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SERBIAN COGNITIVE RESERVE INDEX QUESTIONNAIRE: ADAPTATION AND VALIDATION

Marija Volarov[1], *Peđa Miladinović*[1], *Ana Gligorijević*[1], *Maša Poznanović*[2], *Jovana Obradović*[1], *Nemanja Nikolić*[1], *& Vojislava Bugarski-Ignjatović*[3]

[1]*Department of Psychology, Faculty of Philosophy, University of Novi Sad, Serbia*
[2]*Faculty of Law and Business Studies Dr. Lazar Vrkatić, Union University, Serbia*
[3]*Department of Psychology, Faculty of Medicine, University of Novi Sad, Serbia*

SUMMARY

Cognitive reserve (CR) is defined as the ability to optimize or maximize usage of neural networks when facing tasks with greater cognitive load serving as a protective factor from cognitive decline. In clinical population, it is assumed that CR has the role of minimizing effects of brain pathology on cognitive functioning through more flexible alterations between engaged neural networks. In the earliest stages of construct development, it was predominately expressed via levels of education or verbal intelligence. However, accumulated research evidence suggested that CR is a multidimensional construct and that various lifelong activities should be taken into account when assessed. Following this line of studies, Cognitive Reserve Index questionnaire (CRIq) was developed providing a standardized procedure for measuring CR that includes years of formal and informal education, professional occupational background and engaging in various cognitively stimulating activities. The goal of this study was exploring the utility of Serbian translation and adaptation of CRIq using a sample of 117 (61% female) healthy adult participants with age ranged from 19 to 86 (M = 41.37, SD = 21.91). Study results suggested the same pattern of age differences as reported in previous studies, while gender differences were not detected. Testing correlations between CRIq scores and measures of cognitive functioning such as intelligence, verbal fluency, categorical fluency, and executive functions yielded significant results only for Education subscale and Intelligence and executive functions (CTT Form A). Future implications for CR assessment and practical utility of CRIq were offered.

Key words: Active models, Brain reserve, Cognitive reserve, Cognitive Reserve Index questionnaire

INTRODUCTION

Passive and active models of reserve

The introduction of brain and cognitive reserve into the field of neuropsychology came as a result of evidence that showed individuals with similar brain pathology differ in terms of cognitive functioning and the course of recovery (Katzman et al., 1989), and that cognitive performances are differentially affected by aging in healthy individuals. Brain reserve (Katzman, 1993; Satz, 1993), and cognitive reserve (CR; Stern, 2002, 2003, 2009) are presented as key constructs within passive and active models, respectively. Passive models describe these differences as a function of variations in innate brain characteristics such as brain size or synapse count. These differences provide different brain damage thresholds which, if exceeded, will result in functional impairment (Pinto & Yeshwant Tandel, 2016; Stern, 2002). Thus, brain reserve had been defined as "differences in brain size and other quantitative aspects of the brain that explain differential susceptibility to functional impairment in the presence of pathology or other neural insult" (Barulli & Stern, 2013, p. 502). Active models, on the other hand, describe active attempts of the human brain to overcome detrimental consequences of brain damage (Pinto & Yeshwant Tandel, 2016; Stern, 2001). Within this framework, CR has been defined as "the ability to optimize or maximize performance through differential recruitment of brain networks, which perhaps reflects the use of alternate cognitive strategies" (Stern, 2002, p. 451). In other words, CR reflects differences in cognitive processes that result from lifetime intellectual activities and different environmental factors (Barulli & Stern, 2013) and that can boost performance during increased task demands but also determines how much brain damage one can tolerate before impaired cognitive functioning becomes obvious. This moderating effect of CR has on the relationship between brain pathology/normal aging and cognitive functioning is depicted in Figure 1.

