were completing BRIEF scales.

2.3 Materials

Behaviour Rating Inventory of Executive Functions ([BRIEF]; Gioia et al., 2000) is a questionnaire for assessment of EF behaviours in home and school environments. It has a parent and a teacher version and it is designed to be used among children ages from 5 to 18. BRIEF allows assessment of EF from the perspective of daily basic behaviour and presents them in a more realistic everyday condition. In our study, the authors used a teacher version of BRIEF – which means that teachers were filling in the questionnaire under condition that they have known the child(ren) for at least 6 months. BRIEF contains 86 items in eight theoretically and empirically derived clinical scales that measure different aspects of executive functioning: inhibit, shift,

emotional control, initiate, working memory, plan/organize, organization of material and monitor. Factor analysis of both versions of BRIEF supported two-factor model. The first factor was identified as Behavioural Regulation Index (BRI), which consists of scales inhibit, shift and emotional control. The second factor called Metacognition Index (MI) includes five remaining scales. The two factors demonstrate moderate correlation between each other and they are used for calculation of the Global Composite Index (GEC) score. BRIEF has two validity scales: Inconsistency – the extent to which respondent answers similar BRIEF items in an inconsistent manner; and Negativity – the extent to which respondent answers selected BRIEF items in an unusually negative manner. In our study, only two scales showed elevated inconsistency scores and they are excluded from the analysis, together with other inadequately completed BRIEF scales.

The BRIEF was translated into the Bosnian language for one of the earlier studies performed by Memisevic and Sinanovic, (2014) using bilingual translation method. The instrument was not standardized and validated for Bosnian cultural environment but it is shown to be feasible in population of children with ID.

BRIEF teacher version was normed for 720 children and Cronbach alpha as measure of internal consistency ranged from 0.84 to 0.98.

2.4 Data Analysis

BRIEF results are presented as *T* scores based on raw score calculated from respondent's answers. *T* scores (M = 50, SD = 10 – based on normative sample) are used to interpret the child's level of EF as reported by teachers on the BRIEF rating form. If *T* is at or above 65 it represents the 1.5 SD above the mean, which is recommended threshold for interpretation of a score as abnormally elevated or clinically significant. Lower scores indicate better functioning.

Confirmatory Factor Analysis (CFA) was performed with principal component analysis on 8 BRIEF main sub-domains using the oblique rotation and 2 fixed factors with delta = 0.58, that was applied because of high correlations between T scores of individual sub-domains.

Reliability analysis of each given factor was performed with Cronbach alpha as measure of internal consistency.

2.5 Ethical Concerns

The present study was written by the principals of the Helsinki Declaration, as revised in 1975, of the World Medical Association which regulates the obligatory nature of the informed consent. Moreover, Ethical Commission of Faculty of Physical Culture, Palacky University Olomouc approved the study as part of first author PhD research project.

Therefore, only children that accepted to participate were included in the study and their parents or caregivers signed an informed consent to participate. All children and their parents/caregivers were informed about the purpose of this study, its risks and procedures and that they can withdraw from the study without any further obligations. The project was explained and all doubts were clarified during series of meetings with schools' staff, children and parents/caregivers.

3 Results

Table 1 shows descriptive statistics of 8 BRIEF scales for which the factor structure has been assessed. It is visible that each BRIEF scale has score above 65 which shows clinically significant result.

For sample adequacy, Kaiser-Meyer-Olkin (KMO) measure was applied and result obtained was "excellent", KMO = 0.88. It is based on Kaiser's index of factorial simplicity (Kaiser, 1974): KMO ≤ 0.5 – unacceptable; 0.5 < KMO ≤ 0.7 – mediocre; 0.7 < KMO ≤ 0.8 – good; 0.8 < KMO ≤ 0.9 – excellent; and KMO > 0.9 – superb.

