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Psychometrically Improved, Abbreviated Versions of Three Classic Measures of Impulsivity and Self-Control

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Abstract

Self-reported impulsivity confers risk factor for substance abuse. However, the psychometric properties of many self-report impulsivity measures have been questioned, thereby undermining the interpretability of study findings using these measures. To better understand these measurement limitations and to suggest a path to assessing self-reported impulsivity with greater psychometric stability, we conducted a comprehensive psychometric evaluation of the Barratt Impulsiveness Scale-11 (BIS-11), the Behavioral Inhibition and Activation Scales (BIS/BAS), and the Brief Self Control Scale (BSCS) using data from 1,449 individuals who participated in substance use research. For each measure, we evaluated: 1) latent factor structure, 2) measurement invariance, 3) test-criterion relationships between the measures, and 4) test-criterion relations with drinking and smoking outcomes. Notably, we could not replicate the originally published latent structure for the BIS, BIS/BAS, or BSCS or any previously published alternative factor structures (English language). Using exploratory and confirmatory factor analysis, we identified psychometrically improved, abbreviated versions of each measure (i.e., 8-item, 2 factor BIS-11 [RMSEA = .06, CFI = .95]; 13-item, 4 factor BIS/BAS [RMSEA = .04, CFI = .96]; 7-item, 2

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factor BSCS [RMSEA = .05, CFI = .96]). These versions evidenced: 1) stable, replicable factor structures, 2) scalar measurement invariance, ensuring our ability to make statistically interpretable comparisons across subgroups of interest (e.g., sex, race, drinking/smoking status), and 3) test-criterion relationships with each other and with drinking/smoking. This study provides strong support for using these psychometrically improved impulsivity measures, which improve data quality directly through better scale properties and indirectly through reducing response burden.

Keywords

Impulsivity; Barratt Impulsiveness Scale; the Behavioral Inhibition and Activation Scales; Brief Self Control Scale; Psychometric Validation; Measurement Invariance

Impulsivity Theory and Self-Report Measures of the Construct

Research on impulsivity has expanded drastically over the past decade; a Google Scholar search (February 10, 2014) indicates that 10,800 articles have been published since 2004 with “Impulsivity,” “Impulsive,” “Impulsiveness,” or “Impulse Control” in the title. This increase in impulsivity research is justified by the strong link between impulsivity and negative outcomes including psychiatric disorders (for a review see Moeller et al., 2001), heavy substance use and gambling (e.g., Leeman & Potenza, 2012); suicidal behavior (for a review see Brezo, Paris, & Turecki, 2006); intimate partner violence (e.g., Shorey, Brasfield, Febres, & Stuart, 2011); drunk driving (e.g., Moan, Norstrom, & Storvoll, 2013); credit card debt (e.g., Pirog & Roberts, 2007); and obesity (e.g., Schag, Schonleber, Teufel, Zipfel, & Giel, 2013), to name a few. However, it is striking that impulsivity research has expanded in advance of robustly validated methods for assessing this complex, multidimensional psychological construct (Dick et al., 2010).

Impulsivity has been defined as “a predisposition toward rapid, unplanned reactions to internal or external stimuli with diminished regard to the negative consequences of these reactions to the impulsive individual or others” (Moeller et al., 2001 with modification by Brewer & Potenza, 2008), and is reflected in a wide array of cognitive and behavioral domains ranging from the simple (e.g., motor response times to rewards/punishments) to the complex (e.g., ability to delay gratification). Given its multifaceted nature, investigators have attempted to fractionate the construct. Seminal work by Barratt (1959) focusing on differentiating impulsivity from anxiety resulted in the creation of the Barratt Impulsiveness Scale (BIS; Barratt, 1959), which remains the most commonly used self-report measure of impulsivity (Stanford et al., 2009). Over time, the BIS and has undergone 11 revisions, the most recent of which (Patton et al., 1995) conceptualizes impulsivity as fitting three primary domains: attentional impulsiveness (e.g., focus and attention to tasks), motor impulsiveness (e.g., acting without thinking), and non-planning impulsiveness (e.g., poor task/future planning).

Impulsive behaviors also may be viewed as the product of two competing neural circuits: an approach-oriented “Go” system driven by reward-based circuitry, and an opposing regulatory or executive “Stop” system. Along these lines, impulsive behaviors can be thought of as reflecting an imbalance between tendencies to respond to salient internal or external stimuli (sometimes referred to as "activation"; Carver & White, 1994) and to inhibit prepotent responses (sometimes referred to as "inhibition"; Carver & White, 1994). Thus, impulsive behavior may be caused by exceedingly strong tendencies to respond and/or inability to inhibit these responses (Carver & White, 1994; Gray, 1987; Wiers, Ames, Hofmann, Krank, & Stacy, 2010). Based on this theory of competing GO/STOP neural circuitry, Carver and White (1994) developed the Behavioral Inhibition and Activation Scales (BIS/BAS). This measure conceptualizes impulsivity in four domains: Drive, Fun Seeking, Responsiveness to Rewards, and Behavioral Avoidance/Inhibition.

A third conceptualization of impulsivity stems from research on the Five Factor Model of personality, which conceptualizes personality along the following dimensions: openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism (Costa & McCrae, 1992). Whiteside and Lynam (2001) created The Urgency, Premeditation, Perseverance, and Sensation Seeking (UPPS) Impulsive Behavior Scale (Whiteside & Lynam, 2001) to assess dimensions of impulsivity across the five domains of personality. Though not included in the present study, this measure is well situated in terms of the extant literature, as it was developed based on nine existing measures of impulsivity and related constructs. When considering the UPPS in relation to the other measures of impulsivity discussed thus far, the BIS-11 factors all fit under the umbrella of (lack of) premeditation in the UPPS (Whiteside & Lynam, 2001); the fun seeking subscale of the BIS/BAS has been aligned with multiple UPPS factors: (lack of) premeditation, (lack of) perseverance and urgency (Sharma, Markon & Clark, in press); and the other BIS/BAS subscales have been found to pertain more closely to sensation seeking as measured by the UPPS (Sharma et al., in press).

When studying impulsivity, it is also important to consider the related construct of self-regulation - the ability to formulate and adhere to a plan by maintaining one's focus and attention though effortful control, even in the absence of immediate, external rewards (Brown, Miller, & Lawendowski, 1999; Carver & Scheier, 2002). As such, high levels of self-regulation would be associated with low levels of impulsivity (Patock-Peckham, Cheong, Balhorn, & Nagoshi, 2001). To assess self-regulation, Tangney and colleges (2004) developed the Brief Self-Control Scale (BSCS) which assesses five domains of self-control: controlling thoughts, controlling emotions, controlling impulses, regulating behavior/performance, and habit-breaking.

Limitations of Existing Self-Report Measures of Impulsivity

As described above, researchers have developed a number of "gold standard" self-report measures like the BIS, the BIS/BAS, and the BSCS that are thought to tap into different aspects of impulsivity and related constructs. However, sufficient evidence for the psychometric properties of these measures is lacking, which compromises the interpretability of study results and, consequently, our understanding of this complex construct.

To be considered a psychometrically sound assessment tool, a given measure must assess the construct that it was designed to assess both accurately (i.e., demonstrate evidence of construct and test-criterion validity) and consistently (i.e., demonstrate evidence of reliability). Prior studies have evaluated some aspects of the reliability and validity of the proposed test scores for the BIS, BIS/BAS, and BSCS, although none of these measures has undergone rigorous psychometric evaluation using the most current approaches described in the paragraphs below (e.g., scalar measurement invariance). With respect to reliability, extant research has focused largely on reporting Cronbach's alpha values as an index of the internal consistency of test scores (e.g., Cogswell et al., 2006; Patton et al., 1995; Tangney et al., 2004).

Regarding validity, studies have most commonly focused on demonstrating that the BIS, BIS/BAS, and/or BSCS test scores are related to outcomes of interest (e.g., Balevich, Wein, & Flory, 2013; Pardo, Aguilar, Molinuevo & Torrubia, 2007). Although some have considered this to be evidence of the concurrent or predictive validity of the test scores, we caution against such an interpretation for the following reasons. Psychometric validation is a tired process, such that evidence for the fundamental aspects of reliability and validity (e.g., confirmable and replicable latent factor structure; internal consistency) is a prerequisite for evaluating more advanced psychometric properties (e.g., test-criterion relationships). In the case of the BIS, BIS/BAS, and BSCS, we argue that examining test-criterion relationships is premature in light of the fact that we were unable to find sufficient evidence in the research literature that the proposed latent factor structures of these measures (i.e., the scoring system organizing items into subscales) are stable (i.e., confirmable and replicable; Floyd & Widaman, 1995). Confirming the latent structure is imperative as it ensures that the scoring instructions, which dictate the composition of a measure's subscales, accurately reflect the true latent structure of the assessed construct. If the proposed structure does not accurately mirror the latent construct, it is unclear what the measure actually assesses and evaluating test-criterion relationships lacks meaning.

A related issue, a psychometrically sound measure must also evidence measurement invariance (i.e., MI), which ensures that the construct is assessed similarly enough across groups of interest (e.g., men versus women) to permit interpretable comparisons to be made (for reviews see Steenkamp & Baumgartner, 1998; Vandenberg & Lance, 2000). Specifically, three levels of invariance must be achieved (i.e., configural, metric, and scalar) to ensure that observed, meanlevel differences in test scores reflect true latent differences attributable to group membership (e.g., to being male) rather than measurement error stemming from sources including discrepant latent structures, systematic group differences in interpreting items, or bias in specific items comprising a scale. Mean level comparisons of impulsivity using the BIS, BIS/BAS, and the BSCS are commonplace in the literature as are evaluations of test-criterion relationships with various outcomes like substance use or psychiatric disorders that rely upon mean subscale scores (e.g., Dissabandara, Loxton, Dias, Daglish, & Stadlin, 2012; Duckworth & Seligman, 2006; Steinberg, Sharp, Stanford, & Tharp, 2013). However, a level of MI permitting statistically meaningful interpretations of such analyses using these measures has not been established (e.g., Campbell-Sills, Liverant, & Brown, 2004; Ireland & Archer, 2008; Leone, Perugini, Bagozzi, Pierro, & Mannetti, 2001). In the absence of explicitly established scalar MI, it is impossible to interpret the presence or absence of group differences because observed differences or apparent null findings may reflect spurious measurement artifacts.