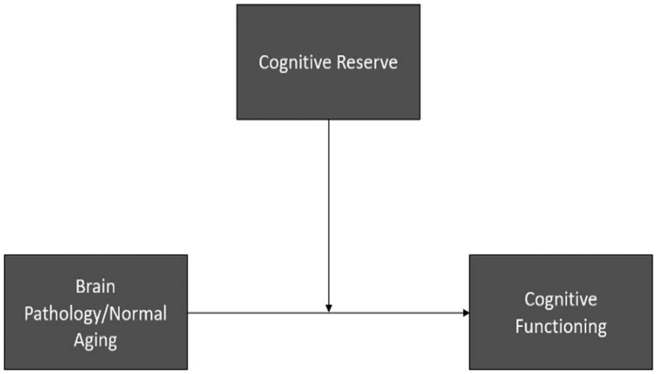

Figure 1. Moderating effect of Cognitive Reserve on the relationship between brain pathology/normal aging and cognitive functioning.

Given that CR is a cognitive construct, attempts were made towards finding the neural basis of CR (Barulli & Stern, 2013; Steffener & Stern, 2002; Stern et al., 2002). Barulli and Stern (2013) proposed its two potential neural bases – neural reserve and neural compensation. Former was related to the ability to optimize or maximize usage of cognitive networks in unimpaired people, and the latter to activation of new brain structures in impaired population - such structures that do not typically underly the particular cognitive activity in healthy individuals (Barulli & Stern, 2013; Stern, 2002). There are at least some indications that this might be the case and they come from functional imaging studies, where Stern (2002) noticed that there is a difference in way healthy individuals are coping with demanding cognitive tasks in comparison with impaired, clinical population. Thus, according to Stern (2002), CR's impact on performance can be visible in healthy individuals engaged in any demanding cognitive task due to its requirement for greater network efficiency and does not necessarily require presence of the brain pathology. However, it has been assumed that compensation is always induced by a brain pathology. Although not usually distinguished in the literature, it is assumed that the distinction between neural reserve and compensation is crucial for correct interpretation of study results, especially when patients and healthy controls are compared to each other (Stern, 2002). Neural reserve (and CR studied in healthy individuals) should be viewed as a protective factor in case of an insult, and compensation reflects attempts to maintain or improve already affected cognitive functioning through activation of alternative neural networks and those with greater CR are more successful in it (Barulli & Stern, 2013).

Active models seem to be more optimistic in terms of practical interventions, suggesting that people's engagement in different activities over the course of life can provide them with greater CR. In other words, the idea of CR posits that different response patterns in face of brain damage depend on lifetime experiences such as education, occupation, and participation in cognitively stimulating leisure activities (e.g., scrabble, reading, playing chess; Opdebeeck, Martyr, & Clare, 2016). Therefore, active models suggest that underpinnings of CR are amenable to change potentially providing us with new guidelines for prevention and cognitive rehabilitation (Stern, 2012). However, it should be pointed out that passive and active models are not mutually exclusive, but rather reflective of parallel processes that could be described as "hardware" (physical) and "software" (functional) entities. Additionally, people with the same brain reserve can differ in levels of CR due to different life experiences (Barulli & Stern, 2013). Finally, it is plausible that a variety of activities involved in building CR can stimulate structural changes, suggesting that CR can affect brain reserve as well (Opdebeeck et al., 2016).

Proxies of cognitive reserve

As opposed to brain reserve, CR cannot be directly observed, and it is still not clear which particular aspects of human functioning should be considered as a good estimate of CR levels. Factors such as IQ, education, occupation, cognitively stimulating leisure activities, social stimulation, sleep, diet and hygiene seem to be the most promising indicators of CR (Pinto & Yeshwant Tandel, 2016), since they all appear to buffer symptoms of brain damage and serve as a protective factor against dementia (Blondell, Hammersley-Mather, & Veerman, 2014; Fratiglioni & Wang, 2007; Scarmeas, Levy, Tang, Manly, & Stern, 2001; Verghese et al., 2003). Yet, there is no consensus on how to operationally define these factors. Consequently, researchers have been choosing both, proxies of CR and instruments used to assess them, making comparison of study results difficult. In one meta-analysis published in 2019 (Kartschmit, Mikolajczyk, Schubert, & Lacruz, 2019) authors evaluated 37 papers and six different questionnaires and failed to single out any of them because their psychometric properties were poorly assessed, if assessed at all.

