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FULL-LENGTH REPORT

The 21-item Barratt Impulsiveness Scale Revised (BIS-R-21): An alternative three-factor model

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ABSTRACT

Background and aims: Due to its important role in both healthy groups and those with physical, mental and behavioral disorders, impulsivity is a widely researched construct. Among various self-report questionnaires of impulsivity, the Barratt Impulsiveness Scale is arguably the most frequently used measure. Despite its international use, inconsistencies in the suggested factor structure of its latest version, the BIS-11, have been observed repeatedly in different samples. The goal of the present study was therefore to test the factor structure of the BIS-11 in several samples. *Methods:* Exploratory and confirmatory factor analyses were conducted on two representative samples of Hungarian adults (N = 2,457; N = 2,040) and a college sample (N = 765). *Results:* Analyses did not confirm the original model of the measure in any of the samples. Based on explorative factor analyses, an alternative three-factor model (cognitive impulsivity; behavioral impulsivity; and impatience/restlessness) of the Barratt Impulsiveness Scale is suggested. The pattern of the associations between the three factors and aggression, exercise, smoking, alcohol use, and psychological distress supports the construct validity of this new model. *Discussion:* The new measurement model of impulsivity was confirmed in two independent samples. However, it requires further cross-cultural validation to clarify the content of self-reported impulsivity in both clinical and nonclinical samples.

KEYWORDS

Barratt Impulsiveness Scale, BIS-11, impulsivity, confirmatory factor analysis, representative sample, alternative factor structure

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INTRODUCTION

The construct of impulsivity contributes importantly to many classic personality theories (Buss & Plomin, 1975; Cloninger, 1987; Costa & McRae, 1985; Eysenck & Eysenck, 1977; Zuckerman, 1979), and efforts to assess appropriately this construct have persisted over recent decades (e.g., Cyders & Smith, 2008; Hamilton et al., 2015a, 2015b; Reise, Moore, Sabb, Brown, & London, 2013; Smith et al., 2007; Steinberg, Sharp, Stanford, & Tharp, 2013; Swann, Bjork, Moeller, & Dougherty, 2002; Whiteside & Lynam, 2001). The clinical relevance

of impulsivity is frequently highlighted because it impacts many mental and behavioral disorders including impulse-control disorders (Grant & Potenza, 2006; Stein, Hollander, & Liebowitz, 1993), attention deficit and hyperactivity disorder (Barkley, 1997; Winstanley, Eagle, & Robbins, 2006), substance-use disorders (Conway, Kane, Ball, Poling, & Rounsaville, 2003; Verdejo-García, Lawrence, & Clark, 2008), behavioral addictions such as gambling (e.g., Blaszczynski, Steel, & McConaghy, 1997; Canale, Vieno, Griffiths, Rubaltelli, & Santinello, 2015; Potenza, Kosten, & Rounsaville, 2001), paraphilias (e.g., Kafka, 1996, 2003), antisocial personality disorder (e.g., Swann, Lijffijt, Lane, Steinberg, & Moeller, 2009), and borderline personality disorder (e.g., Dougherty, Bjork, Huckabee, Moeller, & Swann, 1999; Links, Heslegrave, & van Reekum, 1999). Impulsivity also significantly influences therapeutic co-operation and prognosis of treatment (e.g., Alvarez-Moya et al., 2011; Ryan, 1997). Consequently, reliable and valid measurements of impulsivity are important.

The present paper focuses on an impulsivity measure that is based on the theoretical framework proposed by Barratt (1965) and later by Barratt and Stanford (1995), including biological, cognitive, social, and behavioral aspects of the construct. However, these approaches only represent specific aspects (i.e., traits related to cognition, attention, self-control, or motor impulsivity) of the much broader umbrella construct of impulsivity. As Depue and Collins (1999) pointed out, impulsivity can be interpreted as a cluster of numerous traits such as sensation seeking, risk-taking, adventuresomeness, boredom susceptibility, or unreliability, many of which are not represented in Barratt and Stanford's approach. Similarly, emotionally laden impulsivity – which is also missing from the aforementioned conceptual framework – is considered to be a truly relevant aspect of the construct in predicting later psychopathology (Berg, Latzman, Bliwise, & Lilienfeld, 2015). The multi-dimensional UPPS/UPPS-P model of impulsivity (Whiteside & Lynam, 2001), including the traits of negative urgency, lack of premeditation, lack of perseverance, sensation seeking, and positive urgency, represents an integrated model and also offers a clear link between emotionally-driven impulsivity and various behavioral measures, including the assessment of aggression (e.g., Bousardt, Noorthoorn, Hoogendoorn, Nijman, & Hummelen, 2018), snack food consumption (Coumans et al., 2018), alcohol use (e.g., Shin, Lee, Jeon, & Wills, 2015) and dependence (Kim et al., 2018), as well as other forms of addictive disorder (Rømer Thomsen et al., 2018). Impulsivity may be assessed by both *tests of performance* (e.g., Bender, 1938; Dougherty, 1999; Golden, 1978; Heaton, Chelune, Talley, Kay, & Curtiss, 1993; Kagan, Rosman, Day, Albert, & Phillips, 1964) and *self-report scales* (Table 1 summarizes these measures).

Regarding the latter measures, a frequently used self-report scale is the Barratt Impulsivity Scale (BIS) (Patton, Stanford, & Barratt, 1995). The BIS, in its initial form, measured several dimensions of impulse control, including behavioral (e.g., psychomotor efficacy), cognitive (e.g., the rapidity of cognitive responses) and physiological (e.g., heart rhythm) aspects (Barratt, 1965). The first version of the BIS comprised 80 items. However, more recently the number of items has been reduced to 30 in order to increase construct validity and to improve other psychometric characteristics (Patton et al., 1995). The revised (11th) version of the scale (BIS-11) comprises six first-order factors and three second-order factors. The first-order factors are Attention and Cognitive Instability (together they comprise the second-order factor Attentional Impulsivity), Motor and Perseverance (together Motor Impulsivity), and Self-control and Cognitive Complexity (together Non-planning Impulsivity).

However, attempts to validate the BIS-11 have usually resulted in factor structures different from the original one (Table 2 summarizes sample characteristics, applied statistics, and factorial solutions described within these studies). Although the factor structure described by Patton and colleagues (1995) was essentially confirmed in Japanese (Someya et al., 2001), Spanish (Oquendo et al., 2001) and Chinese (Yang, Yao, & Zhu, 2007) samples, only non-planning impulsivity was reproduced in an Italian study (Fossati, Di Ceglie, Acquarini, & Barratt, 2001). Furthermore, the majority of validating studies did not confirm the original model.

Miller, Joseph and Tudway (2004) assessed the component structure of four frequently used self-report measures of impulsivity – including the BIS-11 – in the general population in Great Britain. Their results showed that the three sub-factors of the BIS-11 can be better defined as a general impulsivity factor. Miller and colleagues (2004) also delineated a three-component structure of impulsivity based on different impulsivity measures: non-planning dysfunctional, functional venturesomeness, and drive/reward responsiveness. Surís and colleagues (2005) assessed the factor structure of the BIS-11 using exploratory factor analysis (EFA) in a sample of 474 U.S. veteran soldiers, and although the three-factor solution was reproduced, the correlation between these factors was high enough to draw a conclusion that the subscale scores of BIS do not provide any additional information over the total score. Paaver and colleagues (2007) adapted the Estonian version of the scale on 683 participants, and found that 27 items of the BIS-11 formed a single scale. Consequently, they used the BIS-11 total score in further analyses. Von Diemen, Szobot, Kessler and Pechansky (2007) were unable to identify the three factors of the original scale. However, the authors suggested that the Portuguese (Brazilian) version of the BIS-11 may be used for male adolescents with some limitations (464 male adolescents partially formed their sample). Güleç and colleagues (2008) essentially replicated the original factor structure using exploratory principal-component analysis. However, the subscale item loadings in the Turkish version were different from the English versions. Furthermore, except for the total score of the scale and the first second-order factor, all subscales of BIS-11 showed inadequate levels of internal consistencies.