There are indicators within the published literature using self-report impulsivity measures that even the most fundamental level of MI (i.e., configural invariance) is often absent. Studies examining the latent factor structure of the the BIS, BIS/BAS, and BSCS are replete with a wide range of proposed factor solutions across samples of interest including, but not limited to the following: 1) undergraduates (e.g., Carver & White, 1994; Patton et al., 1995 [sample 1]; Tangney et al., 2004); 2) community samples (e.g., Jorm et al., 1998; Maloney, Grawitch, & Barber, 2012; Reise, Moore, Sabb, Brown, & London, 2013); 3) psychiatry inpatients/outpatients (e.g., Campbell-Sills et al., 2004; Patton et al., 1995 [sample 2]); and 4) incarcerated individuals (e.g., Haden & Shiva, 2008, 2009; Poythress et al., 2008). Across these subsamples, latent factor structures of 1 to 3 factors have been proposed for the BIS (e.g., Haden & Shiva, 2008, 2009; Patton et al., 1995; Reise et al., 2013; Spinella, 2007; Steinberg et al., 2013). For the BIS/BAS, solutions ranging from 2 to 5 factors have been proposed (e.g., Beck, Smits, Claes, Vandereycken, & Bijttebier, 2009; C. Carver & White, 1994; Heubeck, Wilkinson, & Cologon, 1998; Heym, Ferguson, & Lawrence, 2008; Johnston, O'Malley, Bachman, & Schulenberg, 2012). Finally, for the BSCS, solutions comprising either 1 or 2 factors have been proposed (i.e., Maloney et al., 2012; Tangney et al., 2004). Collectively, prior research suggests disagreement in the factor structures of the BIS, BIS/BAS, and BSCS and insufficient evidence of configural invariance.

Implementing different factor analytic techniques across studies likely contributes to the discrepancies in latent structures identified across studies of the BIS, BIS/BAS, and the BSCS. For example, studies have used exploratory (i.e., EFA) methods (e.g., Principal Components Analysis) and/or confirmatory (i.e., CFA) methods (e.g., Robust Maximum Likelihood). Further, different rotations (e.g. orthogonal, oblique) have been specified. Finally, divergent strategies have been used for factor selection (e.g., Kaiser-Guttman rule; scree plot; factor loadings).

Aims of the Current Study

The purpose of the current study was to conduct a state-of-the-art psychometric evaluation of three self-report measures of impulsivity (i.e., the BIS-11 [Patton et al, 1995]; the BIS/BAS [Carver & White, 1994]; and the BSCS [Tangney et al., 2004]). These measures were chosen because they are featured prominently in the research literature despite evidence of the psychometric instability of their respective latent structures. Our primary goal was to evaluate evidence for the fundamental aspects of validity and reliability (e.g., latent factor structure, measurement invariance, internal consistency), with a secondary focus on evaluating preliminary test-criterion relationships among the measures and with substance use outcomes. Conducting such an investigation could help eliminate the possibility that the noted discrepancies in identified latent factor structures for the BIS-11, BIS/BAS, and BSCS are the result of systematic measurement error in these assessment tools. To accomplish the study goals, we conducted a series of statistical analyses, described below, using data from a total of 1,449 adults who participated in substance use research. Here we specifically pooled data across studies conducted as part of two complementary

Center projects at XX University (see Methods for details). We chose to conduct the current set of analyses in a sample of substance users given the strong link between substance use and impulsivity (e.g., Leeman & Potenza, 2012).

METHODS

Participants

De-identified data used for this investigation were collected as part of the baseline assessment batteries of studies completed as part of two large XX-based Center projects (i.e., the Transdisciplinary Tobacco Use Research Center [TTURC] and Center for the Translational Neuroscience of Alcohol [CTNA]). We collected the TTURC data (n= 781) from 1999–2010 and the CTNA data (n= 656) from 2006 – 2011 (see Table 1 for demographic information for each sample and the total sample). The goals of the TTURC studies were to evaluate risk factors for smoking cessation failure and to develop improved treatments. These studies generally enrolled current smokers who were seeking smoking cessation treatment. The goals of the CTNA studies were to understand the neurobiology of risk for alcohol dependence and to develop treatments. The CTNA studies enrolled a range of low and high-risk drinkers based on family history of alcohol dependence and current drinking to participate in imaging and laboratory based studies.

Measures

The core baseline assessments in both centers documented demographic characteristics, personal history of smoking and alcohol use, family history of alcoholism, and impulsivity. These instruments are described below.

Demographic Characteristics—We assessed sex, age, race, and level of education.

Smoking Status—We determined smoking status based on participant responses to the question “Do you currently smoke cigarettes?”

Alcohol Consumption—Based on recommendations made by the Task Force on Recommended Alcohol Questions, as part of NIAAA’s Council, we assessed several aspects of participants’ alcohol use (e.g., quantity, frequency, maximum drinks consumed in 24 hours). For the current study, we focused on lifetime maximum drinks, which has been shown to be an endophenotype related to alcohol dependence (Saccone et al., 2000), and on current binge drinking status (defined as consuming ≥ 4 for women or ≥ 5 drinks for men in 2 hours).

Alcohol-Related Problems—We assessed alcohol-related problems using the Short Inventory of Problems (i.e., SIP; Miller, Tonighan, & Longabaugh, 1995), a 15-item questionnaire that captures adverse drinking consequences in 5 domains (social, interpersonal, intrapersonal, physical and impulsive behavior) and yields a total score.

Family History of Alcoholism—Within the TTURC, we assessed family history status using the following question: “Has any of your first degree blood relatives (parents, siblings, or children only) ever had what you would call a significant drinking problem? For example, have they had at least one of the following problems due to their drinking behavior: Legal problems (e.g. traffic violations, disorderly conduct, public intoxication), health problems (e.g., blackouts, DTs, cirrhosis of the liver), marital or family problems, work problems, received treatment for alcoholism (e.g., AA, Antabuse, detox), or social problems (e.g., fights, loss of friends)?"

Within the CTNA, we used the Psychiatric Family History by Interview (i.e., FHAM; Rice et al., 1995) to obtain information about family history of parental alcoholism. The FHAM is a reliable method for obtaining family history information and the specificity and sensitivity of the FHAM for the diagnosis of substance dependence is good.

Impulsivity and Self-Regulation

Barratt Impulsiveness Scale, Version 11—(Patton et al., 1995; see Table 2 for BIS items). The 30-item BIS was designed to assess a range of impulsive tendencies using a 4-point scale ranging from "rarely/never" to "almost always/always." The measure is the most widely used impulsivity measure (Stanford et al., 2009), but controversy exists about which aspects of impulsivity the BIS assesses (for a review see Vasconcelos, Malloy-Diniz, & Correa, 2012). One English-language study (Spinella, 2007) has replicated the 3-factor structure outlined by Patton and colleagues (1995) in which impulsivity was conceptualized as reflecting deficits in attention, motor control, and planning. However, the vast majority of studies have not replicated these 3 factors (e.g., Haden & Shiva, 2008, 2009; Ireland & Archer, 2008; Li & Chen, 2007; Reise et al., 2013; Steinberg et al., 2013). We review the original factor solution and more recent solutions with greatest psychometric promise below.

***Original 3-Factor Model* (BIS-11, Patton et al., 1995):** Refining the previous version of the BIS (i.e., the BIS-10; Barratt, 1985), Patton and colleagues (1995) used principal components analysis to identify 3 correlated, second-order factors (i.e., Attentional, Motor, Non-Planning Impulsiveness). Each second-order factor comprised the following two first-order factors: Attentional Impulsiveness (attention and cognitive instability), Motor Impulsiveness (motor and perseverance), and Non-planning Impulsiveness (self-control and cognitive complexity). Analyses were conducted using a combined sample of undergraduates (n = 412), psychiatric inpatients (n = 248), and incarcerated males (n = 73). Invariance was not evaluated.

Brief 1-Factor Model: Using a confirmatory, multidimensional item-response theory approach, Steinberg et al. (2013) evaluated the latent structure of the BIS-11 in a sample of undergraduates (n = 1,178), finding support for a unidimensional, 8-item version of the BIS.

Brief 2-Factor Models: Haden and Shiva (2008) used EFA within a sample of 425 mentally ill forensic inpatients to identify a 24-item, 2-factor solution (i.e., Motor Impulsivity and Non-planning Impulsivity). In a subsequent study (Haden & Shiva, 2009), they replicated the structure in a comparable sample (n = 327) using CFA.

Reise and colleagues (2013) used EFA and CFA to identify an alternative 13-item, 2-factor solution with a sample of healthy adults (n = 691). In conducting analyses on the full BIS-11, they found that the BIS contains many synonymous items which, they later point out, are problematic from a factor analytic perspective because it is not possible to distinguish common variance from item-specific variance. To address this issue, they identified 11 item parcels comprising either 2 or 3 strongly related items (e.g., the mean of items 17 ["I act on impulse"] and item 19 ["I act on the spur of the moment"]). A 2-factor solution in which 3 item parcels loaded on to each factor at ≥ .50 was most promising. Subsequent CFA analyses confirmed the presence of 2 factors: 1) "Cognitive Impulsivity" and 2) "Behavioral Impulsivity with some cognitive aspects."

Brief 3-Factor Model: Spinella (2007) used EFA to identify a 15-item version of the BIS-11 within a large community sample (N = 700). The Brief 3-factor BIS maintained the latent structure of the original BIS-11. Internal reliability for the total scale was good (α = .81).

Behavioral Inhibition and Activation Scales—(BIS/BAS; Carver & White, 1994; see Table 2 for BIS/BAS items). The BIS/BAS was designed to use a 4-point rating scale (1 = "not true at all for me" to 4 = "very true for me") to assess two systems hypothesized to motivate behavioral and emotional responses (Gray, 1987): (1) behavioral inhibition (BIS) and (2) behavioral activation (BAS). Items assessing BIS capture sensitivity to aversive stimuli and reflect avoidance-motivated behaviors thought to underlie the experience of anxiety and fear (Gray, 1987; McNaughton & Gray, 2000). In contrast, the BAS system reflects sensitivity to reward through approach-motivated behaviors. Latent factor structures of the BIS/BAS ranging from 1–5 factors have been examined. The strongest, albeit mixed, support has emerged for either a four-factor version consistent with the original structure of the measure (Carver & White, 1994) or a 5-factor version consistent with the revised version of Incentive Sensitization Theory (Gray & McNaughton, 2000) in which BIS anxiety and fear are conceptualized independently. Psychometrically plausible models are reviewed below.

Original Four-Factor Model: The original version of the BIS/BAS by Carver & White (1994) was developed in a large sample of college students (N = 732) and comprises 4 subscales: Sensitivity to Punishment [BIS], BAS Reward Responsiveness, BAS Drive, and BAS Fun Seeking. While many studies have relied on a composite of the 3 BAS subscales (i.e., Reward + Drive + Fun Seeking), research suggests that the 3 BAS subscales represent related, yet independent constructs (e.g., Ross, Millis, Bonebright, & Bailley, 2002).

Brief 4-Factor Model: A 17-item brief BIS/BAS (Campbell-Sills et al., 2004) that maintains the latent structure proposed by Carver and White (1994) was derived using data from sample of outpatients (N = 1,825) with anxiety and mood disorders. Subscale reliabilities were acceptable, ranging from .73 to .82. Metric invariance was established for sex, but it is unclear whether scalar invariance was achieved. The model testing scalar invariance resulted in a significant decrement in model fit, but the authors noted that "fit diagnostics revealed no salient localized points of strain in the solution." However, no additional fit indices were provided, making it impossible to evaluate decrement in model fit according to more recent methods (Chen, 2007). As such, it is uncertain whether BIS/BAS scores could be compared meaningfully across sex within this outpatient sample.