In most studies, only education was considered a CR proxy and even in that case there were differences in terms of the scale that was used to assess the education levels (e.g., numerical scale for the number of years of education vs. discrete scale for qualification). The results reported so far imply that higher education is negatively associated with a cognitive decline that occurs with aging (Pinto & Yeshwant Tandel, 2016), as well as with brain disorders (Nucci, Mapelli, & Mondini, 2011). However, there are some fluctuations in the results and strength of the relationship of higher education with both cognitive decline and brain disorders depending on the cognitive function that was used as an outcome (Opdebeck et al., 2016). In addition, differences in type and quality of education in different contexts could potentially confound the observed effects. A meta-analysis published by Opdebeeck et al., in 2016, found significant relationships between CR and the following cognitive domains: working memory, executive functions, visuospatial abilities, language, and overall cognitive functioning in healthy older people, although estimated effect sizes varied from small to medium. Furthermore, Roldan-Tapia and colleagues (Roland-Tapia et al., 2017) reported the same pattern of results suggesting that working memory, visuo-constructive abilities, and some executive functions are moderated by education.

Besides education, greater premorbid intelligence has been frequently shown as a protective factor for executive functions impairments among individuals infected with hepatitis C (Basso & Bornstein, 2000), which places it within the theoretical framework of CR. Measures such as Vocabulary subscale of the Wechsler Adult Intelligence Scale (WAIS; Wechsler, 1981) or National Adult Reading Test (NART; Nelson, 1982) are typically used to estimate premorbid levels of intelligence as a proxy of CR. However, some authors do not consider verbal IQ as an indicator of CR, but rather as a measure of cognition that should be defined in terms of the outcome (Opdebeck et al., 2016), which could potentially explain why education has been chosen more often as one of the components of CR over intelligence.

Stern and colleagues (Stern et al., 1994) addressed occupational attainment and Alzheimer's disease in a sample of non-demented old individuals. After following them for more than 4 years, they concluded that more skillful and educated people not only had a lower risk of developing dementia but also showed slower cognitive declines, championing the idea that occupational attainment can be considered as a potential building block of CR (Stern et al., 1994). Finally, negative associations between engaging in cognitively stimulating activities (e.g., physical activity, social, and individual types of leisure activities), cognitive decline (assessed in various ways), and dementia received support in previous studies, both cross-sectionally and longitudinally (for a systematical review see Wang, Xu, & Pei, 2012).

Most recent approach to measurement of CR

Given the previously cited results, a significant portion of studies emphasized the importance of assessing multiple proxies of CR simultaneously given their synergistic contribution to overall CR levels (Evans et al., 1993; Mortel, Meyer, Herod, & Thornby, 1995; Stern et al., 1994; Stern et al., 1995). This has led to several attempts of developing multidimensional scales for measuring CR: Cognitive Reserve Questionnaire (Rami et al., 2011), Cognitive Reserve Scale (León, García-García, & Roldán-Tapia, 2014) for Spanish speakers, and Cognitive Reserve Index Questionnaire (CRIq; Nucci, et al., 2011), which has been translated to several languages (translations are available at www.cognitivereserveindex.org) leading to its more frequent use and validations. CRIq covers three domains – Education, Work Activity, and Leisure time, enabling calculation of CR scores for each domain as well as the overall CR index. Considering a growing body of literature aiming to provide answers related to the conceptual nature of CR, its neural basics and overall potential of its clinical usefulness and, at the same time, lack of the consensus how it should be measured, studies oriented toward understanding of constituents of CR should be prioritized. While it was rarely investigated in healthy participants (e.g., Arcara et al., 2017; Puccioni & Vallesi, 2012; Yaneva, Massaldjieva, Mateva, & Bakova, 2019), most of the CRIq data are available in clinical population (e.g., Ihle et al., 2020; Milanini et al., 2016. Therefore, this study aims to address the validity of Serbian translation and adaptation of CRIq in healthy participants (Nucci et al., 2011) and provide some directions for its practical implementation. This is the first study of this kind in Serbian population. In addition to CRIq, measures of intelligence, cognitive flexibility and phonemic fluency are administered to address the issue of congruent validity. Finally, we aim to test if there are any age and gender differences in Overall CRI, as well as in its subdomains.