Table 1. Widely used self-report impulsivity measures

Name of self-report measure	Reference	Original number of items	Original number of scales/factors (latent structure)	Conceptual framework
Emotionality Activity, Sociability and Impulsivity inventory (EASI-III)	Buss and Plomin (1975)	20	10 scales (General emotionality, Fear, Anger, Tempo, Vigor, Sociability, Lack of inhibitory control, Decision time, Lack of persistence, and Sensation Seeking)	Impulsivity as a basic temperament and tendency to respond quickly instead of response inhibition
I-7: Impulsiveness and Venturesomeness Questionnaire Eysenck et al. (1985)	Eysenck and Eysenck (1977)	54	3 subscales (Impulsiveness, Venturesomeness, and Empathy)	Impulsivity as one of the facet of the Psychoticism-Extraversion-Neuroticism model
Dickman Impulsiveness Scale	Dickman (1990)	23	2 subscales (Dysfunctional impulsivity, and Functional impulsivity)	Impulsivity as a multifaceted trait that does not necessarily lead to dysfunctional outcomes but may predict optimal human functioning
Zuckerman-Kuhlman Personality Questionnaire	Zuckerman et al. (1993)	99	5 factors (Impulsive Sensation Seeking, Sociability, Neuroticism-Anxiety, Aggression-Hostility, and Activity)	Impulsivity as one of the dimensions of the Five Factor Models of personality
Behavioral Inhibition and Activation Scales (BIS/BAS)	Carver and White (1994)	24	2 scales (BIS and BAS), 4 subscales (BIS: Sensitivity for punishment, BAS: Reward Responsiveness, Drive, and Fun seeking)	Impulsivity as the product of the competing neural circuits of "Stop" (regulatory/executive/ behavioral inhibition) and "Go" (reward-driven behavioral activation)
Barratt Impulsivity Scale (BIS-11)	Patton et al. (1995)	30	3 second-order factors (Attentional, Motor and Non-planning impulsivity), 6 first-order factors (Attention, Cognitive instability, Motor, Perseverance, Self-control, and Cognitive complexity)	Impulsivity as a multifaceted predisposition
The Urgency, Premeditation, Perseverance, and Sensation Seeking (UPPS) Impulsive Behavior Scale	Whiteside and Lynam (2001)	45	4 subscales (Premeditation, Urgency, Sensation Seeking, and Perseverance)	Impulsivity as one of the dimensions of the Five Factor Models of personality
Frontal Systems Behavior Scale (FrSBe)	Grace and Malloy (2001)	46	3 factors (Executive Dysfunction with Apathy, Executive Dysfunction with Disinhibition, and Disinhibition with Apathy)	Impulsivity as a consequence of brain damage and orbitofrontal dysfunction
Multidimensional Personality Questionnaire (MPQ)	Patrick et al. (2002)	276	11 primary trait factors (Wellbeing, Potency, Achievement, Social Closeness, Stress Reaction, Alienation, Aggression, Control, Harm Avoidance, Traditionalism, and Absorption)	Impulsivity as an underlying trait that induces trait-consistent behaviors
Brief Self Control Scale (BSCS)	Tangney et al. (2004)	36 (long version) 13 (brief version)	Unidimension of self-control	Impulsivity as the result of lacking self-regulation

Table 2. Characteristics of former validation studies of BIS-11

Reference	Language version	Study sample	Type of analyses	Factorial structure		Additional comments
				First-order factors	Second-order factors	
Patton et al. (1995)	English	College undergraduates (n = 412) Psychiatric inpatients (n = 248)Male prison inmates (n = 73)	Exploratory principal components analysis (PCA)	Attention Cognitive Instability Motor Perseverance Self-control Cognitive Complexity	Attentional impulsivity Motor impulsivity Non-planning impulsivity	
Someya et al. (2001)	Japanese	Female college tudents (n = 34)Hospital workers (n = 416)	Confirmatory factor analysis (CFA)	Attention Cognitive Instability Motor Perseverance Self-control Cognitive Complexity	Attentional impulsivity Motor impulsivity Non-planning impulsivity	
Oquendo et al. (2001)	Spanish	Psychiatric outpatients (n = 29)	Measuring scale equivalences	Attention Cognitive Instability Motor Perseverance Self-control Cognitive Complexity	Attentional impulsivity Motor impulsivity Non-planning impulsivity	
Fossati et al. (2001)	Italian	College undergraduates (n = 763)	Exploratory principal components analysis (PCA)	Attention Motor impulsiveness Lack of delayed gratification Perseverance Self-control Cognitive complexity	Attentional and motor impulsiveness Perseverance and lack of delayed gratification Non-planning impulsivity	
Miller et al. (2004)	English	Adults from the general population (n = 245)	Principal components analysis (PCA)	Attention Cognitive Instability Motor Perseverance Self-control Cognitive Complexity	Cognitive impulsiveness Motor impulsiveness Non-planning impulsiveness	The high inter-relationship of the three subscales indicates a more general impulsivity factor
Surís et al. (2005)	English	Treatment seeking U.S. veteran soldiers (n = 474)	Explaratory factor analysis (EFA)	Attention Cognitive Instability Motor Perseverance Self-control Cognitive Complexity	Cognitive impulsiveness Motor impulsiveness Non-planning impulsiveness	Due to the high inter-relationship of the three subscales, BIS subscale scores do not provide any additional information over the total score
Yang et al. (2007)	Chinese	Undergraduate university students (n = 209)	Confirmatory factor analysis (CFA)	Attention Cognitive Instability Motor	Attentional impulsivity Motor impulsivity	

(continued)

Table 2. Continued

Reference	Language version	Study sample	Type of analyses	Factorial structure		Additional comments
				Perseverance Self-control Cognitive Complexity	Non-planning impulsivity	
Paaver et al. (2007)	Estonian	Young adults from a longitudinal study (n = 683)	Inter-item correlation	27 out of 31 items formed a single impulsivity scale		The BIS total score was used instead of distinct subscales
Von Diemen et al. (2007)	Brazilian Portuguese	Male adolescents and young adults (n = 464)	Explaratory factor analysis (EFA)	Items form lack of attention Items from lack of planning	Factor 1	Items 4, 17, 18, 23, 24, 26, and 27 were excluded from the factorial solution
				Motor Items from the lack of attention and planning subscales	Factor 2	
				Items from the lack of planning subscale	Factor 3	
Güleç et al. (2008)	Turkish	College undergraduates (n = 237) Psychiatric patients (n = 83)	Exploratory principal components analysis (PCA)	Attention Cognitive Instability Motor Perseverance Self-control Cognitive Complexity	Attentional impulsivity Motor impulsivity Non-planning impulsivity	Not all the original items loaded in the same original factor group and except for the total score and the first second-order factor, all subscales of BIS-11 showed inadequate levels of internal consistencies.
Ireland and Archer (2008)	English	Subsamples of adult men prisoners (n = 383 and 250) Subsamples of adult women prisoners (n = 250 and 220)	Explaratory factor analysis (EFA) Confirmatory factor analysis (CFA)	Items from the original Attentional, Motor and Non-planning impulsivity scales	Distractibility	Items 3 and 22 failed to load in any factor, furthermore, the three factor solution did not fit the data for women, only after the Distractibility factor was removed
				Items from the original Attentional, Motor and Non-planning impulsivity scales	Behavioral impulsivity	
				Items from the original Attentional, Motor and Non-planning	Cognitive planning skills	

(continued)

Table 2. Continued

Reference	Language version	Study sample	Type of analyses	Factorial structure		Additional comments
				impulsivity scales		
Preuss et al. (2008)	German	Controls from the general population (n = 810) Psychiatric inpatients (n = 211)	Confirmatory factor analysis (CFA)	Adequate factor reliability was found only in the case of Self-control and Motor impulsivity		No alternative factorial solution was suggested
Haden and Shiva (2009)	English	Mentally ill forensic inpatients (n = 327)	Confirmatory factor analysis (CFA)	12 items 12 items	Motor impulsivity Non-planning impulsivity	Items 3, 5, 16, 23, 24, 27 were exluded and a two-factor solution was retained
Steinberg et al. (2013)	English	Undergraduate university students (n = 1,178)	Item bifactor analysis (IBA)	A unidimensional impulsivity construct (including the original items: 1, 2, 5, 8, 9, 12, 14, 19)		More than half of the items did not have a substantial relation to the general underlying impulsivity construct, therefore a unidimensional model and an 8-item brief measurement tool (BIS-Brief) was suggested
Ellouze et al. (2013)	Arabic	Adults from the general population (n = 134)	Exploratory principal components analysis (PCA)	Items 10, 12, 13, 15 and 18 Items 14, 17 and 28 Items 8 and 20	Cognitive impulsivity Motor impulsivity Non-planning impulsivity	
Reise et al. (2013)	English	Community sample (n = 691)	Explaratory factor analysis (EFA) Confirmatory factor analysis (CFA)	Items from the original Attentional and Non-planning impulsivity scales Items from the original Motor and Non-planning impulsivity scales	Cognitive impulsivity Behavioral impulsivity	Cognitive and behavioral impulsivity might also be interpreted as „method" factors representing constraint (Cognitive) and impulsivity (Behavioral)
Reid et al. (2014)	English	Three subgroups of addicted patients (methamphe-tamine users; pathological gamblers and hypersexual	Exploratory principal components analysis (PCA) Confirmatory factor analysis (CFA)	Items from the original Motor, Attentional and Non-planning impulsivity scales Items from the original Motor and Non-	Motor impulsiveness Immediacy impulsiveness	Authors found the best fit indices for a three-factor solution but only 12 items were retained from the original BIS

(continued)

Table 2. Continued

Reference	Language version	Study sample	Type of analyses	Factorial structure		Additional comments
		respondents) (n = 353)		planning impulsivity scales		
				Items from the original Attentional and Non-planning impulsivity scales	Non-planning impulsiveness	
Malloy-Diniz et al. (2015)	Brazilian Portuguese	Adults from the general population (n = 3,053)	Reliability analysis for three and two-factor solutions, based on Cronbach's alpha	n.d. n.d.	Inhibition control Non-planning impulsivity	Authors found the best reliability for the two-factor solution recommended by Vasconcelos and colleagues (2012)
Lindstrøm et al. (2017)	Norwegian	Healthy controls from the general population (n = 47) Parkinson's disease patients (n = 43) Chronic headache patients (n = 20)	Explaratory factor analysis (EFA) Confirmatory factor analysis (CFA)	Items from the original Attentional and Non-planning impulsivity scales Items from the original Motor and Non-planning impulsivity scales	Cognitive impulsivity Behavioral impulsivity	The factorial solution was similar to the one proposed by Reise et al. (2013), however, items 3 and 4 were excluded in this analysis

Note: n.d. = not described in the specific study.