Five-Factor Model: Heym and colleagues (2008) conducted a factor analysis of the BIS subscale that produced 2 subscales reflecting fear-mediated BIS and anxiety-mediated BIS. Fear items included "Even if something bad is about to happen to me, I rarely experience fear or nervousness [item 2]," "I have few fears compared to my friends [item 22]," and "If I think something unpleasant is going to happen, I usually get pretty worked up [item 16]." To evaluate this conceptualization of the BIS within the context of the full BIS/BAS, we tested a 5-factor model that specified the 3 original BAS subscales and 2 BIS subscales (i.e., Fear and Anxiety).

The Brief Self-Control Scale—(Tangney et al., 2004; See Table 2 for items).

Original 1-Factor Model: Tangney and colleagues (2004) used EFA to develop a long version (36 items) and a brief version (13 items) of the Self-Control Scale to assess self-control in undergraduates. Both versions use a 5-point rating scale (1 = "not at all" to 5 = "very much") to assess aspects of a single latent factor – Self Control (e.g., self-discipline, deliberate non-impulsive action, healthy habits, self control in the context of work ethic, and reliability). Most studies have used the brief version because it evidences similar psychometrics to the full version (e.g., Cronbach's α full / brief = .89 / .85; three-week test-retest reliability full / brief = .89 / .87).

2-Factor Model: Using EFA and CFA, Maloney and colleagues (2012) demonstrated that the BSCS has two subscales: Impulsivity and Restraint. Importantly, while the factor structure was derived independently within two diverse samples (i.e., working adults and undergraduates), measurement invariance was not evaluated. The 2-factor version of the BSCS evidenced good internal reliability (Impulsivity = .73; Restraint = .72).

DATA ANALYTIC PLAN

Summary of Data Analyses

For each measure, we first used CFA to test whether the original factor structure for each measure and/or any published English-language brief/alternative version(s) was upheld in our data. If no existing factor structure fit our data, we sought to identify a stable latent structure using EFA and, subsequently, CFA techniques. Once a stable structure was identified, we evaluated measurement invariance to determine whether meaningful comparisons could be made across several subgroups of interest (e.g., sex, age, race,). Finally, for all measures in which we were able to demonstrate scalar measurement invariance, we conducted an initial, and preliminary, investigation of test-criterion relationships among the measures as well as with alcohol use and cigarette smoking outcomes.

Evaluating Latent Factor Structure

First, we attempted to replicate the latent factor structures of the BIS-11, the BSCS, and the BIS/BAS using CFA. We evaluated the viability of the latent factor structures associated with the scoring instructions specified for the original, full-length version of each measure as well as for any published brief version(s) within our two datasets, respectively (i.e., TTURC and CTNA, see above for more details). To maximize our statistical power for conducting subsequent analyses in the study, we hoped to create a master dataset that combined the TTURC and CTNA data for the purpose of conducting further psychometric evaluations of any models that evidenced adequate fit in each sample, respectively. Prior to combining these datasets, which differed from one another on a number of characteristics (e.g., participant age, gender, alcohol use patterns, smoking status), it was first necessary to evaluate measurement invariance by dataset to ensure our ability to meaningfully combine all data (see the section titled “Evaluating Measurement Invariance” for details and Table 1 for a depiction of demographic characteristics by sample).

With respect to the initial CFA models, we specified robust maximum likelihood estimation because it is robust to non-normality and produces model fit indices (e.g., CFI, RMSEA). We used Full Information Maximum Likelihood to process missing data. We employed the following criteria to determine adequate model fit: Bentler’s Comparative Fit (CFI; Bentler, 1990) and Tucker Lewis Indices (TLI; Tucker & Lewis, 1973) > .90 (Bentler, 1990), Root Mean Square Error of Approximation (RMSEA) < .07 (Steiger, 2007), and Standardized Root Mean Square Residual (SRMR) < .08 (Hu & Bentler, 1999). We excluded the chi-square statistic because its dependence on sample size makes it a poor choice for evaluating fit in large samples (Chen, 2007).

Establishing a Stable Latent Factor Structure

If we could not confirm the originally proposed factor structure of a measure, we used EFA and CFA to identify a stable latent factor structure. Given that we were working with two distinct datasets, we chose to evaluate the latent structure of the measures using EFA in one sample (TTURC was randomly selected to serve as sample 1) and to attempt to cross-validate any identified structures in the second sample (i.e., CTNA). For all EFA models run within the TTURC dataset, we specified robust maximum likelihood estimation and oblique rotation (i.e., CF-Varimax [oblique]) to account for potential correlations among latent factors in multi-factor models. We then used the following information to determine the most viable solution for each measure: Eigenvalues > 1, scree plots, fit indices, the number of items per scale (i.e., items with factor loadings > .50 and cross-loadings < .32), and solution interpretability (Costello & Osborne, 2005; Jöreskog & Sörbom, 1989). Once we identified a viable EFA model for each measure in the TTURC dataset, we attempted to cross-validate them within the CTNA dataset using the CFA approach outlined in the previous section (i.e., Evaluating Latent Structure”).

Evaluating Measurement Invariance

After identifying a latent structure for each measure that fit the data well, we used multi-group CFA to evaluate measurement invariance, or the extent to which the identified latent structure held up across subgroups of interest (i.e., dataset, sex, age, race [Caucasian versus not], family history of alcoholism, binge drinking status, smoking status, and years of education). Although other statistical methods are available (e.g., Merkle & Zeileis, 2013), prior to conducting MI analyses, we converted continuous variables (i.e., age and years of education) into categorical variables as follows. For age, a categorical variable was created based on terciles (i.e., ≤ 25; 26–39; > 39). For years of education, we split the sample into those who completed high school or less and those who completed further education.

With respect to evaluating MI, we first evaluated configural invariance (i.e., constrained the basic latent structure to equality across groups) to determine whether the same conceptual framework (i.e., number of factors and constituent items) was relevant across groups. Configural invariance was established if the CFA model provided adequate fit to the data based (i.e., CFI and TLI > .90 [Bentler, 1990]; RMSEA < .07 [Steiger, 2007]; and SRMR < .08 [Hu & Bentler, 1999]) and if all items loaded significantly onto their respective factor. If configural invariance was established, we evaluated metric invariance (i.e., constrained factor loadings to invariance across groups) to determine if latent factors related to their constituent items comparably across groups (i.e., magnitude of factor loadings were equivalent). Based on research by Chen (2007), we evaluated metric (and scalar) MI based on changes in RMSEA, CFI, and SRMR fit indices rather than on changes in chi-square values; the dependence of chi-square on sample size makes it a poor choice for evaluating fit in large samples (Chen, 2007) and all of the subsamples of interest in the current study (e.g., male versus female; family history negative versus positive) were larger than 300 [See Table 1]). Metric invariance was established if the change in model fit from the configurally invariant model did not exceed the following statistical cutoffs: RMSEA ≥ .015, CFI ≥ -.01 or SRMR ≥ .030 (Chen, 2007). Finally, if metric invariance was established, we evaluated scalar invariance (i.e., constrained item intercepts to equality) to establish whether mean responses for corresponding items were similar across groups. Scalar invariance was established if the change in model fit from the metric invariant model did not exceed CFI ≥ −.010, accompanied by a change in SRMR ≥ .010 or RMSEA ≥ .015 (Chen 2007). Scalar invariance must be demonstrated for mean-level comparisons across groups to be statistically meaningful (Chen, 2008; Steenkamp & Baumgartner, 1998; Widaman & Reise, 1997). Scalar invariance or partial scalar invariance is a prerequisite for conducting even a simple *t*-test.

Evaluating Internal Consistency of the New Measures

As an index of internal reliability, we calculated Cronbach's alpha (α) for each of the subscales of the new measures. We considered α values ≥ .70 to reflect adequate reliability.

Evaluating Differences in Impulsivity and Self-Control based on Participant Demographics

We conducted multivariate GLM analyses to evaluate the extent to which group membership (in all subgroups for which scalar [or partial scalar] measurement invariance was established) was associated with impulsivity. Separate analyses were run for each measure. Consistent with prior research (e.g., Andrews, Meda, Thomas, Potenza, Krystal, Worhunsky, Stevens et al., 2011; Cross, Copping, & Campbell, 2011; Leeman & Potenza, 2012), we hypothesized that highly impulsive individuals and those with poor self-control would be more likely to be male, younger, family history positive, heavier drinkers, and to smoke cigarettes than their less impulsive counterparts.

Evaluating Relationships between the BIS, BIS/BAS, and BSCS Test Scores

As evidence of the convergence/divergence of the proposed interpretation of test scores for the BIS, BIS/BAS, and BSCS we conducted bivariate correlations to look at relationships among these measures. We hypothesized that subscales reflecting impulsivity would significantly correlate 1) positively with one another and 2) negatively with self-control.

Evaluating Relationships between Self-Reported Impulsivity and Substance Use Outcomes

For each measure, we used univariate GLM analyses to evaluate preliminary test-criterion relationships with respect to two cross-sectional alcohol outcomes: maximum number of drinks consumed in a single day (i.e., max drinks lifetime) and the experience of alcohol-related problems. We chose these outcomes given their high relevance to and correspondence with alcohol use disorders (Saccone et al., 2000). We employed logistic regression to evaluate relationships between the impulsivity measures and smoking status (i.e., current smoker / non-smoker). We included several model covariates to determine the contribution of impulsivity to each outcome over and above known influences: dataset, race, family history of alcoholism, sex, age, education, cigarette smoking status (alcohol models only), binge drinking status (smoking models only), and typical drinks per drinking day (alcohol-related problems models only).

RESULTS

Sample Demographics

Using a Bonferroni corrected alpha value of .005 (.05/10), The TTURC and CTNA samples significantly differed on all demographic variables assessed with the exception of race (Table 1). The differences between samples supported our initial decision to run all factor analytic models independently by sample and the need to evaluation measurement invariance by sample prior to conducting further analyses.

Evaluating Latent Factor Structure

Table 3 reports fit indices for models evaluating the original and alternative published factor structures of the BIS-11, BIS/BAS, and BSCS. Acceptable fit was defined as: CFI and TLI > .90 (Bentler, 1990), RMSEA < .07 (Steiger, 2007), and SRMR < .08 (Hu & Bentler, 1999).

Models Evaluating the Originally Proposed Factor Structure of Each Measure—Across measures, the CFA models in which the original latent factor structures were specified did not fit our data. For example, the model testing the fit of the original version of the BIS-11 in which three higher order factors (i.e., attentional, motor, and non-planning impulsivity) comprise six first order factors fit the data poorly in both samples: TTURC / CTNA RMSEA = .091 / .087; CFI = .548 / .570; TLI = .511 / .535; and SRMR = .108 / .096.