METHOD

Sample and procedure

Sample in this study included 117 (61% female) healthy adult participants from Serbia. The age ranged from 19 to 86 (*M* = 41.37, *SD* = 21.91) and participants were divided into three different categories: young adults from 18-35 years old (*N* = 63, *M* = 23.43, *SD* = 3.32), middle-aged adults from 36-55 years old (*N* = 19, *M* = 47.52, *SD* = 5.82) and older adults, over 55 years old (*N* = 34, *M* = 71.18, *SD* = 9.05). Social networks were used for study advertisement and only participants without diagnosed neurological condition were recruited. Testing was conducted over the course of 6 months (from December 2017 to June 2018) at the Center for memory disorders and dementia at Clinical Center of Vojvodina, by a group of graduate and undergraduate students who were previously trained in neuropsychological and psychological assessment using the same battery of instruments that has been used to collect the data for this study. The study has received ethical approval. The participants were informed about the nature and the details of the study, after which they choose whether they want to participate or not. Written consent form was obtained for every subject.

Instruments

Cognitive Reserve Index Questionnaire (CRIq; Nucci et al., 2011). For the purpose of this study CRIq was translated from English to Serbian with minor adaptations according to Serbian cultural context. Permission for translation has been obtained from the original test authors. Originally, CRIq was created for Italian speaking population as an attempt to provide a standardized measure of CR that is potent to overcome CR assessment shortcomings that have been recognized in earlier studies (e.g., inconsistency in variables that were considered as proxies of CR, as well as inconsistency in their measurement). CRIq has three sections for assessing three different proxies of CR: Education (both formal and informal), Work activity (occupational attainment with different levels of required skills and qualifications) and Leisure time (activities carried out continuously, weekly, monthly and annually). However, leisure activities are coded only if they are carried out frequently (e.g., at least three times a week/month/year).

Wechsler Adult Intelligence Scale – Information subscale (Berger, Marković, & Mitić, 1995; Wechsler, 1981). In this study, only Information subscale from Serbian version of WAIS was used. This scale has thirty questions related to a general knowledge. In clinical practice it is often use as an indicator of premorbid capacities because it requires an access to a long-term memory which is assumed to stay intact the longest in case of ongoing pathological processes.

Color Trails Test (CTT; D'Elia et al., 1996). CTT is a culture-fair alternate form of TMT, hence a measure of visuo-perceptual scanning, graphomotor sequencing and cognitive flexibility. Form A consists of 25 numbers, with even numbers in pink circles, and odd numbers in yellow circles. Participants are instructed to connect all the circles following the sequence of numbers from 1 to 25, as fast as possible, ideally without lifting a pencil from the paper. Form B is slightly more complex. It contains sequence of 25 numbers, all colored in both yellow and pink variant. Participants are instructed to connect numbers from 1 to 25 by using pink and yellow circles interchangeably (starting from the pink colored number 1, connecting with number 2 in yellow, then with number 3 in pink, and so on). For both forms time until the completion and number of errors are recorded.

Test of phonemic and semantic verbal fluency (FF-KK; Pavlović, 2003). FF-KK is Serbian adaptation of Benton Controlled Oral Word Association (COWA) Test (Benton & Hamsher, 1976) used in neuropsychological assessment. To assess verbal phonemic fluency participants are instructed to name as many as possible words starting with S, K and L, and for assessment of semantic verbal fluency animal naming is used. Participants have 60 seconds per task. Total number of words per phoneme is calculated. Total number of named animals is used as an indicator of semantic verbal fluency.