Different second-order factors (labeled as Cognitive Planning Skills, Behavioral Impulsivity and Distractibility) were identified in a prison sample in Great Britain (Ireland and Archer, 2008). Preuss and colleagues (2008) adapted and studied the German version of the BIS-11 in healthy individuals and patients with alcohol dependence, suicide attempts, and borderline personality disorder by using confirmatory factor analysis (CFA). The authors were unable to reproduce the original model. However, they did not suggest a new model in their study. Another study, conducted in the United States examined a sample of 327 mentally ill forensic inpatients (Haden & Shiva, 2009) and identified two factors (labeled as Motor Impulsivity and Non-planning Impulsivity), including 24 items retained from principal component analysis. Steinberg and colleagues (2013), based on their analysis on BIS-11 psychometric properties, suggested a novel unidimensional solution and a revised instrument named the Barratt Impulsiveness Scale-Brief (BIS-Brief). A preferable two-factor solution (Inhibition Control and Non-planning) was found in a Brazilian population (Malloy-Diniz et al., 2015; Vasconcelos, Malloy-Diniz, & Corrêa, 2012). Ellouze, Ghaffari, Zouari, Zouari, and M'rad (2013) assessed 134 individuals from the general population to examine the factor structure of the Arabic version of BIS-11 and reported three factors, with different item loadings from the original English version. In the United States, examination of the factor structure of the BIS-11 in individuals with gambling disorder, hypersexuality and methamphetamine dependence identified a 12-item three-factor solution including motor, non-planning and immediacy impulsiveness (Reid, Cyders, Moghaddam, & Fong, 2014). More recently, Lindstrøm, Wyller, Halvorsen, Hartberg, and Lundqvist (2017) assessed the psychometric properties of the Norwegian version of the BIS-11 in a sample of healthy individuals and patients with Parkinson's disease or headaches and reported a two-factor solution with moderate fit. This model confirmed the cognitive and behavioral factors that were originally suggested by Reise et al. (2013).

Considering these findings, it may be concluded that psychometric analyses of the BIS-11 have resulted in diverse models, indicating one-factor, two-factor, and three-factor

solutions. Previous studies indicate that impulsivity assessed using the BIS might fall into the facets of cognitive, behavioral, and/or non-planning impulsiveness. However, different factor solutions have led to various interpretations regarding the underlying latent factors of the impulsivity construct. It should be noted that most of the aforementioned studies utilized relatively small sample sizes derived from special populations and non-probability/non-representative samples. Furthermore, approximately half of the studies applied only PCA or EFA without CFA, and most of these studies did not cross-validate their measurement models with independent samples. Additionally, the vast majority of the studies treated items as continuous indicators rather than as ordinal scales. BIS uses four-point Likert type response format, and it is not clear how treating this format as continuous and neglecting the floor or ceiling effects in responses may make it difficult to make a conclusion concerning the measurement model. Only one previous study reported the response distribution of BIS items reflecting that at least 13 items showed severe floor effect and two items showed ceiling effects (Martínez-Loredo, Fernández-Hermida, Fernández-Artamendi, Carballo, & García-Rodríguez, 2015). In contrast, another study simply stated the low frequency of extreme responses (Reise et al., 2013). Among studies applying a CFA approach, serious deviation from multivariate normal distribution can decrease the degree of fit when maximum likelihood estimation is applied (Finney & DiStefano, 2006). Furthermore, such studies use a response option as a linear scale instead of an ordinal scale which might impact on fit indices in measurement models.

Consequently, the aim of the present study was to analyze the factor structure of the BIS-11 in Hungary in a general population nationwide representative samples and a relatively large college sample. Given that impulsivity is best described as a multidimensional construct, including traits related to urgency, sensation seeking, impatience, or boredom susceptibility (Depue & Collins, 1999; Whiteside & Lynam, 2001), we hypothesized that when performing a CFA testing the originally proposed measurement model, we could confirm or refute the original measurement model. If the original measurement model was not supported, we intended to develop a measurement model which are consistently replicated in several samples with EFA and CFA approaches. The present study also tested the construct validity of the BIS by assessing participants' potential psychiatric symptoms, level of aggression, and various behavioral patterns (including alcohol use, smoking and physical exercise). Associations have already been demonstrated between (i) motor impulsivity, non-planning impulsivity, and increased aggression (Krakowski & Czobor, 2018), (ii) cognitive (attentional) impulsivity, depression, and alcohol dependence (Jakubczyk et al., 2012), (iii) each facet of impulsivity (attentional, motor and non-planning) and current cigarette smoking (Heffner, Fleck, DelBello, Adler, & Strakowski, 2012), and (iv) impulsivity and lower physical activity (Bénard et al., 2017).

METHODS

Samples and procedure

Community Sample 1 (CS1): The BIS was assessed within the framework of the *National Survey on Addiction Problems in Hungary 2007* (NSAPH2007) (Paksi, Rózsa, Kun, Arnold, & Demetrovics, 2009). This survey, in addition to the assessment of addictive behaviors, aimed to assess some personality/trait-like characteristics. The target population of the survey was the total population of Hungary between the ages of 18 and 64 years. The sampling frame comprised the whole resident population with a valid address, according to the register of the Central Office for Administrative and Electronic Public Services on January 1, 2006 (6,662,587 individuals). Data collection was executed on a gross sample of 3,183 people, stratified according to geographical location, degree of urbanization and age (overall 186 strata) representative of the sampling frame. Participants were surveyed using a 'mixed-method' approach via personal visits. Questions regarding background variables and introductory questions referring to some specific phenomena were asked in the course of face-to-face interviews, while symptom scales and the Brief Symptom Inventory (BSI) were applied using self-administered paper-and-pencil questionnaires. These questionnaires were returned to the interviewer in a closed envelope to ensure confidentiality. The net sample size was 2,710 (response rate: 85.1%). However, only 2,457 people completed the BIS questionnaire. The ratio of samples belonging to each stratum was adjusted to the characteristics of the sampling frame by means of a weighted matrix for each stratum category.

College Sample: This convenience sample of university and college students was collected in the context of a behavioral genetic study. The advertisements were posted in universities and colleges. Inclusion criteria was the willingness to provide genetic sampling. Only one exclusion criterion was applied (i.e., participants with known any psychiatric disorder were excluded). All participants provided written informed consent. The number of participants with valid BIS-11 data was 765 including 46.4% males and 53.6% females. Mean age was 20.96 years (SD = 2.4, skewness: 1.198, kurtosis: 1.492).

Community Sample 2 (CS2): The BIS-11 was assessed within the framework of the *National Survey on Addiction Problems in Hungary 2015* (NSAPH2015) (Paksi, Demetrovics, Magi, & Felvinczi, 2017). The target population of the survey was the total population of Hungary between the ages of 18 and 64 years. The sampling frame consisted of the whole resident population with a valid address, according to the register of the Central Office for Administrative and Electronic Public Services on January 1, 2014 (6,583,433 individuals). The NSAPH2015 research was conducted on a nationally representative sample of the Hungarian adult population aged 16–64 years (gross sample 2,477, net sample 2,274 individuals) with the age group of 18–34 years being overrepresented. The size of the weighted sample of the 18–64 year-old adult population was 1,490 individuals.

Statistical analysis of the weight-distribution suggests that weighting did not create any artificial distortion in the database leaving the representativeness of the sample unaffected. The extent of the theoretical margin of error in the weighted sample is ±2.5%, at a reliability level of 95% which is in line with the original data collection plans. Participants were surveyed similarly as in previous NSAPH2007 research. The sample that provided responses on the BIS (n = 2040) were used in the current CFA analysis.