Models Evaluating Published Versions of the BIS-11, the BSCS, and the BIS/BAS with Alternative Factor Structures—We first evaluated the 13-item 2-factor structure of the BIS-11 proposed by Reise and colleagues (2013) (i.e., Cognitive Impulsivity and Behavioral Impulsivity). As outlined by Reise et al (2013), we combined items into 6 parcels prior to running the CFA to account for the synonymous nature of many of the items. We created parcels by taking the mean of the relevant items. The resulting model fit poorly across samples (TTURC / CNTA RMSEA = .091 / .099; CFI = .937 / .929; TLI = .888 / .867; SRMR = .040 / .042).

We next tested the single factor structure for the Brief BIS proposed by Steinberg and colleagues (2012). The model did not fit the data in either sample.

For the BIS/BAS, we evaluated a 17-item, 4-factor brief version of the BIS/BAS proposed by Campbell-Sills et al (2004) that did not fit the data (TTURC / CTNA RMSEA = .071 / .077, CFI = .834 / .827; TLI = .830 / .792; SRMR = .079 / .081). We also tested a 5-factor model in which BIS Fear was treated distinctly from BIS Anxiety on the basis of research conducted by Heym and colleagues (2008). The model did not fit the data adequately (TTURC / CTNA RMSEA = .069 / .072; CFI = .830 / .823; TLI = .798 / .790; SRMR = .074 / .076).

With respect to the BSCS, we evaluated the 8-item, 2-factor structure proposed by Maloney and colleagues (2012). The model did not fit the data well (TTURC / CTNA RMSEA = .064 / .097, CFI = .926 / .898; TLI = .891 / .849, SRMR = .043 / .047)[1].

Establishing a Stable Latent Factor Structure for the BIS, BIS/BAS and the BSCS—For the BIS, we ran an EFA model within the TTURC dataset. A subscale must contain at least 3 items to be considered psychometrically stable and to permit estimation of latent variables (Joreskog & Sorbom, 1989; Levitt, Sher, & Bartholow, 2009). Based on this criterion and the number of items on the BIS (i.e., 30), the BIS could comprise no more than 10 stable subscales. As such, we permitted EFA to extract up to 10 factors. The following information was used to determine the most viable solution for each measure: Eigenvalues > 1, scree plots, fit indices, the number of items per scale (i.e., items with factor loadings > .50 and cross-loadings < .32), and solution interpretability (Costello & Osborne, 2005; Jöreskog & Sörbom, 1989). Of the possible solutions, a 2-factor solution (9 items) seemed most promising. We labeled the two latent factors “Poor Self-Regulation” and “Impulsive Behavior.” Examples of (reverse scored) items on the “Poor Self-Regulation” factor included, “I am self-controlled” and “I plan tasks carefully,” and examples items on the “Impulsive Behavior” factor include, “I act on the spur of the moment” and “I say things without thinking.” Using CFA, we attempted to cross-validate the model to the CTNA dataset, but model fit was inadequate (RMSEA = .101; CFI = .873; TLI = .824; SRMR = .060). A large modification index was observed between items 17 (“I act on “impulse”) and 19 (I act on the spur of the moment; MI = 174.25). Modification indices were also observed between item 17 and items 2, 5, and 19. As such, we eliminated item 17 and reran the CFA. The revised model fit the data well, (RMSEA = .057, CFI = .960, TLI = .941, SRMR = .

[1]Although the 2-factor model specified by Maloney et al. (2012) did not fit our data well for either the TTURC or CTNA samples, the 2-factor model specified by Maloney et al., (2012) evidenced adequate model fit within the full sample (RMSEA = .064, CFI = .937, TLI = .908, SRMR = .037). As such, we conducted measurement invariance analyses to evaluate whether the structure was invariant across each of the subgroups of interest (e.g., sex, race). Scalar invariance was achieved for family history status only. In light of the full set of analyses, we decided to proceed with EFA analyses to determine if a more reliable structure could be identified.

038), and all items significantly loaded on their respective factors (loadings > .50; See Table 4). Interestingly, the 8 items that were retained mirror the items identified by Steinberg and colleagues (2013).

For the BIS/BAS (20 items), we ran an EFA model that permitted extraction of up to 6 factors. Of the possible solutions, a 13 item, 4-factor solution was most promising (see Table 4), and we successfully cross-validated this model within the CTNA dataset (RMSEA = .042; CFI = .957; TLI = .943; SRMR = .046). The 4 factors of our novel, brief version conceptually mirrored those specified within the original model (i.e., Drive, Fun, Reward, and Behavioral Inhibition).

For the BSCS, we ran an EFA model that permitted extraction of 1 to 4 factors. Across the possible solutions, the most viable was a 7-item, 2-factor model with latent factors corresponding to "Impulse Control" and "Self-Discipline" (see Table 4). When we fit this model to the CTNA data using a CFA framework, we successfully cross-validated the 7-item, 2-factor structure (RMSEA = .010; CFI = .999; TLI = .989; SRMR = .022). Particularly reassuring, our factor "Impulse Control" was identical to that observed by Maloney and colleagues (2012). However, only 2 items (out of 3) on our factor "Self-Discipline" overlapped with the four items that made up the "Restraint" factor described by Maloney and colleagues (2012).

Summary of the Analyses of Latent Factor Structure—For the BIS-11, we identified a novel, brief version in which the 8 items proposed by Steinberg and colleagues (2012) formed 2 factors (i.e., Poor Self-Regulation and Impulsive Behavior). For the BIS/BAS, we identified a novel 13-item, 4-factor version that retained the same conceptual structure as the original measure (i.e., Drive, Fun, Reward, and Behavioral Inhibition). Finally, for the BSCS, a novel, 2-factor solution that was conceptually similar to that proposed by Maloney et al., (2012) fit the data well (i.e., Self-Discipline and Impulse Control). At this point, all prerequisites for evaluating measurement invariance of the brief versions of the BIS, BSCS, and BIS/BAS had been met.

Evaluating Measurement Invariance

As mentioned previously, there was considerable variability between the TTURC and CTNA datasets (e.g., sex, race, family history status). To determine whether invariance analyses for the broad range of demographic characteristics of interest could be conducted using data from the combined TTURC and CTNA samples, we first conducted analyses to determine if self-reported impulsivity was invariant across the datasets. We ran separate models testing configural, metric and scalar measurement invariance for the BIS, BSCS, and the BIS/BAS (Table 5). As an example of how we ran invariance analyses for each measure, we present detailed results of the models testing invariance for the 8-item, 2-factor Brief BIS below.

Configural invariance of the Brief BIS—To evaluate configural invariance, we specified a 2-group CFA model in Mplus in which we simultaneously fit the 8-item, 2-factor Brief BIS to the TTURC and CTNA data. We specified maximum likelihood estimation with robust standard errors and chi-squares. We set the loadings of the factor metrics (i.e., the highest loading items for each factor) to 1.0 and the factor means to zero. Remaining model parameters (e.g., factor loadings, intercepts, variances) were estimated freely. The resulting model evidenced good fit (RMSEA = .059; CFI = .956; TLI = .935; SRMR = .039) and all items significantly loaded onto their respective factors within both datasets, indicating the configural invariance had been achieved. As expected, the latent factors "Poor Self-Regulation" and "Impulsive Behavior" were correlated significantly (r = .50 [TTURC] and r = .65 [CTNA]), but the magnitudes of these correlations did not indicate multi-collinearity (r > .80 Meyers, Gamst, & Guarino, 2006). Model fit for the configurally invariant model served as the benchmark against which we compared the fit of the model testing metric invariance.

Metric invariance of the Brief BIS—To evaluate metric invariance, we constrained item factor loadings to equality across the two datasets and set the latent factor means to zero. A series of statistical cutoffs established by Chen (2007) indicate that non-invariance exists in cases in which the decrement in model fit between the model testing metric invariance and the configurally invariant model exceeds RMSEA ≥ .015, CFI ≥ −.01 or SRMR ≥ .030. Based on these criteria, the resulting model (RMSEA = .053; CFI = .958; TLI = .947; SRMR = .042) did not evidence significant decrement in fit when compared to the configurally invariant model (Δ RMSEA = −.006, Δ CFI = .002, Δ TLI = .012, and Δ SRMR = .003). Thus, individual items related to their respective latent factors similarly within the TTURC and CTNA datasets.

Scalar invariance of the Brief BIS—To test scalar invariance, we constrained factor loadings and item intercepts (item means) to equality while allowing the latent factor means to be estimated freely. Chen (2007) suggested unique change in fit indices for models evaluating scalar invariance, with decrement in model fit between the model testing scalar invariance and the metric invariant model of CFI ≥ −.010 accompanied by a change in SRMR ≥ .010 or RMSEA ≥ .015 indicating variance. Based on these cutoffs, the resulting model (RMSEA = .057; CFI = .950; TLI = .940; SRMR = .043) did not evidence significant decrement in fit compared to the metric invariant model (Δ RMSEA = .004; Δ CFI = −.008; Δ TLI = −.007, Δ SRMR = .001).

A Summary of All Remaining Measurement Invariance Analyses—We demonstrated scalar invariance of the brief BSCS and the brief BIS/BAS in the TTURC and CTNA datasets. As such, we ran all subsequent models evaluating measurement invariance of impulsivity by sex, age, race, family history status, binge drinking status, cigarette smoking status, and education within the combined dataset. We demonstrated scalar invariance for each measure across all subgroups of interest with the exception of the BSCS by age and years of education (See Table 5). For both models, we identified 2 biased items: "Pleasure and fun sometimes keep me from getting work done" (item 9 from "Impulse Control") and "I am able to work effectively toward long term goals" (item 11 from "Self Discipline"). We specified two new models evaluating partial scalar invariance by age and education status in which group-specific intercepts were estimated for items 9 and 11. Neither model evidenced significant decrement in fit from the metric invariant models, thus demonstrating partial scalar invariance by age and education status. Although establishing full scalar invariance is preferable, partial scalar invariance also allows for mean differences to be compared meaningfully (e.g., Steenkamp & Baumgartner, 1998).

Evidence for the Internal Consistency of the New Measures

Within the total sample, we calculated Cronbach's alpha as an index of internal reliability for each of the subscales of the new brief measures. The subscales of the brief BIS-11 and the BSCS were reliable (Brief BIS-11 α (lack of) Self-Regulation = .75; α Impulsive Behavior = .72; BSCS Self-Discipline α = .70; Impulse Control α =.75). For the BIS/BAS, Drive (α = .77), Fun Seeking (α = .70), and Behavioral Inhibition (α =.73) were reliable. The Reward Responsiveness subscale was less consistent (α =.60). However, alpha was not improved by removing any of the three items in the Reward Responsiveness subscale, suggesting the items should be retained.

Evaluating Differences in Impulsivity and Self-Control based on Participant Demographics

For each measure, we conducted multivariate GLM analyses to evaluate the extent to which group membership (e.g., sex, age, race, education, family history, binge drinking, smoking) influenced self-reported impulsivity (Table 6). Demographic variables accounted for significant variance in each measure. Where significant findings emerged, membership in at-risk groups (i.e., males, youth, family history positive individuals, binge drinkers, smokers; subscale means are not depicted) was associated with higher levels of impulsivity, reduced behavioral inhibition, and lower levels of self-control (means not depicted). For race, non-white individuals reported stronger BIS/BAS Drive and Reward Sensitivity than their white counterparts.