Data preparation

CRIq scores were computed according to the recommendations proposed by Nucci et al., (2011). Since CRIq scores are based on the number of years activities have been practiced they were highly correlated with age: Working Activity $r = .76$ ($p < 0.01$); Leisure time $r = .70$ ($p < 0.01$), overall CRI (created as an average scores of three CR domains) $r = .74$ ($p < 0.01$), except Education domain which correlated -.10 ($p > 0.05$) with age. To rule out this effect of the age, four linear regressions were conducted using one of the CR proxies as a criterion and age as a predictor in order to create standardized residuals that were used for further analyses. Additionally, obtained residualized scores were transformed into a scale with $M = 100$ and $SD = 15$ for the ease of comparison within each age class (Nucci et al., 2011).

RESULTS

In Table 1 are presented descriptive statistics for the scores obtained from the instruments used in the study. According to Curran et al., recommendations (Curran, West, & Finch, 1996), values greater than ±3 for skewness, and greater than ± 10 for kurtosis were considered as potentially problematic.

Table 1. *Descriptive statistics for the variables used in the study*

	N	*Min*	*Max*	*M*	*SD*	*Skewness*	*Kurtosis*
CRI: Working activity	115	0	75	18.74	18.86	0.81	-0.23
CRI: Leisure Time	115	14	550	147.03	109.77	1.05	0.84
CRI: Education	115	1	30	16.12	3.59	0.51	4.76
Overall CRI	115	8.67	208	60.63	41.12	0.93	0.52
WAIS: Information	117	6	30	23.20	5.27	-1.31	1.72
FF-KK: S	117	2	22	11.02	4.29	0.23	-0.27
FF-KK: K	117	3	21	12.44	4.09	-0.28	-0.19
FF-KK: L	117	2	19	10.38	3.87	0.15	-0.55
FF-KK: Animal naming	117	8	37	17.81	4.92	0.72	2.01
CTTa: Time	117	15	170	50.56	26.82	2.02	5.39
CTTa: Errors	106	0	2	0.06	0.27	5.26	29.94[a]
CTTb: Time	117	37	334	96.99	54.38	2.06	5.04
CTTb: Errors	106	0	4	0.21	0.66	4.26	20.53

Note: Presented are descriptives for raw CRI scores.

Age and gender differences in CR

To assess age differences *One-way ANOVA* was applied comparing young, middle-aged and older adults on standardized and transformed Education, Working activity, Leisure time and Overall CRI scores. The obtained results were suggestive of small but significant effect of age on Working activity F (2,111) = 6.225, p = 0.003, η^2 = 0.101, Leisure time F (2,111) = 3.799, p = 0.025, η^2 = 0.064 and Overall CRI F (2,111) = 5.110, p = 0.008, η^2 = 0.084, while the effect of age on Education was not statistically significant F (2,111) = 1.261, p = 0.287, η^2 = 0.022. Further multiple comparisons have been done using Scheffe post-hoc analysis and the results are presented on Graph 1. For Working activity score significant differences have been recorded between young adults and middle-aged adults ($p < 0.01$) and between middle-aged adults and older adults ($p < 0.01$). Next, there was significant mean difference between young adults and middle-aged adults on Leisure time score ($p < 0.05$). However, given that the mean score for older adults differs from the mean score for younger adults for only 0.02, we could assume that the significant difference would be registered between middle-aged (N = 19) and older adults (N = 34) as well, in case of a larger sample size. Finally, post-hoc

a Due to low frequency of registered errors on CTT and unacceptably skewed data, these variables were omitted from further analyses.

analysis revealed significant differences in Overall CRI between young and middle-aged adults ($p < 0.05$) and between middle-aged and older adults ($p < 0.05$).