Measures

Barratt Impulsiveness Scale – Eleventh Revision (BIS-11): The impulsivity was assessed using the Hungarian version of the most recent Barratt Impulsivity Scale (BIS-11) originally published by Patton et al. (1995). The questionnaire was designed to assess self-reported impulsivity of both healthy individuals and psychiatric populations. The instrument includes 30 items, scored on a four-point scale: (1) rarely/never, (2) occasionally, (3) often, (4) almost always/always. Conventionally, the three main impulsivity factors are: Attentional impulsiveness (poor attention and cognitive instability), Motor impulsiveness (motor activity and poor perseverance), and Non-planning impulsiveness (poor self-control and cognitive complexity). The total score is the sum of all the items. The English version of the questionnaire was translated using the 'forward–backward' procedure recommended by Beaton, Bombardier, Guillemin and Ferraz (2000). The item was translated into Hungarian and an independent translator translated the Hungarian items back to English. The original and translated versions of items were compared, and discrepancies were resolved. Following this procedure, the Hungarian items were pilot tested prior to the present study and some minor changes were carried out in order to enhance translation clarity and applicability. Although various factorial solutions were found across different studies and samples (as previously already described in the Introduction), the BIS-11 is generally characterized by acceptable or good validity and reliability indices with a Cronbach's alpha score usually higher than 0.7 for the first-order and second-order factors, and ranging between 0.62 (Von Diemen et al., 2007) and 0.80 (Yang et al., 2007) for the total BIS score.

Brief Symptom Inventory (BSI): The BSI is a 53-item self-report symptom inventory designed to assess briefly psychological symptom patterns of psychiatric and medical patients, and it reflects good psychometric properties in a Hungarian nonclinical sample (Urbán et al., 2014), and with internal consistency coefficients usually reported between 0.7 and 0.9 for its subscales and Global Severity Index in both clinical and nonclinical samples (e.g. Adawi et al., 2019; Derogatis & Spencer, 1982; Roser, Hall, & Moser, 2016). Each item of the questionnaire is rated on a five-point scale of distress from 0 (not at all) to 4 (very much). The BSI comprises nine primary symptom dimensions: somatization (which reflects distress arising from bodily perceptions), obsessive-compulsive (which reflects obsessive-compulsive symptoms), interpersonal sensitivity (which reflects feelings of personal inadequacy and inferiority in comparison with others), depression (which reflects depressive symptoms, as well as lack of motivation), anxiety (which reflects anxiety symptoms and tension), hostility (which reflects symptoms of negative affect, aggression and irritability), phobic anxiety (which reflects symptoms of persistent fears as responses to specific conditions), paranoid ideation (which reflects symptoms of projective thinking, hostility, suspiciousness, fear of loss of autonomy), and psychoticism (which reflects a broad range of symptoms from mild interpersonal alienation to dramatic evidence of psychosis) (Derogatis, 1983; Derogatis & Savitz, 2000). This measure was administered in the CS1 only. The internal consistency of the 90 items of the Global Severity Index was excellent in the present sample (0.98). Omega coefficients of the subscales ranged between 0.87 and 0.95 in the present sample (for further psychometric details, see Urbán et al., 2014).

Buss-Perry Aggression Questionnaire: This 29-item scale was developed to assess physical aggression, verbal aggression, anger, and hostility (Buss & Perry, 1992). Each item is answered on a five-point Likert-type response option, indicating how uncharacteristic or characteristic each statement is to the participant. This measure was administered in the college sample only. The questionnaire is characterized by acceptable or good reliability indices, with Cronbach's alpha scores usually exceeding 0.7 across various cultures and samples (e.g., Demırtaş Madran, 2013; Gerevich, Bácskai, & Czobor, 2007; Valdivia-Peralta, Fonseca-Pedrero, González-Bravo, & Lemos-Giráldez, 2014). In the present study, internal consistency (Cronbach's alpha) for Verbal Aggression, Physical Aggression, Anger and Hostility were 0.64, 0.84, 0.83 and 0.79, respectively.

Behavioral indicators: The present study applied current smoking, regular exercise, the frequency of drinking alcohol, problematic drinking and binge drinking as behavioral indicators to support construct validity of the impulsivity scale. Current smoking was defined as regular or occasional smoking versus non-smoking currently. Regular exercise was defined as doing any exercise at least weakly. Alcohol use was measured with frequency of the alcohol consumption during the past 30 days. An indicator of monthly or more frequent binge drinking which was defined as consuming more than 6 units of alcohol was also assessed. These indicators were administered in CS1 only.

Statistical analysis

A CFA was performed testing the originally proposed measurement model. Given that the first CFA did not provide adequate fit indices, the analytical procedure examined increasingly restrictive solutions of latent structure using EFA and CFA. Both EFAs and CFAs were performed with MPLUS 8.0 (Muthén & Muthén, 1998–2017). We treated the items as ordinal indicators and used the weighted least squares mean and variance adjusted estimation method (WLSMV; Brown, 2006; Finney & DiStefano, 2006) in both EFAs and CFAs. We used the full information maximum likelihood estimator to deal with missing data (Muthén &

Muthén, 1998–2017). In the EFAs, goodness of fit is characterized by the root-mean-square error of approximation (RMSEA), its 90% confidence interval (90% CI), and Cfit with a *P*-value of 0.05 for test of close fit. In the CFAs, goodness of fit was evaluated using RMSEA and its 90% confidence interval (90% CI), *P*-value for test of close fit to 0.05, standardized root-mean-square residual (SRMR), and comparative fit index (CFI) and Tucker-Lewis Fit Index (TLI). As recommended by Brown (2006) and Kline (2005), multiple indices were selected in order to provide different information for evaluating model fit.

To conduct the analyses in the present study, we randomly selected three non-overlapping groups from the first community sample (CS1). Sample 1 (n = 802) was used to perform an initial EFA on the original items. Sample 2 (n = 827) was used to conduct a separate EFA to cross-validate the factor structure found in the first analysis. Samples 1 and 2 informed the specification of an appropriate CFA solution in Sample 3 (n = 828). Finally, the present study tested the measurement model among two independent samples comprising university and college students (Sample 4, n = 765) and another representative community sample (CS2, N = 2,040).

In order to support the construct validity of the new factor structure of BIS, we needed to demonstrate that the factors had different patterns of association with concurrent criterion variables. We applied three sets of variables. One group of criterion variables comprised psychiatric symptomatology. We expected that impulsivity would be positively associated with general psychological distress but that factors of impulsivity would show different pattern of associations with specific symptom factors (Hirschtritt, Potenza, & Mayes, 2012; Chamberlain, Stochl, Redden, & Grant, 2018). The other group of criterion variables were behavioral ones. We choose this group because previous extensive research has investigated the associations between impulsivity and substance use including smoking (Kale, Stautz, & Cooper, 2018) and alcohol use (Dick et al., 2010). We also added an indicator of regular exercise which we hypothesized would be negatively associated with impulsivity because individuals engaging in regular exercise rely on their self-control (Englert, 2016; Finne, Englert, & Jekauc, 2019). The final group of criterion variables were related with aggressive behaviors. Impulsivity and aggressiveness are closely related constructs (García-Forero, Gallardo-Pujol, Maydeu-Olivares, & Andrés-Pueyo, 2009). However, we expected that impulsivity factors would relate differently to different type of aggressive behaviors.

The data and scripts are available for a reasonable request.

Ethics

The study protocol was approved by the Local Ethical Committee (TUKEB) and Institutional Review Board of the Faculty of Education and Psychology, ELTE Eötvös Loránd University (2015/76) and the study was conducted with respect to guidelines of the Declaration of Helsinki. All subjects were informed about the study and all provided informed consent.

RESULTS

Descriptive statistics

The community sample represented the adult population of Hungary (18–64 years). The distributions and mean ages were calculated with the sample weights in the two community samples. In the first community sample (CS1), the distributions of gender were almost equal (49% males and 51% females) and the mean age was 40.3 years (SD = 13.4). In the student sample, the distribution of gender was 46.4% males and 53.6% females, and the mean age was 20.96 years (SD = 2.4). In CS2, the distribution of gender was 46% males and 54% females, and the mean age was 41.6 years (SD = 13.2).

Confirmatory Factor Analysis (CFA) of the original measurement model of Barratt Impulsivity Scale (BIS-11)

A CFA was performed with the originally proposed measurement model in the community sample (CS1, N = 2,457) and in the student sample (N = 687). The fit indices indicated inadequate fit to the data both in the community sample (χ^2 = 14,671, df = 402, P < 0.0001; CFI = 0.577; TLI = 0.543; RMSEA = 0.120 [0.119–0.122], Cfit < 0.001; SRMR = 0.121) and in the university sample (χ^2 = 3,063, df = 402, P < 0.0001; CFI = 0.701; TLI = 0.677; RMSEA = 0.093 [0.090–0.096], Cfit < 0.001; SRMR = 0.093).

The one-factor measurement model was also tested because the total score of the BIS-11 has been used frequently in recent research. One total score hypothetically reflects only one factor. The fit indices also indicated inadequate level of fit (χ^2 = 15,464, df = 405, P < 0.0001; CFI = 0.554; TLI = 0.521; RMSEA = 0.123 [0.121–0.125], Cfit < 0.001; SRMR = 0.126) in the community sample and also (χ^2 = 3,477, df = 405 P < 0.0001; CFI = 0.701; TLI = 0.677; RMSEA = 0.100 [0.097–0.103], Cfit < 0.001; SRMR = 0.096) in the college sample. Instead of performing extensive search for the sources of misfit in modification indices and regression residuals, the analysis moved toward a more exploratory analysis as described in the Statistical Analysis section.