Evaluating Relationships between the BIS, BIS/BAS, and BSCS Test Scores

The direction of the relationships among the subscales of the new measures was largely as expected (see Table 7). Brief BIS Poor Self-Regulation scores were 1) modestly positively correlated with Brief BIS/BAS Fun Seeking and Inhibition, 2) modestly negatively correlated with Brief BIS/BAS Reward, and 3) strongly negatively correlated with Brief BSCS Impulse Control and Self-Discipline. Brief BIS Impulsive Behavior scores were 1) modestly positively correlated with Brief BIS/BAS Drive and Inhibition, 2) strongly positively correlated with Brief BIS/BAS Fun Seeking, and 3) strongly negatively correlated with Brief BSCS Impulse Control and Self-Discipline. Brief BSCS Impulse Control scores were 1) modestly negatively correlated with Brief BIS/BAS Drive and Inhibition and 2) strongly negatively correlated with Brief BIS/BAS Fun Seeking. Brief BSCS Self-Discipline scores were 1) modestly negatively correlated with Brief BIS/BAS Drive and Inhibition and 2) modestly positively correlated with Brief BIS/BAS Drive and Reward.

Evaluating Relationships between Self-Reported Impulsivity and Substance Use Outcomes

For each impulsivity measure, we used univariate GLM analyses to evaluate concurrent validity with respect to two alcohol-related outcomes: 1) lifetime maximum number of drinks consumed in a single day (i.e., max drinks), and 2) the experience of alcohol-related problems (i.e., problems). In the model for problems, we controlled for participants' typical drinking behavior (i.e., average number of drinks consumed per drinking day) to ensure that problems were not simply a proxy for heavy drinking. We used logistic regression to evaluate relationships between impulsivity and current smoking status.

Models Evaluating Associations with Alcohol Use Behavior

Demographic Covariates—Across univariate GLM models, age and education status were not associated with drinking outcomes (see Table 8). CTNA participants, males, and smokers consumed more alcohol (max drinks) and experienced more problems across impulsivity models. In the two models examining the BSCS and the BIS/BAS as predictors of max drinks, white and black participants, respectively, drank more than participants of "other" racial backgrounds (p-values < .05). However, in the model examining the BSCS as a predictor of problems, black participants experienced more problems than white participants (p = .036). Finally, in all models predicting problems, a family history of alcoholism and heavier typical alcohol consumption (i.e., drinks consumed per drinking day) was associated with experiencing more problems.

New Brief BIS—Poor Self-Regulation was associated with consuming a larger number of max drinks ($\eta p = .01$, $p = .010$) and experiencing more problems ($\eta_p^2 = .04$, $p < .001$). BIS Impulsive Behavior also was associated with experiencing more problems ($\eta_p^2 = .01$; $p = .010$).

New Brief BIS/BAS—Stronger Fun-Seeking was associated with consuming a larger number of max drinks ($\eta p = .01$, $p = .007$) and experiencing more problems ($\eta p = .03$, $p < .001$). Weaker Behavioral Inhibition was associated with more problems ($\eta_p^2 = .01$; $p = .006$).

New Brief BSCS—Weaker Self-Discipline was associated with consuming a larger number of max drinks ($\eta p = .01$, $p = .011$) and experiencing more problems ($\eta p = .01$, $p < .010$). Weaker Impulse Control was associated with experiencing more problems ($\eta_p = .13$; $p < .001$).

Models Evaluating Associations with Cigarette Smoking Status

Demographic Covariates—Across logistic regression models, race and family history of alcoholism status were not associated with smoking status (Table 9). TTURC participants, those who were older (i.e., 25–39, >39 years), those with fewer years of education (i.e., high school diploma or less), and binge drinkers were more likely to smoke. In the model examining the Brief BIS as a predictor of smoking, being female was associated with greater odds of smoking.

New Brief BIS—The model accounted for 57% of the variance in smoking status, with 87.8% of smokers and 78.4% of non-smokers categorized correctly. Experiencing poorer Self-Regulation was associated with increased odds of smoking cigarettes (OR = 1.09, $p = .031$).

New Brief BIS/BAS—The model accounted for 57% of the variance in smoking status, with 87.8% of smokers and 78.9% of non-smokers categorized correctly. Experiencing stronger Fun-Seeking (OR = 1.13, *p* = .047) and weaker Behavioral Inhibition (OR = 1.10, *p* = .044) was associated with increased odds of smoking.

New Brief BSCS—The model accounted for 55% of the variance in smoking status, with 86.1% of smokers and 76.8% of non-smokers categorized correctly. Experiencing both poorer Self-Discipline (OR = 1.06, *p* = .038) and Impulse Control (OR = 1.10, *p* = .035) was associated with increased odds of smoking.

DISCUSSION

The ability to make valid scientific inferences from research data is inextricably linked to measurement quality. Building evidence for the validity and reliability of a proposed interpretation of test scores is a tiered process; evidence for more “basic” psychometrics (e.g., a stable latent structure, measurement invariance, internal consistency) must be in place in order for more advanced psychometric evaluations (e.g., test-criterion validity) to be meaningful. To address the fact that self-report measures of impulsivity generally lack the most basic level of psychometric support, we conducted a state-of-the-art psychometric evaluation of three widely used but poorly validated self-report impulsivity measures. Results provided strong evidence for the utility of brief, psychometrically refined versions of the BIS-11, the BIS/BAS, and the BSCS. We discuss the contributions and limitations of the proposed interpretations of test scores as well as recommendations for their use below.

A Summary of Evidence for the Psychometric Stability of the Proposed Interpretations of Test Scores

Given that we were unable to replicate any previously proposed latent factor structures for the BIS, BIS/BAS, or the BSCS, we used EFA and CFA to identify psychometrically stable latent structures for each measure (i.e., The Brief BIS [8-items; 2 factors]; The Brief BIS/BAS [13 items; 4 factors]; the Brief BSCS [7 items; 2 factors]). All subscales were internally consistent with the exception of BIS/BAS Reward Responsiveness (alpha = .60), although the relatively low coefficient may be due to the small number of items (Sijtsma, 2009). Further, establishing MI for each of the new measures *ensured* our ability to compare aspects of impulsivity across multiple subgroups of interest with a sufficient degree of statistical confidence for the first time. Consistent with our hypotheses and with past research, membership in historically at-risk groups (e.g., males, smokers) was associated with higher levels of impulsivity, poor self-control, and reduced behavioral inhibition. Correlations among the novel proposed interpreations of test scores for each measure provided evidence of convergence and divergence as expected. Providing further evidence of test-criterion relationships, the novel proposed interpretations of test scores accounted for significant variance in substance use outcomes including heavy alcohol use (i.e., BIS Poor Self-Regulation, BIS/BAS Fun Seeking, BSCS Self-Discipline) and alcohol-related problems (i.e., BIS Impulsive Behavior and Poor Self-Regulation; BIS/BAS Fun Seeking and Inhibition; BSCS Impulse Control and Self Discipline). A similar pattern was observed for smoking, suggesting that smoking risk is also linked to cognitive and behavioral forms of impulsivity.

Limitations

The study findings must be considered in light of its limitations. First, our psychometric evaluation was limited to three widely used self-report impulsivity measures (i.e., BIS, the BIS/BAS, and the BSCS). As such, it is impossible to speak to the psychometric properties of other self-report measures that have gained prominence, including the UPPS Impulsive Behavior Scale (Whiteside & Lynam, 2001; Cyders, Smith, Spillane, Fischer, & Annus, 2007). We began collection of the data reported in the current study prior to publication of the UPPS. In our later work, we retained the same measures of impulsivity for purposes of continuity with this prior work. Second, although the current study provides solid evidence for the fundamental psychometric properties of the brief measures (e.g., latent structure, MI) and preliminary evidence for cross-sectional test-criterion relationships, further studies are needed to build evidence for additional aspects of reliability and validity (e.g., predictive validity; convergent/discriminant relationships with other measures). Third, differential item coding (i.e., reverse versus typical coding) may have contributed to the latent structures that were identified in the current study, a concern that has been raised by others in the field (e.g., Johnson et al., 2003; Reise et al., 2013). For example, the Brief BIS Poor Self-Regulation subscale comprises all reversed coded items and the Impulsive Behavior subscale comprises typically scored items. This alternative explanation of our findings cautions against including reverse coded items in the development of new measures. Finally, we identified the novel, latent factor structures for the BIS, BIS/BAS, and BSCS within two datasets that are not representative of the general population (i.e., one composed largely of individuals seeking smoking cessation treatment and one composed of non-treatment seeking drinkers who voluntarily participated in alcohol-related research). Although it is not clear the extent to which the current proposed interpretations of test scores will generalize to other samples, confidence in our findings is bolstered considerably by the demonstration of MI across a number of subgroups.

In spite of these limitations, the current study provides strong statistical evidence for the utility of the novel, brief versions of the BIS, BIS/BAS, and BSCS. When considering the psychometric evaluations of these measures in concert, the abbreviated versions of the BIS, BIS/BAS, and BSCS represent psychometrically enhanced alternatives to previously published versions of these measures. Their use may enhance researchers' abilities to detect interesting and clinically meaningful relationships involving these measures.

Recommendations for Use and Future Research

Based on our pattern of results, we make the following recommendations for future studies of impulsivity using the BIS, BIS/BAS, or BSCS: 1) The interpretations of test scores that we have proposed for the brief BIS, BIS/BAS, and BSCS represent clear psychometric improvements to prior interpretations *in our data*; previously proposed interpretations of test scores were not supported. Our ability to demonstrate replicable factor structures and scalar measurement invariance for the proposed interpretation of test scores for each measure across a number of subgroups is a significant strength and makes it more likely that the proposed interpretations will be replicable in new samples. We nonetheless encourage researchers to explicitly evaluate the fit of our proposed interpretations to their own data (as well as the fit of any other measures they intend to use) prior to conducting statistical analyses to ensure that any conclusions drawn from their analyses are valid. 2) The solid psychometric properties of the brief BIS, BIS/BAS, and BSCS suggest that each of these measures is suitable for inclusion in new research projects, and researchers are encouraged to select the measure or measures that best suit their research question. Among other potential benefits, the use of these brief measures would reduce participant burden. However, researchers should keep in mind when deciding on a course of action that a number of concerns have been raised about measures like the BIS and BIS/BAS (e.g., dated item content with poor current relevance, reverse scored items). When considered in this context, the proposed interpretations may be best conceptualized as an alternative scoring rubric that may be most helpful for analyzing data that have already been collected. 3) We acknowledge the potential criticism that the current study introduces yet another novel set of interpretations of test scores for the BIS, BIS/BAS, and BSCS into a literature that is replete with many different interpretations. After all, the large number of previously published interpretations (suggesting failure of configural measurement invariance) served as the impetus for the current study. Although the interpretations we have proposed represent psychometric improvements to prior interpretations, due primarily to the establishment of measurement invariance, we are limited by our data with respect to the ability to evaluate their efficacy across a wide range of samples. Thus, we propose the creation of a data repository. If data from (all) previous trials were available, it would be possible to conduct a very comprehensive psychometric evaluation of these measures in which a latent factor structure could be identified and measurement invariance could be tested across a wide range of populations (e.g., undergraduates, children, mentally ill forensic inpatients, outpatients with mood and anxiety disorders, substance users, etc.). Conducting such an investigation would help to identify the most psychometrically stable interpretation of test scores for each measure and would help to facilitate comparisons of the facets of impulsivity across studies. 4) We encourage researchers to develop new psychometrically sound measures of impulsivity that build upon our findings while addressing the limitations of previously developed measures (e.g., redundant items, dated content, reverse scoring). 5) In the meantime, we encourage researchers to use the psychometrically sound, novel proposed interpretations of test scores for the brief BIS, BIS/BAS, and BSCS outlined in the current study.