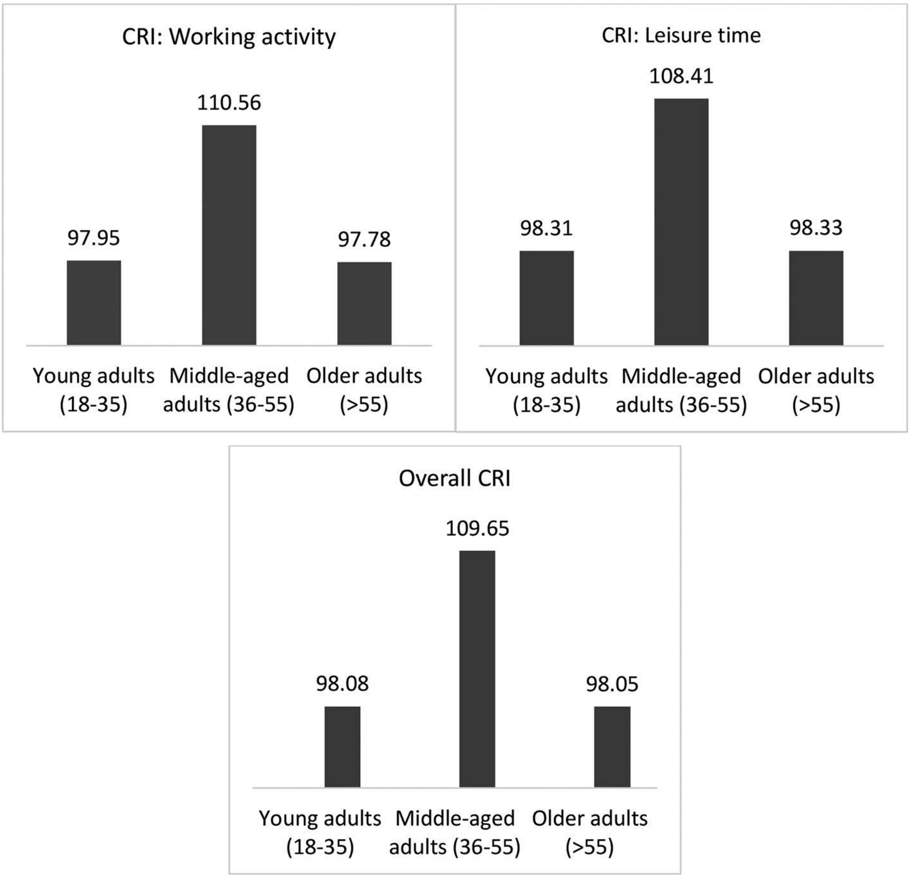

Figure 2. Results of Scheffe post-hoc test for multiple comparisons

Gender differences were tested using *t*-test for independent samples. As seen in Table 2, no significant gender differences were found on Education, Working activity, Leisure time or Overall CRI.

Table 2. *T-test results for gender differences on CRIq scores*

CRI proxy	Gender	*N*	*M*	*SD*	*t*	*df*	*p*
Education	male	44	100.62	14.82	0.35	112	0.725
	female	70	99.61	15.10			
Working activity	male	44	97.89	12.04	-1.20	112	0.233
	female	70	101.33	16.44			
Leisure time	male	44	98.22	17.55	-1.01	112	0.316
	female	70	101.12	13.04			
Overall CRI	male	44	98.33	17.82	-0.94	112	0.347
	female	70	101.05	12.82			

Within Table 3 average CR scores were presented separately for females and males, across gender groups. Age range for females was from 20-86 (*M* = 41.51, *SD* = 21.68), and for males 19-85 (*M* = 41.15, *SD* = 22.52), and applied *t*-test yielded non-significant age differences between genders *t* (114) = -0.084, *p* <0.05.