Developing a new model: Exploratory factor analyses (EFAs)

An EFA was performed with a robust weighted least squares (WLS) approach (estimator = WLSMV) which is applicable to ordinal level of response options and promax rotation with the 30 items on Sample 1 from CS1 (N = 802). Acceptability of the factor solution was based on goodness of fit index (RMSEA < 0.08, Cfit > 0.05, 90% CI < 0.08), the scree plot, the interpretability of the solution, and salient

factor loadings (>0.30). Unfortunately, parallel analysis was not available with WLSMV estimator. One-to four-factor solutions were examined. RMSEA values were 0.119 for the one-factor solution; 0.067 for the two-factor solution; and 0.057 for the three-factor solution. Therefore, the three-factor solution was retained (χ^2 = 1,256, df = 348, $P < 0.0001$). The first four eigenvalues for the sample correlation matrix were 6.57, 4.38, 1.75, and 1.49. Factor loadings are presented in Table 3.

The EFA was repeated on Sample 2 from CS1 (N = 827). As in Sample 1, here the new three-factor solution also provided the best and most interpretable factor solution (χ^2 = 1,189, df = 348, $P < 0.0001$; RMSEA = 0.054, SRMR = 0.053). The first four eigenvalues for the sample correlation matrix were 6.97, 4.48, 1.70, and 1.45. Factor loadings are presented in Table 3. In the item-selection process, the following rules were followed. Analyses retained items which had loading on the factor larger than 0.50. The exclusion criteria were specified before the analysis. First, items with factor loadings less than 0.30 were excluded in at least one of the two analyses. Second, items with salient cross loadings were excluded. If a cross-loading was identified in only one analysis from the two parallel EFAs, a cutoff of 0.50 was used. In case of more than two cross-loadings, a cutoff of 0.30 was used to exclude items from further

Table 3. Exploratory factor analysis on Barratt Impulsiveness Scale in two independent samples.

No.		Factor 1 *Cognitive impulsivity*		Factor 2 *Behavioral impulsivity*		Factor 3 *Impatience/ restlessness*		Communalities	
		Sample 1	Sample 2	Sample 1	Sample 2	Sample 1	Sample 2	Sample 1	Sample 2
9	*I concentrate easily*	**0.79**	**0.78**	0.08	0.06	−0.20	−0.09	0.61	0.61
12	*I am a careful thinker*	**0.75**	**0.77**	−0.07	−0.04	−0.15	−0.14	0.60	0.65
8	*I am self-controlled*	**0.67**	**0.66**	−0.03	−0.16	−0.13	−0.02	0.47	0.50
13	*I plan for job security*	**0.66**	**0.57**	−0.02	0.05	−0.13	−0.05	0.45	0.32
20	*I am a steady thinker*	**0.65**	**0.69**	−0.11	−0.05	0.10	0.01	0.46	0.48
1	*I plan tasks carefully*	**0.62**	**0.68**	−0.17	−0.02	−0.05	−0.13	0.47	0.50
7	*I plan trips well ahead of time*	**0.57**	**0.62**	−0.07	−0.06	0.13	0.06	0.35	0.39
15	*I like to think about complex problems*	**0.55**	**0.55**	0.11	0.19	0.14	0.12	0.33	0.33
30	*I am future oriented*	**0.50**	**0.52**	0.04	−0.01	0.13	0.18	0.27	0.29
10	*I save regularly*	**0.47**	**0.45**	−0.07	−0.18	0.17	0.16	0.26	0.25
29	*I like puzzles*	**0.36**	0.29	0.10	−0.07	0.16	0.29	0.17	0.15
19	*I act on the spur of the moment*	−0.06	−0.04	**0.81**	**0.90**	−0.02	−0.17	0.61	0.67
17	*I act "on impulse"*	0.07	0.01	**0.75**	**0.78**	0.01	−0.11	0.51	0.51
14	*I say things without thinking*	0.07	0.09	**0.68**	**0.64**	−0.06	−0.09	0.37	0.33
18	*I get bored easily when solving thought problems*	−0.11	−0.11	**0.55**	**0.37**	−0.10	0.02	0.28	0.18
2	*I do things without thinking*	−0.26	−0.11	**0.53**	**0.56**	0.05	0.06	0.44	0.39
4	*I am happy-go-lucky*	−0.17	−0.17	**0.45**	**0.49**	0.17	0.20	0.53	0.46
5	*I don't "pay attention"*	−0.11	−0.15	**0.41**	**0.32**	0.11	0.22	0.40	0.27
6	*I have "racing" thoughts*	0.13	0.12	**0.48**	**0.37**	0.12	0.15	0.30	0.22
3	*I make up my mind quickly*	0.28	**0.36**	**0.37**	**0.49**	0.06	−0.21	0.15	0.23
24	*I change hobbies*	0.04	0.06	0.05	0.19	**0.52**	**0.51**	0.41	0.41
21	*I change residences*	−0.02	0.06	−0.07	−0.02	**0.57**	**0.52**	0.30	0.26
22	*I buy things on impulse*	0.04	0.07	0.33	0.23	**0.46**	**0.44**	0.49	0.36
26	*I often have extraneous thoughts when thinking*	−0.01	−0.06	0.32	0.22	**0.42**	**0.50**	0.44	0.44
25	*I spend or charge more than I earn*	−0.12	−0.17	0.32	0.20	**0.38**	**0.48**	0.40	0.44
28	*I am restless at the theater or lectures*	−0.10	−0.09	−0.10	−0.22	**0.91**	**0.98**	0.73	0.76
11	*I "squirm" plays or lectures*	−0.10	−0.01	0.13	−0.13	**0.84**	**0.84**	0.59	0.59
16	*I change jobs*	−0.04	−0.02	0.29	0.20	0.26	**0.35**	0.25	0.24
27	*I am more interested in the present than the future*	0.12	0.01	0.28	0.21	−0.03	0.07	0.07	0.06
23	*I can only think about one problem at a time*	0.06	−0.07	0.29	0.13	−0.07	0.09	0.06	0.05
Factor determinacies		0.94	0.95	0.94	0.94	0.94	0.95		
Factor correlations									
Impulsive behavior		**−0.19**	**−0.19**						
Impatience		0.04	−0.06	**0.57**	**0.60**				

Note: Sample 1 N = 802; Sample 2 N = 827; Rotation is an oblique type (Promax). Salient factor loadings (≥0.30) are boldfaced. No. of items selected in further models are boldfaced. Boldfaced correlation coefficients are significant at least at $P < 0.001$.

analyses. The retained items are emboldened in Table 3. As result of the above criteria, 21 items remained of the original 30 items. We have repeated all analysis with items as ordinal scales and weighted least square mean and variance adjusted WLSMV estimator, we have received similar factor solutions. The Appendix contains the newly created 21-item BIS scale with its evaluation guideline.

The first factor was labeled as *cognitive impulsivity* and contained ten items. The range of factor loadings was between 0.36 and 0.79 in Sample 1, and 0.29–0.78 in Sample 2. However, due to the predefined selection criteria, nine items of this factor were retained in the final model. These items generally referred to tendencies of planning ahead and focusing on tasks. The second factor was labeled as *behavioral impulsivity* and contained nine items; however, only five items reached the required level of salient factor loadings in both samples and also satisfied the predefined criteria. The range of factor loadings was between 0.37 and 0.81 in Sample 1 and 0.49–0.90 in Sample 2. The items of this factor generally referred to the immediacy of behavior regardless of its consequences. The third factor was labeled as *impatience/restlessness* and contained eight items; however, only seven items were retained in the final model due to selection criteria. The range of factor loadings was between 0.29 and 0.91 in Sample 1 and 0.35–0.98 in Sample 2. The items of this factor generally referred to instability of behavior and cognitive functions and the low level of self-regulation.

Correlations between factors reflected the expected directions. The cognitive impulsivity factor consisting of reversed items correlated negatively with the behavioral impulsivity factor ($r = -0.19$ in Sample 1, and $r = -0.19$ in Sample 2) and with the impatience/restlessness factor ($r = 0.04$ *n.s.* in Sample 1, and $r = -0.06$ in Sample 2). Behavioral impulsivity and impatience/restlessness factors correlated positively ($r = 0.57$ in Sample 1, and $r = 0.60$ in Sample 2). All these correlations supported the requirement of divergent validity indicating that the factors represented different constructs.