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Table 1

Demographic Characteristics by Sample

	TTURC (*n* = 781)	**CTNA (*n* = 656)**	**TOTAL SAMPLE (N = 1437)**
Gender (# Male)***	344	390	734
Age (mean [std. dev])***	35.62 (11.93)	30.94 (10.68)	33.56 (11.62)
Categorical Age (# ≤ 25; 25–39; > 39)***	218; 253; 310	272; 198; 143	490; 451; 453
Race (# Caucasian)	523	495	1018
Education (# > High School)***	376	510	886
Family History Status (# FH Positive)***	381	230	611
Current Smoking Status (# Smokers)***	631	148	779
Binge Drinking Status (# Binge Drinkers)***	512	317	829
Maximum Drinks in 1 Day (Lifetime)***	5.73 (2.47)	7.15 (1.90)	6.29 (2.36)
Alcohol-Related Problems (Past Year)***	2.69 (5.64)	8.17 (9.76)	4.82 (7.98)

Note. Significant differences across datasets noted as:

*** $p < .001$

Table 2

Items Associated with the Original and Alternative Versions of the Barratt Impulsiveness Scale, the Behavioral Inhibition and Activation Scales and the Brief Self-Control Scale

	Barratt Impulsiveness Scale	Behavioral Inhibition and Activation Scales	Brief Self-Control Scale
1	**I plan tasks carefully.***[1a; 2a; 3; 4a; 5a; 6b]	A person's family is the most important thing in life.	**I am good at resisting temptation**.[1b; 2a; 3b]
2	**I do things without thinking**.[1b; 2b; 3; 4b; 5b]	Even if something bad is about to happen to me, I rarely experience fear or nervousness.* .[2d; 4e]	I have a hard time breaking bad habits.*.[2a; 3b]
3	I make-up my mind quickly.[2b]	**I go out of my way to get things I want**.[1a, 2a; 3a; 4a]	I am lazy.[2a]
4	I am happy-go-lucky.[4a; 2b]	**When I'm doing well at something I love to keep at it**.[1b, 2b; 4b]	I say inappropriate things.*.[2a]
5	**I don't pay attention**.[1a; 2c; 3; 5c]	I'm always willing to try something new if I think it will be fun.[2c; 3c; 4c]	**I do certain things that are bad for me, if they are fun**.[1a; 2a; 3a]
6	I have “racing” thoughts.[2c; 4b; 6a]	How I dress is important to me.	I refuse things that are bad for me.[2a]
7	I plan trips well ahead of time.*.[2a; 4a; 6b]	**When I get something I want, I feel excited and energized**.[1b, 2b; 4b]	I wish I had more self-discipline.*.[2a; 3b]
8	**I am self controlled**.*.[1a; 2a; 3; 4a; 6b]	**Criticism or scolding hurts me quite a bit**.[1d, 2d, 3d; 4d]	**People would say that I have iron self-discipline**.[1b; 2a; 3b]
9	**I concentrate easily***.[1a; 2c; 3; 4a; 5c; 6b]	**When I want something I usually go all-out to get it**.[1a; 2a; 3a; 4a]	**Pleasure and fun sometimes keep me from getting work done***.[1a; 2a; 3a]
10	I save regularly.*.[2a; 4a; 5a]	**I will often do things for no other reason than that they might be fun**.[1c, 2c, 3c; 4c]	I have trouble concentrating.*.[2a]
11	I “squirm” at plays or lectures.[2c; 4b; 5c]	It's hard for me to find the time to do things such as get a haircut.	**I am able to work effectively toward long-term goals**.[1b; 2a]
12	**I am a careful thinker***.[1a; 2a; 3; 4a; 5a; 6b]	**If I see a chance to get something I want I move on it right away**.[1a; 2a; 3a; 4a]	**Sometimes I can't stop myself from doing something, even if I know it is wrong**.*.[1a; 2a; 3a]
13	I plan for job security.*.[2a; 4a; 5a]	**I feel pretty worried or upset when I think or know somebody is angry at me**.[1d, 2d, 3d; 4d]	**I often act without thinking through all the alternatives**.*.[1a; 2a; 3a]
14	**I say things without thinking**.[1b; 2a; 3; 4b; 5b]	When I see an opportunity for something I like I get excited right away.	
15	I like to think about complex problems.*.[2a;4a]	**I often act on the spur of the moment**.[1c, 2c, 3c; 4c]	
16	I change jobs.[2b]	**If I think something unpleasant is going to happen I usually get pretty worked up**.[1d, 2d, 3d; 4e]	
17	I act “on impulse.”.[2b; 4b; 5b; 6a]	I often wonder why people act the way they do.	
18	I get easily bored when solving thought problems.[2a; 4b; 5c]	When good things happen to me, it affects me strongly.[2b; 4b]	
19	**I act on the spur of the moment**.[1b; 2b; 3; 4b; 5b; 6a]	I feel worried when I think I have done poorly at something important.[2d, 3d; 4d]	
20	I am a steady thinker.*.[2c; 4a; 6a; 6b]	**I crave excitement and new sensations**.[1c, 2c, 3c; 4c]	

	Barratt Impulsiveness Scale	Behavioral Inhibition and Activation Scales	Brief Self-Control Scale
21	I change residences.[2b; 4b; 6a]	When I go after something I use a "no holds barred" approach.[2a; 3a; 4a]	
22	I buy things on impulse.[2b; 4b; 5b]	I have very few fears compared to my friends.* .[2d ; 3d; 4e]	
23	I can only think about one thing at a time.[2b]	**It would excite me to win a contest**.[1b, 2b; 4b]	
24	I change hobbies.[2c; 6a]	**I worry about making mistakes**.[1d, 2d, 3d; 4d]	
25	I spend or charge more than I earn.[2b; 4b]		
26	I often have extraneous thoughts when thinking.[2c; 4b]		
27	I am more interested in the present than the future.[2a]		
28	I am restless at the theater or lectures.[2c; 4b; 5c]		
29	I like puzzles.*.[2a; 4a]		
30	I am future oriented.*.[2b; 4a; 5a]		

*Note***Bolded** items are included in the new, brief versions of the BIS-11, the BIS/BAS, and the BSCS.

*denotes reverse scored items.

Superscript text denotes the following: New Brief Barratt Impulsiveness Scale (1a = Self-Control, 1b = Impulsive Behavior); Original 3-factor BIS-11 (Patton et al., 1995, 2a = Nonplanning, 2b = Motor, 2c = Attention); 1-factor Brief BIS (Steinberg et al., 2012; all items = 3); 12-item, 2-factor Brief BIS (Haden & Shiva, 2008; 2009; 4a = Non-Planning and 4b = Motor Impulsivity); 15-item, 3-factor Brief BIS (Spinella, 2007; 5a = Non-Planning, 5b = Motor, 5c =Attetion = 5c); 13-item 2-factor Brief BIS (Reise et al., 2013; 6a = Behavioral Impulsivity, 6b = Cognitive Impulsivity); New Brief Behavioral Inhibition and Activation Scales (1a = Drive, 1b = Reward Responsiveness, 1c = Fun Seeking, 1d = Behavioral Inhibition); Original Version (Carver & White, 1994; 2a = Drive, 2b = Reward Responsiveness, 2c = Fun Seeking, 2d = Behavioral Inhibition); Brief version (Campbell-Sills et al., 2004; 3a = Drive, 3b = Reward Responsiveness, 3c = Fun Seeking, 3d = Behavioral Inhibition); Five Factor Version (Heym et al., 2003; 4a = Drive, 4b = Reward Responsiveness, 4c = Fun Seeking, 4d = Behavioral Inhibition Anxiety; 4e = Behavioral Inhibition Fear); New Brief Self Control Scale (1a = Impulse Control, 1b =Self Discipline); Original Brief Self Control Scale (Tangney et al., 2004; 2a = Self-Control); 8-item Brief Self Control Scale (Maloney et al., 2012; 3a = Impulse Control, 3b = Self Discipline).

Table 3

Model Fit of the Original, Alternative Published Versions, and New Versions of the Barrett Impulsivity Scale, the Behavioral Inhibition and Activation Scales, and the Brief Self Control Scale

	DATASET 1 (TTURC)				DATASET 2 (CTNA)			
VERSIONS OF THE BIS-11	**RMSEA**	**CFI**	**TLI**	**SRMR**	**RMSEA**	**CFI**	**TLI**	**SRMR**
Original Version (Patton et al., 1995) 30 items; six 1st order subscales and three 2nd order subscales	.087	.590	.549	.107	.081	.638	.602	.092
Original Version (Patton et al., 1995) 30 items; 3 subscales	.091	.548	.511	.108	.087	.570	.535	.096
Brief Version (Spinella, 2007) 15 items; 3 subscales	.098	.782	.737	.095	.088	.813	.774	.104
Brief Version (Haden & Shiva, 2008; 2009) 24 items; 2 subscales	.084	.716	.688	**.076**	.087	.683	.651	.082
Brief Version (Reise et al., 2013) 13 items; 2 subscales	.091	**.937**	.988	**.040**	.099	**.929**	.867	**.042**
Brief Version (Steinberg et al., 2012) 8 items; 1 subscale	.159	.676	.547	.088	.107	.838	.773	**.064**
NEW Brief Version of the BIS 8 items; 2 subscales	**.041**	**.980**	**.969**	**.030**	**.055**	**.962**	**.941**	**.039**
VERSIONS OF THE BIS/BAS								
Original Version (Carver & White, 1994) 20 items; 4 subscales	.070	.823	.795	**.079**	.072	.817	.788	**.079**
2 Factor Version (consistent with Gray IST, 1987) 20 items; 2 factors	.084	.731	.698	**.079**	.077	.827	.792	.081
5 Factor Version 2 (Heym, 2008) 20 items, 5 subscales	**.069**	.830	.798	**.074**	.072	.823	.790	**.076**
Brief Version (Campbell-Sills et al., 2004) 17 items; 4 subscales	.071	.834	.830	**.079**	.077	.827	.792	.081
NEW Brief Version of the BIS/BAS 13 items, 4 subscales	***.053***	***.927***	*.880*	***.033***	**.042**	**.957**	**.943**	**.046**
VERSIONS OF THE BSCS								
Original Version (Tangney et al., 2004) 13 items; 1 subscale	.089	.754	.704	**.069**	.101	.795	.754	**.066**
Brief Version (Maloney, 2012) 8 items; 2 subscales	**.064**	**.926**	.891	**.043**	.097	.898	.849	**.047**
NEW Brief Version of the BSCS 7 items, 2 subscales	***.076***	*.853*	*.884*	***.045***	**.011**	**.999**	**.989**	**.022**

Note. Abbreviations are: BIS-11 (Barratt Impulsiveness Scale, version 11); BIS/BAS (Behavioral Inhibition and Activation Scales); BSCS (Brief Self-Control Scale; RMSEA (Root Mean Square Error of Approximation); CFI (Bentler's Comparative Fit Index); TLI (Tucker Lewis Index); SRMR (Standardized Root Mean Square Residual). *Italicized* fit indices indicate model fit associated with exploratory factor analysis. **Bolded** model fit indices indicate acceptable model fit based on the following recommendations: CFI & TLI > .90 (Bentler, 1990), RMSEA < .07 (Steiger, 2007), and SRMR) < .08 (Hu & Bentler, 1999).