Table 1: *Mean T-scores of children with intellectual disability on the BRIEF scales*

Variable	BRIEF *T*-score, mean	Standard Deviation	Number of cases
Inhibit	**66.2981**	17.68433	104
Shift	**78.0577**	20.85820	104
Emotional control	**69.5769**	18.83690	104
Initiate	**71.1923**	14.84422	104
Working memory	**74.2404**	18.71840	104
Plan/organize	**67.5288**	13.09855	104
Organization of material	**67.2500**	23.36072	104
Monitor	**70.4615**	16.37185	104

The results of CFA have shown two factor structure of BRIEF in children with ID and together they explain 80.60% of total variance. First factor explains 69.82% (MI) of total variance, while second one explains 10.77% (BRI) (Table 2). Table 3 shows coefficients of correlation between individual variables (BRIEF scales) and two extracted factors. High correlations of individual variables with each of two factors are visible. Inhibit, Shift and Emotional control correlate stronger with second factor (BRI), whereas Initiate, Working memory, Plan/organize and Organization of materials correlate stronger with first factor (MI). An interesting thing happened with Monitor scale that correlated strongly with both factors, but with small advantage to BRI.

Table 2: *Results of Confirmatory Factor Analysis – Total Variance Explained*

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	5.586	**69.819**	69.819	5.586	**69.819**	**69.819**	5.186
2	0.862	**10.770**	80.589	0.862	**10.770**	**80.589**	4.709
3	0.646	8.072	88.660				
4	0.333	4.158	92.819				
5	0.206	2.576	95.394				
6	0.158	1.974	97.369				
7	0.117	1.466	98.835				
8	0.093	1.165	100.000				

In order to better present separation of variables into factors, Pattern matrix table was used with regression coefficients of variables for each factor from rotated space (See Table 4). Separation of variables into factors is much clearer, namely difference in regression coefficients for individual factors is much bigger. For example, for Inhibit we have: βMI = 0.153 vs βBRI = 0.790, so it is clear that Inhibit has to go under BRI factor. The difference is high for all other variables except monitor where the difference in coefficients is still small, but again in favour to BRI: βMI = 0.44 vs βBRI = 0.546.

Table 3: *Coefficients of correlation between individual variables (BRIEF scales) and two extracted factors*

	Component	
	1- MI	2- BRI
Inhibit	0.736	**0.903**
Shift	0.635	**0.702**
Emotional control	0.517	**0.921**
Initiate	**0.935**	0.576
Working memory	**0.954**	0.664
Plan/organize	**0.916**	0.688
Organization of material	**0.797**	0.739
Monitor	**0.845**	**0.872**

Note: MI – metacognition index; BRI – behavioral regulation index

In Table 5 authors present reliability analysis with use of Cronbach alpha as a measure of Internal consistency. The goal of this analysis was to better understand extracted factors, so Table 5 shows Cronbach alpha for both factors with and without monitor scale.

Table 4: *Pattern Matrix- Regression coefficients for each variable on each factor*

	Component	
	1- MI	**2- BRI**
Inhibit	0.153	**0.790**
Shift	0.258	**0.512**
Emotional control	–0.359	**1.186**
Initiate	**1.120**	–0.250
Working	**1.019**	–0.088
Plan/organize	**0.898**	0.025
Organization of material	**0.553**	0.330
Monitor	**0.441**	**0.546**

Note: MI – metacognition index; BRI – behavioural regulation index

It is visible that BRI factor without monitor has smaller alpha (0.815) from BRI with monitor (0.876), whereas MI factor is overloaded with monitor (0.924), while without it, is closer to the higher limit of acceptance for Cronbach alpha (0.905).

Table 5: *Cronbach alpha as a measure of Internal consistency for both factors*

Factors	**N of items**	**Cronbach's Alpha**
BRI: Inhibit Shift Emotional control	3	0.815
BRI: Inhibit Shift Emotional control Monitor	4	0.876
MI: Initiate Working Plan/organize Organization of material Monitor	5	0.924
MI: Initiate Working Plan/organize Organization of material	4	0.905

Note: MI – metacognition index; BRI – behavioural regulation index

4 Discussion

The purpose of this study was to assess factor validity of Bosnian version of BRIEF by using confirmatory factor analysis. Additional goal was to expand body of knowledge on EF in children with ID.