Table 3. *Average CR scores for males and females across age groups*

	Age	N	Education	Working activity	Leisure time	Overall CRI
Male	Young adults (18-35)	25	95.36	97.71	97.48	97.10
	Middle aged adults (36-55)	5	117.56	122.68	125.13	127.66
	Older adults (>55)	14	95.38	97.96	89.94	90.05
Female	Young adults (18-35)	36	101.92	98.11	98.89	98.76
	Middle aged adults (36-55)	14	100.41	106.23	102.45	103.22
	Older adults (>55)	20	100.91	97.66	104.20	103.64

CR and cognitive functioning

Upper section of Table 4 shows Pearson's coefficient of correlation for CIRq scores: Education, Working activity, Leisure time, Overall CRI. While subscales demonstrated small-to-moderate correlations among each other, overall CRI score correlate moderately with Education and Working activity, and almost perfectly with Leisure time.

Table 4. *Pearson correlations between CRI scores and cognitive functions*

	Education	Working activity	Leisure time	Overall CRI
CRI: Education	--	0.252**	0.413**	0.467**
CRI: Working activity	--	--	0.215*	0.359**
CRI: Leisure time	--	--	--	0.988**
WAIS: Information	0.287**	0.131	0.158	0.179
FF-KK: S	0.164	-0.085	0.067	0.058
FF-KK: K	0.153	0.014	0.121	0.122
FF-KK: L	0.114	-0.08	0.043	0.034
FF-KK: Animal naming	0.211*	0.099	0.061	0.08
CTTa: Time	-0.203*	-0.073	-0.184	-0.192*
CTTb: Time	-0.167	-0.04	-0.117	-0.123

Note: ** *p* <0.01, * *p* <0.05

For testing convergent validity of CIRq scores Pearson correlations were calculated between Education, Working activity, Leisure time, Overall CRI and different measures of cognitive functioning. Education correlated positively with WAIS Information subscale which is usually used as a measure of premorbid intelligence, and categorical fluency, and negatively with time to task completion on CTT Form A (all three obtained effects were small). Overall CRI correlated significantly only with time to completion of CTT Form A in a negative direction.

DISCUSSION

Passive and active models of reserve were developed in an attempt to explain lack of direct relationship between the degree of a present brain pathology and manifest cognitive impairment (Stern, 2002). Key concept within the passive models is brain reserve, while CR represents key element of the active ones, with an idea that former is determined by innate characteristics, while the latter is shaped by lifelong, cognitively stimulating experiences. Given that CR cannot be directly measured it is yet to be determined which activities that people are practicing during the life are playing the role in building CR, which serves as a protective factor from non-pathological age-related cognitive decline in healthy people and serves as a buffer when brain pathology is already present. In the latest years, studies have shown that education, occupation and cognitively stimulating leisure activities seem to be the most prominent proxies of CR. However, different scales were used for the assessment of those proxies, and they were rarely presented all together within the same study, which causes difficulties in comparing the results across different studies. Cognitive Reserve Index questionnaire (CRIq; Nucci et al., 2011) was developed with an idea of overcoming described shortcomings of previous studies by providing a standardized measure of CR that incorporates those proxies that most of the studies argued for – education, working activity and leisure time. Education is measured through reported number of years of formal and informal education, working activity through number of years spent engaging in different levels of professional occupation, and Leisure time through years of practicing different stimulating activities such as reading, going to the movies, driving, etc. CRIq enables calculating scores for each proxy as well as overall CR index (averaged value based on subscale scores). The questionnaire was translated to several languages so far, and the aim of this study was to address validity issues of its Serbian translation and adaptation using a community sample consisted of healthy participants (without diagnosed neurological conditions). After controlling for the effect of age due to its linear relationship with scores, age differences were tested, and the obtained results were fairly similar to those reported in studies in different languages (Maiovis et al., 2015; Nucci et al., 2011) with significant differences on Working activity, Leisure time and Overall CRI, but not on Education. In addition, post-hoc analyses revealed the same pattern of the results as it was previously reported (Maiovis et al., 2015; Nucci et al., 2011) with middle-aged adults scoring higher on Working activity, Leisure time and Overall CRI in contrast to young and older adults. In addition, age differences in Working activity and lack of gender differences are consistent with Yaneva et al.'s study (Yaneva, et al., 2019).