Table 4

Latent Factor Structure and Item Loading of the New Brief Versions of the Barrett Impulsivity Scale, the Behavioral Inhibition and Activation Scales, and the Brief Self-Control Scale

	DATASET 1 (TTU RC)				DATASET 2 (CTN A)			
NEW BRIEF BIS-11 ITEMS								
	Poor Self-	*Impulsive Behavior*			Poor Self-	Impulsive Behavior		
I plan tasks carefully. (1)	.60				.62			
I am self-controlled. (8)	.71				.66			
I concentrate easily. (9)	.65				.67			
I am a careful thinker. (12)	.70				.65			
I do things without thinking. (2)		.82				.73		
I don't pay attention. (5)		.55				.53		
I say things without thinking. (14)		.63				.54		
I act on the spur of the moment. (19)		.58				.60		
NEW BRIEF BIS/BAS ITEMS								
	Inhibition	*Driv*	*Fu*	*Rewar*	Inhibition	Driv	Fu	Rewar
Criticism or scolding hurts me quite a bit. (8)	*.54*				.72			
I feel pretty worried or upset when I think or known someone is angry at	*.70*				.75			
If I think something unpleasant is going to happen I usually get worked	*.64*				.61			
I worry about making mistakes. (24)	*.65*				.41			
I go out of my way to get things I want. (3)		*.58*				.73		
When I want something I usually go all-out to get it. (9)		*.90*				.77		
If I see a chance to get something I want, I move on it right away. (12)		*.53*				.69		
I will often do things for no other reason than that they might be fun. (10)			*.60*				.63	
I often act on the spur of the moment. (15)			*.69*				.71	
I crave excitement and new sensations. (20)			*.61*				.64	
When I'm doing well at something I love to keep at it. (4)				*.70*				.46
When I get something I want, I feel excited and energized. (7)				*.58*				.67
It would excite me to win a contest. (23)				*.56*				.49
NEW BRIEF BSCS ITEMS								
	Self-Discipline	*Impulse Control*			Self-Discipline	Impulse Control		

	DATASET 1 (TTU RC)		DATASET 2 (CTN A)	
I am good at resisting temptation. (1)	*.53*		.75	
People would say I have iron self-discipline. (8)	*.59*		.62	
I am able to work effectively toward long-term goals. (11)	*.54*		.49	
I do certain things that are bad for me, if they are fun. (5)		*.55*		.70
Pleasure and fun sometimes keep me from getting work done. (9)		*.62*		.60
I can't stop myself from doing something, even if I know its wrong. (12)		*.66*		.74
I often act without thinking through all the alternatives. (13)		*.63*		.66

Note. Abbreviations are: BIS-11 (Barratt Impulsiveness Scale, version 11); BIS/BAS (Behavioral Inhibition and Activation Scales); BSCS (Brief Self-Control Scale); Inhib (Behavioral Inhibition [BIS]). Italicized font indicates that item loadings are the result of exploratory factor analysis.

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Table 5

Evaluating Measurement Invariance of the New Brief BIS, BSCS, and BISBAS across Subgroups of Interest

	Dataset (TTURC vs. CTNA)				**Sex**				**Age**				**Race**			
BIS-11	**RMSEA**	**CFI**	**TLI**	**SRMR**	**RMSEA**	**CFI**	**TLI**	**SRMR**	**RMSEA**	**CFI**	**TLI**	**SRMR**	**RMSEA**	**CFI**	**TLI**	**SRMR**
Configural	.059	.956	.935	.039	.063	.949	.925	.041	.068	.951	.934	.047	.062	.952	.929	.040
Metric	.053	.958	.947	.042	.058	.950	.937	.044	.068	.945	.933	.056	.057	.952	.939	.046
Scalar	**.057**	**.950**	**.940**	**.043**	**.061**	**.939**	**.931**	**.045**	**.069**	**.936**	**.932**	**.055**	**.054**	**.953**	**.937**	**.048**
BIS/BAS																
Configural	.043	.956	.942	.041	.044	.953	.948	.041	.035	.968	.960	.046	.049	.954	.937	.041
Metric	.044	.950	.938	.052	.041	.955	.945	.043	.034	.968	.961	.050	.048	.954	.941	.045
Scalar	**.046**	**.943**	**.934**	**.055**	**.042**	**.951**	**.944**	**.045**	**.043**	**.946**	**.941**	**.053**	**.049**	**.946**	**.938**	**.048**
BSCS																
Configural	.044	.978	.964	.032	.040	.980	.968	.028	.042	.979	.966	.029	.040	.982	.971	.034
Metric	.045	.972	.962	.045	.037	.980	.973	.035	.037	.981	.974	.032	.048	.968	.958	.052
Scalar	**.051**	**.957**	**.950**	**.054**	**.049**	**.959**	**.952**	**.041**	*.055*	*.950*	*.942*	*.043*	**.049**	**.960**	**.957**	**.060**
Partial Scalar									**.039**	**.977**	**.970**	**.033**				

	Years of Education				**Family History (Alcohol)**				**Binge Drinking Status**				**Smoking Status**			
BIS-11	RMSEA	CFI	TLI	SRMR	RMSEA	CFI	TLI	SRMR	RMSEA	CFI	TLI	SRMR	RMSEA	CFI	TLI	SRMR
Configural	.059	.956	.935	.039	.063	.949	.925	.041	.068	.951	.934	.047	.062	.952	.929	.040
Metric	.053	.958	.947	.042	.058	.950	.937	.044	.068	.945	.933	.056	.057	.952	.939	.046
Scalar	**.057**	**.950**	**.940**	**.043**	**.061**	**.939**	**.931**	**.045**	**.069**	**.936**	**.932**	**.055**	**.054**	**.953**	**.937**	**.048**
BIS/BAS																
Configural	.042	.957	.943	.042	.038	.963	.951	.039	.039	.963	.951	.042	.043	.957	.943	.042
Metric	.041	.957	.948	.046	.036	.964	.956	.043	.036	.965	.957	.044	.041	.957	.947	.047
Scalar	**.044**	**.948**	**.938**	**.049**	**.037**	**.960**	**.955**	**.044**	**.035**	**.966**	**.960**	**.044**	**.046**	**.942**	**.934**	**.050**
BSCS																
Configural	.043	.979	.966	.031	.027	.992	.986	.024	.036	.984	.973	.028	.045	.977	.962	.038
Metric	.042	.976	.968	.041	.030	.988	.983	.037	.032	.985	.979	.031	.049	.967	.955	.048
Scalar	*.053*	*.955*	*.948*	*.056*	**.027**	**.988**	**.986**	**.043**	**.040**	**.972**	**.968**	**.038**	**.054**	**.952**	**.945**	**.054**
Partial Scalar	**.047**	**.967**	**.959**	**.049**												

Note. Abbreviations are BIS-11 (Barratt Impulsiveness Scale, version 11); BIS/BAS (Behavioral Inhibition and Activation Scales); BSCS (Brief Self Control Scale). *Italicized* font denotes measurement variance. **Bolded** model fit indices indicate strongest level of invariance achieved. A model was configurally invariant if RMSEA < .07 (Steiger, 2007), CFI & TLI > .90 (Bentler, 1990), and SRMR < .08

(Hu & Bentler, 1999). A model was metric invarint if decrement in fit between the configural and metric models did not exceed the following: RMSEA ≥ .015, CFI ≥ −.01, or SRMR ≥ .030. A model was scalar invariant if decrement in model fit between the metric and scalar models did not exceed CFI ≥ −.010 accompanied by a change in RMSEA ≥ .015 or SRMR ≥ .010. A measure was partial scalar invariant if model decrement in model fit between the metric and scalar models did not exceed CFI ≥ −.010 accompanied by a change in RMSEA ≥ .015 or SRMR ≥ .010 after accounting for biased items.

Table 6

Demographic Characteristics Influence Impulsivity and Self-Control

	BRIEF BIS-11				BRIEF BIS/BAS				BRIEF BSCS			
	MULTIVARIATE TESTS											
Demographics	**Pillai's Trace**	**F**	**df**	η_p^2	**Pillai's**	**F**	**df**	**ηp2**	**Pillai's**	**F**	**df**	**ηp2**
Sex	0.10	3.59	(2, 726)	$.10^{*}$	0.08	16.31	(4, 722)	$.08^{***}$	0.04	14.76	(2, 758)	$.04^{**}$
Age	0.03	4.70	(4, 1454)	$.01^{*}$	0.08	7.43	(8, 1446)	$.04^{***}$	0.03	6.41	(4, 1518)	$.02^{**}$
Race	0.01	3.68	(2, 726)	$.01^{*}$	0.03	6.37	(4, 722)	$.04^{***}$	0.01	2.24	(2, 758)	0.01
Education	0.00	0.38	(2, 726)	.00	0.00	0.18	(4, 722)	0.00	0.01	1.96	(2, 758)	0.01
Family History	0.02	8.92	(2, 726)	$.03^{***}$	0.01	2.29	(4, 722)	0.01	0.01	5.90	(2, 758)	$.01^{**}$
Binge Drinking	0.01	4.90	(2, 726)	$.01^{**}$	0.03	4.77	(4, 722)	$.03^{***}$	0.02	5.87	(2, 758)	$.02^{**}$
Smoking Status	0.01	1.77	(2, 726)	.01	0.03	5.09	(4, 722)	$.03^{***}$	0.01	3.93	(2, 758)	$.01^{*}$
	UNIVARIATE TESTS											
	BIS Subscales	Mean	F	ηp2	BIS/BAS	Mean	F	ηp2	BSCS	Mean	F	ηp2
Sex	Poor Self-Reg.	28.09	5.68	$.01^{*}$	Drive	0.00	0.00	.00	Self-Dis.	3.34	0.61	.00
	Imp. Behavior	19.23	4.37	$.01^{*}$	Fun	48.66	13.92	$.02^{***}$	Imp.	303.52	28.42	$.04^{**}$
					Inhibition	122.63	23.05	$.03^{***}$				
Age	Poor Self-Reg.	28.16	5.70	$.02^{**}$	Drive	24.91	7.32	$.02^{***}$	Self-Dis.	7.48	1.36	.00
	Imp. Behavior	28.90	6.57	$.02^{***}$	Fun	73.06	20.90	$.06^{***}$	Imp.	127.30	11.92	$.03^{**}$
					Reward	3.13	1.86	.01				
					Inhibition	17.70	3.33	.01				
Race	Poor Self-Reg.	13.94	2.82	.00	Drive	29.41	8.65	$.01^{**}$	Self-Dis.	21.13	3.84	.01
	Imp. Behavior	30.55	6.94	$.01^{**}$	Fun	13.41	3.84	.01	Imp.	21.11	1.98	.00
					Reward	7.74	4.60	$.01^{*}$				
Education	Poor Self-Reg.	2.70	0.55	.00	Drive	0.69	0.20	.00	Self-Dis.	4.48	0.82	.00
	Imp. Behavior	2.34	0.53	.00	Fun	0.30	0.08	.00	Imp.	19.80	1.85	.00
					Reward	0.08	0.05	.00				