The results of our study have shown that original two factor version of BRIEF is applicable to population of children with ID. The scales that loaded significantly to second factor Behavioural Regulation Index were Inhibit, Shift, Emotional control and Monitor. The first factor Metacognition index was significantly contributed by 4 remaining scales: Working memory, Initiate, Plan/organize and Organization of materials. However, unlike in the results of original BRIEF version our findings have shown that monitor scale corelated strongly with both factors, but it is classified under BRI as correlation with BRI was stronger.

The reason why monitor scale contributed significantly to both factors could be explained in a fact that this scale can be divided in two parts: self-monitor (allows a person to monitor its own behaviour, and what effect has on others) and task-monitor (ability to assess own work or tasks during or after performance). This new classification of monitor scale was found by Gioia, Isquith, Retzlaff, and Espy (2002) in study with clinical populations (e.g. children with autism spectrum disorders, learning disabilities, etc.) where original factor structure of BRIEF was re-examined and new three-factor model (BRI, MI and Emotional regulation index) with nine scales was proposed. The self-monitor scale contributed significantly to BRI factor, whereas task-monitor was more related to MI factor, which explains monitor loading strongly on both factors in our study.

Moreover, the monitor scale in our study actually correlated more strongly with BRI than with MI, which is not the first time this is happening as the same was found in some other studies with clinical populations (Egeland & Fallmyr, 2010; Gilotty, Kenworthy, Wagner, Sirian, & Black, 2002; McCandless & O' Laughlin, 2007).

Generally, there are not many studies that used BRIEF to assess EF in children with ID, and to our knowledge, only one focused on investigating its factor structure in this population. The author of that study also confirmed two-factor structure of BRIEF with exemption of inhibit scale that correlated strongly with both factors (Memisevic, 2015). As author explained, the probable cause of this is that results of inhibit scale depend on some other scale under Metacognition index factor. Unfortunately, beside this study authors have not found any other study that examined facture structure of BRIEF in population of children with ID to discuss this topic in more detail. However, there are also other studies on this topic performed with children from other clinical populations. For example, Slick, Lautzenhiser, Sherman, and Eyrl (2009) supported re-examined version of BRIEF by Gioia et al. (2002) with three factors and nine scales in children with epilepsy. Furthermore, in

study of verification of French version of BRIEF using confirmatory factor analysis and structural equation modelling, three-factor model and division of monitor scale was also supported in combination of healthy children and adolescents (Fournet, Roulin, Monnier, et al., 2010).

Our study additionally supports diverse concept of EF and its multifactorial structure. It further supports stability and feasibility of BRIEF in assessment of EF with different clinical samples with specific contribution to population of children with ID. There are few limitations in our study – such as possible influence of additional variables on EF such as socioeconomic status of children (parental education, income level, etc.) that has not been included in the study. Additionally, there are some limitations for BRIEF related to objectivity and inter-rater reliability because different teachers might perceive certain behaviours differently. In order to avoid this, the authors provided teachers with clear instructions and also monitored data collection by checking potential concerns about completion of the BRIEF via e-mail and phone.

5 Conclusion

This study confirmed an original version of BRIEF developed by Gioia et al. (2000), but also expended the literature on EF in children with ID. Even though it can be said that BRIEF has shown very good reliability and feasibility in population of children with ID, future studies may focus on its standardization to this population specifically, as normative sample for standardization of the BRIEF have not included subjects with any developmental or acquired disorders (Strauss, Sherman & Spreen, 2006).

Taking into consideration stability of the results in this population so far, its application across the life span, as well as importance of EF for children, the BRIEF should be considered as valid and reliable assessment instrument for development of individual educational plans for children with ID in schools. Adding assessments of EF skills to the repertoire of evaluation tools used in early childhood programs would not only provide important data for program planning but would also encourage attention to this critical domain of skill development.

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(reviewed twice)

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