Confirmatory factor analysis (CFA) of the new three-factor model

Based on the previous analyses in Samples 1 and 2, a three-factor solution was tested in Sample 3 (N = 828) from the first community sample (CS1). Using items as ordinal scales and applying WLSMV estimation in CFA, we received close to adequate fit ($\chi^2 = 887.9$, df = 186, $P < 0.0001$; CFI = 0.918; TLI = 0.907; RMSEA = 0.068 [0.063–0.072] Cfit < 0.001; SRMR = 0.067). Searching for the partial misfit, large error covariances were identified between Item 11 ("*I 'squirm' at plays or lectures*") and Item 28 ("*I am restless at the theater or lectures*") in the Impatience/restlessness factor. Error covariance reflected the common variance between these items that is not explained by the latent Impatience/restlessness factor. Both items had the shared meaning regarding the tendency not to be calm and patient when indicated or needed. Freeing these error covariances, the degree of model fit became acceptable ($\chi^2 = 689$, df = 185, $P < 0.001$; CFI = 0.941; TLI = 0.933; RMSEA = 0.057 [0.053–0.062] Cfit < 0.004; SRMR = 0.058). Therefore, the final model included 21 items of the original 30 items. The factor loadings and factor correlations are presented in Table 4.

Correlations between the factors ranged from 0.21 to 0.70 (Table 4). Cognitive impulsivity correlated with impatience/restlessness ($r = 0.21$), and with behavioral impulsivity ($r = 0.41$). As expected, Behavioral impulsivity correlated positively with Impatience/restlessness ($r = 0.65$) as well. The indices of internal consistency of each factors were calculated: *cognitive impulsivity:* Cronbach's $\alpha = 0.80$ [0.77–0.82], McDonald's $\omega = 0.81$; *behavioral impulsivity:* Cronbach's $\alpha = 0.74$ [0.71–0.77], McDonald's $\omega = 0.76$; *impatience/restlessness:* Cronbach's $\alpha = 0.69$ [0.66–0.72], McDonald's $\omega = 0.69$.

In order to cross-validate the new measurement model of impulsivity, a CFA analysis was repeated on an independent sample of college students. The newly developed model yielded close to adequate level of fit to this sample ($\chi^2 = 1{,}363.9$, df = 186, $P < 0.0001$; CFI = 0.833; TLI = 0.811; RMSEA = 0.091 [0.086–0.096], Cfit < 0.001; SRMR = 0.078).

After the inspection of modification indices, one error covariance was freed including between Item 11 ("*I 'squirm' at plays or lectures")* and Item 28 *("I am restless at the theater or lectures).* The degree of fit increased significantly and became closer to be acceptable ($\chi^2 = 1{,}040.5$, df = 185, $P < 0.0001$, CFI = 0.878; TLI = 0.862, RMSEA = 0.078 [0.073–0.082], Cfit = 0.001, SRMR = 0.067). Similar to the previous sample, correlations between the factors ranged from 0.63 to 0.71 (Table 4). Cognitive impulsivity strongly correlated with impatience/restlessness ($r = 0.63$), and with behavioral impulsivity ($r = 0.66$). As expected, behavioral impulsivity also correlated with impatience/restlessness ($r = 0.71$). We tested the internal consistency of the factors in this sample: *cognitive impulsivity:* Cronbach's $\alpha = 0.81$ [0.80–0.82], McDonald's $\omega = 0.82$; *behavioral impulsivity:* Cronbach's $\alpha = 0.72$ [0.71–0.74], McDonald's $\omega = 0.74$; *impatience/restlessness:* Cronbach's $\alpha = 0.68$ [0.66–0.70], McDonald's $\omega = 0.68$.

For further cross-validation, the new shorter version of the BIS was administered in a large, representative community sample. The newly developed model yielded adequate level of fit to this sample ($\chi^2 = 1{,}021.1$, df = 186, $P < 0.0001$; CFI = 0.949; TLI = 0.942; RMSEA = 0.049 [0.046–0.051], Cfit < 0.796; SRMR = 0.058). After the inspection of modification indices, one error covariance was freed including between Item 11 ("*I 'squirm' at plays or lectures*") and Item 28 ("*I am restless at the theater or lectures*"). The degree of fit increased significantly and demonstrated a good fit ($\chi^2 = 974.2$, df = 185, $P < 0.0001$, CFI = 0.952; TLI = 0.945, RMSEA = 0.047 [0.044–0.050], Cfit = 0.935, SRMR = 0.057). We also tested the internal consistency of the factors in this sample as well: *cognitive impulsivity:* Cronbach's $\alpha = 0.84$ [0.83–0.85], McDonald's $\omega = 0.84$; *behavioral impulsivity:* Cronbach's $\alpha = 0.77$ [0.75–0.88], McDonald's $\omega = 0.77$; *impatience/restlessness:* Cronbach's $\alpha = 0.81$ [0.80–0.82], McDonald's $\omega = 0.81$.

Table 4. Confirmatory factor analysis of the new measurement model in sample 3, sample of college students and a community sample: standardized factor loadings.

Item No	Item	Cognitive impulsivity			Behavioral impulsivity			Impatience/restlessness		
		Sample 3	College students	Community sample	Sample 3	College students	Community sample	Sample 3	College students	Community sample
		Factor loadings								
9	*I concentrate easily**	−0.74	−0.58	−0.75						
12	*I am a careful thinker**	−0.74	−0.78	−0.80						
1	*I plan tasks carefully**	−0.71	−0.74	−0.74						
20	*I am a steady thinker**	−0.68	−0.44	−0.69						
8	*I am self-controlled**	−0.67	−0.58	−0.70						
13	*I plan for job security**	−0.60	−0.44	−0.60						
7	*I plan trips well ahead of time**	−0.56	−0.58	−0.65						
30	*I am future oriented**	−0.49	−0.20	−0.54						
10	*I save regularly**	−0.43	−0.49	−0.52						
19	*I act on the spur of the moment*				0.90	0.86	0.79			
17	*I act "on impulse"*				0.76	0.74	0.80			
2	*I do things without thinking*				0.66	0.73	0.64			
14	*I say things without thinking*				0.54	0.61	0.66			
18	*I get bored easily when solving thought problems*				0.55	0.39	0.65			
25	*I spend or charge more than I earn*							0.76	0.58	0.75
26	*I often have extraneous thoughts when thinking*							0.74	0.60	0.68
22	*I buy things on impulse*							0.69	0.53	0.70
24	*I change hobbies*							0.64	0.36	0.77
28	*I am restless at the theater or lectures*							0.58	0.51	0.85
21	*I change residences*							0.47	0.37	0.71
11	*I "squirm" plays or lectures*							0.53	0.42	0.73
		Correlations between factors								
Behavioral impulsivity		**0.41**	**0.66**	**0.26**						
Impatience/restlessness		**0.21**	**0.63**	**0.19**	**0.71**	**0.69**	**0.74**			

Note: Sample 3: N = 828; College student sample: N = 765. Community sample: N = 2,040. Boldfaced correlations are significant at least $P < 0.001$. *: reversed items.

Construct validity of the three-factor model of impulsivity in a community sample

To examine the construct validity of the three-factor impulsivity model in the community sample, the present study first examined the correlations of the new factors of impulsivity with the subscales of the BSI, and second the associations were tested between the new three factors and gender, age, and behavioral indicators including smoking, indicators of alcohol use, and exercise behaviors. The correlations between the impulsivity factors and BSI are presented in Table 5. Here, we also applied Bonferroni

Table 5. Correlations between new factors of impulsivity and global severity index and subscales of Brief Symptom Inventory.

	Cognitive impulsivity	Behavioral impulsivity	Impatience/ restlessness
Global Severity Index	**0.32**	**0.33**	**0.37**
Subscales of Brief Symptom Inventory			
Somatization	−0.09	**−0.13**	**−0.20**
Obsessive-Compulsive	**0.69**	**0.31**	−0.07
Interpersonal Sensitivity	0.06	0.18	−0.01
Depression	0.05	−0.10	−0.08
Anxiety	−0.07	**−0.33**	**−0.43**
Hostility	0.06	**0.28**	**0.25**
Phobic Anxiety	−0.02	−0.05	0.13
Paranoid Ideation	**−0.25**	−0.00	0.10
Psychoticism	0.03	**0.22**	**0.45**

Note: N = 2,632; After the Bonferroni correction, the correlations that are significant at least at $P < 0.0017$ are boldfaced.

correction in order to avoid the inflated Type I error. The Global Severity Index and Obsessive-Compulsive scale showed positive correlations with cognitive impulsivity, while the Paranoid Ideation scale showed moderate negative correlations with cognitive impulsivity. The behavioral impulsivity factor was positively correlated with the Global Severity Index, Obsessive-Compulsive, Hostility, and Psychoticism scales, and negatively correlated with Somatization and Anxiety. The impatience/restlessness factor had positive and significant correlations with the Global Severity Index, Hostility, and Psychoticism scales, and had negative and significant correlations with Somatization and Anxiety scales.