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	MULTIVARIATE TESTS											
	BRIEF BIS-11				BRIEF BIS/BAS				BRIEF BSCS			
Demographics	Pillai's Trace	F	df	η_p^2	Pillai's	F	df	ηp2	Pillai's	F	df	ηp2
					Inhibition	2.07	0.39	.00				
Family History	Poor Self-Reg.	17.21	3.48	.01	Drive	12.73	3.74	.01	Self-Dis.	15.66	2.85	.00
	Imp. Behavior	78.55	17.84	.02***	Fun	19.31	5.53	.01	Imp.	108.35	10.15	.01**
					Reward	1.48	0.88	.00				
					Inhibition	20.18	3.79	.01				
Binge Drinking	Poor Self-Reg.	46.46	9.40	.01**	Drive	9.87	2.90	.00	Self-Dis.	34.10	6.21	.01**
	Imp. Behavior	1.95	0.44	.00	Fun	13.60	3.89	.01*	Imp.	99.62	9.33	.01**
					Reward	0.02	0.01	.00				
					Inhibition	27.56	5.18	.01*				
Smoking Status	Poor Self-Reg.	17.40	3.52	.01	Drive	11.14	3.28	.00	Self-Dis.	37.01	6.73	.01**
	Imp. Behavior	3.65	0.83	.00	Fun	24.28	6.95	.01**	Imp.	37.23	3.49	.00
					Reward	0.09	0.05	.00				
					Inhibition	48.41	9.10	.01**				

Note.

* $p < .05$

** $p < .01$

*** $p < .001$

Abbreviations are BIS-11 (Barratt Impulsiveness Scale, version 11); BIS/BAS (Behavioral Inhibition and Activation Scales); BSCS (Brief Self Control Scale); Poor Self-Reg (Poor Self-Regulation); Imp. behavior (Impulsive behavior); Self-Dis (Self-Discipline); Imp. Cont. (Impulse Control).

Table 7

Relationships among the New Brief Versions of the Barrett Impulsivity Scale, the Behavioral Inhibition and Activation Scales, and the Brief Self-Control Scale

	Brief BIS		**Brief BIS/BAS**			
	Poor Self-Regulation	**Impulsive Behavior**	**Drive**	**Fun Seeking**	**Reward**	**Inhibition**
Drive	−0.05	.13***	--	--	--	--
Fun Seeking	.25***	.49***	--	--	--	--
Reward	−.10***	0.05	--	--	--	--
Inhibition	.12***	.16***	--	--	--	--
Impulse Control	−.42***	−.54***	-.17***	−.42***	−0.01	−.17***
Self-Discipline	−.51***	−.29***	.09**	−.17***	.08**	−.15***

Note.

** p < .01

*** p < .001.

Samples sizes for each cell ranged from 1117 to 1174. Abbreviations are BIS (Barratt Impulsiveness Scale, version 11); BIS/BAS (Behavioral Inhibition and Activation Scales); BSCS (Brief Self Control Scale). “--” denotes correlations that are not relevant.

Table 8

Self-Reported Impulsivity Predicts Maximum Drinks Consumed (Lifetime) and Alcohol-Related Problems above and beyond Participant Demographics

		Max # Drinks (Lifetime)			Alcohol-Related Problems		
		df	***F***	η_p^2	**df**	***F***	η_p^2
Brief	Model	(10, 767)	7.84	.09***	(11, 742)	20.32	.23***
BIS-11	Intercept	(1, 767)	39.32	.05***	(1, 742)	2.16	.00
	Dataset	(1, 767)	37.11	.05***	(1, 742)	51.18	.07***
	Sex	(1, 767)	11.84	.02**	(1, 742)	20.80	.03***
	Age	(2, 767)	0.24	.00	(2, 742)	1.08	.00
	Race	(2, 767)	2.86	.01	(2, 742)	1.42	.00
	Education	(1, 767)	2.24	.00	(1, 742)	3.47	.01
	Family Hx.	(1, 767)	1.22	.00	(1, 742)	9.62	.01**
	Smoking	(1, 767)	11.74	.02**	(1, 742)	11.08	.02***
	Binge Drinking	--	--	--	(1, 742)	8.48	.01**
	Poor Self-Regulation	(1, 767)	6.66	.01**	(1, 742)	31.39	.04***
	Impulsive Behavior	(1, 767)	0.00	.00	(1, 742)	6.61	.01*
Brief	Model	(12, 763)	6.51	.09***	(13, 738)	14.96	.21***
BIS/BAS	Intercept	(1, 763)	14.66	.02***	(1, 738)	0.64	.00
	Dataset	(1, 763)	38.28	.05***	(1, 738)	53.20	.07***
	Sex	(1, 763)	8.03	.01**	(1, 738)	22.58	.03***
	Age	(2, 763)	0.19	.00	(2, 738)	1.04	.00
	Race	(2, 763)	3.68	.01*	(2, 738)	2.07	.01
	Education	(1, 763)	3.85	.01	(1, 738)	2.75	.00
	Family Hx	(1, 763)	1.03	.00	(1, 738)	11.24	.02***
	Smoking	(1, 763)	11.65	.02**	(1, 738)	13.36	.02***
	Binge Drinking	--	--	--	(1, 738)	11.68	.02***
	Drive	(1, 763)	1.80	.00	(1, 738)	0.96	.00
	Fun	(1, 763)	7.19	.01**	(1, 738)	23.59	.03***

		Max # Drinks (Lifetime)			Alcohol-Related Problems		
		df	***F***	η_p^2	**df**	***F***	η_p^2
	Reward	(1, 763)	0.21	.00	(1, 738)	0.01	.00
	Inhibition	(1, 763)	2.15	.00	(1, 738)	7.45	.01**
Brief	Model	(10, 799)	11.78	.13***	(11, 775)	36.23	.34***
BSCS	Intercept	(1, 799)	106.90	.12***	(1, 775)	276.22	.26***
	Dataset	(1, 799)	59.13	.07***	(1, 775)	72.62	.09***
	Sex	(1, 799)	15.78	.02***	(1, 775)	10.12	.01**
	Age	(2, 799)	0.08	.00	(2, 775)	0.00	.00
	Race	(2, 799)	3.42	.01*	(2, 775)	3.24	.01*
	Education	(1, 799)	3.47	.01	(1, 775)	0.53	.00
	Family Hx	(1, 799)	0.38	.00	(1, 775)	6.07	.01*
	Smoking	(1, 799)	18.65	.02***	(1, 775)	7.71	.01**
	Binge Drinking	--	--	--	(1, 775)	12.97	.02***
	Impulse Control	(1, 799)	0.94	.00	(1, 775)	114.78	.13***
	Self Discipline	(1, 799)	6.50	.01*	(1, 775)	9.40	.01**

Note.

* $p < .05$

** $p < .01$

*** p < 001

Abbreviations are BIS-11 (Barratt Impulsiveness Scale, version 11); BIS/BAS (Behavioral Inhibition and Activation Scales); BSCS (Brief Self Control Scale). Reference groups are as follows: TTURC dataset, female sex, age < 25 years, White race, education ≤ high school, family history negative for alcoholism, and non-binge drinkers.

Table 9

Self-Reported Impulsivity Predicts Cigarette Smoking Status above and beyond Participant Demographics

	Variables	*B* (SE)	Wald	Odds Ratio
Brief	Dataset	2.90 (.22)	167.26	18.13***
	Sex	0.45 (.22)	4.04	1.57*
	Age (ref. < 25)		13.15	
	25–39 years	.63 (.24)	6.61	1.87**
	>39 years	.90 (.27)	11.36	2.47***
	Race (ref. White)		0.35	
	Black	.07 (.28)	0.06	1.07
	Other	−.20 (.40)	0.24	.82
	Education	−1.15 (.27)	18.61	.32***
	Family History	.19 (.21)	0.84	1.22
	Binge Drinking	.80 (.23)	12.14	2.23***
	Poor Self-Regulation	.09 (.04)	4.66	1.09*
	Impulsive Behavior	.06 (.01)	1.37	1.06^{T}
Brief	Dataset	2.82 (.22)	160.64	16.82***
	Sex	.34 (.23)	2.09	1.40
	Age (ref. < 25)		16.30	
	25–39 years	.67 (.25)	7.42	1.95**
	>39 years	1.07 (.28)	14.65	2.91***
	Race (ref. White)		0.43	
	Black	−.02 (.28)	0.00	.98
	Other	−.26 (.40)	0.43	.77
	Education	−1.18 (.26)	19.88	.31***
	Family History	.25 (.21)	1.37	1.28
	Binge Drinking	.82 (.23)	12.58	2.28***
	Drive	.08 (.07)	1.55	1.09
	Fun	.12 (.06)	3.96	1.13*
	Reward	−.03 (.09)	0.13	.97
	Inhibition	−.09 (.05)	4.04	.91*
Brief	Dataset	2.85 (.22)	169.96	17.20***
	Sex	.36 (.22)	2.66	1.43
	Age (ref. < 25)		12.14	
	25–39 years	.57 (.24)	5.75	1.76*
	>39 years	.85 (.26)	10.78	2.35***
	Race (ref. White)		0.35	
	Black	.13 (.27)	0.22	1.13
	Other	−.10 (.37)	0.08	.90

Variables	*B* (SE)	Wald	Odds Ratio
Education	−1.17 (.25)	21.78	.31***
Family History	.17 (.20)	0.67	1.18
Binge Drinking	.87 (.23)	14.63	2.39***
Impulse Control	−.07 (.03)	4.29	.94*
Self Discipline	−.10 (.05)	4.28	.91*

Note. superscript $T < .10$

* $p < .05$

** $p < .01$

*** $p < .001$

Abbreviations are BIS-11 (Barratt Impulsiveness Scale, version 11); BIS/BAS (Behavioral Inhibition and Activation Scales); BSCS (Brief Self Control Scale). Reference groups are: TTURC dataset, female sex, age < 25 years, White race, education ≤ high school, family history negative for alcoholism, and non-binge drinkers.