Investigating correlations among CRIq subscales as well as correlations between CRIq subscales and different measures of cognitive functioning several important remarks have been made. Firstly, taking into account very high correlation between Overall CRI and Leisure time scale we do not recommend usage of the Overall CRI score until additional independent data using this questionnaire are not collected. Obtained correlation may suggest that the most salient aspect of Overall CRI are leisure activities meaning that Overall CRI calculated as an average value based on three CR subscales is not a representative measure of general CR. However, high correlation between the

Overall CRI and CR subscales has been found in the study by Nucci et al. (2011) where Overall CRI correlated .80 with Education and Working Activity, and .70 with Leisure time. Moreover, significant but low correlations between different CR aspects may reflect the importance of assessing different lifelong activities when measuring CR and they go in line with all previously reported notions that all these aspects (i.e., education, occupation, and leisure time) should be considered if one strives to capture the real picture of person's CR. Low correlations between subscales are consistent with those reported by Italians and Greeks (Maiovis, 2016; Nucci et al., 2011). However, we assume additional efforts need to be made when calculating CR scores based on CRIq. Such score should be able to differentiate, for example, those who were engaged in activities that require different amounts of cognitive load, or in jobs that require different qualifications and different type of investment (e.g., cognitive versus physical). This could possibly be done by weighting responses in each section differently. In addition, relations between CRIq scores and Information subscale from WAIS, phonemic fluency, semantic verbal fluency and time needed to complete TMT (forms A and B) which is a measure of visuo-perceptual scanning, graphomotor sequencing and cognitive flexibility were explored. The obtained results showed that only greater score on Education subscale was related to better cognitive performance on TMT form A, animal naming and Information. The only other significant result suggested that Overall CRI score was related to better performance on TMT form, too. These findings are comparable with those reported by Puccioni and Vallesi (2012). Namely, these authors reported that higher CRI was significantly associated with better cognitive control measured by Stroop, suggesting that better CR can bypass age-related attentional impairments. But, as it has already been noted, results that include Overall CRI score in this study should be taken with caution as it is not clear how it should be interpreted. Based on the pattern of the results this study yielded it could be argued that after all only Education subscale seems to be useful when assessing CR because it is the only subscale that was related to several measures of cognitive functioning, and these results provided some evidence for convergent validity for Education proxy only. Nonetheless, sample size used in this study was considerably small and it might be the case that the study was underpowered to detect other significant effects. Furthermore, significant but relatively small correlation obtained between Education subscale and Information subscale, and lack of significant correlation with other CR proxies, imply that Information score is probably not the best choice, or at least should not be used alone for the assessment of premorbid cognitive functioning as it has been usually done in clinical practice. Other possible explanation for the lack of significant relations between CR and used measures of cognitive functioning is that these measures of cognitive functioning were not enough cognitively demanding for healthy participants, hence the performance was not depending on their CR levels. Thus, other measures of cognitive functioning should be considered when addressing the CR questions in nonclinical samples. Alternatively, these cognitive measures could be used with additional cognitive load. Frequency of the type of the activities that had a role in constituting Working activity and Leisure time scores (e.g., knitting vs. playing chess) need to be explored further because it may affect the way these scores behave in relationship with other variables. Finally, conclusions based on this study data are somehow limited with its cross-sectional nature.

To sum up, given that this is the first study examining Serbian version of CRIq, additional studies that include larger samples, as well as inpatient samples are necessary before making final conclusions related to the scale. However, based on this study we highly recommend choosing subscale scores for assessing CR over Overall CRI score. Finally, this version of CRIq seems to be a promising tool for the assessment of CR since it reflects some of the characteristics that were reported in previous studies for its other versions (Maiovis et al., 2015; Nucci et al., 2011; Puccioni & Vallesi, 2012; Yaneva, et al., 2019) showing that there is some stability and consistency within its multiple administrations even in different cultural contexts.

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