In order to test the associations between the three factors and behavioral indicators, a CFA was performed with covariates. This is sometimes called the multiple indicators and multiple causes (MIMIC) model in which the impact of covariates on latent variables are estimated simultaneously. The partial standardized regression coefficients are presented in Table 6. In the evaluation of the coefficients, we used a stricter criterion for significance according to Bonferroni correction for multiple testing. No gender-related differences were found in the three factors of impulsivity. Age was negatively associated with cognitive impulsivity, behavioral impulsivity and impatience/restlessness. As expected, cognitive impulsivity was negatively associated with exercise and positively associated with substance use including smoking and binge drinking. Behavioral impulsivity – again, as expected – was positively associated with smoking and binge drinking, but not with exercise. Finally, impatience/restlessness was positively associated with binge drinking. We also tested the incremental validity of the three factors of impulsivity in a multivariate predictor model in which the behavioral indicators were the outcomes and the three factors were the predictors. Cognitive impulsivity was the strongest predictor of all four indicators. Higher cognitive impulsivity was related with lower probability of regular exercise, higher likelihood of smoking and binge drinking, and higher frequency of alcohol use while the other two factors were controlled. Behavioral impulsivity also significantly predicted cigarette smoking, alcohol use, and binge drinking, but in these cases the significance levels of the coefficients were below the stricter criterion based on Bonferroni correction.

Table 6. The association between the three factors of impulsivity and gender, age, regular exercise, smoking and alcohol use in a CFA with covariates analysis: Standardized regression coefficients.

	Cognitive impulsivity	Behavioral impulsivity	Impatience/ restlessness	
MIMIC model				
Gender	0.04	0.06	−0.02	
Age	**−0.01****	**−0.01****	**−0.02*****	
Regular exercise	**−0.31*****	−0.06	0.12	
Smoking status	**0.21*****	**0.23*****	0.13*	
Alcohol use in the last 30 days	0.01**	0.01**	<0.01	
Binge drinking	**0.46*****	**0.46*****	**0.38*****	
R^2 (%)	5.4	6.6	10.1	
Multivariate predictor model[a]				
	Cognitive impulsivity	Behavioral impulsivity	Impatience/ restlessness	R^2 (%)[b]
Regular exercise	**−0.26*****	−0.05	0.13**	5.6%
Smoking status	**0.16*****	0.15**	−0.03	4.7%
Alcohol use in the last 30 days	**0.84*****	0.70*	−0.20	1.6%
Binge drinking	**0.30*****	0.16*	0.07	12.3%

Note: N = 2,409; *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$. Boldfaced coefficients are significant at $P < 0.0028$ (Bonferroni correction for multiple testing).
[a] Age and gender are controlled.
[b] Calculated without age and gender.

Construct validity of the three-factor model of impulsivity in a college sample: A CFA with covariates model

To lend further support to the construct validity of the new three-factor model of impulsivity in another independent sample, univariate analyses and a CFA were performed with covariates in the college sample. Associations were tested between the three factors of impulsivity and the subscales of the Buss-Perry Aggression Questionnaire including verbal aggression, physical aggression, anger, and hostility. The standardized regression coefficients in univariate analyses and the partial standardized regression coefficients in the CFA with covariates analysis are presented in Table 7. In the univariate analyses, verbal aggression, physical aggression,

Table 7. The associations between three factors of impulsivity and aggression hostility in college students

	Cognitive impulsivity	Behavioral impulsivity	Impatience/ restlessness
Univariate predictors			
Gender	0.05	0.08*	0.11**
Age	0.01	−0.03.	−0.01
Verbal aggression	**0.22*** **	**0.43*** **	**0.27*** **
Physical aggression	**0.14*** **	**0.28*** **	**0.16*** **
Anger	**0.18*** **	**0.23*** **	**0.29*** **
Hostility	**0.17****	**0.18*** **	**0.36*** **
Multivariate predictor model			
Gender	0.06	**0.14****	0.12**
Age	0.07	−0.05	0.02
Verbal aggression[a]	**0.15*** **$_a$**	**0.34*** **$_b$**	**0.14**** **$_a$**
Physical aggression	0.08	**0.21*** **	0.13**
Anger	0.06	<0.01	0.06
Hostility	0.09	0.09	**0.28*** **
R^2 (%)	7.4	23.9	18.6

Note: N = 769. *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$. Boldfaced coefficients are significant at $P < 0.0028$ (Bonferroni correction for multiple testing). #: Pairwise comparisons of the regression coefficients are presented with subscript letters. Parameters sharing the similar subscript are not significantly different. Behavioral impulsivity has a significantly stronger association ($P < 0.001$) with verbal aggression than the other two factors

anger, and hostility were significantly and positively associated with the cognitive impulsivity, behavioral impulsivity and impatience/restlessness factors. In the multivariate analyses, cognitive impulsivity, behavioral impulsivity, and impatience/restlessness were positively associated with verbal aggression. Comparisons of coefficients revealed that behavioral impulsivity had a stronger association with verbal aggression than the other two factors. Behavioral impulsivity was also significantly associated with physical aggression, and impatience/restlessness was positively associated with hostility.

DISCUSSION

The originally proposed factor structure of the Barratt Impulsivity Scale (BIS-11) was not supported in two independent large samples. However, the present study created a new, alternative three-dimensional measurement model for impulsivity based on a series of exploratory and confirmatory factor analyses. Three factors were identified comprising (i) cognitive impulsivity, (ii) behavioral impulsivity, and (iii) impatience/restlessness. Additionally, the number of items was reduced from 30 to 21, and these items appear to define the self-reported impulsivity construct more concisely. This factor structure was confirmed in further two independent samples.

The first factor – labeled as *cognitive impulsivity* – integrates those reversed items that refer to the lack of planning, instability and emotional imbalance. It includes nine items, six of which stem from the original Non-planning Impulsiveness factor, two from the Attentional Impulsiveness factor, and one from the Motor Impulsiveness factor. However, the correlations between cognitive impulsivity and the other two factors were relatively weak. Labeling this factor, we followed the original naming. However, here we would emphasize that this factor can be seen as a reversed self-control (low self-control) factor. The construct of impulsivity and self-control are sometimes treated as different constructs and sometimes as a continuum from impulsivity (low self-control) to high self-control (Duckworth & Kern, 2011). For example, the correlation between impulsivity assessed using the BIS-11 correlates very strongly with self-control measures ($r = -0.72$; Mao et al., 2018). The second factor was labeled as *behavioral impulsivity*, and reflects a form of impulsivity which has a mainly behavioral manifestation. It is closely related to the original Motor Impulsiveness factor in that three of its five items derive from it. However, it also contains two items of the original Non-planning Impulsiveness (one item from the Self-control and one from the Cognitive Complexity first order factors). The third factor was labeled as *impatience/restlessness* and refers to difficulties in concentrating on tasks or implementing behavior in wider contexts, including being restless in different situations. This factor includes seven items, with three items from the former Motor Impulsiveness factor and four items from the Attentional Impulsiveness factor (two items from the Attention and two from the Cognitive Instability sub-factors). Considering the conceptual basis of the proposed three-factor model, cognitive and behavioral impulsivity might be well interpreted within the conceptual framework of Barratt and Stanford (1995), while in case of impatience/restlessness – following a content analysis of its items - we could state that this factor might mostly be related to lack of perseverance. None of these factors can be explained or interpreted by further models and facets of impulsivity (e.g. Depue & Collins, 1999; Whiteside & Lynam, 2001). The BIS-11 factors in their original structure mainly fit under the umbrella of the UPPS model's (lack of) premeditation construct, additional facets of impulsivity (such as boredom susceptibility, urgency) are therefore simply better identified by other models and measures which indicates the aforementioned limits of BIS-11. Our factorial solution is not consistent with any other previous models which again highlights the diversity of impulsivity as assessed using the BIS scale across different samples.

The earlier outlined associations between impulsivity and mental and behavioral disorders suggest that the BSI designed to evaluate psychological problems might be suitable in estimating the construct validity of the alternative three-factor model. However, it needs to be noted that specific behavioral indicators showed significant associations with more than one impulsivity factor. This result is not in support of the validity of the proposed model. CFA with covariates analysis conducted on the community sample showed a significant effect of the Global Severity Index of the BSI on all three factors of the new model. All three factors had consistent positive associations with the Global Severity Index, illustrating the role of impulsivity in various psychiatric conditions, consistent with the approach of the NIMH Research Domain Criteria (RDoC) (Insel, 2014).

Furthermore, results demonstrated different patterns of symptoms and among the new three factors of impulsivity.

Obsessive-compulsive symptoms were related with cognitive impulsivity and behavioral impulsivity in accordance with previous findings that people suffering from obsessive-compulsive disorders show higher attentional impulsivity score (Sahmelikoglu Onur et al., 2016). However, this association can be explained with cognitive and behavioral impulsivity components. Hostility was related with behavioral impulsivity and impatience/restlessness among the large community sample. However, among the college sample, hostility was associated with impatience/restlessness only in the multivariate analysis. These results are in accordance with a previous study which presented evidence that hostility correlates with attentional and motor impulsivity (Menon, Sarkar, Kattimani, & Mathan, 2015). Furthermore, our study found that impatience/restlessness may be a component through which hostility is related with impulsivity. The present study also tested the effect of a number of behavioral data on the newly established factors. Regular exercise had a negative association only with cognitive impulsivity which is in accordance with the assumption that regular exercise requires self-control and planning (Englert, 2016; Finne et al., 2019). The associations between impulsivity and substance use including cigarette smoking (Kale et al., 2018) and alcohol use (Dick et al., 2010) are well documented. In our study, cognitive impulsivity concurrently predicted smoking, alcohol use, and binge drinking while controlling for two other factors of impulsivity. Behavioral impulsivity also concurrently predicted substance use. However, the effect size of the coefficients were much smaller.

As a further step in testing construct validity, we tested the associations between aggressive behaviors and the three factors of impulsivity. The association between impulsivity and aggression has been widely studied in the literature, with implications of overlapping genetic background (Seroczynski, Bergeman, & Coccaro, 1999), and molecular psychobiological mechanisms (Lesch & Merschdorf, 2000). Furthermore, the construct of impulsive aggression reflects the interconnected nature of these dimensions. The results of the present study indicated significant covariances of the Buss Perry Aggression Questionnaire scales with all factors of the alternative model of the BIS-11. The directions of these effects were in accordance with the content of the factors. More specifically, verbal and physical aggression were associated more strongly with behavioral impulsivity than the other two components of impulsivity, and hostility was associated only with impatience/restlessness.

To interpret our results by using RDoC units of analysis, the construct of impulsivity as measured by the BIS-R-21 might be characterized by a) a tendency to act with less forethought than the majority of the individuals with equal knowledge and ability, b) a predisposition toward unplanned reactions to either internal or external stimuli; c) lack of considering potential negative consequences of one's acts; d) a persistent pattern of inattention; e) a pattern of hyperactivity; and f) impaired decision making. These aspects of impulsivity are often linked to the etiology and symptomatology of various psychiatric disorders, including addictions (Brooks, Lochner, Shoptaw, & Stein, 2017). Considering the five major domains of RDoC (i.e. negative valence, positive valence, cognitive, social and arousal & regulation), impaired cognitive control, lack of attention and disinhibition (all from the Cognitive domain) are main hallmark of the BIS-R-21 measured impulsivity construct.

The results of the present study further indicate that instead of the original 30-item version, an abbreviated 21-item version of BIS-11 shows better psychometric properties. A shortened version of the instrument was also recommended by Spinella (2007), named BIS-15 (containing 15 items), which is now available in English, German (Meule, Vögele, & Kübler, 2011) and Spanish (Orozco-Cabal, Rodriguez, Herin, Gempeler, & Uribe, 2010). Further examination of the reliability and validity of this novel version – named the 21-item Barratt Impulsiveness Scale Revised (BIS-R-21) – is suggested for both clinical and non-clinical settings.

Limitations and future research

The present study is not without limitations. A mixed sample was assessed, with two community samples being representative to the Hungarian adult population, while the Hungarian college sample – recruited via convenience sampling – was a non-probability sample. Language and culture may have severe impact on interpreting each items (Vasconcelos et al. 2012). Therefore, it is still not clear if the results presented here are generalizable to other countries and language versions of this scale. The relevance of the content of each item may also vary in different age groups. Some items may have different meanings for adults compared to university students. This may explain the structural instability in different age groups. Furthermore, the severity of psychoactive substance use was not measured by commonly applied validated instruments, such as the Alcohol Use Disorder Identification Test (AUDIT) for alcohol (Babor, Higgins-Biddle, Saunders, & Monteiro, 2001), or the Fagerström Test for Nicotine Dependence (Heatherton, Kozlowski, Frecker, & Fagerström 1991) for smoking severity. Construct validity was tested by correlating the three factors with similar self-reported scales (e.g., Brief Symptom Inventory, Buss-Perry Aggression Questionnaire), but not with other levels of assessment, such as continuous performance tests or other behavioral assessments of impulsivity (e.g. Hamilton et al., 2015a, 2015b).

In order to better define the construct impulsivity and its components, future research is needed to reanalyze the factor structure by using a larger pool of impulsivity items rather than the brief version of the BIS scale, as it was done in the development of the UPPS-P (Whiteside & Lynam, 2001) and other recent disinhibition scales. New and potentially more precise factor labels might also be derived from further studies that compare the presented three factors with other self-reported impulsivity measures (see Table 1) and/or clinical diagnoses (e.g., ADHD or impulse control disorders). This would help in reaffirming these labels and may lead to their refinement in terms of their name, nature and interpretation.

CONCLUSIONS

The newly presented measurement model of impulsivity was confirmed in two independent samples. However, it requires further cross-cultural validation to clarify the content of self-reported impulsivity. Its construct validity needs additional testing by comparing BIS-R-21 results with those obtained via other methods.

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Conflict of interest: The authors declare no conflict of interest.

APPENDIX

The 21-item Barratt Impulsiveness Scale Revised (BIS-R-21)

		Response categories			
		Rarely never/Never	Occasionally	Often	Almost always/ Always
1	*I plan tasks carefully*	1	2	3	4
2	*I plan trips well ahead of time*	1	2	3	4
3	*I do things without thinking*	1	2	3	4
4	*I "squirm" at plays or lectures*	1	2	3	4
5	*I am self-controlled*	1	2	3	4
6	*I concentrate easily*	1	2	3	4
7	*I say things without thinking*	1	2	3	4
8	*I change residences*	1	2	3	4
9	*I save regularly*	1	2	3	4
10	*I act "on impulse"*	1	2	3	4
11	*I buy things on impulse*	1	2	3	4
12	*I am a careful thinker*	1	2	3	4
13	*I get easily bored when solving thought problems*	1	2	3	4
14	*I change hobbies*	1	2	3	4
15	*I plan for job security*	1	2	3	4
16	*I act on the spur of the moment*	1	2	3	4
17	*I spend or charge more than I earn*	1	2	3	4
18	*I am a steady thinker*	1	2	3	4
19	*I often have extraneous thoughts when thinking*	1	2	3	4
20	*I am future oriented*	1	2	3	4
21	*I am restless at the theater or lectures*	1	2	3	4

Scoring:
(1) Cognitive impulsivity (the sum of the reversed items 1*, 2*, 5*, 6*, 9*, 12*, 15*, 18*, 20*)
(2) Behavioral impulsivity (the sum of the items 3, 7, 10, 13, 16)
(3) Impatience/restlessness (the sum of the items 4, 8, 11, 14, 17, 19, 21)
Note: The factor 'Cognitive impulsivity' shows weak correlation with both 'Behavioral impulsivity' and 'Impatience/restlessness'. This needs to be considered when interpreting impulsivity as the total score of BIS-R-21.

A 21 tételes Módosított Barratt Impulzivitás Skála (BIS-R-21)

		Válaszkategóriák			
		Soha/Ritkán	Néha	Gyakran	Majdnem mindig/ Mindig
1	*Gondosan megtervezem a feladataimat.*	1	2	3	4
2	*Jó előre megtervezem az utazásaimat.*	1	2	3	4
3	*Gondolkodás nélkül cselekszem.*	1	2	3	4
4	*Fészkelődöm olyankor, amikor hosszabb ideig csendben, ülve kellene maradnom.*	1	2	3	4
5	*Nagy az önuralmam.*	1	2	3	4
6	*Könnyen tudok koncentrálni a dolgokra.*	1	2	3	4
7	*Gondolkodás nélkül kimondom a dolgokat.*	1	2	3	4
8	*Váltogatom a lakhelyeimet.*	1	2	3	4
9	*Rendszeresen teszek félre pénzt.*	1	2	3	4
10	*Gondolkodás nélkül, az első benyomásom alapján, azonnal cselekszem.*	1	2	3	4
11	*Hirtelen ötlettől vezérelve vásárolok.*	1	2	3	4
12	*Alaposan át szoktam gondolni a dolgokat.*	1	2	3	4
13	*Könnyen megunom az elméleti kérdéseken való töprengést.*	1	2	3	4
14	*Váltogatom a hobbijaimat.*	1	2	3	4
15	*Stabil munkahelyre törekszem.*	1	2	3	4
16	*A pillanat hevében cselekszem.*	1	2	3	4
17	*Többet költök, mint amennyit keresek.*	1	2	3	4
18	*Kitartó gondolkodó vagyok.*	1	2	3	4
19	*Gondolkodás közben elkalandozik a figyelmem.*	1	2	3	4
20	*Foglalkoztat a jövő.*	1	2	3	4
21	*Nyugtalanná válok, amikor csendben, ülve kellene maradnom.*	1	2	3	4

Pontozás:
(1) Kognitív impulzivitás (az alábbi fordított tételek összege: 1*, 2*, 5*, 6*, 9*, 12*, 15*, 18*, 20*)
(2) Viselkedési impulzivitás (az alábbi tételek összege: 3, 7, 10, 13, 16)
(3) Türelmetlenség/nyugtalanság (az alábbi tételek összege: 4, 8, 11, 14, 17, 19, 21)
Megjegyzés: A 'kognitív impulzivitás' faktora gyenge korrelációt mutat mind a 'viselkedési impulzivitás', mind a 'türelmetlenség/ nyugtalanság' faktorokkal. Ezt érdemes figyelembe venni, amikor a BIS-R-21 összpontszámaként értelmezzük az impulzivitás konstruktumát.

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